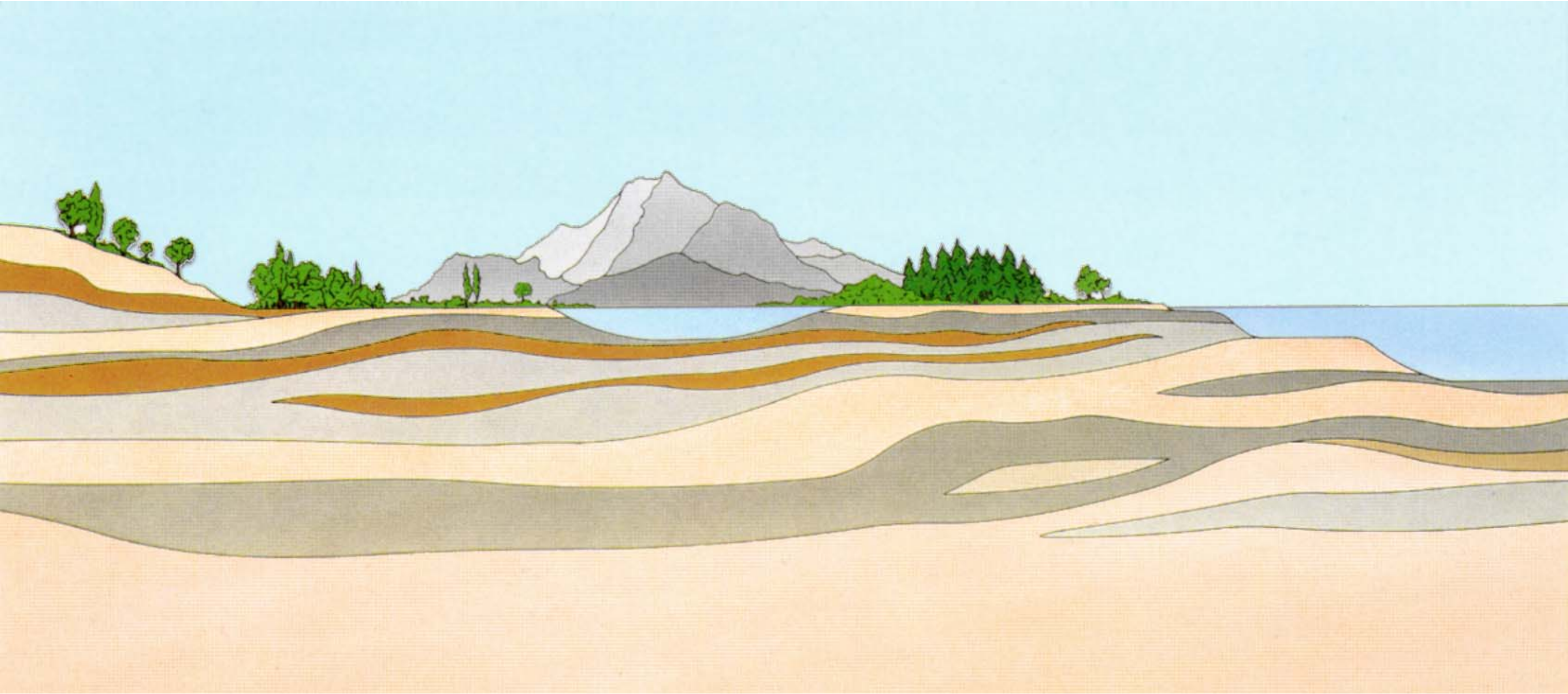
FUGRO WEST, INC.

PASO ROBLES GROUNDWATER BASIN WATER BALANCE REVIEW AND UPDATE

Prepared for:
County of San Luis Obispo, Department of Public Works
City of Atascadero
Atascadero Mutual Water Company
Templeton Community Services District
City of Paso Robles

March 2010



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Project No. 3014.036

County of San Luis Obispo
Public Works Department
County Government Center, Room 207
San Luis Obispo, California 93408

Attention: *Ms. Courtney Howard*

Subject: Paso Robles Groundwater Basin Water Balance Review and Update

Dear Ms. Howard:

This report presents an update of the water balance for the Paso Robles Groundwater Basin and the Atascadero Subbasin for the water years of 1998 to 2009, as well as a projected water balance for both the Basin and Subbasin for the future period of 2010 to 2025.

The water balance calculations presented in this report show that demand in both the Atascadero Subbasin and the Paso Robles Groundwater Basin as a whole is approaching the average annual perennial yield. Given the degree of uncertainty of the estimates of inflow and outflow components of the water balance equation, it may be advisable to assume that the Basin is essentially in balance by a small margin.

Total annual groundwater outflow (i.e., total groundwater pumping) in the Paso Robles Groundwater Basin and the Atascadero Subbasin increased during the period from 1998 to 2009. In 2009, the water balance calculation (assuming a rural domestic water demand of 1.0 acre feet per year per dwelling unit (AFY/DU)) shows that total groundwater outflow in the Basin was approximately 91,915 AF (or approximately 94% of the perennial yield of 97,700 AFY). The water balance for the scenario that assumes a rural domestic water demand of 1.7 AFY/DU indicates total groundwater outflow of 96,781 AF in 2009 (or approximately 99% of the perennial yield).

In the Atascadero Subbasin, the water balance calculation (assuming a rural domestic demand of 1.0 AFY/DU) shows that total groundwater outflow in the Subbasin in 2009 was approximately 15,255 AF (or about 93% of the perennial yield of 16,400 AFY). The water balance calculation for the scenario that assumes a rural domestic demand of 1.7 AFY/DU indicates total groundwater outflow in the Subbasin in 2009 of 16,012 AF (or approximately 98% of the perennial yield).

With outflows in the Basin and Subbasin approaching the perennial yield values, it may be appropriate in future investigations to evaluate groundwater in storage separately for the three different aquifer regimes (shallow alluvial aquifers, the Paso Robles Formation in the Subbasin, and the Paso Robles Formation within the entire Basin). Given the significant groundwater in storage in the alluvium within the Subbasin relative to the storage in the Paso Robles Formation in the Subbasin, it is appropriate that future studies account for annual groundwater extractions in the Subbasin from the alluvium separately from those from the Paso Robles Formation. For example, the City of Paso Robles produces approximately one-half of their groundwater production from the alluvial aquifer in the Atascadero Subbasin. Such pumping has little to no impact on water levels within the Paso Robles Formation in the Subbasin. The perennial yield for the Subbasin theoretically applies to combined groundwater extractions from the shallow alluvium and deeper Paso Robles Formation. Exceeding the perennial yield in the Subbasin may not necessarily be reflected by decreasing groundwater levels in the Paso Robles Formation since significant pumping occurs in the alluvium, as evidenced by the pumping totals of the City of Paso Robles. Therefore, the overdraft status of the Subbasin needs to be evaluated by assessment of groundwater level changes in both the alluvium and the Paso Robles Formation relative to the respective pumping from those aquifers.

The results of this study reinforce the need for implementation of an effective basin monitoring and management plan. The results also demonstrate the need to update the County's numerical groundwater flow model, which was developed by Fugro and is based on data through 1997. An update and recalibration of the model would help to refine the many uncertainties and assumptions that were used throughout this water balance update.

Please let us know if you have any questions.

Sincerely,

FUGRO WEST, INC.

Nels Ruud, Ph.D
Project Hydrogeologist

Paul A. Sorensen, P.G., CHg
Principal Hydrogeologist

CONTENTS

TABLES

FIGURES

PLATES

PASO ROBLES GROUNDWATER BASIN WATER BALANCE REVIEW AND UPDATE

1.0 INTRODUCTION

This report presents an update of the annual water balance for the Paso Robles Groundwater Basin (Basin) and the Atascadero Groundwater Subbasin (Subbasin) for the period of 1998 to 2009 (Plate 1). The purpose of the report is to provide the County of San Luis Obispo (County) with updated information to assist in the preparation of a Resource Capacity Study (RCS) for the Basin and Subbasin and ongoing Basin and Subbasin management efforts. This update is a continuation of the water balance that was estimated as part of the Paso Robles Groundwater Basin Study (Fugro and Cleath 2002). That study consisted of data collection, conceptualization of the basin hydrogeology, and estimation of a water balance from 1981 to 1997. Phase II of that study (Fugro, ETIC, and Cleath 2005) consisted of the development of a numerical groundwater flow model for the Basin that was used to evaluate several future scenarios of water supply and demand in the Basin. The results of Phase I were documented in a report entitled "*Final Report Paso Robles Groundwater Basin Study*" (Fugro West, 2002). Similarly, the findings of Phase II were documented in a report entitled "*Final Report Paso Robles Groundwater Basin Study, Phase II Numerical Model Development, Calibration, and Application*" (Fugro West, 2005). A major application of the groundwater model during Phase II was to estimate the perennial yields of the Basin and the Subbasin, which were estimated to be 97,700 acre-feet per year (AFY) and 16,400 AFY, respectively.

Groundwater pumping in the Basin during the 2006 water year was recently estimated in a study performed by Todd Engineering for the City of Paso Robles and the County (Todd, 2009). The results of that study were documented in a report entitled "*Evaluation of Paso Robles Groundwater Basin Pumping, Water Year 2006*" (Todd, 2009). The water balance update performed in this study expands on the work of Fugro and Cleath (Fugro West, 2002) and Todd (2009). The water balance consists of the quantification of the major natural and anthropogenic sources of groundwater recharge and discharge in the Basin and Subbasin from 1998 to 2009. The 1998 to 2009 water balance was then combined with the 1981 to 1997 water balance from Fugro (2002). Cumulative groundwater storage changes in the Basin and Subbasin from 1981 to 2009 were calculated from their respective water balances.

In addition to updating the water balances from 1998 to 2009, this report also provides a projected water balance for both the Basin and Subbasin for the future period of 2010 to 2025. These projected water balances include future water demand estimates of the major urban communities in the Basin and Subbasin (the projections do not include estimates of future changes in agricultural pumping, which constitutes the single largest component of groundwater pumping in the Basin). Within the next few years, the cities of Paso Robles and Atascadero and the community of Templeton each anticipate receiving surface water supplies from the Nacimiento Water Project. These supplies will be used in conjunction with pumped groundwater to satisfy local urban water demands in the future. In addition to providing an alternative and reliable source of water supply, these surface water deliveries will also reduce the future groundwater pumping demands of these communities.

Numerous uncertainties and assumptions are used, by necessity, in the calculation of the water balance. Additional detailed studies that might refine the methodologies used to develop the assumptions, or the development of new data that might reduce the uncertainties, could potentially significantly affect the results of these calculations. Furthermore, the projected water balances from 2010 to 2025 are not intended to provide absolute predictions of future groundwater recharge and discharge rates, and subsequent groundwater storage changes. Instead, they provide for a general assessment of anticipated future groundwater pumping demands with respect to current estimates of perennial yield given assumed trends in agricultural, urban, and rural water use and future climate. The specific assumptions used in the calculation of the water balances for the Basin and Subbasin from 2010 to 2025 are discussed in this report.

The groundwater supplies in the Basin and Subbasin are predominantly derived from aquifer storage of the Salinas River alluvium and the Paso Robles Formation (Plate 2). Although these aquifers are hydraulically connected, the recharge and discharge processes operating on them are not identical. Therefore, this report also provides a qualitative discussion of the interaction between the underflow in the Salinas River alluvium and the groundwater reservoir of the Paso Robles Formation. That discussion provides clarification of the perennial yield concept with respect to the groundwater flow and storage characteristics of the alluvium and the Paso Robles Formation.

2.0 BACKGROUND AND SETTING

2.1 STUDY AREA

The Paso Robles Groundwater Basin is 505,000 acres in size and spans southern Monterey County and northern San Luis Obispo County (Plate 1). The Paso Robles Groundwater Basin is divided into eight sub-areas: 1) Atascadero Groundwater Subbasin, 2) Bradley Subarea, 3) Creston Subarea, 4) Estrella Subarea, 5) North Gabilan Subarea, 6) San Juan Subarea, 7) Shandon Subarea, and 8) South Gabilan Subarea. The Atascadero Groundwater Subbasin is 14,577 acres in size.

The four major urban communities in the Basin are the cities of Paso Robles and Atascadero, and the communities of Templeton and San Miguel (Plate 1). The City of Paso Robles is the water purveyor to its resident population and also operates the associated wastewater treatment plant. The Templeton Community Services District (CSD) and the San Miguel CSD each also provide both potable water service and wastewater treatment for their respective communities. The Atascadero Mutual Water Company (MWC) is the water purveyor to the City of Atascadero, however wastewater treatment is provided by the City of Atascadero.

2.2 RECENT CLIMATE

Measured annual precipitation from 1998 to 2009 at seven rainfall gauge stations located in the Basin is presented in Table 1 (data obtained from County of San Luis Obispo Department of Public Works). The locations of the seven gauge stations are shown on Plate 1. (Four instances of missing annual precipitation measurements are indicated by “red” cells in

Table 1. For those instances, annual precipitation was estimated using correlation relationships with the other gauge stations.) Overall, average annual precipitation over the seven stations varied from 9.6 inches at Camatta Canyon Station No. 138 to 30.3 inches at Santa Margarita Station No. 95 (Table 1).

An annual reference precipitation time series for the Basin was calculated as the average of annual precipitation from six of the seven stations. The Santa Margarita station was omitted from the average calculation because rainfall levels at that station were considered significantly higher, and thus non-representative, than those measured in the valley or otherwise lower lying areas in the Basin. The calculated average of the annual reference precipitation from 1998 to 2009 was 12.9 inches (Table 1).

Based on designated water year types, the water years of 2007 and 2008 were considered ‘critical’; 2001, 2002, 2004, and 2009 were considered ‘dry’; 2003 was ‘below normal’; 1999 and 2000 were ‘above normal’; and 1998, 2005, and 2006 were ‘wet’ water years. Given these water year types and the average annual reference precipitation for the Basin (i.e., 12.9 inches), seven of the twelve years from 1998 to 2009 were below the average annual reference precipitation while the other five years were above.

A long-term average annual precipitation of 17.6 inches per year was computed for the Atascadero MWC Station No. 34 using annual precipitation totals from 1916 to 2009 (Figure 1). Measured annual precipitation for each year from 1998 to 2009 was subtracted from the long-term average of 17.6 inches per year (i.e., to generate the annual departure from the long-term mean) and these departures are presented in Table 2. These departures were then summed to calculate the cumulative change in precipitation from 1998 to 2009 with respect to the long-term average (Table 2). From 1998 to 2009, the cumulative departure of precipitation from the long-term average was –10.4 inches. This negative cumulative departure indicates that the region from 1998 to 2009 received less precipitation on an average annual basis (i.e., 0.9 inches per year less) in comparison to its long-term annual average. The cumulative departure curve for the Atascadero MWC Station No. 34 over the long-term period of 1916 to 2009 is presented on Figure 2.

3.0 ESTIMATED WATER BALANCES FROM 1998 TO 2009

The water balances for the Basin and Subbasin consist of the major groundwater recharge and discharge processes that occur in these areas. In general, the major groundwater recharge components of each water balance are: 1) subsurface inflows, 2) deep percolation of precipitation, 3) streambed percolation, 4) agricultural irrigation return flows, and 5) discharge of treated wastewater. Conversely, the major groundwater discharge components of each water balance are: 1) subsurface outflows, 2) agricultural pumping, 4) urban pumping, 5) small commercial pumping, 6) rural domestic pumping, and 7) phreatophyte extraction. Of note, the County water year begins on July 1 and ends after June 30. For example, the 2006 water year began on July 1, 2005 and ended after June 30, 2006. Therefore, the 12-year study period in this water balance update is from July 1, 1997 to June 30, 2009.

As directed, most of the components of the water balance were based on the assumptions and values presented in the previous Basin study (Fugro, 2002), and were either held constant throughout the water balance update or modified according to a straight-line interpolation between the two known data points of 1997 and 2006. The primary components that were modified as part of this study include the water duty factor of rural domestic pumping (Section 3.2.5) and wastewater discharge and return flows (Section 3.1.5).

As described in Section 3.2.5 – Rural Domestic and Small Community Pumping, two different sets of water duty factors were used to estimate rural domestic pumping in the Basin and Subbasin. This resulted in the development of two water balances for the Basin (Tables 3 and 4) and two water balances for the Subbasin (Tables 5 and 6) from 1998 to 2009. Tables 3 and 4 differ only in the estimation of rural domestic pumping in the Basin. Likewise, Tables 5 and 6 also differ only in the estimation of rural domestic pumping in the Subbasin. These tables are introduced here and are referenced in the subsequent sections that describe the estimation of the individual components in the Basin and Subbasin.

It should be noted that the precision of the results estimated by the methods employed in this study and subsequently presented in the report text and tables do not imply a similar level of accuracy. In other words, a number of assumptions were invoked in the estimation of the recharge and discharge components. These estimated components therefore represent approximations that lie within a reasonable range of expected values. The values of the estimated components were presented "as is" in the report text and tables rather than being subjected to numerical rounding.

3.1 GROUNDWATER RECHARGE

3.1.1 Subsurface Inflows

Annual subsurface inflow in the Basin from 1998 to 2009 was calculated using a linear regression equation developed between estimated annual subsurface inflow and annual measured precipitation at Atascadero MWC Station No. 34 from 1981 to 1997 (Table 1). As part of the regression equation parameter estimation, a multiple R-square statistic is calculated. The multiple R-square statistic is the correlation coefficient of a predicted dependent variable and the measured dependent variable used in the regression equation to estimate the prediction. This statistic provides a measure of the amount of variation that the independent variable (i.e., annual precipitation) can account for of the dependent variable (i.e., subsurface inflow) in the regression relationship. In other words, the multiple R-square statistic provides a measure of how well predictions are made by the regression equation. The multiple R-square statistic varies between 0 and 1, where a value close to 0 indicates that the regression equation is a poor predictor of the dependent variable and a value close to 1 indicates that the regression equation is a good predictor. The computed multiple R-square statistic between annual subsurface inflow and annual precipitation from 1981 to 1997 is 0.94. The regression equation line and the paired values of annual subsurface inflow and annual precipitation from 1981 to 1997 are plotted together on Figure 3. Annual subsurface inflow in the Basin was then estimated from 1998 to 2009 using this regression equation and varied from 3,510 AF in 2007 to 13,033 AF in 2005, with an average annual value of 6,729 AF (Tables 3 and 4).

