VI. WATER QUALITY

Water quality reflects the composition of water as affected by natural causes and human activities, expressed in terms of measurable quantities and related to intended use. This chapter discusses the mineral quality conditions of both groundwater and surface water in the study area.

Because both groundwater and surface water are used for domestic supply within the study area, the California Department of Health Services' Drinking Water Standards and relative hardness are the criteria used in this study to evaluate the water quality. The concentrations of total dissolved solids (TDS), sulfate, chloride, and nitrate from the list of constituents in the Drinking Water Standards, along with the Department's classification of relative hardness, were selected as indicators of water quality (Table 22). High concentrations of any of these constituents would compromise the suitability of a water as a potable supply.

The California Department of Health Services set primary standards for nitrate concentrations in drinking water--the primary standards pertain to constituents that present a health hazard. The potential health effects of high nitrate concentrations in potable water have long been recognized. Infants may suffer from methemoglobinemia following ingestion of water with nitrate concentrations greater than 45 milligrams per liter (mg/L) as nitrate (Keeney, 1986). Other potential health effects include birth defects, cancer, and nervous system impairments (Ibid.).

Secondary standards for drinking water set by the California Department of Health Services pertain to constituents that in excessive amounts may affect aesthetic qualities of water by imparting taste and odor and by staining fixtures. TDS, sulfate, and chloride have secondary standards.[1]

Hardness can reduce the effectiveness of soap and shorten the life of hot water appliances, particularly water heaters and hot water piping.

The quality of water used for agriculture can also be measured relative to guidelines for irrigation or livestock. There are no government regulations for agricultural waters, but limits have been recommended by Ayers (1977), McKee and Wolfe (1963), National Academy of Sciences and National Academy of Engineering (1973), and others. Limits vary by soil type and farming practices. Water quality guidelines for agriculture are in Appendix F.

[1]Discussions of the significance of these constituents may be found in McKee and Wolfe (1963) and similar water quality texts.

TABLE 22
DRINKING WATER STANDARDS FOR SELECTED CONSTITUENTS*
AND CLASSIFICATION OF RELATIVE HARDNESS

Constituents	Units	Recommended Limits	Upper Limits**	Short Term Limits	MCL***	Other Limits
Total Dissolved Solids	mg/L	<500	1,000	1,500	--	--
Specific Conductance	micro-mhos/cm	900	1,600	2,200	--	--
Sulfate	mg/L	<250	500	600	--	--
Chloride	mg/L	<250	500	600	--	--
Nitrate	mg/L	--	--	--	45	--
Department of Water Resources classification of relative hardness. Hardness as $CaCO_3$						
Soft	mg/L		--	--	--	<100
Moderate	mg/L		--	--	--	100-200
Very hard	mg/L		--	--	--	>200

*From: California Administrative Code, 1989, California Domestic Water Quality and Monitoring Regulations: Sections 64435 (a), 64444.5, and 64473 (a), Chapter 15, Title 22.
**Maximum permissible when no other water available
***Maximum Contaminant Level

Factors Affecting Groundwater Quality

Groundwater begins as rain or snow containing only traces of chemical constituents acquired from atmospheric gases, vapors, and airborne particulates. Runoff then infiltrates and picks up dissolved chemicals from the soil and the geologic environment. Human activities also may affect the quality of groundwater. These activities include use and reuse of groundwater, waste disposal practices, application of agricultural fertilizers and pesticides, irrigation return flow, urban runoff, leakage of solvents and gasoline from underground storage tanks and piping, and oil field operations.[2] Effects from human activities can be obscured by the strong influence that natural hydrogeologic and geochemical effects may have in some areas. These changes in groundwater quality are largely unavoidable and would become of concern only if they threaten ongoing and potential beneficial uses of the groundwater supply.

Probable sources impairing the groundwater quality can be categorized as nonwaste related and waste related.

[2]Organic chemical and metal contamination of groundwaters that can result from human activities is a water quality concern for all groundwater resources; however, this type of water quality degradation is not within the scope of this study.

Nonwaste-related Sources

Nonwaste-related sources of impairment are: (1) local rocks, (2) mineralized zones, (3) residual saline deposits, (4) connate water, and (5) sea water intrusion.

1. Depending upon their chemical composition, local rocks will contribute a wide range of chemicals in solution to the groundwater. The Jurassic rocks underlying the basin and forming much of the hills and mountains of the watershed contribute calcium, magnesium, bicarbonate, and TDS to the groundwater. These chemicals contribute to the hardness of the water.

2. Fractured and pulverized rock in and near faults creates mineralized zones that more readily yield chemicals to groundwater than do adjacent undisturbed areas.

3. Residual saline deposits contain salts deposited in the past by ocean water in some marine terraces or trapped in the sediments of estuary or lagoonal deposits. Unusually high chloride concentrations in groundwater would suggest residual saline deposits as a possible source, but contributions from these deposits may be indistinguishable from local sea water intrusion.

4. Connate water is water trapped in the interstices of sedimentary rocks at the time of their deposition. It traditionally applies to old sediments. Waters that have been in long-time contact with old sediments contain greater concentrations of minerals than does groundwater at shallow depths where the groundwater has been in the sediments relatively briefly. Connate waters are high in TDS and sulfate concentrations.

5. Sea water intrusion, the movement of sea water into the freshwater aquifers underlying land, occurs when the normal seaward gradient of groundwater is reversed to a landward gradient by heavy pumping or by drought conditions that lower the groundwater level near or below sea level. Sea water intrusion may occur in unconfined water table conditions or in discrete aquifers at depth. A rise in the chloride concentration in the groundwater may be the first sign of sea water intrusion.

Waste-related Sources

In the study area, this category includes: (1) domestic and municipal waste discharges and (2) irrigation return water and livestock waste.

1. When discharged to land, domestic and municipal wastewater, whether treated or untreated, will contribute solutes to the groundwater, notably chloride, nitrate, and TDS.

   Wastewater from Arroyo Grande, Oceano, and Grover Beach is treated in the South San Luis Obispo County Sanitation District's WWTP, and the effluent is discharged via an ocean outfall. Wastewater from the Pismo Beach WWTP is discharged through the South

San Luis Obispo County Sanitation District's ocean outfall. Because wastewater from these communities is discharged out of the basin, it does not affect groundwater quality. In Nipomo Mesa, however, the two Nipomo Community Services District's WWTPs practice land disposal and discharge treated effluent to percolation ponds or use it to irrigate a golf course.

Before the construction of the South San Luis Obispo Sanitation District's WWTP and ocean outfall, wastewater was treated in cesspools, in septic tanks, or in the old Arroyo Grande community WWTP, which discharged to percolation ponds. Use of the plant was discontinued in June 1966. These old waste discharges probably continue to leach waste components to the groundwater during heavy rains or high groundwater conditions and can affect local groundwater quality.

The only large industrial waste discharger, an oil refinery near Highway 1 on Nipomo Mesa, discharges its wastewater to the ocean and out of the area.

2. Return flow from irrigation adds many different compounds to groundwater including sulfate, nitrate, and TDS. Evapotranspiration then concentrates the constituents in the applied supply water. The contributions from livestock waste are similar to those from irrigation.

Groundwater Quality

To evaluate groundwater quality in this study, mineral quality data for the study area were compiled from various sources, including the Department's own files, State Water Resources Control Board, California Department of Health Services, USGS, and local agencies. Sampling and analyses of groundwater were not conducted in this study (these activities were not within the scope of study). The decision to sample the seven sea water intrusion monitoring wells was made after work began on the study. These wells were sampled in March 1996.

The compiled database contains mineral analyses of groundwater from 403 wells sampled between 1927 and 2000 within the study area. Of these wells, about 50 percent were sampled only once. Analyses for some well waters are only partial (just one or two constituents). The cation-anion balances were checked for all complete analyses. Analyses that did not exhibit a cation-anion balance were omitted from the compiled database.

Groundwater sampling in the study area has not been uniform temporally or spatially and the extent of recent available data varies greatly. Municipal system wells in the Tri-Cities Mesa[3] and Nipomo Mesa parts of the groundwater basin have been sampled at regular intervals and water

[3]No recent quality data were available for the Arroyo Grande Plain and Los Berros Creek parts of the Tri-Cities Mesa - Arroyo Grande Plain portion of the main Santa Maria Basin.

quality data are available for these wells for the period of record through 2000. In Nipomo Valley Subbasin, a few wells were sampled once or twice in the 1990s and one well was sampled in 2000. Elsewhere in the basin, groundwater from wells was last sampled and analyzed in the late 1960s or 1970s, except for a few wells sampled in 1987. Groundwater in some parts of the basin has never been sampled.

The available groundwater quality data represent samples obtained from production wells, except for samples from the sea water intrusion monitoring wells. Production wells generally have long screened intervals, perforating multiple aquifers. Each aquifer may contain water of distinctly different quality, and each aquifer may yield water to the production well at different or variable rates. Thus, the water quality samples represent mixtures of groundwater from different aquifers. Only the sea water intrusion monitoring wells have piezometers at selected depths and yield depth-dependent samples.

