VII. WATER BUDGET

An important component of this study is an itemized accounting (water budget) of all inflows, outflows, and changes in the amount of groundwater in storage to provide information for water supply planning within the main Santa Maria Groundwater Basin in San Luis Obispo County. For this accounting, the investigators had sufficient data to develop valid water budgets, weighing the amounts of groundwater inflow against the amounts of groundwater outflow, for each of the three portions into which the main groundwater basin was divided: Tri-Cities Mesa - Arroyo Grande Plain, Nipomo Mesa, and Santa Maria Valley (Plate 19).

Using the general equation "*Inflow - Outflow = Surplus/Deficiency*," the components of groundwater inflow and outflow were determined for each year of the 1975 through 1995 study period and for future years 2010 and 2020. The future water budgets are based on projected land use changes and associated changes in water demands and on the base period 1984 through 1995, which represents long-term average hydrologic conditions.[1]

The surplus or deficiency for each year of a water budget is actually the amount of change in groundwater in storage that takes place. Thus, for this study, the water budgets show the amount of change in groundwater in storage in the three portions of the main groundwater basin.

Table 24 presents the water budget for the main Santa Maria Groundwater Basin and Tables 25 through 27 present the water budgets for Tri-Cities Mesa - Arroyo Grande Plain, Nipomo Mesa, and Santa Maria Valley, respectively. The water budget for the main basin was arrived at by totaling the applicable components of the budgets for the three portions of the basin.

As can be seen in Table 24, the base period total inflow for the main groundwater basin was 29,200 AF and total outflow, 33,100 AF. The outflow therefore exceeded inflow by 3,900 AF. In 1995, a wet year, inflow was greater than outflow by 44,200 AF. Outflow is projected to exceed inflow by 4,700 AF in 2010 and by 7,100 AF in 2020.

A description of the calculation procedures followed, the type and quantity of data analyzed, and the results of the determination are discussed separately for the various components of groundwater inflow and groundwater outflow.

[1]Because of the wet water year 1998, the long-term mean for the period of record through water year 1995 is about 0.4 inch less than the long-term mean for the period of record through water year 2000 at precipitation station Nipomo 2NW.

TABLE 24

MAIN SANTA MARIA GROUNDWATER BASIN WATER BUDGET

(Thousands of acre-feet)

Components	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	2010*	2020*	Base Period**
Inflow																								
Deep Percolation of Precipitation ***	2.7	0.9	0.0	30.7	2.9	3.1	2.7	19.4	34.7	0.9	0.9	19.3	1.0	1.2	1.0	0.0	2.5	3.0	21.0	1.0	29.2	5.5	5.2	6.8
Urban Return Water	0.6	0.6	0.6	0.7	0.7	0.7	0.8	1.0	1.0	1.1	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.3	1.3	1.2	1.2	1.9	2.5	1.3
Agricultural Return Water	3.5	4.2	4.2	4.3	4.3	3.9	4.2	4.1	4.1	4.0	3.8	3.7	3.6	3.4	3.3	3.1	2.9	3.1	3.0	3.0	2.9	2.3	2.8	3.3
Other Return Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stream Infiltration	3.5	0.7	0.5	30.1	30.7	36.5	4.2	9.3	36.8	39.1	0.5	15.6	0.4	1.0	0.5	0.4	12.9	9.2	25.7	7.8	36.7	12.5	12.5	12.5
Incidental Recharge of Recycled Wate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	1.1	1.1	0.2
Subsurface Flow into the Main Groundwater Basin	4.9	4.7	4.7	5.8	5.8	5.8	5.6	5.8	5.8	5.6	5.6	5.8	4.7	4.7	4.7	4.7	5.1	5.1	5.1	4.9	5.1	5.1	5.1	5.1
Total Inflow	15.2	11.1	10.0	71.6	44.4	50.0	17.5	39.6	82.4	50.7	12.1	45.8	11.1	11.8	11.1	9.9	25.1	22.0	56.4	18.2	75.4	28.4	29.2	29.2
Outflow																								
Urban Groundwater Extractions	2.6	2.7	2.9	3.1	3.3	3.4	3.9	4.4	4.9	5.4	5.9	6.1	6.3	6.3	6.6	6.8	6.6	6.5	6.2	6.1	5.9	9.3	11.9	6.2
Agricultural Groundwater Extractions	16.2	16.5	16.6	16.9	17.1	17.3	17.4	17.3	17.4	17.4	17.4	16.9	16.5	16.0	15.6	15.1	14.8	14.7	14.4	14.3	14.0	12.6	13.2	15.7
Other Groundwater Extractions	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Subsurface Outflow to the Ocean	9.8	9.0	9.0	12.6	12.6	12.6	12.1	12.1	12.6	11.3	10.6	11.7	9.0	9.0	9.0	9.0	10.1	10.1	10.1	9.0	10.1	10.0	10.0	10.0
Total Outflow	29.7	29.3	29.6	33.7	34.1	34.4	34.5	34.9	36.0	35.2	35.0	35.8	32.9	32.4	32.3	32.1	32.7	32.5	31.9	30.6	31.2	33.1	36.3	33.1
Surplus/Deficiency (Inflow Minus Outflow)	-14.5	-18.2	-19.6	37.9	10.3	15.6	-17.0	4.7	46.4	15.5	-22.9	10.0	-21.8	-20.6	-21.2	-22.2	-7.6	-10.5	24.5	-12.4	44.2	-4.7	-7.1	-3.9
Cumulative Surplus/Deficiency		-32.7	-52.3	-14.4	-4.1	11.5	-5.5	-0.8	45.6	61.1	38.2	48.2	26.4	5.8	-15.4	-37.6	-45.2	-55.7	-31.2	-43.6	0.6			

Note: All values rounded to the nearest 100 acre-feet.