A similar linear regression relationship was also developed between annual estimated subsurface inflow in the Subbasin and annual measured precipitation at Atascadero MWC Station No. 34 from 1981 to 1997. The associated multiple R-square was also 0.94. The regression equation line and the paired values of annual subsurface inflow and annual precipitation from 1981 to 1997 are plotted together on Figure 4. From 1998 to 2009, estimated subsurface inflows in the Subbasin varied from 375 AF in 2007 to 1,325 AF in 2005, with an average annual value of 696 AF (Tables 5 and 6).

3.1.2 Deep Percolation of Precipitation

Annual deep percolation of precipitation in the Basin from 1998 to 2009 was estimated using a methodology developed by Blaney (1933). The Blaney method was also used in the Phase I Report to estimate deep percolation of precipitation in the Basin from 1981 to 1997 (Fugro West, 2002). Originally, Blaney (1933) measured the amount of precipitation that percolated beyond the root zone for different categories of vegetative cover and for different amounts of precipitation. Using the measured data, Blaney developed a linear regression relationship between the rate of deep percolation of precipitation and the rate of precipitation falling on the ground surface for each of the vegetative cover categories. The applicable vegetative cover categories from the Blaney study used in this update are: 1) grasses and weeds, 2) truck, alfalfa, and miscellaneous crops, 3) non-irrigated grain crops, and 4) deciduous tree crops. The associated linear regression equations developed by Blaney for these four categories are displayed on Figure 5. As noted in the Phase I Report, regression equations were not developed specifically for urban, rural, and suburban land uses, and vineyard crops. As in the Phase I Report, it is assumed here that deep percolation of precipitation for urban, rural, and suburban land uses is modeled by the regression equation for grasses and weeds. Similarly, deep percolation of precipitation for vineyards is modeled using the regression equation for deciduous tree crops.

The total acreage for each of the four vegetative cover categories listed above in the Basin from 1998 to 2009 is presented in Table 7. A reference annual precipitation used here in the Blaney method was calculated as the average annual precipitation of all the gauged stations in Table 1 (excluding the data from the Santa Margarita Station No. 95 (see Section 2.1 – Recent Climate for discussion)). Applying the Blaney method, annual deep percolation of precipitation in the Basin was estimated to be negligible or small during the water years of 1999, 2000, 2002 to 2004, and 2007 to 2009. For the two wettest water years, annual deep percolation of precipitation was estimated to be 321,785 AF in 1998 and 215,760 AF in 2005 (Tables 3 and 4).

Annual deep percolation of precipitation in the Subbasin was also estimated using the regression equations developed by Blaney (1933). The total acreage for each of the four vegetative cover categories is presented in Table 8. Again, annual precipitation used in the Blaney method was calculated as the average annual precipitation of all the gauged stations in Table 1, except for Santa Margarita Station No. 95. Similar to the Basin, annual deep percolation of precipitation in the Subbasin was estimated to be negligible or small during 1999, 2000, 2002 to 2004, and 2007 to 2009. For the two wettest water years, annual deep percolation of precipitation was estimated to be 16,803 AF in 1998 and 18,478 AF in 2005 (Tables 5 and 6).

It should be noted that the annual estimate of deep percolation of precipitation for a particular year is not identical to the amount of precipitation that recharges the aquifer system during that same year. The recharge rate of precipitation that has percolated into the subsurface is a function of the thickness and transmissive properties of the unsaturated zone. For example, groundwater recharge from precipitation in the shallow Salinas River alluvium likely occurs within the same year that the precipitation infiltrates into the coarse-grained sediments associated with the alluvium. However, the downward flow of precipitation is generally slower through the deeper and lesser permeable sediments of the unsaturated zone associated with a large area of the Paso Robles Formation. As such, the unsaturated zone attenuates the rate at which deep percolation of precipitation recharges the underlying aquifer. The significant volume of precipitation that percolates into the subsurface during a particular year may take several years to recharge the aquifer.

3.1.3 Streambed Percolation

Annual streambed percolation in the Basin from 1998 to 2009 was also estimated using a linear regression relationship developed between estimated annual streambed percolation and annual measured precipitation at Santa Margarita Booster Station No. 95 from 1981 to 1997. The calculated multiple R-square statistic in this regression relationship was 0.82. The regression equation line and the paired values of annual streambed percolation and measured precipitation from 1981 to 1997 are plotted together on Figure 6. Annual streambed percolation in the Basin was then estimated from 1998 to 2009 using this regression equation and varied from 1,500 AF in 2007 to 103,408 AF in 1998, with an average annual value of 40,700 AF (Tables 3 and 4).

A similar linear regression relationship was also developed between annual estimated streambed percolation in the Subbasin and annual measured precipitation at Santa Margarita Booster Station No. 95 from 1981 to 1997. The associated multiple R-square was 0.77. The regression equation line and the paired values of annual streambed percolation and annual precipitation from 1981 to 1997 are plotted together on Figure 7. From 1998 to 2009, estimated streambed percolation in the Subbasin varied from 5,071 AF in 2007 to 16,994 AF in 1998, with an average annual value of 9,874 AF (Tables 5 and 6).

3.1.4 Agricultural Irrigation Return Flows

Annual agricultural irrigation return flows in the Basin from 1998 to 2009 were estimated as a percentage of the gross annual agricultural groundwater pumping (i.e., applied irrigation water). During 1997, irrigation return flows in the Basin were estimated in the Phase I Report to be an average of about 2.2 percent of the gross agricultural pumping demand. From a practical standpoint, it is unlikely that inefficiencies could be reduced below this percentage loss by further improvements to irrigation methods. Therefore, annual irrigation return flows from 1998 to 2009 were estimated as 2.2 percent of annual gross agricultural pumping. Using this percentage loss, annual irrigation return flows in the Basin increased annually from 1,139 AF in

1998 to 1,388 AF in 2009, with an average annual value of 1,264 AF (Table 9). In the Subbasin, annual irrigation return flows increased from 23 AF in 1998 to 32 AF in 2009, with an average annual value of 28 AF (Table 9).

3.1.5 Wastewater Discharge

Wastewater discharge includes discharge of treated effluent from wastewater treatment plants and discharge from on-site septic systems. The City of Paso Robles, City of Atascadero, Templeton CSD, and San Miguel CSD each discharge treated wastewater effluent in the Salinas River alluvium from their respective treatment facilities. Annual discharge volumes of treated wastewater from 1998 to 2009 from these four treatment facilities are presented in Table 10 (a complete data set for 1998 to 2001 was not available from San Miguel CSD and are annual discharge values are estimated. Wastewater discharge by the Templeton CSD began in 2003). The City of Paso Robles and San Miguel CSD discharge to areas in the Salinas River alluvium that are located in the Basin but downstream of the Subbasin. Conversely, the City of Atascadero and Templeton CSD discharge treated wastewater in areas of the alluvium within the Subbasin. The combined annual discharge of treated wastewater in the Basin by all four treatment facilities varied from 4,102 AF in 1999 to 4,862 AF in 2005, with an average annual value of 4,497 AF (Table 10). The annual discharge of treated wastewater in the Subbasin by the City of Atascadero and Templeton CSD varied from 1,030 AF in 2000 to 1,423 in 2005, with an average annual value of 1,178 AF (Table 10).

Small commercial enterprises that provide their own water supply by private wells (see 3.2.4 – Small Commercial Pumping) are assumed to discharge their wastewater in on-site septic systems. Similarly, rural residences and small community water systems that operate private wells (see 3.2.5 – Rural Domestic and Small Community System Pumping) are also assumed to discharge their wastewater in on-site septic systems. For both small commercial and rural domestic/small community private well systems, annual wastewater discharge is further assumed to be 50 percent of the annual pumped volume. Consequently, annual wastewater discharge from small commercial systems increased from 751 AF in 1998 to 1,315 in 2009 in the Basin (Tables 3 and 4) and from 157 AF in 1998 to 237 AF in 2009 in the Subbasin (Tables 5 and 6).

As described later in 3.2.5 – Rural Domestic and Small Community System Pumping, two different sets of water duty factors were used to estimate annual pumping by rural domestic private wells. Under water duty factor Set No. 1, annual wastewater discharge from rural domestic/small community systems increased from 2,824 AF in 1998 to 3,476 AF in 2009 in the Basin (Table 3) and from 530 AF in 1998 to 541 AF in 2009 in the Subbasin (Table 5). Conversely, under water duty factor Set No. 2 annual wastewater discharge from rural domestic/small community systems increased from 4,801 AF in 1998 to 5,909 AF in 2009 in the Basin (Table 4) and from 902 AF in 1998 to 919 AF in 2009 in the Subbasin (Table 6).

3.2 GROUNDWATER DISCHARGE

3.2.1 Subsurface Outflows

Annual subsurface outflow in the Basin from 1981 to 1997 was estimated as a constant value of 600 AF. This estimate for the Basin was also applied to each year from 1998 to 2009 (Tables 3 and 4). Similarly, annual subsurface outflow in the Subbasin from 1981 to 1997 was estimated as a constant value of 150 AF and was also applied to each year from 1998 to 2009 (Tables 5 and 6).

3.2.2 Agricultural Pumping

Gross agricultural pumping in the Basin and Subbasin during 2006 was estimated to be 60,000 and 1,348 AF, respectively (Todd, 2009). Estimated gross agricultural pumping in the Basin during 1997 by Fugro and Cleath (Fugro West, 2005) was used in conjunction with the corresponding Todd estimate during 2006 to estimate via straight-line interpolation the annual gross agricultural pumping in the Basin from 1998 to 2005. Annual gross agricultural pumping from 2007 to 2009 was subsequently estimated by extrapolation from the 2006 estimate by Todd (2009). Similarly, annual gross agricultural pumping in the Subbasin from 1998 to 2005 and from 2007 to 2009 was also estimated by straight-line interpolation and extrapolation, respectively.

By this methodology, annual gross agricultural pumping in the Basin increased from 51,794 AF in 1998 to 63,077 AF in 2009 (Table 10). In a similar manner, annual gross agricultural pumping in the Subbasin increased monotonically from 1,059 AF in 1998 to 1,456 AF in 2009 (Table 10).

3.2.3 Urban Pumping

Annual urban pumping from 1998 to 2009 by the City of Paso Robles, Atascadero MWC, Templeton CSD, and San Miguel CSD is presented in Table 11. Production wells operated by the Atascadero MWC and Templeton CSD are located entirely within the Subbasin whereas the production wells operated by San Miguel CSD are located entirely within the Estrella Sub-area of the Basin. The City of Paso Robles Thunderbird well field is located in the shallow alluvium within the Subbasin whereas the City's other shallow and deep production wells are located in the Estrella Sub-area of the Basin. According to historical data, approximately 50 percent of the City's total groundwater extraction occurs in the Thunderbird well field. Therefore, for this study it is assumed that 50 percent of the City's annual extraction from 1998 to 2009 occurs within the Subbasin and the other 50 percent occurs in the Estrella Sub-area.

Annual urban pumping from 1998 to 2009 for the City of Paso Robles, Templeton CSD, and San Miguel CSD were estimated by straight-line interpolation using reported pumped volumes for 1997 and 2006. Annual pumping by the Atascadero MWC was instead reported for each calendar year from 1998 to 2009. In Table 11, annual pumping by the City of Paso Robles increased from 6,026 AF in 1998 to 8,032 AF in 2009; increased from 1,181 AF in 1998 to 1,782 AF in 2009 for Templeton CSD; and increased from 239 AF in 1998 to 379 AF in 2009 for San

Miguel CSD. Annual pumping by the Atascadero MWC varied from 6,189 AF in 2009 to 6,307 AF in 1998, with an average annual pumping rate of 6,248 AF. Total annual urban pumping in the Basin by all four purveyors increased from 13,752 AF in 1998 to 16,382 AF in 2009, whereas the total annual urban pumping in the Subbasin increased from 10,500 AF in 1998 to 11,987 AF in 2009 (Table 11).

3.2.4 Small Commercial Pumping

Small commercial pumping in the Basin and Subbasin during 2006 was estimated to be 2,323 and 430 AF, respectively, by Todd (2009). Similarly, small commercial pumping in the Basin and Subbasin during 1997 was estimated to be 1,400 and 300 AF, respectively, by Fugro and Cleath (Fugro West, 2002). These estimates during 1997 and 2006 were used to estimate, via straight-line interpolation, the annual small commercial pumping in the Basin and Subbasin from 1998 to 2005. Annual small commercial pumping in the Basin and Subbasin from 2007 to 2009 was subsequently estimated by extrapolation from the corresponding estimates for 2006 by Todd (2009). Using this approach, annual small commercial pumping in the Basin increased from 1,503 AF in 1998 to 2,631 AF in 2009 (Tables 3 and 4). Similarly, annual small commercial pumping in the Subbasin increased from 314 AF in 1998 to 473 AF in 2009 (Tables 5 and 6).

3.2.5 Rural Domestic and Small Community Pumping

Rural domestic pumping for the 2006 water year was estimated by Todd (2009) for the eight major sub-areas of the Basin. For this, Todd performed a survey of the dwelling unit types associated with the rural parcels in each sub-area and assumed that each dwelling unit pumped groundwater at a water duty factor of 1.7 acre-foot per year per dwelling unit (AFY/DU). As of the 2006 water year, there were 6,596 dwelling units in the Basin and 1,076 dwelling units within the Subbasin. The parcels surveyed by Todd included those serviced by small community water systems. Therefore, the rural domestic pumping demand estimated by Todd represented both actual rural domestic demand as well as small community pumping demand. Similarly, the rural domestic pumping demand estimated in this study will also include actual rural domestic demand and small community pumping demand.

Rural domestic pumping in the Basin and Subbasin during 1997 in the Phase I Report was also estimated using a water duty factor of 1.7 AFY/DU. The Phase I Report estimate of rural domestic pumping during 1997 was 9,400 AF whereas the estimate for the Subbasin was 1,800 AF. Dividing these two pumping rates by 1.7 AFY/DU results in 5,529 dwelling units in the Basin and 1,059 dwelling units in the Subbasin. The number of dwelling units for each year from 1998 to 2005 in the Basin was then estimated by interpolating between the calculated number of dwelling units during 1997 and the surveyed number from Todd (2009) for 2006. The number of dwelling units for 2007 to 2009 was simply extrapolated from the 2006 number. A similar approach was also used to estimate the number dwelling units for each year in the Subbasin from 1998 to 2005 and from 2007 to 2009.

Rural domestic pumping was estimated for two different sets of water duty factors. Set No. 1 consisted of a single water duty factor of 1.0 AFY/DU that was applied to all dwelling units in the Basin (i.e., all dwelling units in the seven sub-areas and the Subbasin). Set No. 2 similarly consisted of a single water duty factor of 1.7 AFY/DU that was also applied to all dwelling units in the Basin.

Annual rural domestic pumping in the Basin increased linearly from 1998 to 2009 for both sets of water duty factors. For Set No. 1, rural domestic pumping increased from 5,648 AF in 1997 to 6,951 AF in 2009 (Table 12). For Set No. 2, rural domestic pumping increased from 9,601 AF in 1997 to 11,817 AF in 2009 (Table 13).

Annual rural domestic pumping in the Subbasin also increased linearly from 1998 to 2009 for both sets of water duty factors. For Set No. 1, rural domestic pumping increased from 1,061 AF in 1997 to 1,082 AF in 2009 (Table 12). For Set No. 2, rural domestic pumping increased from 1,803 AF in 1997 to 1,839 AF in 2009 (Table 13).

3.2.6 Phreatophyte Extraction

Phreatophyte extraction refers to consumptive use by vegetation along the riparian corridors in the Basin. Areas of riparian vegetation in the Basin were mapped as part of the Phase I Report and a water duty factor was subsequently applied in that study to estimate the annual consumptive use of the phreatophytes. In this study, annual phreatophyte extraction in the Basin from 1998 to 2009 was estimated using a linear regression equation developed between estimated annual phreatophyte extraction in the Basin and annual measured precipitation at Atascadero MWC Station No. 34 from 1981 to 1997 (Figure 8). The calculated multiple R-square statistic in this regression relationship was 0.96. From 1998 to 2009 estimated phreatophyte extraction in the Basin varied from 1,592 AF in 2007 to 7,085 AF in 2005, with an average annual value of 3,449 AF (Tables 3 and 4).

A similar linear regression equation was developed between annual phreatophyte extraction in the Subbasin and measured precipitation at Atascadero MWC Station No. 34 from 1981 to 1997 (Figure 9). The calculated multiple R-square statistic in this regression relationship was 0.9. Using this relation, estimated subsurface inflows in the Subbasin from 1998 to 2009 varied from 74 AF in 2007 to 334 AF in 2005, with an average annual value of 162 AF (Tables 5 and 6).

3.3 GROUNDWATER STORAGE CHANGES AND BASIN OVERDRAFT STATUS

3.3.1 Groundwater Storage Changes

Annual groundwater storage change is equal to the difference between annual recharge and annual discharge. Cumulative groundwater storage change is equal to the sum of the annual changes in groundwater storage over the study period.

Annual and cumulative groundwater storage changes in the Basin from 1998 to 2009 for rural domestic water duty factor sets No. 1 and No. 2 are presented in Tables 3 and 4. Under Set No. 1 (rural domestic pumping of 1.0 AFY/DU), annual groundwater storage change varied from a decrease of 72,736 AF in 2007 to an increase of 366,756 AF in 1998, with an average annual change of 19,108 AF. Cumulatively, groundwater storage increased by 229,292 AF under Set No. 1 from 1998 to 2009. Under Set No. 2 (rural domestic pumping of 1.7 AFY/DU), annual groundwater storage change varied from a decrease of 75,086 AF in 2007 to an increase of 364,779 AF in 1998, with an average annual change of 16,903 AF. Cumulatively, groundwater storage increased by 202,834 AF under Set No. 2 from 1998 to 2009.