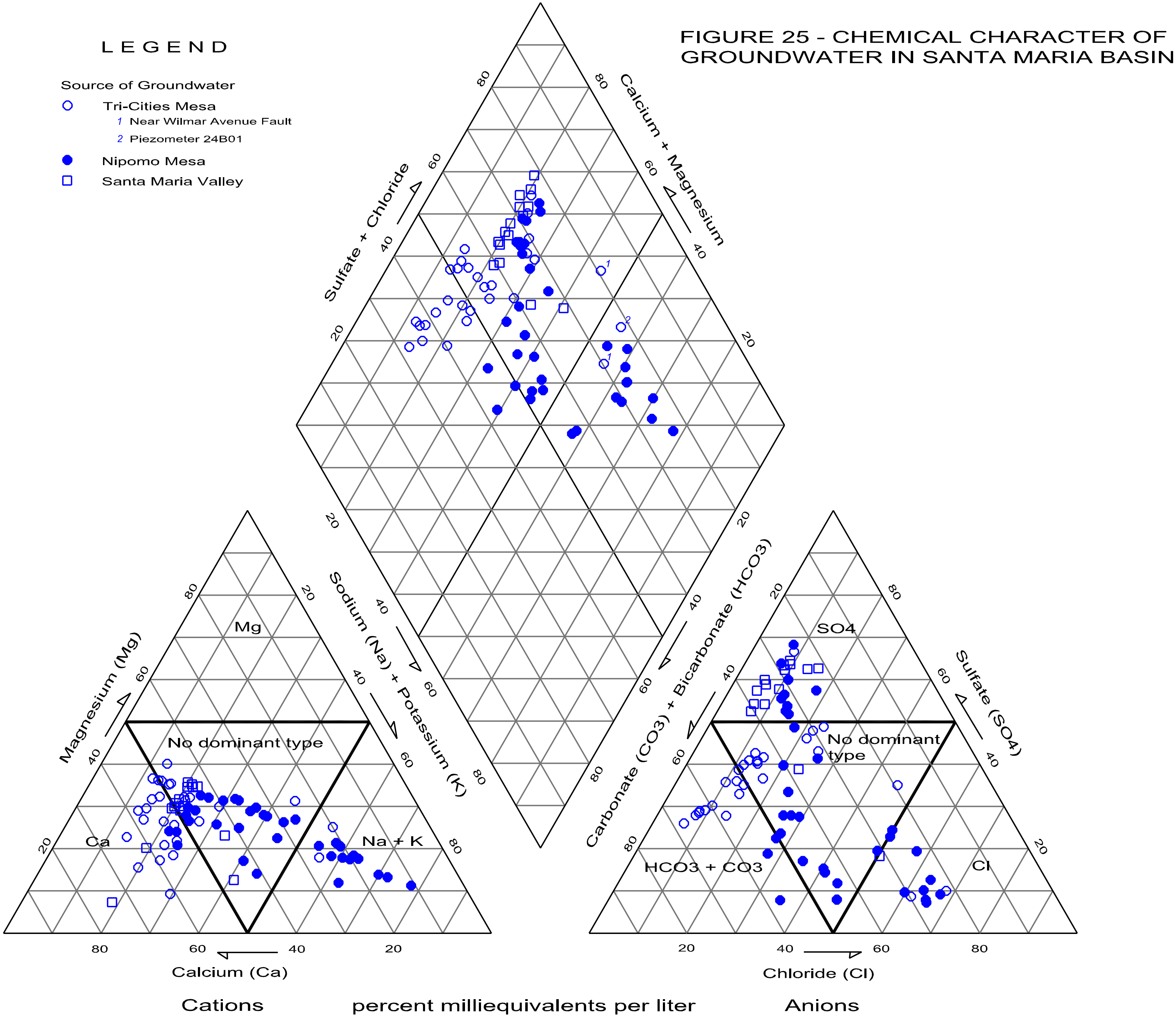
Because of the available database for this study, the evaluation of groundwater quality in the study area is limited to graphical techniques and summary statistical analysis, including Stiff and trilinear diagrams, boxplots, and chemical hydrographs.

Stiff diagrams were constructed and are presented on a map of the study area (Plate 15). Stiff diagrams illustrate the relative abundance of the major mineral ions in water samples. The shapes of the diagrams indicate dominant cations and anions characterizing the water and the width of the diagram is an approximation of the total ionic content. The character of a water may be considered as a unique signature that often persists even after mixing with another water. Spatial relationships and patterns of differences and similarities in groundwater composition within the study area may be perceived from the plate. The Stiff diagrams are based on analyses of groundwater sampled between 1990 and 2000, except for some 1980s analyses in parts of the basin lacking more recent data. In these parts of the basin, the Stiff diagrams are shown in gray on the plate.

Because of the complexity of the basin, a trilinear diagram was prepared as another means of representing the chemical character of groundwater (Figure 25). Analyses from 79 wells were plotted on the diagram. The wells were sampled between 1990 and 2000, except four wells sampled in the 1980s. A trilinear diagram shows the relative contribution of major cations and anions, on a charge-equivalent basis, to the total ionic content of the groundwater. Cations are shown in the left triangle and anions in the right triangle; the central diamond integrates the data. This diagram is useful for comparing large number of groundwater analyses throughout the basin, and it points out arrays of data and singularities. It can also be helpful for showing the effects of mixing two waters from different sources.

Plate 15 shows the areal distribution of groundwater quality, but does not show variations in chemical quality with depth. To evaluate vertical variability in groundwater quality, Stiff diagrams were constructed and plotted on the coastal cross-section A-A’ (Plate 16). The diagrams were constructed from the analyses of depth-dependent groundwater samples collected in March 1996 from the piezometers of seven sea water intrusion monitoring wells.

FIGURE 25 - CHEMICAL CHARACTER OF GROUNDWATER IN SANTA MARIA BASIN



Boxplots were constructed to depict graphically the statistical descriptors of the recent data (1990 through 2000) for quality constituents--TDS, sulfate, chloride, nitrate, and total hardness (Figure 26). These plots display the main aspects of the data--the middle 50 percent of the data values, between the values in the upper and lower 25 percent quartiles; the whiskers indicate the range of values outside an interval of the interquartile range; and values outside the whisker range are plotted individually as outliers and extremes. Outlier and extreme values play important roles in providing information on a data set. These values may represent unusual hydrogeologic conditions or degradation from human activities. The variability of the selected constituents, as well as differences in quality between divisions within the groundwater basin, can be observed from these boxplots.

Chloride is a useful constituent to detect quality changes. In hydrochemical groundwater evolution, the chloride ion tends to be the most conservative, being affected very little by biological processes, by precipitation, or by anion exchange reactions in the soil (Pomeroy and Orlob, 1967). Chloride concentrations therefore normally increase down the hydraulic gradient and with groundwater residence (Lloyd and Heathcote, 1985). The normal increase in chloride concentration is disturbed only where pollution or dilution occurs. Thus, chloride is an excellent indicator of the direction of groundwater flow and of changes associated with long-term cycles of rainfall or runoff or changes in land or water use.

Because chloride concentrations in groundwater may indicate quality changes over time, this parameter was used to evaluate trends in the groundwater quality--if degradation has occurred over time. Wells with recurrent analyses of chloride concentrations over their period of record were evaluated and statistically tested to see if any trend existed. Three hydrographs are given as figures accompanying the text for that part of the groundwater basin.

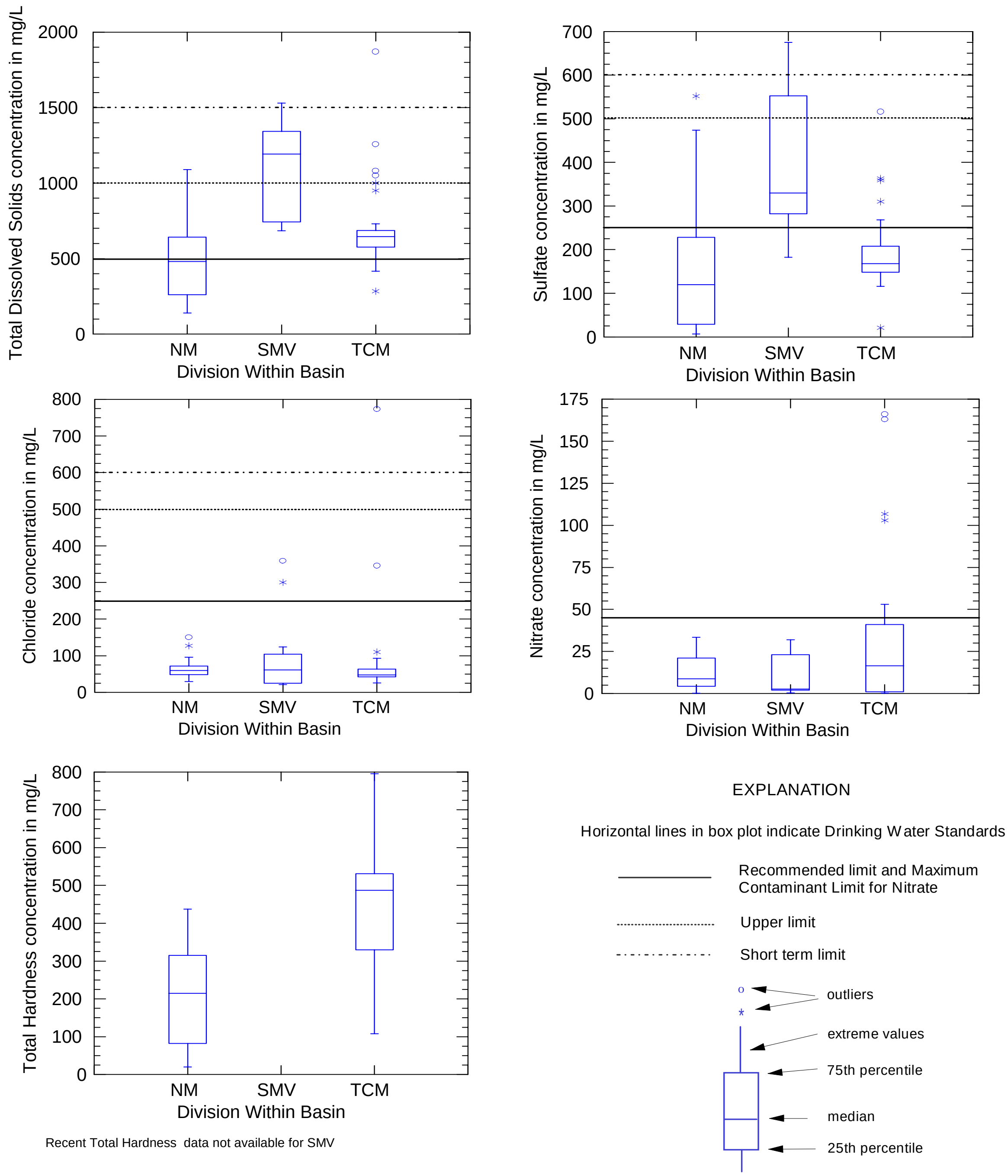
Care must be taken in interpreting any apparent trends in groundwater quality from the graphs and in extrapolating from data from a few wells to an entire basin. A basin will not change uniformly in quality. The geologic fabric and chemical composition, character, and hydraulic properties of groundwater are highly variable from place to place. Groundwater quality tends to change at “points.” Any changes in quality over time are essentially specific to the wells represented in the graphs.