*The future water budgets are based on projected land use changes and associated changes in water demands and on the base period, which represents long-term average hydrologic conditions.

**Base period is water year 1984 through water year 1995. Base period values are the average of values for years 1984 through 1995.

***All or a portion of this amount of water is available for deep percolation; however, because of antecedent groundwater conditions, variations in storm intensities, variations in soil moisture at the beginning and end of the rainy season, and variations in other related characteristics, the amount reaching groundwater is unknown.

TABLE 25

TRI-CITIES MESA - ARROYO GRANDE PLAIN WATER BUDGET

(Thousands of acre-feet)

Components	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	2010*	2020*	Base Period**
Inflow* **																								
Deep Percolation of Precipitation[1]	1.3	0.6	0.0	4.2	1.4	1.5	1.3	2.7	4.9	0.6	0.6	2.7	0.6	0.7	0.6	0.0	1.3	1.5	2.9	0.6	4.1	1.1	1.1	1.4
Urban Return[2]	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.8	1.0	0.5
Agricultural Return[2]	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.6	0.6	0.5	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.2	0.2	0.3
Other Return[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stream Infiltration[3]	0.8	0.6	0.5	1.9	1.0	1.5	0.9	1.1	2.4	1.3	0.5	1.0	0.4	0.3	0.5	0.4	0.7	0.8	1.2	0.3	1.6	0.8	0.8	0.8
Subsurface Inflow from Nipomo Mesa[4]	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Subsurface Inflow from Pismo Creek Valley Subbasin[4]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Subsurface Inflow from Arroyo Grande Valley Subbasin[5]	1.3	1.1	1.1	1.3	1.3	1.3	1.1	1.3	1.3	1.1	1.1	1.3	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.1	1.3	1.2	1.2	1.2
Subsurface Inflow from Bedrock to Tri-Cities Mesa[4]	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Total Inflow	7.4	6.3	5.6	11.4	7.7	8.3	7.3	9.1	12.6	7.0	6.2	9.0	6.0	5.9	6.0	5.2	7.0	7.4	9.2	5.8	10.8	7.1	7.3	7.2
Outflow* **																								
Urban Groundwater Extractions[2]	0.8	0.8	0.9	0.9	1.0	1.0	1.3	1.6	1.9	2.2	2.5	2.5	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	3.4	4.4	2.3
Agricultural Groundwater Extractions[2]	3.7	3.6	3.5	3.5	3.4	3.3	3.0	2.7	2.5	2.2	1.9	1.7	1.5	1.4	1.2	1.0	1.1	1.2	1.3	1.4	1.5	0.9	0.9	1.5
Other Groundwater Extractions[2]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Subsurface Outflow to Ocean[5]	3.2	2.8	2.8	3.7	3.7	3.7	3.2	3.2	3.7	2.8	2.8	3.7	2.8	2.8	2.8	2.8	3.7	3.7	3.7	2.8	3.7	3.2	3.2	3.2
Total Outflow	7.8	7.3	7.3	8.2	8.2	8.1	7.6	7.6	8.2	7.3	7.3	8.0	6.8	6.6	6.4	6.2	7.2	7.3	7.4	6.6	7.6	7.6	8.6	7.1
Surplus/Deficiency (Inflow Minus Outflow)	-0.4	-1.0	-1.7	3.2	-0.5	0.2	-0.3	1.5	4.4	-0.3	-1.1	1.0	-0.8	-0.7	-0.4	-1.0	-0.2	0.1	1.8	-0.8	3.2	-0.5	-1.3	0.1
Cumulative Surplus/Deficiency		-1.4	-3.1	0.1	-0.4	-0.2	-0.5	1.0	5.4	5.1	4.0	5.0	4.2	3.5	3.1	2.1	1.9	2.0	3.8	3.0	6.2			

Note: All values rounded to the nearest 100 acre-feet.

*The future water budgets are based on projected land use changes and associated changes in water demands and on the base period, which represents long-term average hydrologic conditions.

**Base period is water year 1984 through water year 1995. Base period values are the average of values for years 1984 through 1995.

***See text for more detailed explanation of determination of estimated amounts of the components of inflow and outflow.

[1]All or a portion of this amount of water is available for deep percolation; however, because of antecedent groundwater conditions, variations in storm intensities, variations in soil moisture at the beginning and end of the rainy season, and variations in other related characteristics, the amount reaching groundwater is unknown.

Values of deep percolation of precipitation were calculated for land use survey years 1977, 1985, and 1995; values for intervening years were determined by weighting the calculated values by the amount of precipitation that year.

[2]Values calculated for 1975, 1980, 1985, 1990, and 1995; values for intervening years are straight-lined projections.

[3]Estimated for each year of the budget from gaged streamflow records of Arroyo Grande Creek at Arroyo Grande and from detailed analysis of previous studies by other investigators.

[4]Estimated 1975, 1985, and 1995 geometric mean values from Table 21, Chapter V. Those values were the same; therefore, values for intervening years are the same amount.

[5]Estimated 1975, 1985, and 1995 geometric mean values from Table 21, Chapter V; for intervening years used either the 1975, 1985, or 1995 value depending on hydrologic conditions.