Annual and cumulative groundwater storage changes in the Subbasin from 1998 to 2009 for rural domestic water duty factor sets No. 1 and No. 2 are presented in Tables 5 and 6. Under Set No. 1, annual groundwater storage change varied from a decrease of 7,508 AF in 2007 to an increase of 23,711 AF in 1998, with an average annual change of 1,804 AF. Cumulatively, groundwater storage increased by 21,646 AF under Set No. 1 from 1998 to 2009. Under Set No. 2, annual groundwater storage change varied from a decrease of 7,885 AF in 2007 to an increase of 23,339 AF in 1998, with an average annual change of 1,429 AF. Cumulatively, groundwater storage increased by 17,147 AF under Set No. 2 from 1998 to 2009.

3.3.2 Groundwater Basin Overdraft Status

The perennial yields of the Basin and Subbasin were estimated during Phase II of the Paso Robles Groundwater Basin Study as 97,700 and 16,400 AFY, respectively (Fugro 2005). The water balance calculation from 1998 to 2009 for water duty factor set No. 1 (which assumes a rural domestic water duty factor of 1.0 AFY/DU) shows an estimated total groundwater outflow in 2009 of 91,915 AF (equal to approximately 94% of the perennial yield). The water balance calculation for set No. 2 (rural domestic water factor of 1.7 AFY/DU) suggests an estimated total groundwater outflow in 2009 of 96,781 AF (or approximately 99% of the perennial yield).

For the Subbasin, the water balance from 1998 to 2009 for water duty factor set No. 1 indicated a total groundwater outflow in the Subbasin in 2009 of 15,255 AF (or approximately 93% of the perennial yield). The water balance for set No. 2 suggests a total groundwater outflow in the Subbasin in 2009 of 16,012 AF (or approximately 98% of the perennial yield).

4.0 PROJECTED WATER BALANCES FROM 2010 TO 2025

Projected water balances in the Basin and Subbasin for the future period of 2010 to 2025 were also computed for this study. For this, projected water demands of the four urban areas were provided by staff representatives of these communities (Table 16). In addition to groundwater pumping, the City of Paso Robles, the City of Atascadero, and the community of Templeton each anticipate receiving surface water supplies from the Nacimiento Water Project starting in 2010 or 2011. These surface water supplies are used in conjunction with pumped groundwater to satisfy local urban water demands. In addition to providing an alternative source of water supply, these surface water deliveries will also offset the future groundwater pumping demands of these communities. Table 16 summarizes the anticipated future water demands of the four urban communities (as represented by information provided to us by staff) and the distribution of anticipated Nacimiento deliveries and groundwater pumping. As urban demands increase (according to the projections shown on Table 16), treated wastewater discharge also increases as shown on Table 17.

In the projected water balances for the Basin and Subbasin, the values of the following recharge and discharge components from 2010 to 2025 are assumed to equal their respective 2009 values: 1) irrigation return flows, 2) subsurface outflows, 3) gross agricultural pumping, 4) rural domestic/small community pumping, and 5) small commercial pumping. The 15-year climate (i.e., annual precipitation) from 1994 to 2009 is also assumed to repeat itself from 2010 to 2025. Therefore, the precipitation-dependent and runoff-dependent components of subsurface inflow, streambed percolation, and phreatophyte extraction from 2010 to 2025 are estimated using the annual estimates from 1994 to 2009. For the projected water balance, land use in the Basin during 2009 is assumed to remain the same for each year from 2010 to 2025. Consequently, annual deep percolation of precipitation from 2010 to 2025 is estimated by the Blaney method using this fixed land use distribution and the annual precipitation totals from 1994 to 2009.

It should be reiterated here that these projected water balances from 2010 to 2025 are not intended to provide absolute predictions of future groundwater recharge and discharge rates, and subsequent groundwater storage changes. Instead, they are meant to provide a general assessment of anticipated future groundwater pumping demands with respect to current estimates of perennial yield given assumed trends in urban groundwater use, which takes into account estimates of urban groundwater pumping, water conservation, and the importation of Nacimiento water. Moreover, the projected water balance assumes that future climate patterns will be similar to historical patterns observed over the original 1981 to 1997 base period. As such, the projected water balance did not attempt to account for possible impacts of theorized global climate change (e.g., long-term upward or downward trends in annual rainfall), or future changes in pumping by agricultural, rural/community, or small commercial pumping.

The projected water balance for the Basin is presented in Table 14. The average annual total groundwater outflow in the Basin from 2010 to 2025 is calculated to be 96,625 AF, and ranges from 92,645 AF to as high as 100,441 AF. Based on an average annual Basin outflow of 96,625 AF, the cumulative change in groundwater storage in the Basin from 2010 to 2025 is 406,943 AF (Table 14). Offsets of urban groundwater pumping by supplemental surface water supplies provided by the Nacimiento Water Project amounted to 66,798 AF from 2010 to 2025. Similarly, aquifer recharge from wastewater discharge in rural domestic/small community and small commercial septic systems accounted for 115,585 AF from 2010 to 2025 or an average of 6 percent of total annual recharge. The combined impacts of the Nacimiento Water Project and the inclusion of wastewater discharges from rural domestic/small community and small commercial operations equate to 44 percent of the 406,943 AF increase in groundwater storage from 2010 to 2025. On an annual average basis, deep percolation of precipitation and streambed percolation accounted for 46 and 37 percent of total annual recharge. Irrigation return flows and wastewater discharge from urban, small commercial, and rural domestic/small community systems accounted for 12 percent of total annual recharge. Subsurface inflows accounted for the remaining 5 percent of total annual recharge. On an annual average basis, agricultural groundwater pumping accounted for 65 percent of total annual discharge. Urban, rural domestic/small community water systems, and small commercial pumping accounted for 15, 12, and 3 percent of total annual discharge. Subsurface outflows and phreatophyte extraction accounted for the remaining 1 and 4 percent of total annual discharge.

The projected water balance for the Subbasin is presented in Table 15. The average annual total groundwater outflow in the Subbasin from 2010 to 2025 is calculated to be 15,420 AF, and ranges from 13,833 AF to 16,592 AF. The cumulative change in groundwater storage in the Subbasin from 2010 to 2025 is 41,224 AF (Table 15). Supplemental surface water supplies provided by the Nacimiento Water Project resulted in an offset of urban groundwater pumping of 43,298 AF from 2010 to 2025. Similarly, aquifer recharge from wastewater discharge in rural domestic/small community and small commercial septic systems amounted to 18,496 AF from 2010 to 2025. On an annual average basis, deep percolation of precipitation and streambed percolation accounted for 22 and 58 percent of total annual recharge. Irrigation return flows and wastewater discharge from urban, small commercial, and rural domestic/small community systems accounted for 14 percent of total annual recharge. Subsurface inflows accounted for the remaining 4 percent of total annual recharge. On an annual average basis, urban groundwater pumping accounted for 73 percent of total annual discharge. Agricultural, rural domestic/small community water systems, and small commercial pumping accounted for 9, 12, and 3 percent of total annual discharge. Subsurface outflows and phreatophyte extraction each accounted for 1 percent of total annual discharge.

5.0 INTERACTION OF SHALLOW ALLUVIUM AND PASO ROBLES FORMATION

The aquifer system in the Paso Robles Groundwater Basin consists of the Paso Robles Formation and the shallow alluvial aquifers associated with the Salinas River, Estrella River, Huer Huero Creek, and other tributary creeks. The aquifer system in the Atascadero Groundwater Subbasin consists of a stretch of the Salinas River alluvium and a region of the Paso Robles Formation. The Atascadero Subbasin is a subbasin within the Paso Robles Basin. The Rinconada Fault acts as a hydraulic barrier within the Paso Robles Formation and represents the boundary that separates the Subbasin from the rest of the Basin. However, the Rinconada Fault does not act similarly as a hydraulic barrier to groundwater flow in the Salinas River alluvium. As such, groundwater flow in the alluvium is continuous along the stretch of the Salinas River that traverses the entire Basin.

Groundwater in storage should be calculated separately for three different subsurface regions: 1) the shallow alluvial aquifers, 2) the Paso Robles Formation within the Subbasin, and 3) the Paso Robles Formation within the entire Basin. The alluvial aquifers are a significant source of recharge to the Paso Robles Formation, particularly along the western region of the Basin and Subbasin where the Salinas River alluvium is located. Although the shallow alluvium and the underlying Paso Robles Formation are distinctly different aquifers, the low permeable layer that separates them varies spatially in terms of thickness and permeability. Consequently, recharge of the Paso Robles Formation from alluvium underflow varies along the stretches of alluvial deposits in the Basin and Subbasin. In addition to the thickness and permeability of the sediments separating the alluvium from the Paso Robles Formation, the rate of recharge is also dependent on the hydraulic head gradient across these sediments (i.e., difference in groundwater levels between the alluvium and the Paso Robles Formation). Pumping in the Paso Robles Formation may result in significant drawdown of groundwater levels in this aquifer, thus increasing the hydraulic gradient and subsequently the recharge rate from the overlying alluvium.

Groundwater flow between the alluvium and the Paso Robles Formation can occur either in the upward or downward direction. The downward direction of groundwater flow occurs in the form of recharge from the alluvium into the Paso Robles Formation. Recharge occurs when a hydraulic head gradient exists between the shallow alluvium and the underlying formation in the downward direction, in other words, when groundwater levels in the alluvium are greater than levels in the Paso Robles Formation. Upward flows of groundwater from the Paso Robles Formation into the shallow alluvium can also occur if the hydraulic head gradient between the two aquifers is in the upward direction. This occurs when the groundwater pressure in the Paso Robles Formation is greater than the hydraulic head in the shallow alluvium. The hydraulic head gradient between the aquifers in a particular area can be determined by measuring groundwater levels in wells screened in the alluvium and subtracting those from measured groundwater levels in nearby wells screened in the Paso Robles Formation.

The actual amount of groundwater in storage in the Paso Robles Formation is significantly greater than that of the shallow alluvial aquifers. Groundwater in storage within the Paso Robles Formation in the Basin from 1981 to 1997 was estimated to be 30,534,000 AF on an average annual basis. The combined area of alluvium in the Basin (i.e., including the Salinas River, Estrella River, Huer Huero Creek, San Juan Creek, and other small creeks in the Basin) is 49,500 acres. Using the spatial distribution of specific yield and groundwater levels during the water year of 1980 from the Basin groundwater flow model, the volume of groundwater in storage in the combined area of alluvium was estimated to be 681,974 AF. In particular, the Salinas River alluvium and its tributaries accounted for 447,480 AF of this storage volume while the Estrella River and its tributaries accounted for 234,494 AF of this total. The combined groundwater in storage for both the alluvial aquifers and the underlying Paso Robles Formation is on the order of 31,215,974 AF. Overall, groundwater in storage in the alluvial aquifers within the Basin accounts for only about 2.1 percent of the total groundwater in storage in the entire Basin.

Groundwater in storage within the Paso Robles Formation in the Subbasin from 1981 to 1997 was estimated to be 513,600 AF on an average annual basis. Within the Subbasin, groundwater in storage in the Salinas River alluvium was estimated to be 134,274 AF. The combined groundwater in storage for both the Salinas River alluvium and the underlying Paso Robles Formation within the Subbasin is on the order of 647,874 AF. Overall, groundwater in storage in the alluvium within the Subbasin accounts for 21 percent of the total groundwater in storage in the Subbasin. In contrast to the Basin where the total groundwater in storage is predominantly in the Paso Robles Formation, the alluvium in the Subbasin accounts for a significant percentage of the total groundwater storage in the Subbasin.

Although the total groundwater in storage in the alluvial aquifers is small relative to the Paso Robles Formation, the alluvial aquifers are a significant source of recharge to the underlying Paso Robles Formation. For example, streambed percolation in the Basin accounts for approximately 38 percent of the total annual recharge on an average annual basis. Moreover, in the Subbasin streambed percolation accounts for as much as 62 percent of the total annual recharge on average.

Due to its large storage capacity, the Paso Robles Formation represents a more robust groundwater reservoir than the shallow alluvial aquifers of the rivers and creeks. Storage changes in the Paso Robles Formation due to annual variations in climate are buffered to a greater degree than those in the alluvial aquifers. By contrast, groundwater storage in the alluvium fluctuates in direct response to annual variations in climate. Consequently, the estimation of a perennial yield for the alluvial aquifers is problematic due to the extreme year-to-year fluctuations in annual precipitation, runoff, and streamflow that provide recharge to the alluvial aquifers. A separate estimated perennial yield for the alluvial aquifers would therefore not provide a measure of the reliable amount of groundwater that could be sustainably extracted from them on an annual basis.

Total annual pumping from the shallow alluvial aquifers and the Paso Robles Formation can be assessed against the estimated perennial yield for the Basin. However, given the large volume of groundwater in storage in the Basin, successive annual exceedences of the perennial yield may not be immediately reflected by decreases in groundwater levels in the Paso Robles Formation in all areas of the Basin.

Given the significant groundwater in storage in the alluvium within the Subbasin relative to the storage in the Paso Robles Formation in the Subbasin, annual groundwater extractions in the Subbasin from the alluvium should be accounted for separately from those from the Paso Robles Formation. Changes in groundwater levels in the alluvium should be evaluated with respect to annual extractions from the alluvium. Similarly, changes in groundwater levels in the Paso Robles Formation within the Subbasin should be evaluated with respect to annual extractions from the Paso Robles Formation within the Subbasin. The perennial yield for the Subbasin theoretically applies to combined groundwater extractions from the shallow alluvium and deeper Paso Robles Formation. Exceeding the perennial yield in the Subbasin may not necessarily be reflected by decreasing groundwater levels in the Paso Robles Formation since significant pumping occurs in the alluvium. Therefore, the overdraft status of the Subbasin needs to be evaluated by assessment of groundwater level changes in both the alluvium and the Paso Robles Formation relative to the respective pumping from those aquifers.

6.0 SUMMARY AND CONCLUSIONS

In this report, the water balances from 1981 to 1997 for the Basin and Subbasin, as originally estimated by Fugro and Cleath (Fugro West, 2002), were updated for the period from 1998 to 2009. Each water balance consisted of the estimated major natural and anthropogenic sources of groundwater recharge and discharge in the Basin and Subbasin from 1998 to 2009. As part of this update, two different sets of water duty factors were used to estimate rural domestic pumping in the Basin and Subbasin. This resulted in the development of two water balances for the Basin (Tables 3 and 4) and two water balances for the Subbasin (Tables 5 and 6) from 1998 to 2009. This report also provided a projected water balance for both the Basin and Subbasin for the future period of 2010 to 2025 (see Tables 14 and 15). The projected water balances, in particular, evaluated the impacts on Basin and Subbasin groundwater storage of offsetting urban groundwater pumping by supplemental surface water supplies from the Nacimiento Water Project for the City of Paso Robles, Atascadero MWC, and Templeton CSD. The major conclusions of the study include:

- The water balance calculations presented in this report show that demand in both the Atascadero Subbasin and the Paso Robles Groundwater Basin as a whole is approaching the average annual perennial yield. Given the degree of uncertainty of the estimates of inflow and outflow components of the water balance equation, the Basin should be considered to be essentially in balance by a small margin.

- Total annual groundwater outflow (i.e., total groundwater pumping) in the Paso Robles Groundwater Basin and the Atascadero Subbasin increased during the period from 1998 to 2009. In 2009, the water balance for the scenario which assumes a rural domestic water demand of 1.0 AFY/DU suggests a total groundwater outflow in the Basin of 91,915 AF (or approximately 94% of the perennial yield of 97,700 AFY). The water balance for the scenario that assumes a rural domestic water demand of 1.7 AFY/DU suggests a total groundwater outflow of 96,781 AF in 2009 (or approximately 99% of the perennial yield).

- In the Atascadero Subbasin, the water balance for water duty factor set No. 1 (assuming a rural domestic demand of 1.0 AFY/DU) and No. 2 (assuming a rural domestic demand of 1.7 AFY/DU) shows total groundwater outflows in the Subbasin during 2009 of 15,255 and 16,012 AF, respectively (or approximately 93% and 98% of the perennial yield of 16,400 AF).

- The two different sets of water duty factors used in the estimation of annual rural domestic pumping resulted in significantly different estimates of cumulative groundwater storage change in the Subbasin from 1998 to 2009. This finding illustrates the need to more accurately quantify the of water duty factors for rural domestic water use throughout the Basin.

- Groundwater in storage in the Basin and Subbasin increased from 1998 to 2009, partly because total groundwater outflow was slightly less than the perennial yield, but also partly because significant recharge from percolation of precipitation occurred in two of these years (1998 and 2005). The overall increase in groundwater storage in both the Basin and Subbasin from 1981 to 2009 generally supports the conclusion that estimated total annual groundwater outflows for each year in the Basin and Subbasin were less than their respective perennial yield values. It should be noted that short-term periods when pumpage might exceed the perennial yield do not necessarily constitute an overdraft condition.

- In the projected water balances from 2010 to 2025, offsets of urban groundwater pumping by supplemental surface water supplies from the Nacimiento Water Project to the City of Paso Robles, Atascadero MWC, and Templeton CSD resulted in beneficial impacts to groundwater storage for the Basin and Subbasin. Offsets of urban groundwater pumping by supplemental surface water supplies of the Nacimiento Water Project from 2010 to 2025 amounted to 66,798 AF in the Basin and 43,298 AF in the Subbasin.