A compilation of groundwater quality data for the study area is given in Appendix F.

Tri-Cities Mesa - Arroyo Grande Plain

Tri-Cities Mesa. In the Tri-Cities Mesa part of the basin, mineral quality constituents in groundwater from 115 wells were analyzed from samples obtained between 1952 and 2000. Of those wells, 25 were sampled between 1995 and 2000, including seven piezometers in three sea water intrusion monitoring wells. Most of these wells with recent data are water agency wells and are sampled recurrently. Sampled wells ranged from 36 to 610 feet in depth and extracted groundwater from either the alluvium or the Paso Robles Formation only, from both those deposits, from the Squire Member of the Pismo Formation, or from the Squire Member in

FIGURE 26 - BOX PLOTS OF TOTAL DISSOLVED SOLIDS, SULFATE, CHLORIDE, NITRATE, AND TOTAL HARDNESS CONCENTRATIONS IN WELL WATERS IN SANTA MARIA GROUNDWATER BASIN, 1990-2000 DATA



Division Within Basin
NM: Nipomo Mesa, 1990-2000 data from 35 wells (including 5 piezometers in 2 sea water intrusion monitoring wells)
SMV: Santa Maria Valley, 1992-1998 data from 4 wells (including 11 piezometers in 2 sea water intrusion monitoring wells)
TCM: Tri-Cities Mesa, 1995-2000 data from 25 wells (including 7 piezometers in 3 sea water intrusion monitoring wells)

combination with the Paso Robles Formation.

Stiff diagrams in Plate 15 show that the dominant cation is calcium and the dominant anions are bicarbonate and sulfate, except for groundwater near the Wilmar Avenue fault. Wells near the fault (18P01 and 19B01) extract groundwater from the Squire Member and are sodium chloride in character. Well 32D11 and piezometer 24B03 are perforated in the Squire Member and wells 30K19 and 19Q02 are perforated in both the Squire Member and the Paso Robles Formation. The other wells with diagrams are perforated in the Paso Robles Formation.

Figure 25 plots the recent data from 25 wells, including seven piezometers in three sea water intrusion monitoring wells. The trilinear diagram shows the similarity of character of most groundwater found in this part of the basin, as well as the different character of groundwater found near the Wilmar Avenue fault.

Plate 16 illustrates vertical variability in groundwater quality in seven piezometers in three sea water intrusion monitoring wells, 32S/12E-24B, 32S/13E-30F, and 32S/13E-30N, in the Tri-Cities Mesa part of the basin. Piezometer 30N02 shows a mineral gain with depth in the Paso Robles Formation. This increase of about 400 mg/L in TDS content may result from the finer grained facies of the aquifer in this part of the basin. The Stiff diagrams show little variation in quality with depth of those piezometers in the Squire Member of the Pismo Formation. Groundwater from piezometer 24B01 in the alluvium of Pismo Creek shows a distinctly different quality and character than the groundwater from the other piezometers. This situation was found to be the result of solution of residual marine and evaporative salts indigenous to the geologic environment in this part of the basin (California Department of Water Resources, 1970).

Boxplots of 1995 to 2000 analyses of groundwater for quality parameters– TDS, sulfate, chloride, nitrate, and total hardness– for Tri-Cities Mesa are shown in Figure 26 along with boxplots of recent data for Nipomo Mesa and Santa Maria Valley. The analyses are from 25 wells, including seven piezometers in three sea water intrusion monitoring wells.

The boxplot for TDS shows that most wells extracted groundwater with concentrations between about 500 and 700 mg/L, meeting the upper limit Drinking Water Standard. The TDS concentrations above 1,000 mg/L were found in two of the sea water intrusion monitoring wells, one well near the Wilmar Avenue fault and in a tributary of Pismo Creek, and two wells about 150 feet deep near Arroyo Grande Creek. Most of the wells extract groundwater with sulfate and chloride concentrations below 250 mg/L, the recommended Drinking Water Standard for both constituents. Six of the analyses for nitrate concentrations in water from wells exceeded the MCL. The wells have a top-perforated interval of less than 100 feet in depth. Most of the groundwater is classified as very hard, although a few wells in the northern part of the mesa produce groundwater classified as moderate.

Groundwater quality in wells in proximity to the Wilmar Avenue fault and along the coast may be affected by mineralization from the fault zone, old saline deposits, or possibly local sea water intrusion in the shallower deposits.

Groundwater is classified as suitable to marginal under water quality guidelines for agricultural irrigation.

Historically, concentrations of TDS in groundwater were as high as 3,640 mg/L; sulfate, 644 mg/L; and chloride, 1,626 mg/L. The wells with these high concentrations typically were along low marshy coastal areas, in the drainage of Pismo Creek, and in the southern part of the mesa near Arroyo Grande Creek. The concentrations were attributed to tidal inflows in lagoons near the shallow wells (California Department of Water Resources, 1970).

To determine if groundwater quality has changed over time, a chloride hydrograph of data from eight wells sampled recurrently was constructed and the data were regressed over time (Figure 27). Of those wells, only well 32S/13E-19Q02 had a statistically significant increase in chloride concentrations over time. This well extracts groundwater from the Paso Robles Formation and the Squire Member of the Pismo Formation. Chloride concentrations rose about 35 mg/L over 25 years. Well 32S/13E-29E01 had a statistically significant downward trend in chloride concentrations over time. This well extracts groundwater from the Paso Robles Formation. Chloride concentrations in groundwater extracted by the other wells show no significant trends over time. The generally stable chloride quality over time is indicative of a net outflow of groundwater to the ocean.

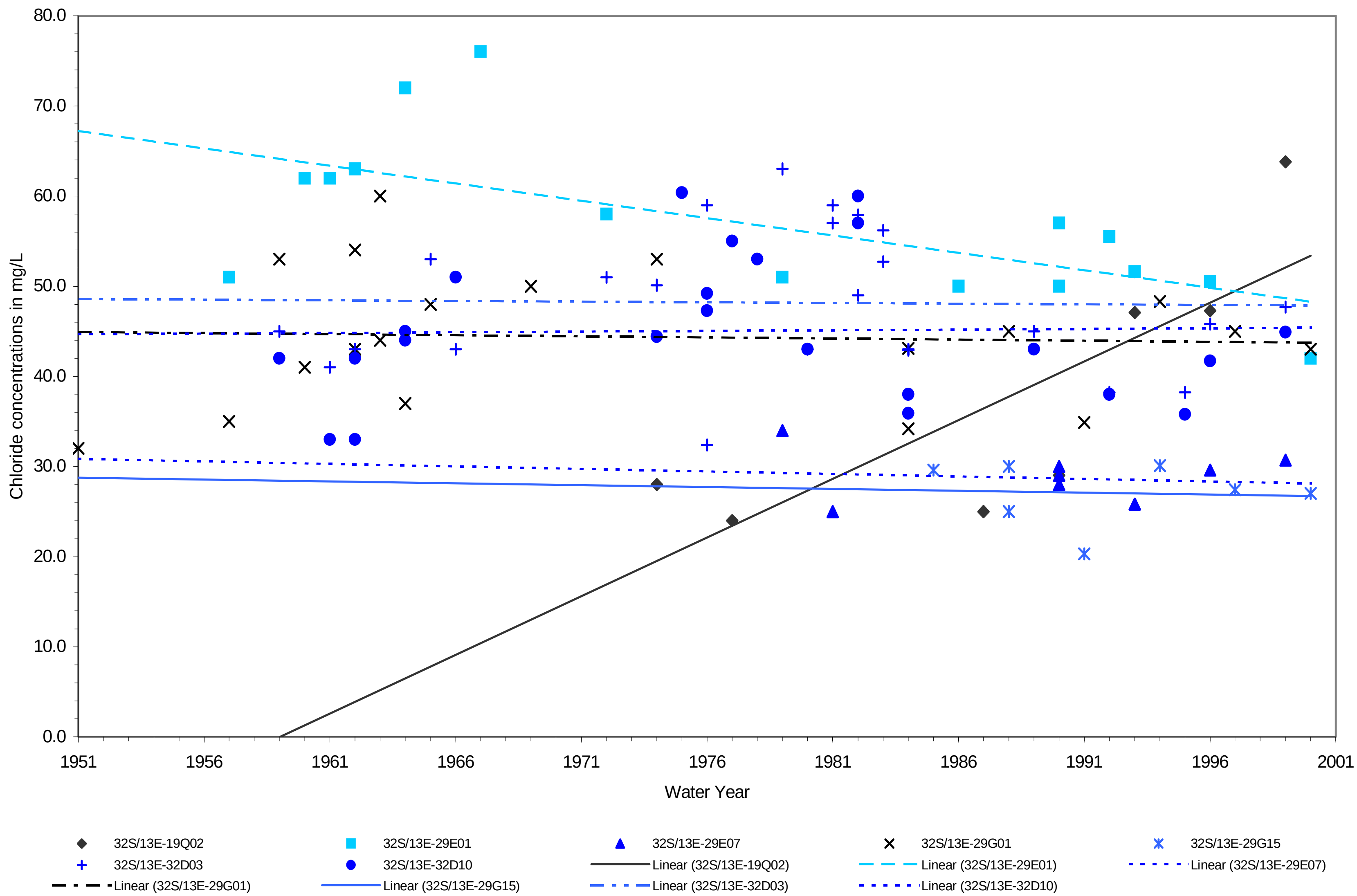
Arroyo Grande Plain and Los Berros Creek. The plain is an area of intense farming. In addition, it receives runoff from Arroyo Grande Valley, also a farming area, and Los Berros Creek, a small valley with orchards and small farm acreage, and in the past, a small feedlot for cattle.