TABLE 26

NIPOMO MESA WATER BUDGET

(Thousands of acre-feet)

Components	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	2010*	2020*	Base Period**
Inflow* **																								
Deep Percolation of Precipitation[1]	0.6	0.2	0.0	13.8	0.6	0.7	0.6	8.8	15.9	0.2	0.2	8.8	0.2	0.2	0.2	0.0	0.6	0.6	9.4	0.2	13.3	2.1	1.8	2.8
Urban Return[2]	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.7	0.7	0.6	0.6	1.0	1.3	0.7
Agricultural Return[2]	0.2	0.8	0.8	0.8	0.8	0.3	0.7	0.6	0.6	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Other Return[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Recharge of Recycled Water[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	1.1	1.1	0.2
Subsurface Inflow from Santa Maria Valley[3]	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.3	2.3	2.3
Subsurface Inflow from Nipomo Valley Subbasin[4]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total Inflow	2.8	3.0	2.8	16.7	3.5	3.1	3.4	11.6	18.7	2.9	2.9	12.9	4.4	4.4	4.5	4.4	4.9	4.9	13.7	4.4	17.5	7.3	7.3	6.8
Outflow* **																								
Urban Groundwater Extractions[2]	1.5	1.6	1.7	1.9	2.0	2.1	2.3	2.5	2.6	2.8	3.0	3.2	3.4	3.5	3.7	3.9	3.7	3.6	3.4	3.3	3.1	5.2	6.6	3.4
Agricultural Groundwater Extractions[2]	1.4	1.5	1.5	1.6	1.6	1.7	1.8	1.8	1.9	1.9	2.0	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.6	1.9
Other Groundwater Extractions[2]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Subsurface Outflow to Tri-Cities Mesa - Arroyo Grande Plain[4]	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Subsurface Outflow to Ocean[5]	0.9	0.5	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.5	0.7	0.5	0.5	0.5	0.5	0.7	0.7	0.7	0.5	0.7	0.6	0.6	0.6
Total Outflow	6.1	5.9	6.0	6.7	6.8	7.0	7.3	7.5	7.7	7.5	7.8	8.2	8.2	8.2	8.4	8.6	8.5	8.4	8.1	7.8	7.7	9.7	11.1	8.2
Surplus/Deficiency (Inflow Minus Outflow)	-3.3	-2.9	-3.2	10.0	-3.3	-3.9	-3.9	4.1	11.0	-4.6	-4.9	4.7	-3.8	-3.8	-3.9	-4.2	-3.6	-3.5	5.6	-3.4	9.8	-2.4	-3.8	-1.4
Cumulative Surplus/Deficiency		-6.2	-9.4	0.6	-2.7	-6.6	-10.5	-6.4	4.6	0.0	-4.9	-0.2	-4.0	-7.8	-11.7	-15.9	-19.5	-23.0	-17.4	-20.8	-11.0			

Note: All values rounded to the nearest 100 acre-feet.

*The future water budgets are based on projected land use changes and associated changes in water demands and on the base period, which represents long-term average hydrologic conditions.

***See text for more detailed explanation of determination of estimated amounts of the components of inflow and outflow.

**Base period is water year 1984 through water year 1995. Base period values are the average of values for years 1984 through 1995.

[1]All or a portion of this amount of water is available for deep percolation; however, because of antecedent groundwater conditions, variations in storm intensities, variations in soil moisture at the beginning and end of the rainy season, and variations in other related characteristics, the amount reaching groundwater is unknown.

Values of deep percolation of precipitation were calculated for land use survey years 1977, 1985, and 1995; values for intervening years were determined by weighting the calculated values by the amount of precipitation that year.

[2]Values calculated for 1975, 1980, 1985, 1990, and 1995; values for intervening years are straight-lined projections.

[3]Estimated 1985 and 1995 geometric mean values from Table 21, Chapter V; used 1985 value for 1975-85 and 1995 value for 1986-95.

[4]Estimated 1975, 1985, and 1995 geometric mean values from Table 21, Chapter V. Those values were the same; therefore, values for intervening years are the same amount.

[5]Estimated 1975, 1985, and 1995 geometric mean values from Table 21, Chapter V; for intervening years used either the 1975, 1985, or 1995 value depending on hydrologic conditions.

TABLE 27
SANTA MARIA VALLEY WATER BUDGET
(Thousands of acre-feet)

Components	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	2010*	2020*	Base Period**
Inflow* **																								
Deep Percolation of Precipitation[1]	0.8	0.1	0.0	12.7	0.9	0.9	0.8	7.9	13.9	0.1	0.1	7.8	0.2	0.3	0.2	0.0	0.6	0.9	8.7	0.2	11.8	2.3	2.3	2.6
Urban Return[2]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Agricultural Return[2]	2.5	2.6	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.0	2.9	2.8	2.8	2.7	2.6	2.5	2.5	2.4	2.4	2.3	1.8	2.3	2.7
Other Return[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stream Infiltration[3]	2.7	0.1	0.0	28.2	29.7	35.0	3.3	8.2	34.4	37.8	0.0	14.6	0.0	0.7	0.0	0.0	12.2	8.4	24.5	7.5	35.1	11.7	11.7	11.7
Subsurface Inflow from Outside Study Area[4]	1.4	1.4	1.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.7
Total Inflow	7.5	4.3	4.1	46.0	35.7	41.1	9.3	21.4	53.6	43.3	5.5	27.7	4.5	5.3	4.4	4.1	17.0	13.5	37.3	11.8	50.9	17.6	18.2	18.8
Outflow* **																								
Urban Groundwater Extractions[2]	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.7	0.9	0.5
Agricultural Groundwater Extractions[2]	11.1	11.4	11.6	11.8	12.1	12.3	12.6	12.8	13.0	13.3	13.5	13.2	13.0	12.7	12.5	12.2	11.9	11.7	11.4	11.2	10.9	10.1	10.7	12.3
Other Groundwater Extractions[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Subsurface Outflow to Nipomo Mesa[5]	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.3	2.3	2.3
Subsurface Outflow to Ocean[6]	5.7	5.7	5.7	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.3	7.3	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	6.2	6.2	6.2
Total Outflow	18.3	18.6	18.8	21.3	21.6	21.8	22.1	22.3	22.6	22.9	22.4	23.4	21.7	21.4	21.3	21.1	20.8	20.6	20.2	20.0	19.7	19.4	20.2	21.4
Surplus/Deficiency (Inflow Minus Outflow)	-10.8	-14.3	-14.7	24.7	14.1	19.3	-12.8	-0.9	31.0	20.4	-16.9	4.3	-17.2	-16.1	-16.9	-17.0	-3.8	-7.1	17.1	-8.2	31.2	-1.8	-2.0	-2.6
Cumulative Surplus/Deficiency		-25.1	-39.8	-15.1	-1.0	18.3	5.5	4.6	35.6	56.0	39.1	43.4	26.2	10.1	-6.8	-23.8	-27.6	-34.7	-17.6	-25.8	5.4			