- It should be noted that the future basin outflow figures shown in the water balance projections through 2025 may understate actual future Basin and Subbasin outflows because, in the projections, rural domestic, commercial, and agricultural pumping were held constant at 2009 rates (this was done in order to illustrate the potential effects of importing Nacimiento Water on urban pumping). Growth or changes in water demand from rural domestic, commercial, or agricultural market changes could result in total basin demand exceeding perennial yield in the future. Furthermore, the water balance projections through 2025 assume a repeat of precipitation patterns from 1994 to 2009. This prior 16-year rainfall record may or may not reflect long-term conditions.

- The projected water balances from 2010 to 2025 were not intended to provide absolute predictions of future groundwater recharge and discharge and subsequent groundwater storage changes. Instead, they provide a general assessment of anticipated future groundwater pumping demands with respect to current estimates of perennial yield given assumed trends in urban groundwater use, which takes into account estimates of urban groundwater pumping, water conservation, and the importation of Nacimiento Water. Moreover, the projected water balance assumed that future climate patterns will be similar to historical patterns observed over the original 1981 to 1997 base period. As such, the projected water balance did not attempt to account for possible impacts of theorized global climate change (e.g., long-term upward or downward trends in annual rainfall), or future changes in pumping by agricultural, rural/small community, or small commercial pumping.

- Percolation of precipitation is a major source of basin recharge that is accompanied by a large degree of uncertainty. The effect of rainfall recharge may not immediately result in a water level change in wells that are located in areas of highest pumping (that is, in areas of depressed water levels). Additional monitoring wells located in recharge areas of the Basin are recommended to monitor the effects of percolation of precipitation in these areas and in the Basin as a whole.

- Streambed percolation is a major component of basin recharge, with large annual fluctuations depending on yearly rainfall. Additional monitoring wells in shallow alluvial aquifers associated with the Salinas River, Estrella River, Huer Huero Creek, and other tributary creeks as well as deep monitoring wells in the Paso Robles Formation adjacent to the streams, and monitoring of water level data in those wells, are recommended to develop data to refine estimates of streambed percolation.

- The results of this study reinforce the need for implementation of an effective basin monitoring and management plan. The results also demonstrate the need to update the numerical groundwater flow model, which is based on data through 1997. An update and recalibration of the Fugro (2005) model would help to refine the many uncertainties and assumptions that were used throughout this water balance update.

- It should be noted that the precision of the results estimated by the methods employed in this study and subsequently presented in the report text and tables do not imply a similar level of accuracy. In other words, a number of assumptions were invoked in the estimation of the recharge and discharge components. These estimated components therefore represent approximations that lie within a reasonable range of expected values. The values of the estimated components were presented “as is” in the report text and tables rather than being subjected to numerical rounding.

7.0 REFERENCES

Blaney, H.F. (1933), Ventura County Investigation, Bulletin No. 46, pp. 82-88, Table 57, California Department of Public Works, Division of Water Resources.

Fugro West, Inc. (2002), Final Report Paso Robles Groundwater Basin Study, Prepared for County of San Luis Obispo Public Work Department, dated August 30.

______ (2005), Paso Robles Groundwater Basin Groundwater Basin Study Phase II, Numerical Model, Development, Calibration and Application, dated February 28.

Todd Engineers (2009), Evaluation of Paso Robles Groundwater Basin Pumping Water Year 2006, report prepared for the City of Paso Robles and San Luis Obispo County Department of Public Works, May.

TABLES

Table 1. Precipitation Measurements at Seven Gauge Stations from 1998 to 2009

Water Year	Paso Robles CDF Station No. 101 (inches)	Atascadero MWC Station No. 34 (inches)	Creston 4.5 NW Station No. 52.1 (inches)	Shandon Station No. 73 (inches)	Santa Margarita Station No. 95 (inches)	San Miguel Station No. 125 (inches)	Camatta Canyon. Station No. 138 (inches)	Estimated Reference (inches)
1998	30.8	33.1	25.5	21.8	57.4	23.2	23.8	26.3
1999	10.5	12.2	8.2	6.9	24.4	7.1	7.4	8.7
2000	14.9	17.2	11.3	8.4	32.0	10.2	7.4	11.6
2001	22.8	19.1	14.6	13.1	28.1	15.3	11.1	16.0
2002	7.5	7.9	5.1	6.1	19.1	5.1	4.9	6.1
2003	13.8	10.7	9.9	10.6	30.7	11.2	9.0	10.9
2004	10.9	8.8	7.4	8.8	18.4	7.3	7.2	8.4
2005	32.6	34.6	21.7	17.5	55.2	22.3	13.0	23.6
2006	23.4	22.5	17.6	15.5	34.3	12.9	10.6	17.1
2007	7.1	7.6	6.3	5.6	12.1	4.4	4.7	5.9
2008	15.3	16.1	11.2	11.4	31.0	10.8	9.1	12.3
2009	9.0	11.0	6.0	7.3	21.3	6.4	6.7	7.7
Minimum	7.1	7.6	5.1	5.6	12.1	4.4	4.7	5.9
Maximum	32.6	34.6	25.5	21.8	57.4	23.2	23.8	26.3
Average	16.5	16.7	12.1	11.1	30.3	11.3	9.6	12.9

Note: Precipitation data obtained from County of San Luis Obispo Department of Public Works

Table 2. Cumulative Departure of Annual Precipitation from 1998 to 2009

Water Year	Annual Precipitation Atascadero MWC Station No. 34 (inches)	Average Annual Precipitation (1916 to 2009) (inches)	Annual Departure from Long-term Annual Average (inches)	Cumulative Departure from Long-term Annual Average (inches)
1998	33.1	17.6	15.5	15.5
1999	12.2	17.6	-5.4	10.2
2000	17.2	17.6	-0.5	9.7
2001	19.1	17.6	1.5	11.3
2002	7.9	17.6	-9.7	1.6
2003	10.7	17.6	-6.9	-5.3
2004	8.8	17.6	-8.8	-14.1
2005	34.6	17.6	17.0	2.9
2006	22.5	17.6	4.9	7.8
2007	7.6	17.6	-10.0	-2.2
2008	16.1	17.6	-1.5	-3.7
2009	11.0	17.6	-6.7	-10.4
Minimum	7.6	--	-10.0	--
Maximum	34.6	--	17.0	--
Average	16.7	--	-0.9	--

Table 3. Water Balance for the Paso Robles Groundwater Basin from 1998 to 2009 for Rural Domestic Water Duty Factor Set No. 1

Water Year	Subsurface Inflow (acre-feet)	Precipitation Percolation (acre-feet)	Streambed Percolation (acre-feet)	Irrigation Return Flow (acre-feet)	Urban Wastewater Discharge (acre-feet)	Rural\Small Community Wastewater Discharge (acre-feet)	Small Commercial Wastewater Discharge (acre-feet)	Total Inflow (acre-feet)	Subsurface Outflow (acre-feet)	Agricultural Groundwater Pumping (acre-feet)	Urban Groundwater Pumping (acre-feet)	Rural\Small Community Groundwater Pumping (acre-feet)	Small Commercial Groundwater Pumping (acre-feet)	Phreatophyte Extraction (acre-feet)	Total Outflow (acre-feet)	Annual Storage Change (acre-feet)	Cumulative Storage Change (acre-feet)
1998	12,511	321,785	103,408	1,139	4,418	2,824	751	446,837	600	51,794	13,752	5,648	1,503	6,784	80,081	366,756	366,756
1999	5,142	0	26,644	1,162	4,102	2,883	803	40,736	600	52,820	13,991	5,766	1,605	2,533	77,316	-36,580	330,177
2000	6,876	11	44,369	1,185	4,239	2,942	854	60,476	600	53,845	14,230	5,885	1,708	3,536	79,804	-19,328	310,849
2001	7,573	8,842	35,181	1,207	4,393	3,002	905	61,103	600	54,871	14,469	6,003	1,810	3,936	81,690	-20,587	290,261
2002	3,626	0	14,269	1,230	4,327	3,061	956	27,469	600	55,897	14,709	6,122	1,913	1,659	80,899	-53,431	236,831
2003	4,599	0	41,206	1,252	4,487	3,120	1,008	55,672	600	56,923	14,948	6,240	2,015	2,220	82,946	-27,275	209,556
2004	3,943	0	12,734	1,275	4,500	3,179	1,059	26,690	600	57,948	15,187	6,359	2,118	1,842	84,054	-57,364	152,192
2005	13,033	215,760	98,220	1,297	4,862	3,239	1,110	337,5220	600	58,974	15,426	6,477	2,220	7,085	90,783	246,739	398,930
2006	8,751	13,119	49,650	1,320	4,744	3,298	1,162	82,043	600	60,000	15,665	6,596	2,323	4,615	89,799	-7,756	391,174
2007	3,510	0	1,500	1,343	4,604	3,357	1,213	15,526	600	61,026	15,904	6,714	2,426	1,592	88,262	-72,736	318,439
2008	6,499	312	41,834	1,365	4,675	3,416	1,264	59,365	600	62,052	16,143	6,833	2,528	3,316	91,472	-32,107	286,332
2009	4,691	0	19,386	1,388	4,620	3,476	1,315	34,875	600	63,077	16,382	6,951	2,631	2,273	91,915	-57,040	229,292
Minimum	3,510	0	1,500	1,139	4,102	2,824	751	15,526	600	51,794	13,752	5,648	1,503	1,592	77,316	-72,736	--
Maximum	13,033	321,785	103,408	1,388	4,862	3,476	1,315	446,837	600	63,077	16,382	6,951	2,631	7,085	91,915	366,756	--
Average	6,729	46,652	40,700	1,264	4,497	3,150	1,033	104,026	600	57,436	15,067	6,300	2,067	3,449	84,918	19,108	--

Table 4. Water Balance for the Paso Robles Groundwater Basin from 1998 to 2009 for Rural Domestic Water Duty Factor Set No. 2

Water Year	Subsurface Inflow (acre-feet)	Precipitation Percolation (acre-feet)	Streambed Percolation (acre-feet)	Irrigation Return Flow (acre-feet)	Urban Wastewater Discharge (acre-feet)	Rural\Small Community Wastewater Discharge (acre-feet)	Small Commercial Wastewater Discharge (acre-feet)	Total Inflow (acre-feet)	Subsurface Outflow (acre-feet)	Agricultural Groundwater Pumping (acre-feet)	Urban Groundwater Pumping (acre-feet)	Rural\Small Community Groundwater Pumping (acre-feet)	Small Commercial Groundwater Pumping (acre-feet)	Phreatophyte Extraction (acre-feet)	Total Outflow (acre-feet)	Annual Storage Change (acre-feet)	Cumulative Storage Change (acre-feet)
1998	12,511	321,785	103,408	1,139	4,418	4,801	751	448,814	600	51,794	13,752	9,601	1,503	6,784	84,034	364,779	364,779
1999	5,142	0	26,644	1,162	4,102	4,901	803	42,754	600	52,820	13,991	9,803	1,605	2,533	81,352	-38,598	326,182
2000	6,876	11	44,369	1,185	4,239	5,002	854	62,536	600	53,845	14,230	10,004	1,708	3,536	83,923	-21,388	304,794
2001	7,573	8,842	35,181	1,207	4,393	5,103	905	63,204	600	54,871	14,469	10,206	1,810	3,936	85,893	-22,689	282,105
2002	3,626	0	14,269	1,230	4,327	5,204	956	29,611	600	55,897	14,709	10,407	1,913	1,659	85,185	-55,573	226,532
2003	4,599	0	41,206	1,252	4,487	5,304	1,008	57,856	600	56,923	14,948	10,609	2,015	2,220	87,315	-29,459	197,073
2004	3,943	0	12,734	1,275	4,500	5,405	1,059	28,915	600	57,948	15,187	10,810	2,118	1,842	88,505	-59,590	137,483
2005	13,033	215,760	98,220	1,297	4,862	5,506	1,110	339,789	600	58,974	15,426	11,012	2,220	7,085	95,317	244,472	381,955
2006	8,751	13,119	49,650	1,320	4,744	5,607	1,162	84,351	600	60,000	15,665	11,213	2,323	4,615	94,416	-10,065	371,890
2007	3,510	0	1,500	1,343	4,604	5,707	1,213	17,876	600	61,026	15,904	11,415	2,426	1,592	92,962	-75,086	296,805
2008	6,499	312	41,834	1,365	4,675	5,808	1,264	61,756	600	62,052	16,143	11,616	2,528	3,316	96,255	-34,498	262,306
2009	4,691	0	19,386	1,388	4,620	5,909	1,315	37,308	600	63,077	16,382	11,817	2,631	2,273	96,781	-59,473	202,834
Minimum	3,510	0	1,500	1,139	4,102	4,801	751	17,876	600	51,794	13,752	9,601	1,503	1,592	81,352	-75,086	--
Maximum	13,033	321,785	103,408	1,388	4,862	5,909	1,315	448,814	600	63,077	16,382	11,817	2,631	7,085	96,781	364,779	--
Average	6,729	46,652	40,700	1,264	4,497	5,355	1,033	106,231	600	57,436	15,067	10,709	2,067	3,449	89,328	16,903	--

Table 5. Water Balance for the Atascadero Groundwater Subbasin from 1998 to 2009 for Rural Domestic Water Duty Factor Set No. 1

Water Year	Subsurface Inflow (acre-feet)	Precipitation Percolation (acre-feet)	Streambed Percolation (acre-feet)	Irrigation Return Flow (acre-feet)	Urban Wastewater Discharge (acre-feet)	Rural\Small Community Wastewater Discharge (acre-feet)	Small Commercial Wastewater Discharge (acre-feet)	Total Inflow (acre-feet)	Subsurface Outflow (acre-feet)	Agricultural Groundwater Pumping (acre-feet)	Urban Groundwater Pumping (acre-feet)	Rural\Small Community Groundwater Pumping (acre-feet)	Small Commercial Groundwater Pumping (acre-feet)	Phreatophyte Extraction (acre-feet)	Total Outflow (acre-feet)	Annual Storage Change (acre-feet)	Cumulative Storage Change (acre-feet)
1998	1,273	16,803	16,994	23	1,334	530	157	37,115	150	1,059	10,500	1,061	314	320	13,404	23,711	23,711
1999	538	4	8,320	24	1,040	531	164	10,621	150	1,095	10,635	1,063	329	119	13,391	-2,769	20,941
2000	711	519	10,323	25	1,030	532	172	13,312	150	1,131	10,771	1,065	343	166	13,626	-314	20,627
2001	780	1,549	9,285	26	1,103	533	179	13,456	150	1,167	10,906	1,066	358	185	13,832	-377	20,250
2002	386	0	6,922	26	1,032	534	186	9,087	150	1,204	11,041	1,068	372	77	13,912	-4,826	15,424
2003	483	0	9,965	27	1,268	535	193	12,473	150	1,240	11,176	1,070	387	104	14,127	-1,653	13,771
2004	418	0	6,748	28	1,188	536	201	9,118	150	1,276	11,311	1,072	401	86	14,296	-5,178	8,593
2005	1,325	18,478	16,408	29	1,423	537	208	38,408	150	1,312	11,446	1,074	416	334	14,732	23,676	32,269
2006	898	5,195	10,920	30	1,272	538	215	19,067	150	1,348	11,582	1,076	430	217	14,803	4,265	36,534
2007	375	0	5,071	30	1,102	539	222	7,339	150	1,384	11,717	1,078	444	74	14,847	-7,508	29,026
2008	673	332	10,036	31	1,152	540	229	12,994	150	1,420	11,852	1,080	459	156	15,116	-2,122	26,904
2009	493	0	7,500	32	1,195	541	237	9,997	150	1,456	11,987	1,082	473	106	15,255	-5,258	21,646
Minimum	375	0	5,071	23	1,030	530	157	7,339	150	1,059	10,500	1,061	314	74	13,391	-7,508	--
Maximum	1,325	18,478	16,994	32	1,423	541	237	38,408	150	1,456	11,987	1,082	473	334	15,255	23,711	--
Average	696	3,573	9,874	28	1,178	536	197	16,082	150	1,258	11,244	1,071	394	162	14,278	1,804	--

Table 6. Water Balance for the Atascadero Groundwater Subbasin from 1998 to 2009 for Rural Domestic Water Duty Factor Set No. 2

Water Year	Subsurface Inflow (acre-feet)	Precipitation Percolation (acre-feet)	Streambed Percolation (acre-feet)	Irrigation Return Flow (acre-feet)	Urban Wastewater Discharge (acre-feet)	Rural\Small Community Wastewater Discharge (acre-feet)	Small Commercial Wastewater Discharge (acre-feet)	Total Inflow (acre-feet)	Subsurface Outflow (acre-feet)	Agricultural Groundwater Pumping (acre-feet)	Urban Groundwater Pumping (acre-feet)	Rural\Small Community Groundwater Pumping (acre-feet)	Small Commercial Groundwater Pumping (acre-feet)	Phreatophyte Extraction (acre-feet)	Total Outflow (acre-feet)	Annual Storage Change (acre-feet)	Cumulative Storage Change (acre-feet)
1998	1,273	16,803	16,994	23	1,334	902	157	37,486	150	1,059	10,500	1,803	314	320	14,147	23,339	23,339
1999	538	4	8,320	24	1,040	903	164	10,993	150	1,095	10,635	1,806	329	119	14,135	-3,141	20,198
2000	711	519	10,323	25	1,030	905	172	13,685	150	1,131	10,771	1,810	343	166	14,371	-686	19,511
2001	780	1,549	9,285	26	1,103	906	179	13,829	150	1,167	10,906	1,813	358	185	14,579	-750	18,761
2002	386	0	6,922	26	1,032	908	186	9,461	150	1,204	11,041	1,816	372	77	14,660	-5,200	13,562
2003	483	0	9,965	27	1,268	910	193	12,848	150	1,240	11,176	1,819	387	104	14,876	-2,028	11,533
2004	418	0	6,748	28	1,188	911	201	9,494	150	1,276	11,311	1,823	401	86	15,047	-5,553	5,980
2005	1,325	18,478	16,408	29	1,423	913	208	38,783	150	1,312	11,446	1,826	416	334	15,484	23,300	29,280
2006	898	5,195	10,920	30	1,272	915	215	19,444	150	1,348	11,582	1,829	430	217	15,556	3,888	33,169
2007	375	0	5,071	30	1,102	916	222	7,716	150	1,384	11,717	1,832	444	74	15,602	-7,885	25,283
2008	673	332	10,036	31	1,152	918	229	13,372	150	1,420	11,852	1,836	459	156	15,872	-2,500	22,783
2009	493	0	7,500	32	1,195	919	237	10,376	150	1,456	11,987	1,839	473	106	16,012	-5,636	17,147
Minimum	375	0	5,071	23	1,030	902	157	7,716	150	1,059	10,500	1,803	314	74	14,135	-7,885	--
Maximum	1,325	18,478	16,994	32	1,423	919	237	38,783	150	1,456	11,987	1,839	473	334	16,012	23,339	--
Average	696	3,573	9,874	28	1,178	910	197	16,457	150	1,258	11,244	1,821	394	162	15,028	1,429	--

Table 7. Land Use Categorization in the Paso Robles Groundwater Basin from 1998 to 2009 for use by the Blaney Method

Water Year	Grasses, Weeds (acres)	Truck, Alfalfa Misc. Crops (acres)	Non-irrigated Grain (acres)	Deciduous Trees (acres)	Total Area (acres)
1998	436,966	4,984	44,603	18,448	505,000
1999	437,404	5,074	41,974	20,548	505,000
2000	437,841	5,165	39,345	22,649	505,000
2001	438,279	5,255	36,716	24,750	505,000
2002	438,717	5,346	34,087	26,851	505,000
2003	439,155	5,436	31,458	28,951	505,000
2004	439,593	5,527	28,829	31,052	505,000
2005	440,030	5,617	26,200	33,153	505,000
2006	440,468	5,707	23,571	35,253	505,000
2007	440,906	5,798	20,942	37,354	505,000
2008	441,344	5,888	18,314	39,454	505,000
2009	441,782	5,978	15,685	41,555	505,000

Note: As described in the text, acreages were estimated by straight-line interpolation using reported pumped values for 1997 and 2006.