No recent quality data were available for the Arroyo Grande Plain and Los Berros Creek parts of the basin. Given the data limitations, no trend analysis or box plots were developed for this part of the basin. Mineral constituents in groundwater from 41 wells were analyzed from samples taken between 1950 and 1987. Of those wells, about three-fourths were sampled only once. Sampled wells are 38 to 396 feet deep, with most in the 90- to 100-foot range.

The chemical character of groundwater in the Arroyo Grande Plain part of the basin was typically either calcium-magnesium sulfate or calcium-magnesium sulfate-bicarbonate. Plate 15 shows diagrams for two 1987 analyses from well samples collected in Los Berros Creek. The dominant cations were calcium or sodium and the dominant anions were sulfate or chloride.

Historical data show that only 10 percent of the sampled wells produced groundwater with TDS concentrations of less than 500 mg/L and about half the wells produced groundwater with sulfate concentrations of less than 250 mg/L. About 15 percent of the sampled wells produced groundwater with concentrations of TDS greater than 1,500 mg/L and sulfate greater than 500 mg/L. These wells are generally near the confluence of Los Berros Creek with Arroyo Grande Creek and in the southern part of the plain. Chloride concentrations in groundwater met the recommended Drinking Water Standard. About 40 percent of the wells produced groundwater

FIGURE 27 - TREND IN CHLORIDE CONCENTRATIONS IN GROUNDWATER, TRI-CITIES MESA



with concentrations of nitrate that exceeded the MCL. Groundwater quality was likely impaired by return irrigation water. The data indicate that most of the sampled groundwater was very hard.

Some wells produced groundwater classified as marginal under water quality guidelines for agricultural irrigation.

Nipomo Mesa

In the Nipomo Mesa part of the basin, mineral quality constituents in groundwater from 101 wells were analyzed from samples taken between 1953 and 2000. Of those wells, 35 have recent data from 1990 through 2000, including two sea water intrusion monitoring wells with five piezometers. Most of these wells with recent data are water agency wells and are sampled recurrently. Sampled wells range in depth from 24 to 810 feet, with well depth typically increasing toward the west and south. South of the Santa Maria River fault, wells extract groundwater from the Paso Robles Formation, with the deeper wells extracting from the Careaga Formation as well. North of the Santa Maria River fault, wells extract groundwater from the Paso Robles Formation and the Squire Member of the Pismo Formation, but none of these wells has been sampled recently.

The Stiff diagrams in Plate 15 illustrate the varied chemical character and generally lower TDS concentrations found in groundwater in Nipomo Mesa. Well 14E01 and wells south of Mesa Road (shown in Plate 15) in Nipomo Mesa extract groundwater from both the Paso Robles and Careaga Formations, except for well 24L01. This well is screened over 520 feet and represents quality from the older dune sand and the Paso Robles and Careaga Formations. Piezometer 36L02 is perforated in the Careaga Formation. The other wells with diagrams in the mesa extract groundwater from the Paso Robles Formation. North of Black Lake Canyon, many wells extract groundwater with sodium as the dominant cation and chloride or bicarbonate as the dominant anion. South of the canyon, no one cation in extracted groundwater typically dominates, but some wells extract groundwater with sulfate as the dominant anion.

Figure 25 clearly shows the diversity of chemical character of groundwater extracted from the mesa. The diagram plots the recent data from 35 wells. The diverse character reflects the complex hydrogeological environment of this part of the basin.

Vertical variability in groundwater quality in Nipomo Mesa is shown in Plate 16 with Stiff diagrams for five piezometers in two sea water intrusion monitoring wells, 12N/36W-36L and 11N/36W-12C. The chemical character of groundwater from piezometers 36L01, 12C01, and 12C02 in the Paso Robles Formation is the same, calcium-magnesium-sodium sulfate. Groundwater from piezometer 12C02 shows a small mineral gain with depth, an increase of about 130 mg/L in TDS concentration. Groundwater from piezometers 36L02 and 12C03 in the Careaga Formation has a lower mineral content than the groundwater in the overlying Paso Robles Formation, a decrease of about 100 to 300 mg/L in TDS concentration. TDS concentrations can be lower in the Careaga Formation than in the Paso Robles Formation. The formation is composed largely of quartz sand, rather than reworked Monterey shale as in the Paso Robles Formation, and is therefore less soluble, tending to decrease TDS concentrations. The major cation in the groundwater from these two piezometers may be either sodium or calcium with secondary cations and the dominant anion is bicarbonate with either sulfate or chloride as a secondary anion.

Boxplots of 1990 to 2000 analyses of groundwater for quality parameters– TDS, sulfate, chloride, nitrate, and total hardness– for Nipomo Mesa are shown in Figure 26. The analyses are from 35 wells, including five piezometers in two sea water intrusion monitoring wells. About three-fourths of the sampled wells produced groundwater with TDS concentrations that are less than 500 mg/L and about 85 percent of the wells produced groundwater with sulfate concentrations that are less than 250 mg/L. The higher sulfate and TDS concentrations in groundwater are generally found in deeper wells and in the western and southern parts of the mesa. Chloride concentrations in extracted groundwater are low, less than about 130 mg/L. Nitrate concentrations in groundwater from these wells met the MCL. About one-third of the sampled wells extract groundwater classified as soft; otherwise, it ranges from moderate to very hard. The soft groundwater is mainly sodium chloride in character.

Groundwater is classified as suitable to marginal under water quality guidelines for agricultural irrigation.

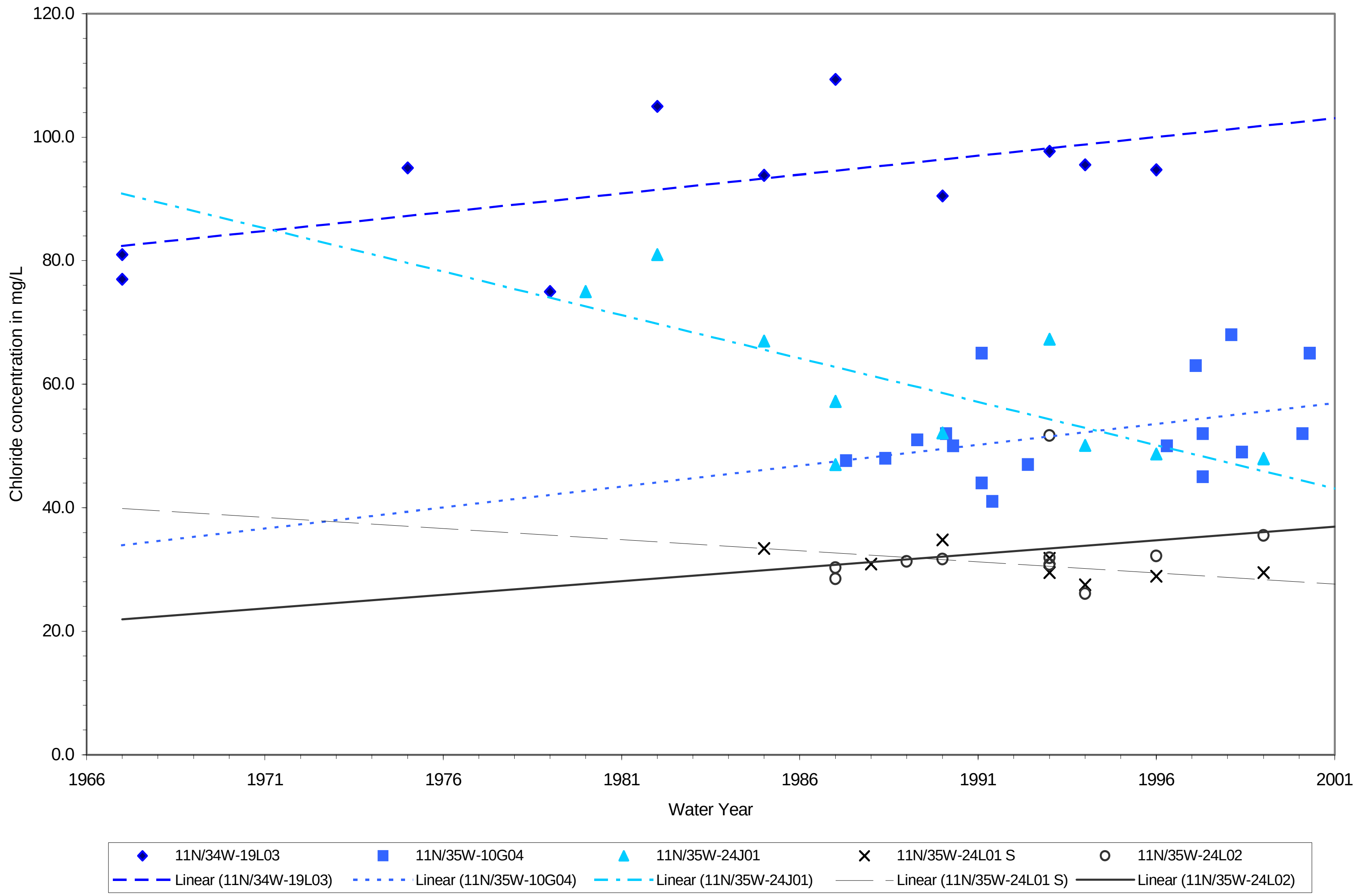
To determine if groundwater quality has changed over time, a chloride hydrograph of data from five wells sampled recurrently was constructed and the data were regressed over time (Figure 28). Of those wells, only well 11N/35W-24J01 had a statistically significant decline in chloride concentrations over time. This well extracts groundwater from the Paso Robles Formation. Chloride concentrations declined about 30 mg/L over about 20 years. Wells 11N/35W-10G04 and 11N/34W-19L03 had statistically significant increases in chloride concentrations over time, rising about 7 mg/L in about 13 years in well 10G04 and about 18 mg/L in about 30 years in well 19L03. Well 10G04 extracts groundwater from the Paso Robles Formation and is within the area of the pumping depression shown in Plate 14. Well 19L03 extracts groundwater from the Paso Robles and Careaga Formations. Chloride concentrations in groundwater extracted by the other wells show no significant trends over time.