Note: All values rounded to the nearest 100 acre-feet.

*The future water budgets are based on projected land use changes and associated changes in water demands and on the base period, which represents long-term average hydrologic conditions.

**Base period is water year 1984 through water year 1995. Base period values are the average of values for years 1984 through 1995.

***See text for more detailed explanation of determination of estimated amounts of the components of inflow and outflow.

[1]All or a portion of this amount of water is available for deep percolation; however, because of antecedent groundwater conditions, variations in storm intensities, variations in soil moisture at the beginning and end of the rainy season, and variations in other related characteristics, the amount reaching groundwater is unknown.

Values of deep percolation of precipitation were calculated for land use survey years 1977, 1985, and 1995; values for intervening years were determined by weighting the calculated values by the amount of precipitation that year.

[2]Values calculated for 1975, 1980, 1985, 1990, and 1995; values for intervening years are straight-lined projections.

[3]Estimated for each year of the budget from gaged streamflow records of Santa Maria River at Guadalupe, Sisquoc River near Garey, and Cuyama River below Twitchell Dam and from detailed analysis of previous studies by other investigators.

[4]Estimated 1975, 1985, and 1995 geometric mean values from Table 21, Chapter V; for intervening years used either 1975, 1985, or 1995 value depending on rainfall and streamflow conditions.

[5]Estimated 1985 and 1995 geometric mean values from Table 21, Chapter V; used 1985 value for 1975-85 and 1995 value for 1986-95.

[6]Estimated 1975, 1985, and 1995 geometric mean values from Table 21, Chapter V; for intervening years used either 1975, 1985, or 1995 value depending on hydrologic conditions except for years 1978-84. For those years used 8,000 AF because of high creek infiltration from Twitchell Reservoir releases (based on Worts's 1918 estimate).

TABLE 28*
RELATIVE RANGE OF ERROR OF ESTIMATE OF HYDROLOGIC QUANTITIES

Components	Range of Percent Error
Gaged Streamflow	5-10
Ungaged Streamflow	10-200
Gaged : Imported Water	5-10
Exported Water	5-10
Wastewater or Drainage	5-10
Precipitation Volume, annual	5-30
Consumptive Use: Municipal	10-25
Industrial	5-20
Irrigation	5-25
Native Vegetation	10-70
Phreatophtyes	10-30
Subsurface Inflow or Outflow	10-100
Change of Storage (Specific Yield - Water Level)	5-40
Pumpage	20-100
Artificial Recharge	2-50
Deep Percolation of Precipitation	Unknown

*From: Peters, 1981.

The accuracy of the water budgets is limited primarily by the accuracy of the assumptions and the data used. All estimates for the various components of the water budget are subject to probable error. There is greater probable error in some items than in others because of the method of estimating used. Table 28, from Peters (1981), which gives the relative range of error in estimating hydrologic quantities, shows that deep percolation of precipitation is the component of the budget most subject to probable error. Although uncertainties (probable error) in individual components can be large in some cases, the estimated amounts in the water budgets are not all simultaneously overestimating or underestimating their actual values.

Inflow Components

Groundwater flows into the main Santa Maria Basin through deep percolation of precipitation; urban, agricultural, and other returns; stream infiltration; incidental recharge of recycled water; and subsurface flows of groundwater between portions within and from outside the main basin.

Deep Percolation of Precipitation

To determine the volume of water available from precipitation to percolate in a specific portion of the main groundwater basin, the amount of precipitation for a selected period was multiplied by the size of the portion. Subtracted from this total were runoff from impervious areas and estimated evapotranspiration. The result was the potential amount of water available to recharge groundwater in the main basin.

However, only a portion of the water available for recharge percolates to groundwater. Some water remains in the vadose zone, with only the remainder infiltrating to groundwater. This is deep percolation. It should be noted, however, that precipitation does not deep percolate until a sufficient amount of rainfall has saturated the upper soil horizon. Then a moisture front moves downward through the vadose zone toward the water table.

In selecting the base period for the study, the water years 1984 through 1995 were chosen to minimize the difference in the amount of water in the vadose zone. It encompasses the most recent pair of wet and dry trends and begins and ends after a series of wet years, although 1994 has been classified as a dry year. Thus, the amounts of water in the vadose zone at the beginning and end of the base period are assumed to be equal.

Because the calculation of deep percolation of precipitation involves the use of precipitation, surface area, runoff, evaporation, and water retained in the vadose zone, all of which are measured or estimated in different units, the calculations cannot be exact. Precipitation and evaporation are measured or estimated to an accuracy of tenths of an inch and are subject to mechanical and human errors. Runoff and water retained in the vadose zone are estimated to the nearest 100 AF. The surface area has been digitized at a scale of 1:24,000 and is reported in acres. Therefore, deep percolation of precipitation was rounded to the nearest 100 AF.