Table 8. Land Use Categorization in the Atascadero Groundwater Subbasin from 1998 to 2009 for use by the Blaney Method

Water Year	Grasses, Weeds (acres)	Truck, Alfalfa Misc. Crops (acres)	Non-irrigated Grain (acres)	Deciduous Trees (acres)	Total Area (acres)
1998	11,892	75	1,958	652	14,577
1999	11,912	90	1,968	608	14,577
2000	11,931	105	1,978	563	14,577
2001	11,950	120	1,988	518	14,577
2002	11,969	136	1,999	473	14,577
2003	11,989	151	2,009	428	14,577
2004	12,008	166	2,019	384	14,577
2005	12,027	182	2,029	339	14,577
2006	12,046	197	2,040	294	14,577
2007	12,065	212	2,050	250	14,577
2008	12,085	227	2,060	205	14,577
2009	12,104	243	2,070	160	14,577

Note: As described in the text, acreages were estimated by straight-line interpolation using reported pumped values for 1997 and 2006.

Table 9. Agricultural Groundwater Pumping and Irrigation Return Flows from 1998 to 2009

	Paso Robles Groundwater Basin			Atascadero Groundwater Subbasin		
Water Year	Gross Agricultural Groundwater Pumping (acre-feet)	Irrigation Return Flows (acre-feet)	Net Agricultural Groundwater Pumping (acre-feet)	Gross Agricultural Groundwater Pumping (acre-feet)	Irrigation Return Flows (acre-feet)	Net Agricultural Groundwater Pumping (acre-feet)
1998	51,794	1,139	50,654	1,059	23	1,036
1999	52,820	1,162	51,658	1,095	24	1,071
2000	53,845	1,185	52,661	1,131	25	1,106
2001	54,871	1,207	53,664	1,167	26	1,142
2002	55,897	1,230	54,667	1,204	26	1,177
2003	56,923	1,252	55,670	1,240	27	1,212
2004	57,948	1,275	56,674	1,276	28	1,248
2005	58,974	1,297	57,677	1,312	29	1,283
2006	60,000	1,320	58,680	1,348	30	1,318
2007	61,026	1,343	59,683	1,384	30	1,354
2008	62,052	1,365	60,686	1,420	31	1,389
2009	63,077	1,388	61,690	1,456	32	1,424

Note: As described in the text, gross agricultural pumping figures were estimated by straight-line interpolation using reported values for 1997 and 2006.

Table 10. Discharge of Treated Urban Wastewater from 1998 to 2009

Water Year	City of Paso Robles (acre-feet)	City of Atascadero (acre-feet)	Templeton CSD (acre-feet)	San Miguel CSD (acre-feet)	Atascadero Subbasin (acre-feet)	Paso Robles Basin (acre-feet)
1998	2,969	1,334	--	115	1,334	4,418
1999	2,948	1,040	--	115	1,040	4,102
2000	3,094	1,030	--	115	1,030	4,239
2001	3,174	1,103	--	115	1,103	4,393
2002	3,180	1,032	--	115	1,032	4,327
2003	3,097	1,125	144	121	1,268	4,487
2004	3,187	1,021	166	125	1,188	4,500
2005	3,303	1,241	182	137	1,423	4,862
2006	3,296	1,037	235	176	1,272	4,744
2007	3,342	965	137	160	1,102	4,604
2008	3,389	1,018	134	134	1,152	4,675
2009	3,291	1,050	144	134	1,195	4,620
Minimum	2,948	965	134	115	1,030	4,102
Maximum	3,389	1,334	235	176	1,423	4,862
Average	3,189	1,083	163	130	1,178	4,497

Note: A complete data set of annual discharge was not available for San Miguel CSD for 1998 through 2001; data shown for 1998 through 2001 are estimated values.

Table 11. Urban Groundwater Pumping from 1998 to 2009

	Atascadero Subbasin Urban Pumping				Paso Robles Basin Urban Pumping		
Water Year	**City of Paso Robles (Thunderbird wells) (acre-feet)**	**Atascadero MWC (acre-feet)**	**Templeton CSD (acre-feet)**	**Total Atascadero Subbasin (acre feet)**	**City of Paso Robles (all wells excluding Thunderbird wells) (acre feet)**	**San Miguel CSD (acre-feet)**	**Total Paso Robles Basin (acre-feet)**
1998	3,013	6,307	1,181	10,500	3,013	239	13,752
1999	3,104	6,296	1,235	10,635	3,104	251	13,991
2000	3,195	6,285	1,290	10,771	3,195	264	14,230
2001	3,287	6,275	1,345	10,906	3,287	277	14,469
2002	3,378	6,264	1,399	11,041	3,378	290	14,709
2003	3,469	6,253	1,454	11,176	3,469	303	14,948
2004	3,560	6,242	1,509	11,311	3,560	315	15,187
2005	3,651	6,232	1,563	11,446	3,651	328	15,426
2006	3,743	6,221	1,618	11,582	3,743	341	15,665
2007	3,834	6,210	1,673	11,717	3,834	354	15,904
2008	3,925	6,200	1,727	11,852	3,925	367	16,143
2009	4,016	6,189	1,782	11,987	4,016	379	16,382
Minimum	3,013	6,189	1,181	10,500	3,013	239	13,752
Maximum	4,016	6,307	1,782	11,987	4,016	379	16,382
Average	3,515	6,248	1,481	11,244	3,515	309	15,067

Note: As described in the text, urban pumping figures were estimated by straight-line interpolation using reported pumped volumes for 1997 and 2006. Additionally, pumping for the City of Paso Robles was assumed, for the purposes of this analysis, to be split 50/50 between pumping from the Thunderbird wells and pumping from all other City wells. The locations of the Thunderbird wells overlie the Atascadero Subbasin; all other City wells overlie the Basin.

Table 12. Rural Domestic Pumping in the Paso Robles Groundwater Basin and the Atascadero Groundwater Subbasin for Water Duty Factor Set No. 1

Water Year	Atascadero Subbasin Rural Parcel Dwelling Units (DU)	Atascadero Subbasin Rural Parcel Water Duty Factor (acre-feet/DU)	Atascadero Subbasin Rural Parcel Groundwater Pumping (acre-feet)	Atascadero Subbasin Rural Parcel Wastewater Return Flows (acre-feet)	Seven Sub-areas Rural Parcel Dwelling Units (DU)	Seven Sub-areas Rural Parcel Water Duty Factor (acre-feet/DU)	Seven Sub-areas Rural Parcel Groundwater Pumping (acre-feet)	Paso Robles Basin Rural Parcel Groundwater Pumping (acre-feet)	Paso Robles Basin Rural Parcel Wastewater Return Flows (acre-feet)
1998	1,061	1.0	1,061	530	4,587	1.0	4,587	5,648	2,824
1999	1,063	1.0	1,063	531	4,704	1.0	4,704	5,766	2,883
2000	1,065	1.0	1,065	532	4,820	1.0	4,820	5,885	2,942
2001	1,066	1.0	1,066	533	4,937	1.0	4,937	6,003	3,002
2002	1,068	1.0	1,068	534	5,054	1.0	5,054	6,122	3,061
2003	1,070	1.0	1,070	535	5,170	1.0	5,170	6,240	3,120
2004	1,072	1.0	1,072	536	5,287	1.0	5,287	6,359	3,179
2005	1,074	1.0	1,074	537	5,403	1.0	5,403	6,477	3,239
2006	1,076	1.0	1,076	538	5,520	1.0	5,520	6,596	3,298
2007	1,078	1.0	1,078	539	5,637	1.0	5,637	6,714	3,357
2008	1,080	1.0	1,080	540	5,753	1.0	5,753	6,833	3,416
2009	1,082	1.0	1,082	541	5,870	1.0	5,870	6,951	3,476

Table 13. Rural Domestic Pumping in the Paso Robles Groundwater Basin and the Atascadero Groundwater Subbasin for Water Duty Factor Set No. 2

Water Year	Atascadero Subbasin Rural Parcel Dwelling Units (DU)	Atascadero Subbasin Rural Parcel Water Duty Factor (acre-feet/DU)	Atascadero Subbasin Rural Parcel Groundwater Pumping (acre-feet)	Atascadero Subbasin Rural Parcel Wastewater Return Flows (acre-feet)	Seven Sub-areas Rural Parcel Dwelling Units (DU)	Seven Sub-areas Rural Parcel Water Duty Factor (acre-feet/DU)	Seven Sub-areas Rural Parcel Groundwater Pumping (acre-feet)	Paso Robles Basin Rural Parcel Groundwater Pumping (acre-feet)	Paso Robles Basin Rural Parcel Wastewater Return Flows (acre-feet)
1998	1,061	1.7	1,803	902	4,587	1.7	7,798	9,601	4,801
1999	1,063	1.7	1,806	903	4,704	1.7	7,996	9,803	4,901
2000	1,065	1.7	1,810	905	4,820	1.7	8,195	10,004	5,002
2001	1,066	1.7	1,813	906	4,937	1.7	8,393	10,206	5,103
2002	1,068	1.7	1,816	908	5,054	1.7	8,591	10,407	5,204
2003	1,070	1.7	1,819	910	5,170	1.7	8,789	10,609	5,304
2004	1,072	1.7	1,823	911	5,287	1.7	8,988	10,810	5,405
2005	1,074	1.7	1,826	913	5,403	1.7	9,186	11,012	5,506
2006	1,076	1.7	1,829	915	5,520	1.7	9,384	11,213	5,607
2007	1,078	1.7	1,832	916	5,637	1.7	9,582	11,415	5,707
2008	1,080	1.7	1,836	918	5,753	1.7	9,780	11,616	5,808
2009	1,082	1.7	1,839	919	5,870	1.7	9,979	11,817	5,909

Table 14. Projected Water Balance for the Paso Robles Groundwater Basin from 2010 to 2025

Water Year	Subsurface Inflow (acre-feet)	Precipitation Percolation (acre-feet)	Streambed Percolation (acre-feet)	Irrigation Return Flow (acre-feet)	Urban Wastewater Discharge (acre-feet)	Rural\Small Community Wastewater Discharge (acre-feet)	Small Commercial Wastewater Discharge (acre-feet)	Total Inflow (acre-feet)	Subsurface Outflow (acre-feet)	Agricultural Groundwater Pumping (acre-feet)	Urban Groundwater Pumping (acre-feet)	Rural\Small Community Groundwater Pumping (acre-feet)	Small Commercial Groundwater Pumping (acre-feet)	Phreatophyte Extraction (acre-feet)	Total Outflow (acre-feet)	Annual Storage Change (acre-feet)	Cumulative Storage Change (acre-feet)
2010	3,746	0	14,664	1,388	4,961	5,909	1,315	30,667	600	63,077	14,720	11,817	2,631	1,728	94,574	-63,907	-63,907
2011	11,810	339,592	108,688	1,388	5,062	5,909	1,315	472,449	600	63,077	13,970	11,817	2,631	6,390	98,486	373,963	310,055
2012	7,577	321	51,092	1,388	5,111	5,909	1,315	71,398	600	63,077	14,606	11,817	2,631	3,938	96,670	-25,272	284,784
2013	8,828	3,373	68,771	1,388	5,194	5,909	1,315	93,463	600	63,077	13,677	11,817	2,631	4,660	96,463	-3,000	281,783
2014	12,511	318,645	103,408	1,388	5,317	5,909	1,315	447,177	600	63,077	15,141	11,817	2,631	6,784	100,051	347,126	628,909
2015	5,142	0	26,644	1,388	5,437	5,909	1,315	44,519	600	63,077	15,107	11,817	2,631	2,533	95,766	-51,246	577,663
2016	6,876	12	44,369	1,388	5,561	5,909	1,315	64,114	600	63,077	16,066	11,817	2,631	3,536	97,727	-33,613	544,050
2017	7,573	8,986	35,181	1,388	5,687	5,909	1,315	64,724	600	63,077	13,503	11,817	2,631	3,936	95,565	-30,841	513,210
2018	3,626	0	14,269	1,388	5,817	5,909	1,315	31,008	600	63,077	12,860	11,817	2,631	1,659	92,645	-61,637	451,572
2019	4,599	0	41,206	1,388	5,950	5,909	1,315	59,052	600	63,077	14,859	11,817	2,631	2,220	95,205	-36,154	415,418
2020	3,943	0	12,734	1,388	6,085	5,909	1,315	30,059	600	63,077	14,528	11,817	2,631	1,842	94,496	-64,437	350,981
2021	13,033	214,856	98,220	1,388	6,225	5,909	1,315	339,631	600	63,077	15,230	11,817	2,631	7,085	100,441	239,190	590,171
2022	8,751	12,997	49,650	1,388	6,368	5,909	1,315	85,062	600	63,077	15,699	11,817	2,631	4,615	98,440	-13,378	576,792
2023	3,510	0	1,500	1,388	6,515	5,909	1,315	18,821	600	63,077	15,922	11,817	2,631	1,592	95,640	-76,819	499,974
2024	6,499	316	41,834	1,388	6,665	5,909	1,315	62,611	600	63,077	15,244	11,817	2,631	3,316	96,686	-34,076	465,898
2025	4,691	0	19,386	1,388	6,820	5,909	1,315	38,193	600	63,077	16,750	11,817	2,631	2,273	97,149	-58,956	406,943
Minimum	3,510	0	1,500	1,388	4,961	5,909	1,315	18,821	600	63,077	12,860	11,817	2,631	1,592	92,645	-76,819	
Maximum	13,033	339,592	108,688	1,388	6,820	5,909	1,315	472,449	600	63,077	16,750	11,817	2,631	7,085	100,441	373,963	
Average	7,045	56,194	45,726	1,388	5,798	5,909	1,315	122,059	600	63,077	14,868	11,817	2,631	3,632	96,625	25,434	

Note: Projected inflow estimates including subsurface inflow, percolation of precipitation, and streambed percolation are based on a repeat of the rainfall pattern from 1994 to 2009.
Water balance projections assume no increases from 2009 pumping levels in agricultural pumping, rural residential growth, and small commercial pumping. This does not reflect past growth trends in these outflow components to the water balance, and could understate future pumping.