Although wells 11N/35W-24L01 and 11N/35W-24L02 showed no increasing trend in chloride concentrations, well 24L02 and another well, 11N/35W-24L03, have shown increases in sulfate and TDS concentrations over their period of record. These wells are within the depression shown in Plate 14 and the increases in concentrations of these two constituents may reflect groundwater inflow from Santa Maria Valley. Data are not available to show any reduction in the quality of groundwater in the mesa from the depression (Plate 14) and subsurface inflow of groundwater from Santa Maria Valley.

Santa Maria Valley

Within the study area, the Santa Maria Valley is largely an agricultural area, with thousands of

FIGURE 28 - TREND IN CHLORIDE CONCENTRATIONS IN GROUNDWATER, NIPOMO MESA



acres under irrigation.

In the Santa Maria Valley part of the basin, mineral quality constituents in groundwater from 74 wells were analyzed from samples taken between 1927 and 1998. Only four wells have recent analyses (1992 through 1998)– these were the two sea water intrusion monitoring wells with recent data for 11 piezometers and two wells with partial analyses. Other than the sea water intrusion monitoring wells, a complete mineral analysis of groundwater was last performed on a sample from only one well in 1987. Data were available for one sample collected in 1985 and one in 1981. The lack of recent data is clearly seen in Plate 15. Sampled wells ranged from less than 50 feet to greater than 600 feet in depth and are perforated in alluvium or the Paso Robles Formation or in both deposits.

Most groundwater in the valley may be characterized as a calcium-magnesium sulfate type (Plate 15). This water type reflects the quality of recharge from the Santa Maria River, which receives its flow from the Cuyama and Sisquoc Rivers. Gypsum deposits in Tertiary and pre-Tertiary marine deposits in the Cuyama Valley have been thought to influence the quality of runoff in the Cuyama River (Singer and Swarzenski, 1970).

The trilinear diagram in Figure 25 shows the dominant calcium-magnesium sulfate type of groundwater. Because the only recent complete analyses available were from the 11 piezometers in the two sea water intrusion monitoring wells, the data from the four wells sampled in the 1980s were included in the diagram.

Plate 16 illustrates vertical variability in groundwater quality for 11 piezometers in two sea water intrusion monitoring wells in the alluvium and the Paso Robles Formation in Santa Maria Valley, 11N/36W-35J and 10N/36W-02Q. The Stiff diagrams show the large mineral decrease in groundwater in the Paso Robles Formation from groundwater in the alluvium, as much as about an 800 mg/L decrease in TDS content. The quality of groundwater in the Paso Robles Formation is generally about the same regardless of depth, except for piezometer 35J03. The groundwater in this piezometer may be affected by downward percolation of poorer quality water from the alluvium or possibly oil field activity.

Boxplots of the recent data shown in Figure 26 illustrate the high concentrations of TDS and sulfate found in the four wells described at the beginning of this section. The concentrations did not meet recommended Drinking Water Standards. Except for one shallow piezometer and one well near Highway 101, chloride concentrations met the recommended Drinking Water Standard and nitrate concentrations met the MCL. The groundwater extracted from these wells was not analyzed for total hardness concentrations.

The use and reuse of groundwater for irrigation have been considered the major factors affecting quality of groundwater in the valley within the study area. The deep percolation of applied water with salts added from use tends to increase the salt concentrations in groundwater with each cycle of use.

Historical data show that concentrations of TDS and sulfate in groundwater from about three-fourths of the sampled wells met the upper limits for drinking water. The groundwater was classified as marginal to unsuitable under water quality guidelines for agricultural irrigation. About 25 percent of sampled wells extracted groundwater with nitrate concentrations that exceeded the MCL; concentrations were as high as 240 mg/L. The higher concentrations tended to be found in the shallower wells. Chloride concentrations in groundwater were generally less than 250 mg/L. Most of the groundwater was classified as very hard.

To determine if groundwater quality has changed over time, a chloride hydrograph of data from eight piezometers in two sea water intrusion monitoring wells sampled recurrently was constructed and the data were regressed over time (Figure 29). Except for the shallowest alluvial piezometer, 10N/36W-2Q07, chloride concentrations have been stable over time. The generally stable chloride quality over time is indicative of a net outflow of groundwater to the ocean. The increase in chloride concentrations in this piezometer is discussed in the section on sea water intrusion in this chapter.

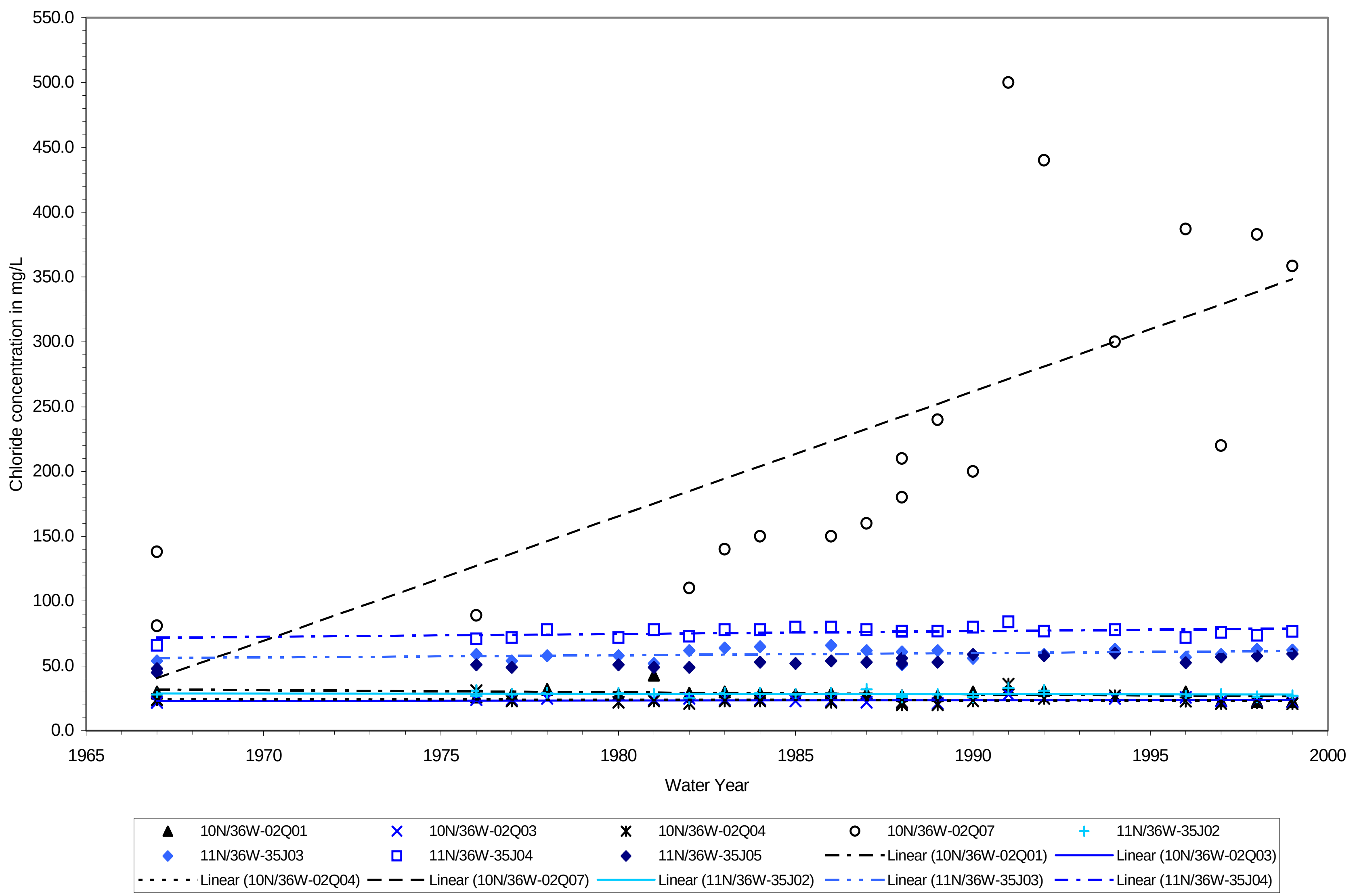
Arroyo Grande Valley Subbasin

No recent quality data were available for Arroyo Grande Valley Subbasin, except for a partial analysis of a sample from one well in 1996. Given the data limitations, no trend analysis or box plots were developed for this part of the basin. Mineral quality constituents in groundwater from 21 wells were analyzed from samples collected between 1954 and 1987. Of those wells, 13 were sampled only once.

The Stiff diagrams of 1980s analyses in Plate 15 show the progressive deterioration of the groundwater quality in a downstream direction. The chemical character of groundwater in the valley is calcium-magnesium bicarbonate in the upstream section above the confluence with Tar Spring Creek and calcium-magnesium sulfate in the downstream section below Tar Spring Creek. This downstream section overlies a zone of multiple faults that is probably highly mineralized and may impact the quality of the groundwater. Irrigation return water also may impact the quality. Sampled wells in the valley are 60 to 150 feet deep.