A precise field determination of deep percolation or detailed soil moisture budget was beyond the scope of this study; therefore, it was assumed that precipitation could percolate deeply only on urban and agricultural irrigated areas when 11 inches of precipitation have fallen annually and on areas of native vegetation when 17 inches of precipitation have fallen annually. In the Tri-Cities Mesa - Arroyo Grande Plain and Santa Maria Valley portions of the main groundwater basin, any amount of rainfall above 30 inches annually was not considered to contribute to deep percolation of precipitation regardless of the land use classification. These criteria were developed by Blaney, et al. (1963) in a six-year study of soil moisture profiles in the Lompoc area. Although the conditions of the Blaney study are not the same as those in the Tri-Cities Mesa - Arroyo Grande Plain and Santa Maria Valley portions of the main groundwater basin, it was assumed that they are sufficiently similar for the estimates to be reasonably valid.

Because the Nipomo Mesa portion of the basin has unique soil characteristics and topographic features, any amount of annual rainfall, including amounts greater than 30 inches, is considered to contribute to deep percolation of precipitation. As mentioned in Chapter IV, at the edges of the bluffs of Nipomo Mesa, a small amount of runoff is draining to adjacent areas, however, the amounts are quite small and have not been quantified in this report.

It also needs to be pointed out that in years with the same total precipitation there will be differences in the amount of water infiltrating to groundwater storage, because of antecedent groundwater conditions, variations in storm intensities, variations in soil moisture at the beginning and end of the rainy season, and variations in other related characteristics. Thus, rigid use of the method would be subject to some error.

For the water budgets, values of deep percolation of precipitation were calculated for 1977, 1985, and 1995;[2] values for intervening years were determined by weighting the calculated values by the amount of rainfall that year. The base period and future years (2010 and 2020) values are the average of the values for 1984 through 1995.

Because of differences in soils, percolation rates and climatic conditions, potential deep percolation as a percentage of precipitation varied widely for the three portions of the main groundwater basin. In Tri-Cities Mesa - Arroyo Grande Plain, deep percolation as a percentage of precipitation ranged from 0 (in dry years) to 14.5 (in wet years) percent over the study period with a base period amount of about nine percent. Deep percolation as a percentage of precipitation in Nipomo Mesa ranged from 0 (in dry years) to 29 (in wet years) percent over the study period with a base period value of almost 12 percent. In Santa Maria Valley, deep percolation as a percentage of precipitation ranged from 0 (in dry years) to 40 (in wet years) percent over the study period with a base period amount of almost 16 percent. As would be expected, deep percolation as a percentage of precipitation in water years classified as dry is low or nonexistent and high in water years classified as wet. The base period amount always falls between these two extreme values.

The base period estimate of potential deep percolation of precipitation was greatest (2,800 AF, 40 percent of total inflow) in Nipomo Mesa, which covers a surface area of almost 17,600 acres (Table 26). The lowest estimate of base period deep percolation of precipitation was 1,400 AF, 19 percent of total inflow, in Tri-Cities Mesa - Arroyo Grande Plain, which covers a surface area of almost 10,800 acres (Table 25). The estimate of base period deep percolation of precipitation for Santa Maria Valley was 2,600 AF, 15 percent of total inflow, with a surface area of almost 21,600 acres (Table 27).

Deep percolation of precipitation follows rainfall trends, with significant amounts of deep percolation occurring only in wet years, such as 1995 (Tables 24-27). Hydrographs of groundwater levels presented in Chapter V, showed corresponding rises in levels, and thus amount of groundwater in storage, in response to deep percolation of precipitation in wet years, except in some wells in parts of the Nipomo Mesa portion of the groundwater basin. In wet years, deep percolation of precipitation accounted for 30 to 40 percent of total inflow in Tri-Cities Mesa - Arroyo Grande Plain; 70 to 80 percent of total inflow in Nipomo Mesa; and 20 to 30 percent of total inflow in Santa Maria Valley.

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[2]Years of land use surveys conducted by the Department.

In some dry years, no deep percolation of rainfall occurred (Tables 24-27). Most of the lack of or decrease in rainfall recharge in dry years is compensated for by decreases in subsurface outflows and amounts of groundwater in storage.

Because of projected land use changes in 2010 and 2020 (increased development and reduction in pervious area), deep percolation of precipitation was estimated to decrease in future years from the base period estimates in each of the three portions of the main groundwater basin (Tables 25-27). In Tri-Cities Mesa - Arroyo Grande Plain, deep percolation of precipitation is projected to be 300 AF less in 2010 and 2020 than in the base period; in Nipomo Mesa, 700 AF less in 2010 and 1,000 AF less in 2020 than in the base period; and in Santa Maria Valley, 300 AF less in 2010 and 2020 than in the base period.

Soil moisture and infiltration studies are needed to more accurately determine the amount of deep percolation of precipitation occurring within the groundwater basin.

Urban Return Water

Urban return is the amount of urban applied water that returns to a surface stream or infiltrates to a groundwater basin through lawn watering, septic tank leach lines, and other urban uses.[3] It was calculated as urban applied water less water not consumed by evapotranspiration or system losses. For the main groundwater basin as a whole, urban return water amounted to 1,300 AF during the base period (Table 24). Of this amount, 500 AF was returned in Tri-Cities Mesa - Arroyo Grande Plain, 700 AF in Nipomo Mesa, and 100 AF in Santa Maria Valley (Tables 25-27). These values were rounded to the nearest 100 AF.