Table 15. Projected Water Balance for the Atascadero Groundwater Subbasin from 2010 to 2025

Water Year	Subsurface Inflow (acre-feet)	Precipitation Percolation (acre-feet)	Streambed Percolation (acre-feet)	Irrigation Return Flow (acre-feet)	Urban Wastewater Discharge (acre-feet)	Rural\Small Community Wastewater Discharge (acre-feet)	Small Commercial Wastewater Discharge (acre-feet)	Total Inflow (acre-feet)	Subsurface Outflow (acre-feet)	Agricultural Groundwater Pumping (acre-feet)	Urban Groundwater Pumping (acre-feet)	Rural\Small Community Groundwater Pumping (acre-feet)	Small Commercial Groundwater Pumping (acre-feet)	Phreatophyte Extraction (acre-feet)	Total Outflow (acre-feet)	Annual Storage Change (acre-feet)	Cumulative Storage Change (acre-feet)
2010	398	0	6,966	32	1,542	919	237	10,095	150	1,456	10,673	1,839	473	81	14,672	-4,577	-4,577
2011	1,203	14,712	17,591	32	1,547	919	237	36,241	150	1,456	10,306	1,839	473	301	14,525	21,715	17,138
2012	781	1,548	11,083	32	1,554	919	237	16,153	150	1,456	11,385	1,839	473	185	15,489	664	17,802
2013	905	5,439	13,080	32	1,560	919	237	22,173	150	1,456	10,362	1,839	473	219	14,500	7,672	25,475
2014	1,273	16,893	16,994	32	1,571	919	237	37,919	150	1,456	11,692	1,839	473	320	15,930	21,989	47,464
2015	538	11	8,320	32	1,577	919	237	11,634	150	1,456	11,519	1,839	473	119	15,556	-3,922	43,541
2016	711	509	10,323	32	1,583	919	237	14,313	150	1,456	12,337	1,839	473	166	16,421	-2,108	41,433
2017	780	1,537	9,285	32	1,588	919	237	14,378	150	1,456	10,629	1,839	473	185	14,732	-355	41,079
2018	386	0	6,922	32	1,593	919	237	10,089	150	1,456	9,837	1,839	473	77	13,833	-3,744	37,334
2019	483	0	9,965	32	1,599	919	237	13,236	150	1,456	11,683	1,839	473	104	15,706	-2,470	34,865
2020	418	0	6,748	32	1,603	919	237	9,957	150	1,456	11,195	1,839	473	86	15,200	-5,243	29,622
2021	1,325	18,515	16,408	32	1,607	919	237	39,043	150	1,456	11,736	1,839	473	334	15,989	23,055	52,676
2022	898	5,198	10,920	32	1,611	919	237	19,814	150	1,456	12,040	1,839	473	217	16,176	3,639	56,315
2023	375	0	5,071	32	1,615	919	237	8,250	150	1,456	12,093	1,839	473	74	16,085	-7,836	48,479
2024	673	332	10,036	32	1,619	919	237	13,849	150	1,456	11,241	1,839	473	156	15,315	-1,466	47,013
2025	493	0	7,500	32	1,623	919	237	10,804	150	1,456	12,567	1,839	473	106	16,592	-5,789	41,224
Minimum	375	0	5,071	32	1,542	919	237	8,250	150	1,456	9,837	1,839	473	74	13,833	-7,836	--
Maximum	1,325	18,515	17,591	32	1,623	919	237	39,043	150	1,456	12,567	1,839	473	334	16,592	23,055	--
Average	727	4,043	10,451	32	1,587	919	237	17,997	150	1,456	11,331	1,839	473	171	15,420	2,577	--

Note: Projected inflow estimates including subsurface inflow, percolation of precipitation, and streambed percolation are based on a repeat of the rainfall pattern from 1994 to 2009.
Water balance projections assume no increases from 2009 pumping levels in agricultural pumping, rural residential growth, and small commercial pumping. This does not reflect past growth trends in these outflow components to the water balance, and could understate future pumping.

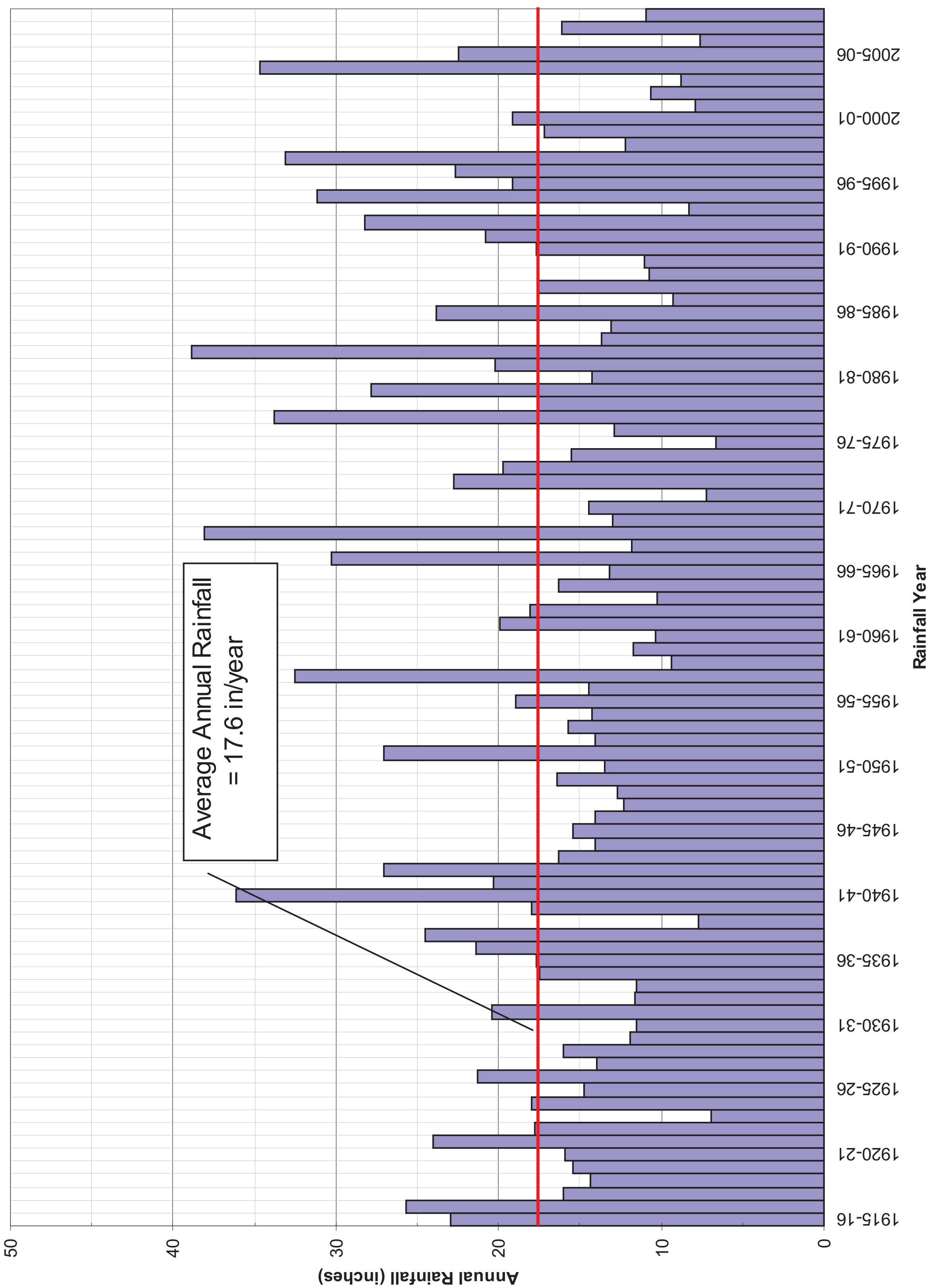
Table 16. Projected Urban Groundwater Pumping and Nacimiento Water Project Deliveries from 2010 to 2025

Water Year	City of Paso Robles			Atascadero MWC			Templeton CSD			San Miguel CSD		
	Groundwater Pumping (acre-feet)	Nacimiento Project Water (acre-feet)	Total Water Demand (acre-feet)	Groundwater Pumping (acre-feet)	Nacimiento Project Water (acre-feet)	Total Water Demand (acre-feet)	Groundwater Pumping (acre-feet)	Nacimiento Project Water (acre-feet)	Total Water Demand (acre-feet)	Groundwater Pumping (acre-feet)	Nacimiento Project Water (acre-feet)	Total Water Demand (acre-feet)
2010	7,299	0	7,299	5,557	2,000	7,557	1,467	250	1,717	398	0	398
2011	6,496	1,000	7,496	5,567	2,000	7,567	1,491	250	1,741	416	0	416
2012	5,571	2,000	7,571	7,075	500	7,575	1,524	250	1,774	435	0	435
2013	5,723	2,000	7,723	5,944	1,639	7,583	1,558	250	1,808	454	0	454
2014	5,955	2,000	7,955	7,091	498	7,589	1,624	250	1,874	472	0	472
2015	6,193	2,000	8,193	6,765	828	7,593	1,657	250	1,907	491	0	491
2016	6,439	2,000	8,439	7,427	170	7,597	1,690	250	1,940	509	0	509
2017	4,692	4,000	8,692	6,559	1,040	7,599	1,724	250	1,974	528	0	528
2018	4,953	4,000	8,953	5,604	1,996	7,600	1,757	250	2,007	547	0	547
2019	5,221	4,000	9,221	7,276	324	7,600	1,797	250	2,047	565	0	565
2020	5,498	4,000	9,498	6,623	975	7,598	1,823	250	2,073	584	0	584
2021	5,783	4,000	9,783	6,988	607	7,595	1,856	250	2,106	603	0	603
2022	6,077	4,000	10,077	7,112	479	7,591	1,890	250	2,140	621	0	621
2023	6,379	4,000	10,379	6,980	605	7,585	1,923	250	2,173	640	0	640
2024	6,690	4,000	10,690	5,940	1,639	7,579	1,956	250	2,206	658	0	658
2025	7,011	4,000	11,011	7,073	498	7,571	1,989	250	2,239	677	0	677

Table 17. Projected Urban Discharge of Treated Urban Wastewater from 2010 to 2025

Water Year	Treated Wastewater Discharge					
	City of Paso Robles (acre-feet)	City of Atascadero (acre-feet)	Templeton CSD (acre-feet)	San Miguel CSD (acre-feet)	Atascadero Subbasin (acre-feet)	Paso Robles Basin (acre-feet)
2010	3,212	1,285	258	207	1,542	4,961
2011	3,298	1,286	261	216	1,547	5,062
2012	3,331	1,288	266	226	1,554	5,111
2013	3,398	1,289	271	236	1,560	5,194
2014	3,500	1,290	281	246	1,571	5,317
2015	3,605	1,291	286	255	1,577	5,437
2016	3,713	1,291	291	265	1,583	5,561
2017	3,825	1,292	296	275	1,588	5,687
2018	3,939	1,292	301	284	1,593	5,817
2019	4,057	1,292	307	294	1,599	5,950
2020	4,179	1,292	311	304	1,603	6,085
2021	4,305	1,291	316	313	1,607	6,225
2022	4,434	1,290	321	323	1,611	6,368
2023	4,567	1,290	326	333	1,615	6,515
2024	4,704	1,288	331	342	1,619	6,665
2025	4,845	1,287	336	352	1,623	6,820

FIGURES



ANNUAL RAINFALL AT THE ATASCADERO MWC STATION NO. 34 FROM 1916 TO 2009

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FIGURE 1.

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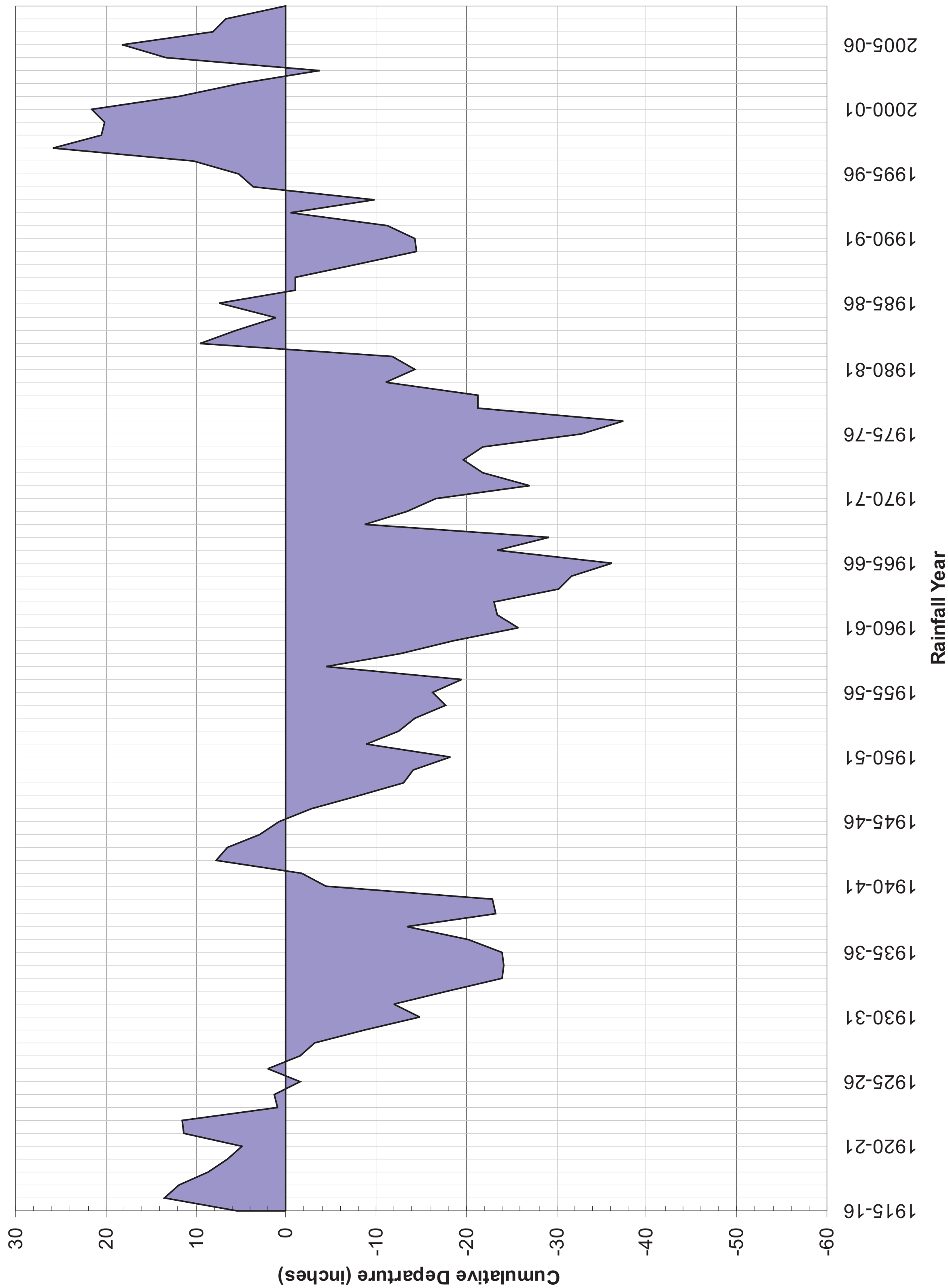

CUMULATIVE DEPARTURE OF ANNUAL RAINFALL AT THE ATASCADERO MWC STATION NO. 34 FROM AVERAGE ANNUAL RAINFALL FROM 1916 TO 2009

FIGURE 2.

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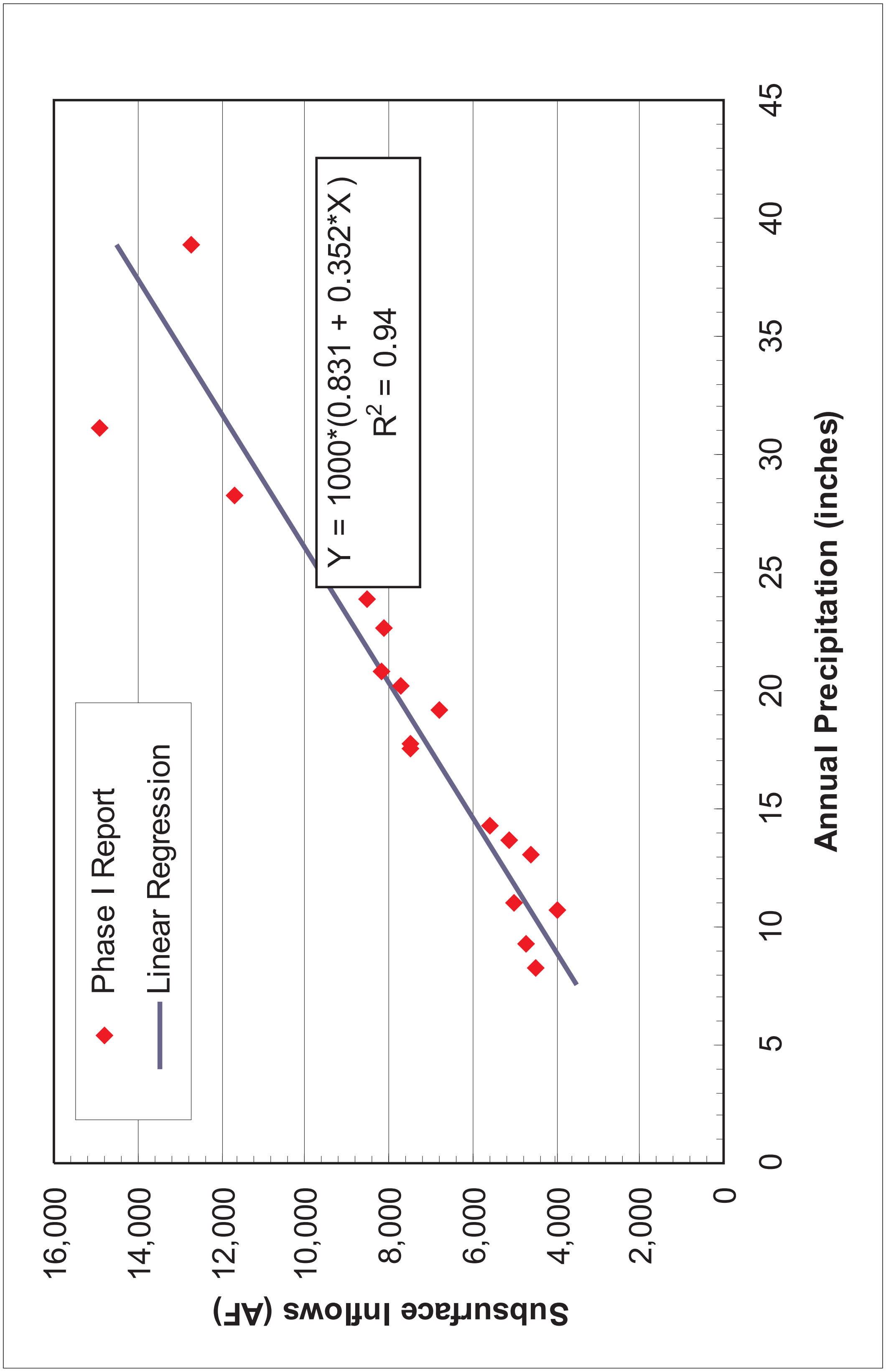
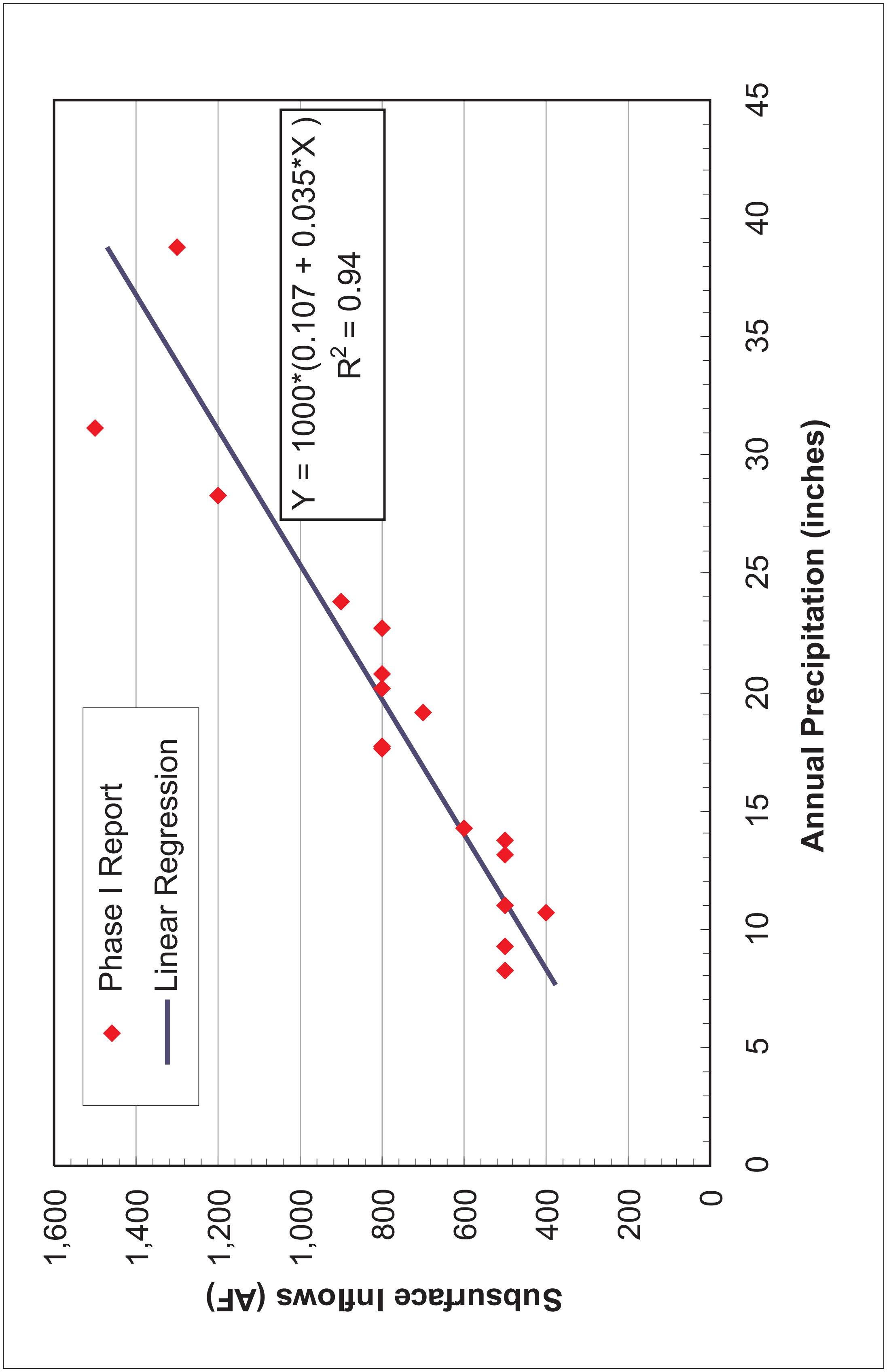