The historical data show that, except for concentrations of TDS and sulfate in water from one well, concentrations of TDS, sulfate, and chloride in groundwater in the upstream section met Drinking Water Standards and the water was classified as suitable under water quality guidelines for agricultural irrigation. In the downstream section, TDS concentrations in extracted groundwater were typically more than 1,500 mg/L and exceeded the short-term Drinking Water Standard. Likewise, the sulfate concentrations were more than about 500 mg/L and exceeded the upper limit of the standard. The concentrations of these constituents also led to the groundwater being classified as marginal to unsuitable under water quality guidelines for agricultural irrigation. Chloride concentrations ranged between 17 and 136 mg/L and met the recommended Drinking Water Standard. Nitrate concentrations in groundwater met the MCL, except in water from two wells. Concentrations in these wells, sampled only one time, were 68 and 102 mg/L. Groundwater in the valley was classified as very hard.

FIGURE 29 - TREND IN CHLORIDE CONCENTRATIONS IN GROUNDWATER, SANTA MARIA VALLEY



Newsom's Hot Springs are in Newsom Canyon, a tributary of Arroyo Grande Valley. The hot sulfur springs, emanating from Miocene rocks, occur probably along mineralized zones. The springs had been developed for public use. One of the springs issued water of 100°F. An 1888 chemical analysis showed that the spring water was magnesium-calcium-sodium bicarbonate in character and had a TDS concentration of 630 mg/L.

Pismo Creek Valley Subbasin

No recent groundwater quality data were available for Pismo Creek Valley Subbasin. The historical data consist of analyses from seven wells sampled in the 1950s and 1960s. Given the data limitations, no trend analysis or box plots were developed for this part of the basin. The data indicate that groundwater quality in Pismo Creek Valley Subbasin generally did not meet Drinking Water Standards for sulfate, chloride, and TDS. Concentrations of sulfate ranged from 740 to 1 mg/L; chloride, from 766 to 49 mg/L; and TDS, from 2,390 to 790 mg/L. Nitrate concentrations in two wells exceeded the MCL. The dominant ions were sodium and chloride-bicarbonate or sulfate-chloride. A study by the Department in 1965 concluded that the poor quality of groundwater in lower Pismo Creek resulted from the presence of faults and mineralized zones, residual saline deposits, and local sea water intrusion. Sampled well depths ranged from 30 to 102 feet.

Nipomo Valley Subbasin

In Nipomo Valley Subbasin, mineral quality constituents in groundwater from 22 wells were analyzed from samples taken between 1962 and 2000. Of those wells, only six were sampled between 1992 and 2000. Sampled wells are between 40 and 400 feet deep. Groundwater is extracted mainly from the Obispo and Monterey Formations.

The chemical character of the groundwater, as shown by Stiff diagrams for wells in Nipomo Valley Subbasin in Plate 15, is mixed, no one cation or anion dominates.

TDS concentrations in groundwater sampled recently ranged between 750 and 1,300 mg/L; sulfate concentrations, between 200 and 340 mg/L; chloride concentrations, between 64 and 130 mg/L; and nitrate concentrations, between not detected and 3.5 mg/L. Like most of the groundwater in the study area, the groundwater is classified as very hard. Historical data show that groundwater in two wells had nitrate concentrations that exceeded the MCL.

Groundwater is classified as suitable to marginal under water quality guidelines for agricultural irrigation.

Occurrence of Nitrate

Nitrate is one of the most problematic of all groundwater mineral constituents and its toxicology is such that Department of Health Services established the 45 mg/L (as nitrate) MCL.

Because nitrate does not occur naturally in the study area, the nitrate found in the groundwater is a result of human activity. The main sources of nitrate are applied fertilizers and wastewater. Minor sources of nitrate are the animal waste produced by cattle feedlots, chicken and hog ranches, and miscellaneous livestock. Some of these sources no longer exist, but the residual nitrate in the soils at the sites may continue to leach out, possibly affecting groundwater quality.

Nitrate from fertilizers is introduced into the groundwater basin over a broad area wherever irrigated acreage exists. Farms and orchards are found in all parts of the basin, but are concentrated in Arroyo Grande Valley and Plain and in Santa Maria Valley. There are also several hundred acres of farms in Nipomo Valley Subbasin. The nitrate and nitrogen compounds in the applied fertilizers are carried to groundwater with deep percolation of rainwater or irrigation return.

In the past, nitrate from wastewater effluent was also introduced into the groundwater basin over a broad area. Before the construction of wastewater collection systems and treatment plants, the standard disposal method was by septic tanks and leachfields and cesspools wherever there was a home, business, or farm. Later and until 1966, the City of Arroyo Grande operated a limited collection system and treatment plant, discharging its treated effluent to percolation ponds and spreading grounds southeast of Grover Beach. These old septic tank leachfields, cesspools, and ponds are no longer operating, but they can continue to contribute nitrate and other minerals to groundwater as rainwater and irrigation return infiltrate to the underlying sediments and leach the nitrate compounds retained in the sediments. The rise and fall of groundwater levels during very wet seasons may also leach nitrate from the vadose zone above the water table.

With the building of the South San Luis Obispo County Sanitation District WWTP's ocean outfall, wastewater from this part of the groundwater basin has largely been removed as an ongoing source of nitrate.

Nipomo Community Services District operates the Black Lake Golf Course and Southland WWTPs. Wastewater from the Black Lake Golf Course WWTP discharges to an aerated lagoon and ultimately is used to irrigate portions of the adjacent golf course. Sampled well water near the Black Lake Golf Course WWTP had low nitrate concentrations. The Southland WWTP, located southwest of Nipomo, collects and treats wastewater from Nipomo and a small part of the mesa. After treatment, the effluent is discharged to percolation ponds from which it incidentally recharges the groundwater basin. Semi-annual sampling, between January 1995 and July 2000, of groundwater from Southland WWTP Monitoring Well Number 1 showed variable nitrate concentrations, ranging between not detected and 301 mg/L, with a median concentration of 30 mg/L (data provided by Doug Jones of Nipomo Community Services District).[4] The nitrate concentration in the well water was 4.4 mg/L in July 2000.

Grover Beach has continued to use the local groundwater, which is high in nitrate, by reducing

[4]Because of the variability in nitrate concentrations, the median value of 30 mg/L was used for Plate 17.

the nitrate concentrations to acceptable levels. In 1989, the city constructed a 2.3-million-gallon per day ion exchange plant. The supply wells are nearby. The product water from the plant is piped directly into the water supply system. A report in 1993 indicated that of the 1,750 AF of water required by the city annually, 500 AF is produced by the nitrate removal plant.

Nitrate concentrations found in water from wells sampled between 1990 and 2000 are plotted in Plate 17. It graphically shows three ranges of nitrate concentrations in groundwater from sampled wells. As can be seen on the plate, groundwater with nitrate concentrations exceeding the MCL is found mainly in the Tri-Cities Mesa part of the basin.

The plate also shows the lack of recent data for large portions of the study area, particularly for agricultural areas (Santa Maria Valley and Arroyo Grande Plain and Valley). Historically, groundwater in these agricultural areas exceeded the MCL. The high nitrate concentrations had been attributed to the ongoing agricultural activities.

In 1979, McCulley published results of a study that used isotopic analyses of nitrate in groundwater to determine the source of nitrate in the Tri-Cities Mesa - Arroyo Grande Plain portion of the basin. Previous studies had been unable to determine whether cultivation practices, fertilizer, or infiltration of wastewater from septic tanks is the source of nitrate. McCulley found that the congruent isotopic range of nitrate in groundwater and agricultural soils demonstrated that most of the nitrate in groundwater was from agricultural land use (1979, p. 827). The study could not differentiate between nitrate derived from nitrogenous fertilizer and from oxidation of organic nitrogen.

The influence from the use of fertilizers will likely continue to be the major factor determining nitrate concentrations in groundwater. Because nitrate concentrations may exceed the California Department of Health Services's MCL in some areas, it would be useful to routinely test for nitrate content in groundwater supplies for domestic use.

Sea Water Intrusion

The Santa Maria Groundwater Basin is hydraulically continuous offshore beneath the ocean. If groundwater pumpage were to exceed recharge to the basin, the natural seaward gradient would reverse and sea water would migrate landward, displacing freshwater in the aquifer. This can eventually result in sea water intrusion into the inland basin and in water supply wells; however, sea water can migrate landward for many years before the inland basin is intruded. Seasons of heavy rainfall, which result in increased recharge to the basin and reduced pumping from the basin, will increase the seaward head in the groundwater and slow encroachment of sea water or even reverse the process.

Data are inadequate to define the configuration and storage of the offshore aquifer and the occurrence and extent of possible sea water intrusion in that aquifer. Thus, a monitoring program for early detection of sea water intrusion into the landward groundwater basin is important for protection of the Santa Maria Groundwater Basin. The monitoring program should include plans to mitigate sea water intrusion before it occurs. Such plans might initially consider changes in spatial distribution and quantity of groundwater pumpage, along with surface water deliveries for artificial recharge.

Concentrations of 100 mg/L or more of chloride in samples are generally considered an indication of sea water intrusion (Izbicki, 1991). Nevertheless, chloride can come from other sources, such as natural mineral deposits, fertilizers, and naturally poor quality water. Consequently, a high concentration of chloride alone as an indicator of sea water intrusion can be misleading. Other indicators of sea water intrusion should be considered together with the high chloride content in determining the presence of sea water intrusion.

In previous studies, the State and San Luis Obispo County constructed sea water intrusion monitoring wells along the coast, between the City of Pismo Beach and the San Luis Obispo-Santa Barbara County line, a distance of about 12 miles. A typical monitoring well contains two or more piezometers, separated by cement plugs to ensure discrete samples from selected depths.

Seven of these monitoring wells, containing a total of 26 piezometers, were sampled in March 1996 for this study.[5] The 1996 water quality data, plus historical data, for these wells are listed in Table 23. The piezometers are identified by State Well Numbers and their piezometer depths are given. Their locations are shown in Plate 18. The data were reviewed to evaluate the status of sea water intrusion in the study area.