Urban return water was projected to increase in year 2020 from the 1995 estimates in Tri-Cities Mesa - Arroyo Grande Plain by 500 AF, or about 200 percent, in Nipomo Mesa by 700 AF, or about 220 percent, and in Santa Maria Valley by 100 AF, or 200 percent.

Agricultural Return Water

Agricultural return water is the amount of crop applied water that infiltrates to the groundwater basin or returns to a surface stream. It was calculated by subtracting agricultural crop evapotranspiration, surface runoff, and other unrecoverable losses from the amount of water applied to crops during the growing season.

The values used for the amounts of crop applied water, runoff, growing season evapotranspiration, and other unrecoverable losses were estimated based on crop types and acreage, soil types, average climatological conditions, and existing irrigation management practices. The totals reported in the tables were rounded to the nearest 100 AF.

[3]Includes return from golf course irrigation.

Base period agricultural returns were 3,300 AF for the main groundwater basin (Table 24). Of this amount, 300 AF was returned in Tri-Cities Mesa - Arroyo Grande Plain, 300 AF in Nipomo Mesa, and 2,700 AF in Santa Maria Valley (Tables 25-27). By year 2020, agricultural return water was projected to decrease in Tri-Cities Mesa - Arroyo Grande Plain by 100 AF or about 33 percent from the 1995 estimate; remain the same, 300 AF, in Nipomo Mesa (less than 100 AF of change, thus it is not reflected in the future amounts); and fluctuate downward 500 AF between 1995 and 2010 and then return to the 1995 amount of 2,300 AF in Santa Maria Valley.

Other Return Water

Other return water is the water from the demands in the other water category that is available to infiltrate to the groundwater. This includes water that comes from various high water-use industries such as those producing ice or concrete and water released to Arroyo Grande Creek for maintaining habitat for steelhead trout.[4] For the main groundwater basin as a whole, the category of other return water was less than 100 AF and thus appears as zero in the tables.

Stream Infiltration

Surface flows in Pismo and Arroyo Grande Creeks and their tributaries contribute the stream infiltration in the Tri-Cities Mesa - Arroyo Grande Plain portion of the basin. Lopez Dam regulates flows on Arroyo Grande Creek. Surface flows in the Santa Maria River contribute to stream infiltration in the Santa Maria Valley portion of the basin. Twitchell Dam regulates some of the flows on the Santa Maria River. Surface flows in Black Lake Canyon may contribute to the underlying groundwater resources in the Nipomo Mesa portion of the basin; however, they were not quantified in this study (less than 100 AF). It is believed that much, if not all, water that percolates toward the underlying groundwater basin in Black Lake Canyon is captured and retained as perched water.

Stream infiltration is dependent on the permeability of the streambed material and the flow regimen of the streams. For this study, the amounts of stream infiltration were estimated for each year of the budget from gaged streamflow records of Arroyo Grande Creek at Arroyo Grande, Santa Maria River at Guadalupe, Sisquoc River near Garey, and Cuyama River below Twitchell Dam. Furthermore, the estimates of stream infiltration for Arroyo Grande Creek were made after a thorough analysis of the data and the following studies: California Department of Public Works, Division of Water Resources, 1921, 1945, and 1955; Arroyo Grande Soil Conservation District and San Luis Obispo County Flood Control and Water Conservation District, 1955; California Department of Water Resources, 1958; Hoover & Associates, Inc., 1985a and 1985b; and Lawrance, Fisk, & McFarland, 1985a, 1985b, and 1985c. The estimates of stream infiltration for Santa Maria River were made after a thorough analysis of the data and the following studies: U. S. Department of Agriculture, 1942 and 1951; Thomasson, 1951; Worts, 1951, U. S. Bureau of Reclamation, 1952 and 1955; Miller and Evenson, 1966; Hughes, 1977;

[4] Cooling water from the Tosco facility is discharged to an ocean outfall.

Lipinski, 1985; and Luhdorff & Scalmanini, 1997.

In addition, the amounts of stream infiltration were determined independently of the deep percolation of precipitation on urban, agricultural and native vegetation land use areas. The base period and 2010 and 2020 stream infiltration values are the average of the 1984 through 1995 values. Stream infiltration values were rounded to the nearest 100 AF.

For the base period, 12,500 AF of streamflow was estimated to infiltrate in the main groundwater basin, with 800 AF (about 10 percent of total inflow) infiltrating in Tri-Cities Mesa - Arroyo Grande Plain and 11,700 AF (about 60 percent of total inflow) infiltrating in Santa Maria Valley (Tables 24, 25, and 27). In wet years, stream infiltration was two to three times greater than the base period amount in both Tri-Cities Mesa - Arroyo Grande Plain and Santa Maria Valley. In dry years, stream infiltration was about 300 to 500 AF (about 10 percent of total inflow) in Tri-Cities Mesa - Arroyo Grande Plain mainly as the result of releases from Lopez Reservoir. In Santa Maria Valley, stream infiltration was zero AF in some dry years, but could be a significant amount if water were available in storage in Twitchell Reservoir for release, as occurred in 1984.

Because of the lack of stream gages on Arroyo Grande Creek at its confluence with the Pacific Ocean and since 1987 on Santa Maria River at Guadalupe, the range of error in estimating streamflow could be 10 to 200 percent (Table 28). If stream infiltration amounts are higher than those estimated in the water budgets, the projected deficiencies in the budgets in 2010 and 2020 could be offset in Tri-Cities Mesa - Arroyo Grande Plain and Santa Maria Valley.