LINEAR REGRESSION OF ESTIMATED SUBSURFACE INFLOW ON MEASURED PRECIPITATION IN THE PASO ROBLES GROUNDWATER BASIN FROM 1981 TO 1997

FIGURE 3.



LINEAR REGRESSION OF ESTIMATED SUBSURFACE INFLOW ON MEASURED PRECIPITATION IN THE ATASCADERO SUBBASIN FROM 1981 TO 1997

FIGURE 4.

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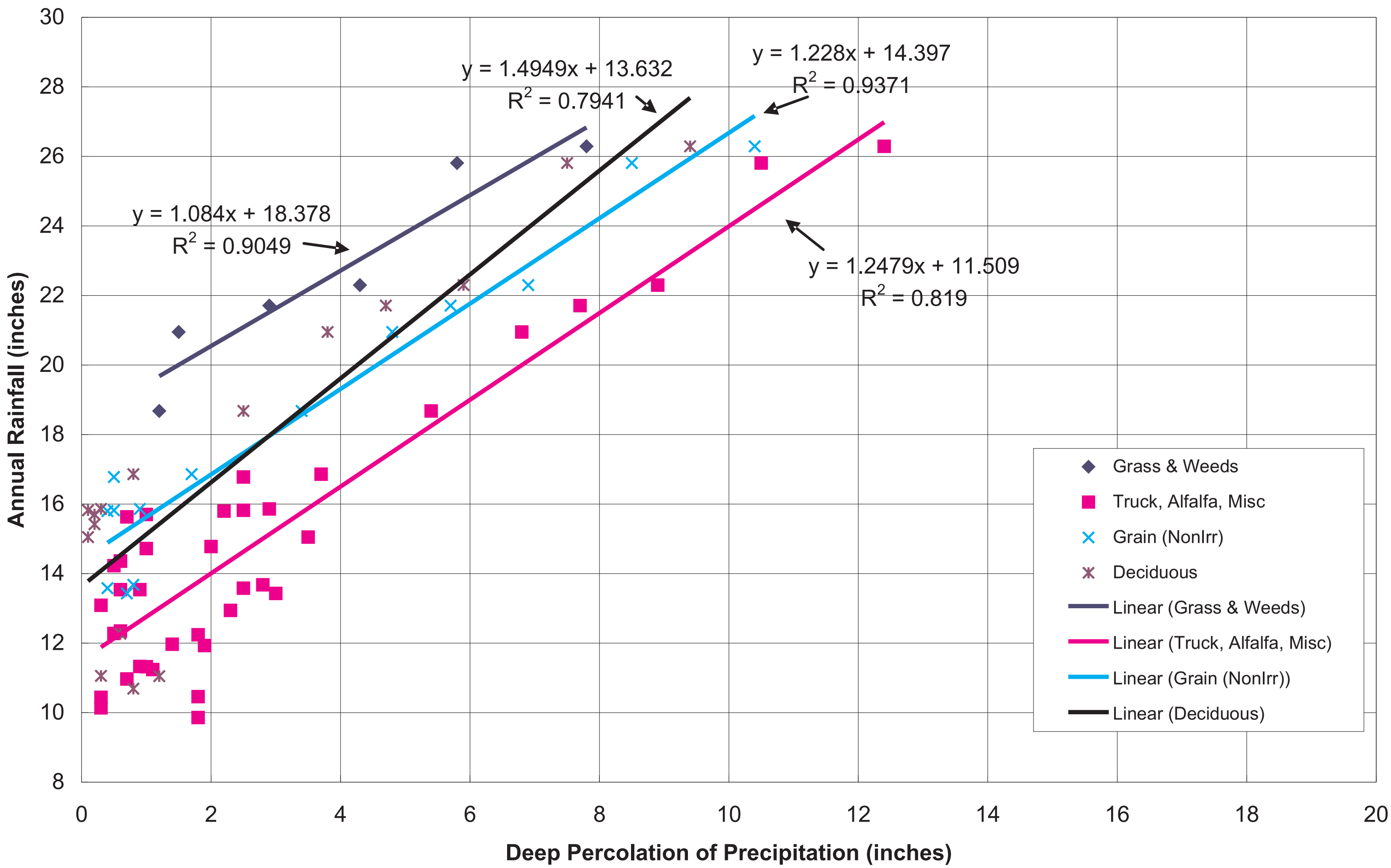
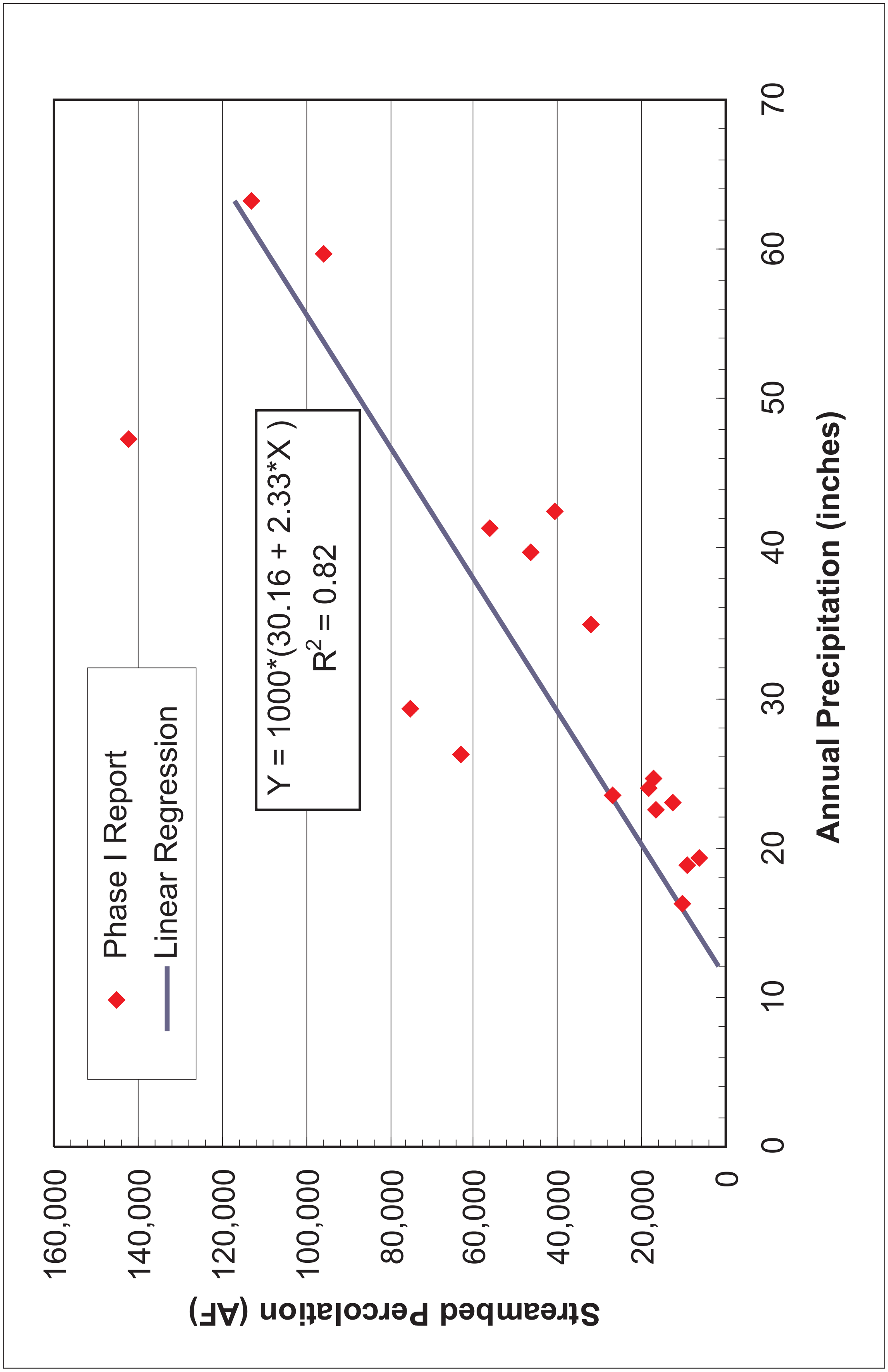


LINEAR REGRESSION OF DEEP PERCOLATION OF PRECIPITATION ON MEASURED RAINFALL FOR FOUR DIFFERENT LAND USE CATEGORIES

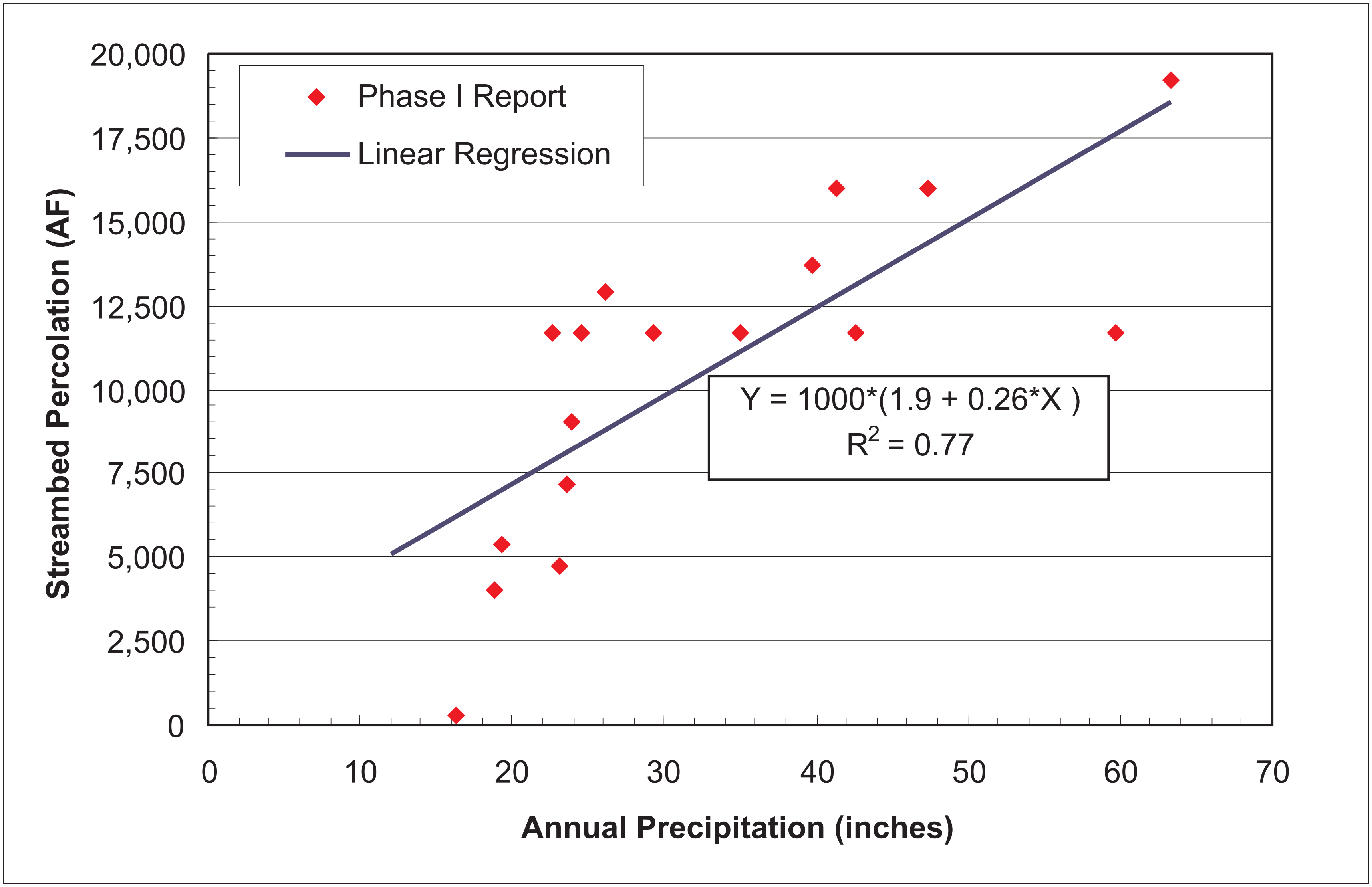
FIGURE 5.



LINEAR REGRESSION OF STREAMBED PERCOLATION ON MEASURED PRECIPITATION IN THE PASO ROBLES GROUNDWATER BASIN FROM 1981 TO 1997

M:\Drafting\JOBFILES\2010\3014\3014.036\Drawings\Figure 6.cdr, 01/12/2010

M:\Drafting\JOBFILES\2010\3014\3014.036\Drawings\Figure 7.cdr, 01/12/2010



LINEAR REGRESSION OF STREAMBED PERCOLATION ON MEASURED PRECIPITATION IN THE ATASCADERO SUBBASIN FROM 1981 TO 1997

FIGURE 7.