In the Pismo Beach-Oceano area, three wells containing nine piezometers sample groundwater from 48 to 435 feet deep. Samples from the shallow piezometer, 32S/12E-24B01, show high concentrations of chloride. However, samples from this depth have historically shown high concentrations of sodium chloride. This situation was found to be the result of solution of residual marine and evaporative salts indigenous to the geologic environment in this part of the basin (California Department of Water Resources, 1970). Samples from piezometers 32S/12E-24B02 and 32S/12E-24B03 show no sign of sea water intrusion. In addition, the four other piezometers in this part of the basin--32S/13E-30F02 and 30F03 and 32S/13E-30N02 and 30N03--show no sign of sea water intrusion.

Seaward of Nipomo Mesa, two wells containing five piezometers monitor depths of 227 to 730 feet. No sign of sea water intrusion is shown by the two piezometers 12N/36W-36L01 and 36L02 nor by the three piezometers 11N/36W-12C01, 12C02, and 12C03, which are on the beach west of Nipomo Mesa.

In Santa Maria Valley near the coast, two wells contain 12 piezometers monitoring groundwater at depths of 18 to 671 feet. The shallow piezometer, 10N/36W-02Q07, has shown high chloride

[5]Samples could not be obtained from three shallow piezometers, 32S/13E-30F01, 32S/13E-30N01, and 11N/36W-35J06, because they were dry.

TABLE 23
SEA WATER INTRUSION MONITORING WELLS, SELECTED DATA

State Well No.	Date yr/mo/day	pH lab	TDS180° mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	HCO_3 mg/L	SO_4 mg/L	Cl mg/L	NO_3 mg/L	B mg/L	Fl mg/L	Total Hardness mg/L	Perforated interval (feet)
32S/12E-24B01 M	660117	8.2	1,700	95	83	406	20.0	440	175	652	1.0	0.07	0.3	579	48-65
32S/12E-24B01 M	760609	8.2	1,706	94	95	400	16.2	474	159	667	0.4	0.12	0.5	625	48-65
32S/12E-24B01 M	960326	7.8	1,870	125	95	380	24.0	427	154	773	0.2	0.27	--	--	48-65
32S/12E-24B02 M	660117	8.3	651	101	32	79	5.0	380	147	62	0.0	0.05	0.3	384	120 - 145
32S/12E-24B02 M	760609	7.9	565	104	27	52	4.0	337	153	34	0.6	0.02	0.5	371	120 - 145
32S/12E-24B02 M	960326	7.8	652	107	24	46	5.0	344	169	54	0.2	0.10	--	--	120 - 145
32S/12E-24B03 M	660117	8.0	670	103	36	74	5.0	345	158	79	1.0	0.00	0.2	405	270 - 435
32S/12E-24B03 M	760609	7.8	569	85	39	53	3.7	330	165	36	0.0	0.06	0.4	373	270 - 435
32S/12E-24B03 M	960326	7.8	646	104	42	52	4.3	412	164	41	0.2	0.12	--	--	270 - 435
32S/13E-30F02 M	660120	7.6	580	94	38	47	2.0	280	152	68	27.0	0.08	0.2	391	75 - 100
32S/13E-30F02 M	760609	8.0	637	98	43	55	2.8	343	172	48	17.6	0.10	0.5	421	75 - 100
32S/13E-30F02 M	960327	7.4	678	98	42	52	3.8	305	166	49	49.0	0.16	--	--	75 - 100
32S/13E-30F03 M	660119	7.8	642	109	40	49	4.0	321	182	69	1.0	0.05	0.3	437	305 - 372
32S/13E-30F03 M	760609	7.8	616	96	49	41	2.6	333	190	43	0.4	0.05	0.5	441	305 - 372
32S/13E-30F03 M	960327	7.6	686	109	48	40	3.4	379	197	41	0.2	0.13	--	--	305 - 372
32S/13E-30N02 M	660121	7.5	1,069	148	63	71	5.0	232	483	54	0.0	0.12	0.5	629	175 - 255
32S/13E-30N02 M	760607	7.9	1,093	150	60	62	4.7	248	484	48	0.0	0.13	0.7	624	175 - 255
32S/13E-30N02 M	960327	8.1	1,050	145	60	71	5.5	243	516	50	0.9	0.23	--	--	175 - 255
32S/13E-30N03 M	660122	7.5	804	132	59	54	3.0	410	250	57	1.0	0.08	0.5	572	60 - 135
32S/13E-30N03 M	760607	8.0	705	99	43	54	2.9	189	168	90	112.5	0.08	0.5	424	60 - 135
32S/13E-30N03 M	960327	7.7	624	78	35	62	4.0	150	161	70	106.8	0.13	--	--	60 - 135
12N/36W-36L01 S	760608	7.9	936	130	48	72	3.5	223	423	38	0.6	0.15	0.7	521	227 - 237
12N/36W-36L01 S	960326	7.8	882	124	47	66	4.8	233	408	35	2.0	0.24	--	--	227 - 237
12N/36W-36L02 S	760608	8.0	820	94	44	118	6.6	393	184	126	0.0	0.36	0.5	414	535 - 545
12N/36W-36L02 S	960326	7.8	772	86	36	130	8.7	390	148	127	0.2	0.50	--	--	535 - 545
11N/36W-12C01 S	760608	8.0	920	139	47	72	3.5	219	439	40	1.4	0.14	0.7	540	280 - 290
11N/36W-12C01 S	960326	8.6	962	136	49	70	4.7	207	474	38	1.8	0.25	--	--	280 - 290

TDS: Total Dissolved Solids, Ca: Calcium, Mg: Magnesium, Na: Sodium, K: Potassium, HCO_3: Bicarbonate, SO_4: Sulfate, Cl: Chloride, NO_3: Nitrate, B: Boron, Fl: Fluoride

TABLE 23 continued
SEA WATER INTRUSION MONITORING WELLS, SELECTED DATA

State Well No.	Date yr/mo/day	pH lab	TDS180° mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	HCO_3 mg/L	SO_4 mg/L	Cl mg/L	NO_3 mg/L	B mg/L	Fl mg/L	Total Hardness mg/L	Perforated interval (feet)
11N/36W-12C02 S	760608	7.7	1,015	129	52	90	4.6	184	488	48	1.4	0.16	0.5	536	450 - 460
11N/36W-12C02 S	960326	8.1	1,090	150	52	80	5.2	246	552	46	1.2	0.27	--	--	450 - 460
11N/36W-12C03 S	760608	7.8	813	89	43	98	5.9	293	235	94	0.4	0.24	0.4	399	720 - 730
11N/36W-12C03 S	960326	8.1	790	97	51	92	6.0	317	246	91	0.2	0.32	--	--	720 - 730
11N/36W-35J02 S	670928	7.7	811	106	46	63	4.0	261	332	28	1.3	0.12	0.4	454	527 - 615
11N/36W-35J02 S	770726	--	860	110	49	60	3.2	260	340	28	--	0.10	--	470	527 - 615
11N/36W-35J02 S	871028	7.5	773	110	48	56	2.2	277	340	26	2.1	0.15	0.2	--	527 - 615
11N/36W-35J02 S	960327	7.4	776	107	52	57	3.2	261	362	27	2.2	0.20	--	--	527 - 615
11N/36W-35J03 S	670928	7.8	1,031	132	55	89	4.0	239	462	54	10.8	0.18	0.6	556	247 - 490
11N/36W-35J03 S	770726	--	1,130	150	58	87	3.5	250	490	54	--	0.10	--	610	247 - 490
11N/36W-35J03 S	871028	7.7	1,200	170	70	85	3.9	279	580	61	15.5	0.21	0.4	--	247 - 490
11N/36W-35J03 S	960327	7.4	1,230	179	64	88	4.0	291	556	57	26.3	0.28	--	--	247 - 490
11N/36W-35J03 S	981117	7.38	1,198	165	74	86	3.9	278	550	62	31.3	0.23	0.4	--	247 - 490
11N/36W-35J04 S	670928	7.5	1,177	159	67	90	4.0	265	530	66	11.5	0.14	0.7	673	175 - 228
11N/36W-35J04 S	770726	--	1,460	190	73	86	4.3	300	600	72	--	0.20	--	780	175 - 228
11N/36W-35J04 S	871028	7.5	1,490	220	86	90	0.3	346	740	77	12.8	0.23	0.4	--	175 - 228
11N/36W-35J04 S	960327	7.4	1,500	343	21	96	4.4	358	665	72	22.7	0.33	--	--	175 - 228
11N/36W-35J04 S	981117	7.3	1,470	202	93	93	4.4	344	664	77	27.3	0.25	0.4	--	175 - 228
11N/36W-35J05 S	670928	7.4	1,029	134	57	81	4.0	260	453	45	5.0	0.13	0.7	569	74 - 138
11N/36W-35J05 S	770726	--	955	160	60	75	3.5	269	500	49	--	0.10	--	650	74 - 138
11N/36W-35J05 S	871028	7.5	1,100	170	66	75	3.6	305	520	52	5.3	0.19	0.5	--	74 - 138
11N/36W-35J05 S	960327	7.4	1,210	--	69	82	3.8	316	554	53	8.9	0.27	--	--	74 - 138
11N/36W-35J05 S	981117	7.3	1,216	163	75	78	4.1	293	555	59	11.4	0.21	0.5	--	74 - 138
10N/36W-02Q01 S	670929	7.9	818	101	52	57	4.0	229	353	29	1.5	0.11	0.4	466	567 - 671
10N/36W-02Q01 S	770726	--	890	120	51	56	3.1	250	360	28	--	0.10	--	500	567 - 671
10N/36W-02Q01 S	871028	7.7	799	110	50	52	3.2	249	370	27	1.9	0.13	0.2	--	567 - 671
10N/36W-02Q01 S	960327	7.2	824	113	55	56	3.7	261	352	30	2.1	0.19	--	--	567 - 671
10N/36W-02Q01 S	981116	7.4	716	91	46	50	3.2	229	287	23	2.0	0.15	0.2	--	567 - 671