Stream infiltration studies are needed to more accurately determine the amount of infiltration to the groundwater basin from Arroyo Grande and Pismo Creeks and Santa Maria River.

Recycled Water

For the main groundwater basin, the incidental recharge of recycled water[5] amounted to 200 AF in the base period and was projected to amount to 1,100 AF in 2010 and 2020.

There is no incidental recharge of recycled water in the Tri-Cities Mesa - Arroyo Grande Plain portion of the groundwater basin at present. Treated wastewater generated in the area is disposed of through an ocean outfall. Although the pipelines conveying water to the treatment plants lose a small amount of the water to groundwater, this is accounted for in the urban return water category in this study. If the South San Luis Obispo County Sanitation District expands its plant capabilities and incidentally recharges recycled water to the Tri-Cities Mesa - Arroyo Grande Plain portion of the groundwater basin, the total inflow of the water budget could increase by up to 950 AF in 2010 and 2020.

[5] All wastewater treatment plants in the main groundwater basin produce effluent that meets secondary standards.

The only portion of the main groundwater basin in which recycled water was incidentally recharged was Nipomo Mesa (Table 26). The amount incidentally recharged is that reported for Nipomo Community Services District's Black Lake and Southland WWTPs (Table 13 in Chapter III). The year 2010 and 2020 values reflect planned expansion of those two plants and the Cypress Ridge project, and construction of a future plant at the Woodlands project.

There is no incidental recharge of recycled water in the Santa Maria Valley at present and none is planned in the future.

A small proportion of the rural population within the main groundwater basin uses septic tank/leach line systems to discharge domestic wastewater. Effluent from these systems either evaporates to the atmosphere or percolates to groundwater. In this study, the portion that percolates to groundwater was accounted for in the urban return water category.

Values of recharge of recycled water were rounded to the nearest acre-foot.

Subsurface Inflows

Subsurface inflows occur from the subbasins to the main basin, from the bedrock into the basin, from one portion to another within the main basin, and from outside the study area into the Santa Maria Valley portion of the basin.

The subsurface inflow estimates in the water budgets are the geometric mean values given for years 1975, 1985, and 1995 in Table 21, Chapter V. The methodology for calculating subsurface flows is discussed in Chapter V.

The 1975, 1985, and 1995 values were applied to those years of the budget. Values for intervening years were derived by applying either the 1975, 1985, or 1995 value based on the amount of rainfall for that year (further explanation is provided on Tables 25-27). The base period and future years (2010 and 2020) values are the average of the values for 1984 through 1995. In Tables 24-27, the subsurface flow values were rounded to the nearest 100 AF.

Subsurface flow into the main groundwater basin within San Luis Obispo County was 5,100 AF during the base period (Table 24). Of this amount, 2,900 AF (40 percent of total inflow) is subsurface flow into the Tri-Cities - Arroyo Grande Plain portion of the main basin from Pismo Creek Valley and Arroyo Grande Valley Subbasins and bedrock (Table 25), 500 AF of subsurface flow from Nipomo Valley Subbasin into the Nipomo Mesa portion of the main basin (about seven percent of total inflow, Table 26), and 1,700 AF of subsurface flow from outside the study area into the Santa Maria Valley portion of the main basin (about nine percent of total inflow, Table 27).

Subsurface flow also occurs between portions of the main groundwater basin. Table 25 shows 1,300 AF of inflow to Tri-Cities Mesa - Arroyo Grande Plain from Nipomo Mesa for all years of the budget (about 20 percent of total inflow in the base period). Table 26 shows 2,300 AF of inflow to Nipomo Mesa from Santa Maria Valley during the base period and future years (about 35 percent of total inflow in the base period).

Outflow Components

Outflow takes place as groundwater extractions for urban, agricultural, and other uses; as subsurface outflow to the ocean; and as subsurface outflow from one portion of the main groundwater basin to another. The largest outflow component for the main groundwater basin is groundwater extractions, with agricultural extractions accounting for about 50 percent of the total outflow in the base period.

Urban Extractions

Urban groundwater extraction values came from information supplied by the urban water agencies, the County, and the USGS.[6] To estimate the groundwater extractions in areas outside the service areas of the major agencies, population, per capita water use, and land use maps were employed. Urban groundwater extractions are reported by the major agencies to an accuracy of about a tenth of an acre-foot. The values shown in the tables have been rounded to the nearest 100 AF.

As shown in Table 24, urban groundwater extractions amounted to 6,200 AF, about 20 percent of total outflow, in the base period for the main groundwater basin. Of this amount, 2,300 AF, about 30 percent of the outflow, were extracted in Tri-Cities Mesa - Arroyo Grande Plain; 3,400 AF, about 40 percent of the outflow, in Nipomo Mesa; and 500 AF, only two percent of the outflow in Santa Maria Valley (Tables 25-27).

Between 1995 and 2020, urban extractions are projected to increase by 2,100 AF or more than 190 percent, in Tri-Cities Mesa - Arroyo Grande Plain; to increase by 3,500 AF, or about 215 percent, in Nipomo Mesa; and to increase by 400 AF, or 180 percent, in the Santa Maria Valley.

Groundwater extracted for urban use accounts for the major portion of extractions in Tri-Cities Mesa - Arroyo Grande Plain and Nipomo Mesa. Beginning in 1985, urban extractions exceeded agricultural extractions in Tri-Cities Mesa - Arroyo Grande Plain and are projected to exceed them by 3,500 AF in 2020. In Nipomo Mesa, urban extractions were about the same amount as agricultural extractions in 1975, exceeding them by ever increasing amounts since then, and are projected to exceed them by 5,000 AF in 2020. The increasing urban extractions in some parts of Nipomo Mesa have created extensive pumping depressions (discussed in Chapter V). In Santa Maria Valley, urban groundwater extractions are a very small component of total extractions and are projected to remain so through 2020.