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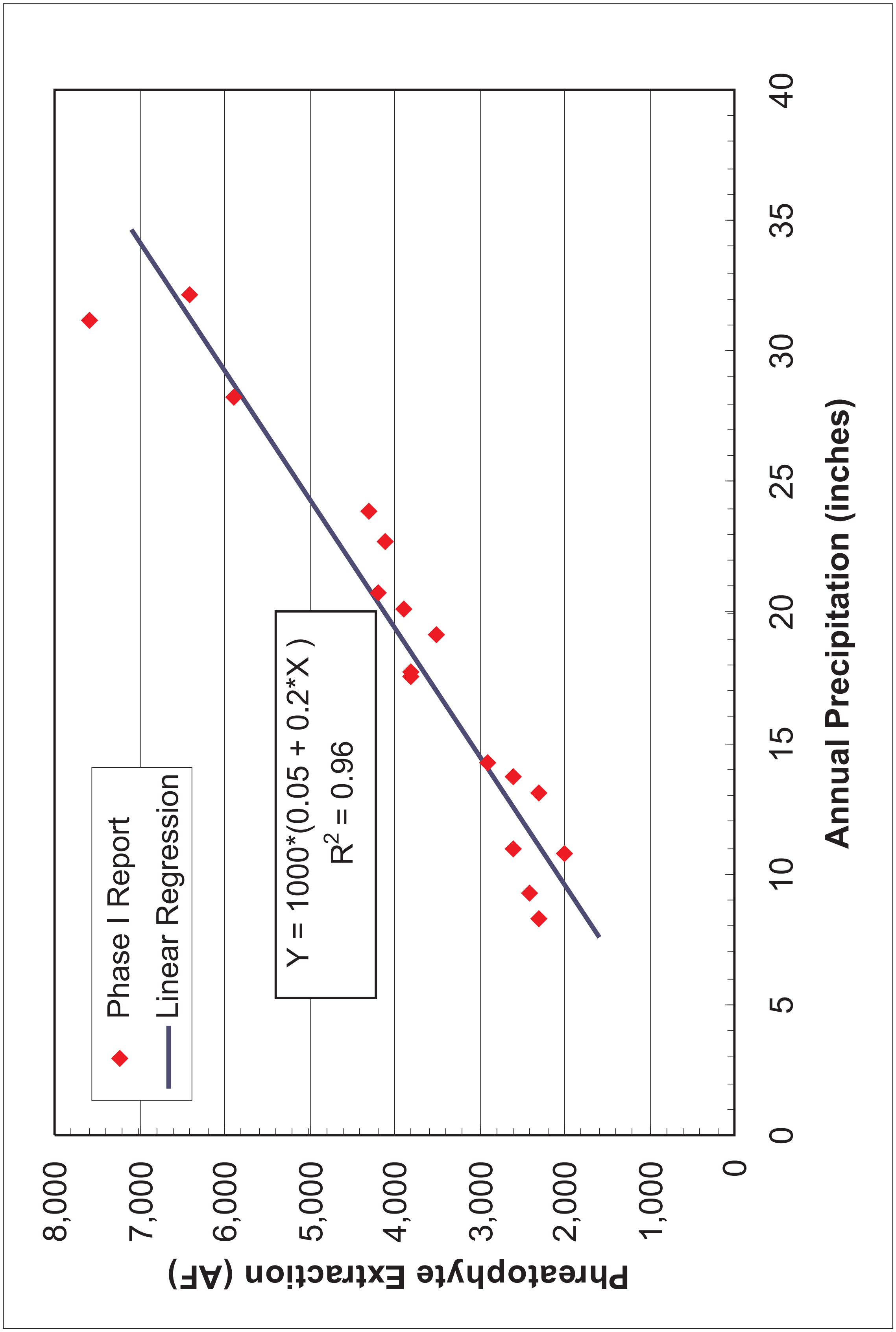
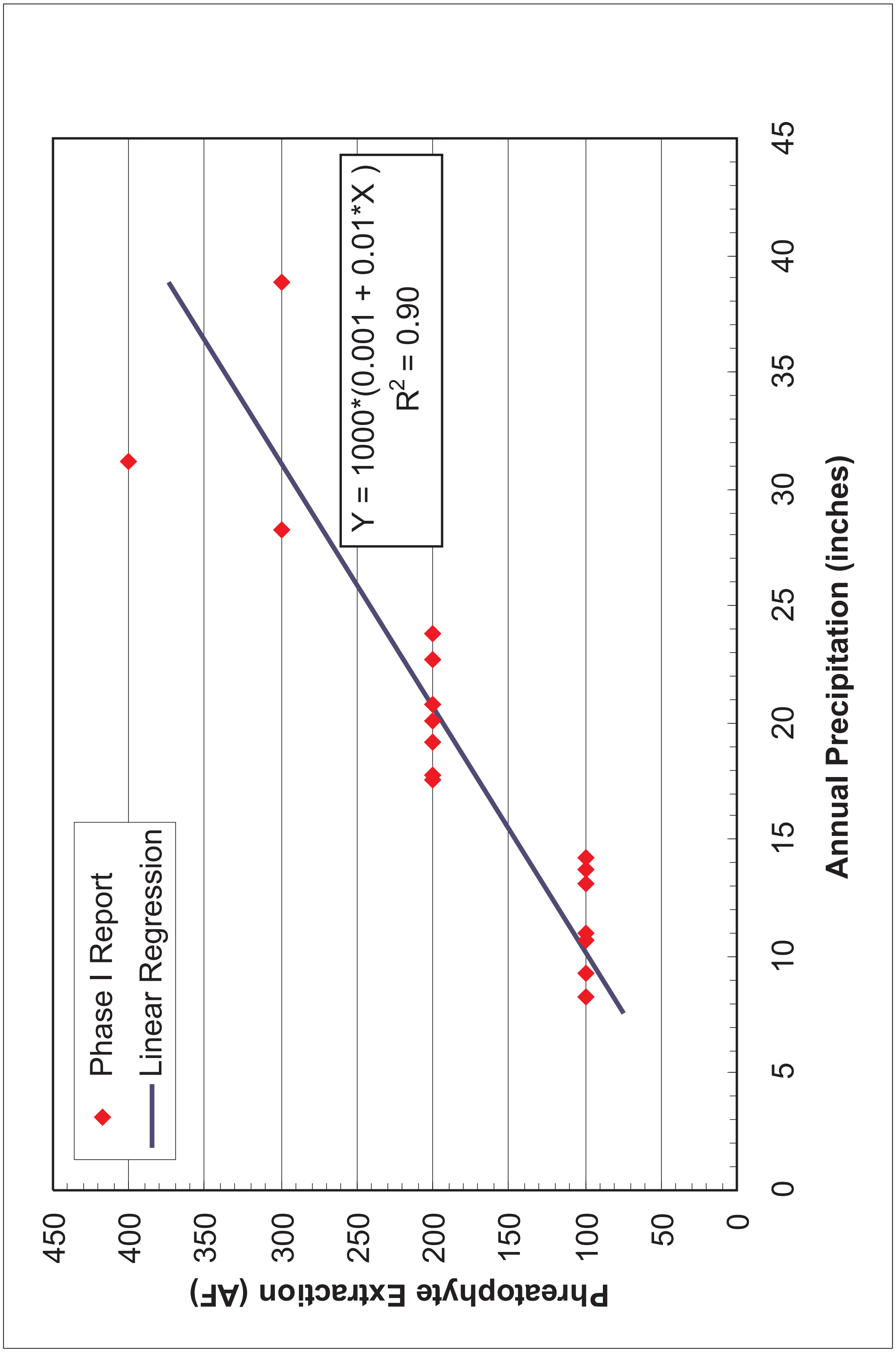


LINEAR REGRESSION RELATIONSHIP BETWEEN MEASURED PRECIPITATION AND PHREATOPHYTE EXTRACTION IN THE PASO ROBLES GROUNDWATER BASIN FROM 1981 TO 1997



LINEAR REGRESSION RELATIONSHIP BETWEEN MEASURED PRECIPITATION AND PHREATOPHYTE EXTRACTION IN THE ATASCADERO SUBBASIN FROM 1981 TO 1997

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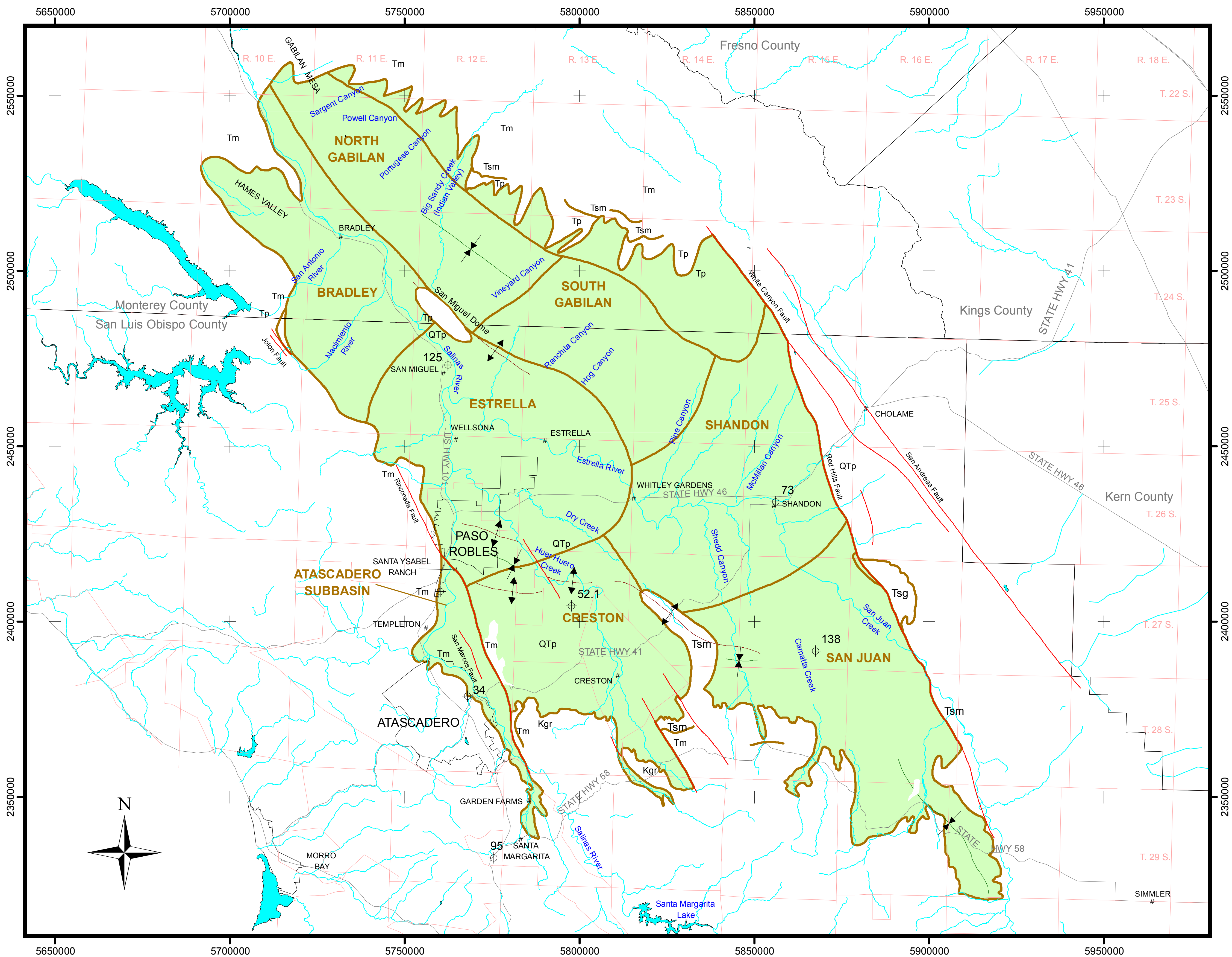
PLATES

March 2010
Project No. 3014.036



Legend

- 101 Precipitation Station
- City
- Basin Outline
- Fault
- Anticline
- Syncline
- Streams
- Highways
- County Line
- Township and Range Grid

Geologic Units		
Paso Robles Groundwater Basin Sediments	Qa	Alluvium
	Qoa	Older Alluvium
	Qls	Landslide
	QTp	Paso Robles Formation
Other Geologic Units	Tp	Pancho Rico Formation
	Tsm	Santa Margarita Sandstone
	Tm	Monterey Shale
	Tv	Vaqueros Formation
	Ts	Simmler Formation
	Tsg	unnamed (maroon) conglomerate
	Kgr	granite rocks

Notes:
1. Geologic units shown on base map around basin boundary are for reference only. For a geologic map of the basin see Figure 5.
2. Township and Range grid reference: Federal Township and Range System, Mt. Diablo Baseline and Meridian

30,000 15,000 0 30,000 Feet

Paso Robles Groundwater Basin Location Map

Paso Robles Groundwater Basin Water Balance Review and Update

Fugro West, Inc.

Plate 1

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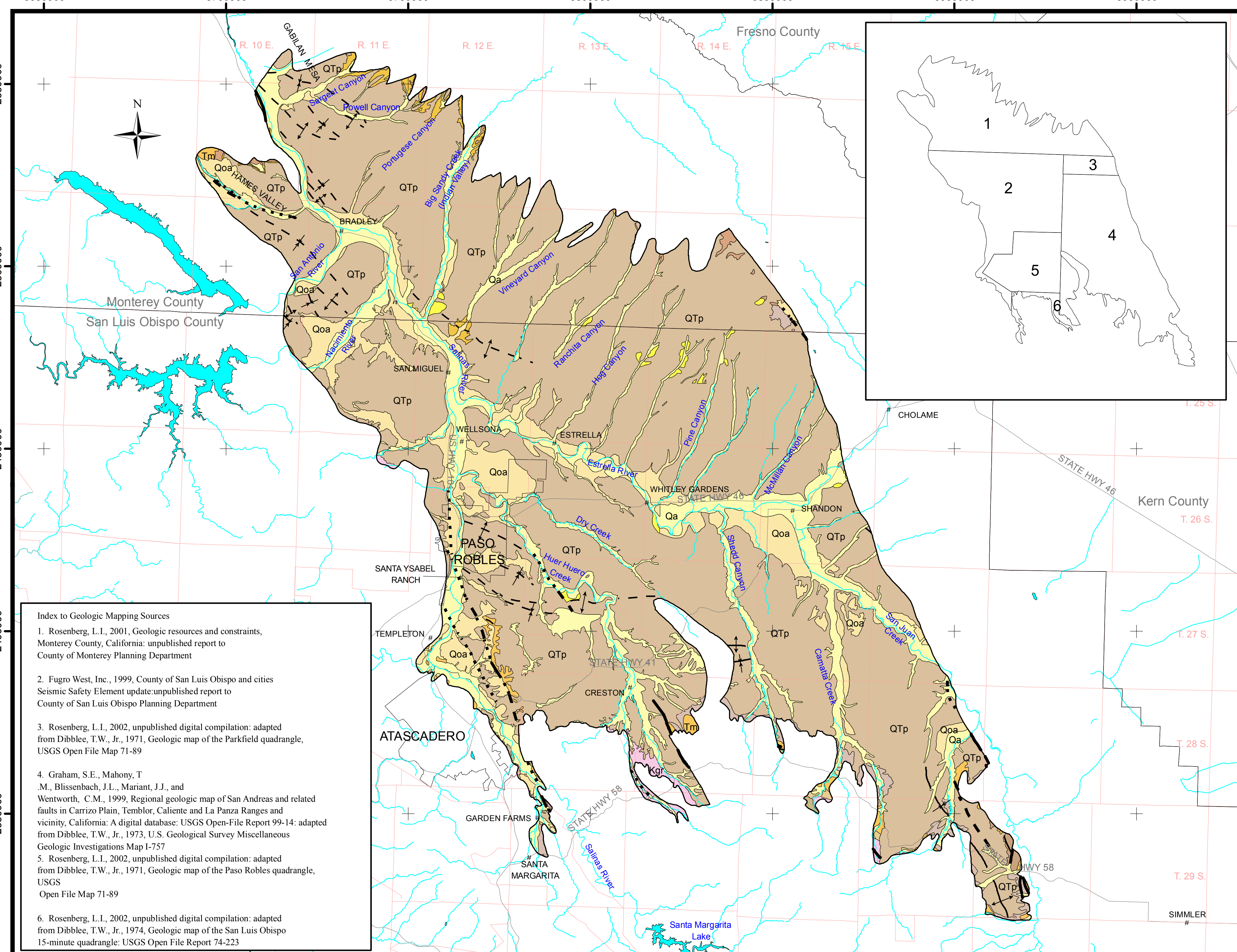
Project No. 3014.036



Index to Geologic Mapping Sources

1. Rosenberg, L.I., 2001, Geologic resources and constraints, Monterey County, California: unpublished report to County of Monterey Planning Department

2. Fugro West, Inc., 1999, County of San Luis Obispo and cities Seismic Safety Element update:unpublished report to County of San Luis Obispo Planning Department

3. Rosenberg, L.I., 2002, unpublished digital compilation: adapted from Dibblee, T.W., Jr., 1971, Geologic map of the Parkfield quadrangle, USGS Open File Map 71-89

4. Graham, S.E., Mahony, T .M., Blissenbach, J.L., Mariant, J.J., and Wentworth, C.M., 1999, Regional geologic map of San Andreas and related faults in Carrizo Plain, Temblor, Caliente and La Panza Ranges and vicinity, California: A digital database: USGS Open-File Report 99-14: adapted from Dibblee, T.W., Jr., 1973, U.S. Geological Survey Miscellaneous Geologic Investigations Map I-757

5. Rosenberg, L.I., 2002, unpublished digital compilation: adapted from Dibblee, T.W., Jr., 1971, Geologic map of the Paso Robles quadrangle, USGS Open File Map 71-89

6. Rosenberg, L.I., 2002, unpublished digital compilation: adapted from Dibblee, T.W., Jr., 1974, Geologic map of the San Luis Obispo 15-minute quadrangle: USGS Open File Report 74-223

Legend

Geologic Units

Paso Robles Groundwater Basin Sediments

Qa	Quaternary alluvium, undifferentiated (Holocene)
Qoa	Older alluvium, undifferentiated (Pleistocene)
Qls	Landslide deposits (Holocene-Pleistocene)
QTp	Paso Robles Formation, undifferentiated (Pliocene-Pleistocene)

Other Geologic Units

Tuc	Unnamed clastic sedimentary unit (probably Pliocene)
Tp	Pancho Rico Formation, undifferentiated (late Miocene to early Pliocene)
Tsm	Santa Margarita Sandstone (late Miocene)
Tbs	Branch Canyon Sandstone (middle to late Miocene)
Tm	Monterey Shale, undifferentiated (middle Miocene)
Tv	Vaqueros Formation, undifferentiated (Oligocene)
Ts	Simmler Formation, undifferentiated (Oligocene?)
Tsg	unnamed conglomerate (Oligocene or Miocene)
Kgr	Granitic rocks (Cretaceous)

Fault, certain
Fault, approximately located
Fault, concealed
Anticline, certain
Anticline, approximately located
Syncline, certain
Syncline, approximately located
Streams
Highways
County Line
Township and Range Grid

Note:
1. Township and Range grid reference: Federal Township and Range System, Mt. Diablo Baseline and Meridian

30,000 15,000 0 30,000 Feet

Geologic Map of the Paso Robles Groundwater Basin

Paso Robles Groundwater Basin Water Balance Review and Update

Fugro West, Inc.

Plate 2

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