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TABLE 23 continued
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State Well No.	Date yr/mo/day	pH lab	TDS180° mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	HCO_3 mg/L	SO_4 mg/L	Cl mg/L	NO_3 mg/L	B mg/L	Fl mg/L	Total Hardness mg/L	Perforated interval (feet)
10N/36W-02Q02 S	670929	7.9	726	90	41	67	4.0	254	294	24	1.3	0.11	0.4	393	467 - 535
10N/36W-02Q02 S	770726	--	780	99	44	59	3.2	260	300	24	--	0.10	--	430	467 - 535
10N/36W-02Q02 S	960327	8.0	758	102	49	56	3.1	273	278	27	2.0	0.19	--	--	467 - 535
10N/36W-02Q03 S	670929	7.8	741	95	47	53	3.0	249	303	22	1.0	0.09	0.4	431	397 - 444
10N/36W-02Q03 S	770726	--	800	100	47	53	2.9	250	310	24	--	0.10	--	440	397 - 444
10N/36W-02Q03 S	871028	7.7	696	99	46	47	3.0	248	300	21	1.9	0.13	0.2	--	397 - 444
10N/36W-02Q03 S	960327	7.2	706	92	45	53	3.5	262	286	26	1.9	0.20	--	--	397 - 444
10N/36W-02Q03 S	981116	7.4	727	92	49	50	3.0	243	297	22	2.0	0.14	0.2	--	397 - 444
10N/36W-02Q04 S	670929	8.1	712	93	44	53	3.0	248	291	24	1.5	0.09	0.4	413	291 - 378
10N/36W-02Q04 S	770726	--	750	100	46	49	2.6	250	290	23	--	0.10	--	440	291 - 378
10N/36W-02Q04 S	871028	7.9	698	96	44	47	2.7	250	300	22	2.3	0.13	0.2	--	291 - 378
10N/36W-02Q04 S	960327	7.0	730	98	46	49	2.7	255	312	23	2.8	0.19	--	--	291 - 378
10N/36W-02Q04 S	981116	7.5	685	88	47	49	2.5	222	277	21	2.7	0.14	0.2	--	291 - 378
10N/36W-02Q05 S	670929	7.6	973	131	54	75	3.0	245	417	56	5.3	0.14	0.5	549	185 - 246
10N/36W-02Q05 S	760521	8.0	943	141	54	77	2.7	254	420	64	6.8	0.18	0.7	574	185 - 246
10N/36W-02Q05 S	960327	8.0	1,200	178	71	83	3.9	261	534	85	7.0	0.27	--	--	185 - 246
10N/36W-02Q06 S	670929	7.8	1,000	139	54	82	3.0	250	439	61	3.5	0.18	0.6	569	130 - 170
10N/36W-02Q06 S	760521	7.9	813	119	52	61	2.6	258	355	42	4.4	0.08	0.6	511	130 - 170
10N/36W-02Q06 S	960327	7.2	1,530	286	58	101	4.4	297	675	124	1.2	0.32	--	--	130 - 170
10N/36W-02Q07 S	670929	7.4	747	103	44	74	4.0	319	214	81	11.0	0.14	0.5	438	19 - 47
10N/36W-02Q07 S	760604	8.2	683	89	40	66	3.5	278	170	89	10.0	0.06	0.7	387	19 - 47
10N/36W-02Q07 S	871028	7.5	839	130	49	91	5.7	322	120	210	--	0.15	0.3	--	19 - 47
10N/36W-02Q07 S	960327	7.2	1,310	195	32	190	11.5	415	190	387	0.3	0.40	--	--	19 - 47
10N/36W-02Q07 S	981116	7.4	1,186	158	73	153	5.6	397	182	358	0.4	0.52	0.4	--	19 - 47

TDS: Total Dissolved Solids, Ca: Calcium, Mg: Magnesium, Na: Sodium, K: Potassium, HCO_3: Bicarbonate, SO_4: Sulfate, Cl: Chloride, NO_3: Nitrate, B: Boron, Fl: Fluoride

concentrations, and in 1991, it showed a marked increase. This increase has diminished, but the concentration remains higher than its historical values, which may be an indication of sea water intrusion into the shallow aquifer. However, because of the shallow depth, this high chloride concentration may result from tidal action and percolation of poor quality surface waters rather than sea water intrusion. The piezometer 10N/36W-02Q06 showed a relatively high chloride reading in 1996. It also had a high sulfate to chloride ratio. Because sea water normally has a low sulfate to chloride ratio, the high sulfate to chloride ratio suggests a strong influence from surface waters and fertilizers. The turbulence resulting from the creation and recovery of pumping depressions may have carried surface waters down to the lower levels. The five other piezometers in this well showed no sign of sea water intrusion.

Piezometers 11N/36W-35J02, 35J03, 35J04, and 35J05 also showed no sign of sea water intrusion.

To protect the quality of the groundwater, a regular yearly sea water intrusion monitoring program would help, with particular attention paid to piezometer 10N/36W-02Q06. A monitoring program, with sampling and analyses of major ions and boron, bromide, iodine, deuterium, and oxygen -16 and -18, would record any trends indicating changes that are not wholly caused by infiltrating surface waters, but may also be caused by sea water intrusion.

Surface Water Quality

The chemical character and quality of surface waters are a function of a complex interrelation of climate, geology, topography, vegetation, runoff, aquifer-stream interconnection, and human activities such as land and water use and waste disposal practices. Surface water quality varies from time to time and from place to place, and quality changes can be pronounced. Typically, the quality varies inversely to the rate of discharge, with waters of lower TDS concentration observed during higher flows. In contrast with the quality of groundwater, the quality of surface water can be highly variable.

The quality of the surface waters recharging the groundwater basin from Arroyo Grande and Pismo Creeks and their tributary creeks and Santa Maria River and Nipomo Creek reflects both base flow and runoff from rainfall. Stormflow results from precipitation runoff and subsurface discharge during the storm period. Baseflow of the Santa Maria River is composed of rising water, discharges of treated wastewater, releases of water stored in Twitchell Reservoir, bank seepage, and nonpoint discharges, including uncontrolled runoff from agricultural and urban areas not related to stormflows. Baseflow of Arroyo Grande Creek is composed of rising water, releases of water stored in Lopez Reservoir, bank seepage, and nonpoint discharges, including uncontrolled runoff from agricultural and urban areas not related to stormflows.

Surface water within the study area has not been sampled for quality since the 1960s and 1970s and this historical sampling was very infrequent.

It is unreasonable to expect that a few samples, as exist for much of the surface waters in the study area, could adequately characterize the spatial and temporal variations in surface water quality, particularly with the dominant control that natural variations in hydrology exercise over variations in quality. "The more water quality varies, the more samples will be required to obtain a reliable estimate of statistical parameters used to describe its behavior "(Sanders et al., 1983, p. 153). With sparse data, the reality of some apparent changes in quality may be questionable because many natural and societal factors may affect quality. Therefore, this section will just briefly summarize the historical quality of surface waters in the study area.

Water from the Arroyo Grande, Tar Spring, Nipomo, and Pismo Creeks have had TDS concentrations generally between 500 and 1,000 mg/L. Water in these creeks has generally been calcium-magnesium bicarbonate in character and has not been used directly for drinking water. Water from Los Berros Creek has contained concentrations of TDS as high as 1,900 mg/L, sulfate as high as 689 mg/L, and nitrate as high as 87.5 mg/L and has been calcium-magnesium sulfate in character. Los Berros Creek water has also not been used directly for drinking water.

Water in the shallow perennial dune lakes near the coast, which are in part recharged by agricultural runoff and irrigation return, has been considered marginal to unsuitable for irrigation. TDS concentrations have ranged between 500 and 3,000 mg/L. High concentrations of nitrate in these lakes have led to increased eutrophication rates (California Department of Fish and Game, 1976). These waters are not used directly for drinking water. Some of the lakes have water that has been sodium chloride in character, and that from others has been calcium-magnesium sulfate.

The surface waters in the Santa Maria River have ranged from storm runoff with TDS concentrations of 250 mg/L to slight runoff with TDS concentrations of 1,600 mg/L and sulfate concentrations of 680 mg/L. The chemical character of the storm runoff is typically calcium-magnesium bicarbonate and that of lower flows calcium-magnesium sulfate. Water from the Santa Maria River is not used directly for drinking water.

Lopez Reservoir (not within the study area) is an important supply source within the study. Concentrations of mineral constituents in water from Lopez Reservoir, before treatment, meet Drinking Water Standards. Concentrations of TDS typically range from about 400 to 600 mg/L; sulfate, about 100 to 140 mg/L; chloride, 15 to 20 mg/l; and nitrate, 0.2 to 0.8 mg/L. The water is classified as very hard. The chemical character of the water is typically calcium-magnesium bicarbonate.

Future Needs

The lack of recent and adequate water quality data throughout the study area is evident in this study. Groundwater in parts of the basin and surface water, except for Lopez Reservoir water, have not been sampled and analyzed since the late 1960s or 1970s. Moreover, vertically discrete groundwater samples were available only for the sea water intrusion monitoring wells. A basinwide study of groundwater quality, characterizing spatial conditions, both areally and with depth, and surface water quality has never been conducted.

Given the importance of the resource, there is need for the county to undertake a comprehensive water quality assessment of the water resources in the study area that includes sampling for an array of quality constituents (inorganic constituents, physical measurements, isotopes, and selected organic constituents) with spatially distributed sample locations (areally and with depth) throughout the basin and be unbiased with respect to known or suspected local problem areas. Such an effort will provide the information necessary to design an effective monitoring program. It is beyond the scope of this study to design the needed assessment or monitoring plan.

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