[6] Urban groundwater extractions include extractions for golf course irrigation.

Agricultural Extractions

The amounts of groundwater extracted for agricultural purposes are not reported to any agency; therefore, the values given in Tables 24-27 are those determined for agricultural applied water demand. These values are based on land use acreage, evapotranspiration of applied water values, unit applied water rates, and irrigation efficiencies. In the tables, they were rounded to the nearest 100 AF.

In the base period, agricultural groundwater extractions from the main groundwater basin were 15,700 AF, accounting for about 50 percent of the total outflow (Table 24). Of this amount, 1,500 AF, about 20 percent of the total outflow, were extracted from Tri-Cities Mesa - Arroyo Grande Plain; 1,900 AF, about 25 percent of the total outflow, from Nipomo Mesa; and 12,300 AF, about 55 percent of the total outflow, from Santa Maria Valley (Tables 25-27).

In Tri-Cities Mesa - Arroyo Grande Plain, agricultural extractions are projected to decline 600 AF, or about 60 percent, between 1995 and 2020, while remaining the same in Nipomo Mesa and declining slightly, 200 AF, in Santa Maria Valley.

Other Extractions

The values given for groundwater extractions for the other uses are those determined for water demand for that category and consist of extractions for cooling, recreation,[7] and miscellaneous uses, such as ice or concrete production. Land use acreage and unit applied water rates were used for these estimates. As reported in the tables, they have been rounded to the nearest 100 AF. Therefore, the base period total for the main groundwater basin was 1,200 AF, which consists of 100 AF in Tri-Cities Mesa - Arroyo Grande Plain and in Santa Maria Valley, and 1,000 AF in Nipomo Mesa (Tables 24-27). Other extractions in 2010 and 2020 are projected to be the base period amounts.

Subsurface Outflows

Subsurface outflows were not only to the ocean, which affects the water budget for the main groundwater basin as a whole, but were also from one portion of the main basin to another, which affect the water budgets of only those portions involved.

The subsurface outflow estimates in the water budgets are the geometric mean values given for years 1975, 1985, and 1995 in Table 21, Chapter V. The methodology for calculating subsurface flows is discussed in Chapter V.

The 1975, 1985, and 1995 values were applied to those years of the budget. Values for

[7]Recreational extractions do not include extractions for golf course irrigation water, which are included in urban extractions.

intervening years were derived by applying either the 1975, 1985, or 1995 values based on the amount of rainfall for that year (further explanation is provided on Tables 25-27). The base period and future years (2010 and 2020) values are the average of the values for 1984 through 1995. In Tables 24-27, the subsurface flow values were rounded to the nearest 100 AF.

During the base period, 10,000 AF were estimated to flow in the subsurface from the main groundwater basin to the ocean (Table 24). Of this amount, 3,200 AF, 45 percent of total outflow, were from the Tri-Cities Mesa - Arroyo Grande Plain portion of the basin (Table 25); 600 AF, less than 10 percent of total outflow, from the Nipomo Mesa portion of the basin (Table 26); and 6,200 AF, about 30 percent of total outflow, from the Santa Maria Valley portion of the basin (Table 27).

Although some of this outflow to the ocean could be captured, there is a risk in doing so. Subsurface outflow to the ocean must be of sufficient quantity for the freshwater head to counterbalance the greater density of sea water to prevent sea water intrusion.

Because of differences in the groundwater elevations, gradients, and direction of flow, water flows in the subsurface from one portion within the main groundwater basin to another, as is discussed in Chapter V. Table 26 shows base period subsurface outflow from Nipomo Mesa to Tri-Cities Mesa - Arroyo Grande Plain as 1,300 AF, about 15 percent of total outflow. Table 27 shows base period subsurface outflow to Nipomo Mesa from Santa Maria Valley amounted to 2,300 AF, about 10 percent of total outflow.

Overview and Significance of Water Budgets

Water budgets, which are itemized accountings of all groundwater inflows and outflows, provide a quantitative means of comparing various processes that affect the hydrologic system. The water budgets determined for the main Santa Maria Groundwater Basin for this study can reveal opportunities and constraints for water supply development.

Because the components in water budgets are estimates, a check of the water budget is essential to ensure the validity of the estimates. To check the budgets, the water supply surplus/deficiency was summarized by year for the study period, 1975 through 1995. Thus, a cumulative surplus/deficiency for the 21 years was determined for each portion of the main groundwater basin. Because the surplus/deficiency value is actually the amount of change of groundwater in storage that takes place, the cumulative values were compared with the change in storage computed by the "specific yield method."[8] The comparison is a means of checking the probable amount of error in the budget (Peters, 1981). The cumulative surplus/deficiency estimates for the three portions of the basin are given in Tables 25-27.

[8] Specific yield method is discussed in Chapter V and was used to estimate groundwater in storage and total storage capacity.

Figures 30-32 show the comparison between the water budget cumulative values and the "specific yield method" values for each portion of the main basin; it can be seen that there is some discrepancy between the two methods. In the Tri-Cities Mesa - Arroyo Grande Plain portion of the basin, the cumulative water budget method estimated a surplus of 6,000 AF of groundwater in storage between 1975 and 1995 and the "specific yield method" estimated a surplus of 1,000 AF (Figure 30). In the Nipomo Mesa portion of the basin, the cumulative water budget method estimated a loss of 11,000 AF of groundwater in storage between 1975 and 1995 and the "specific yield method" estimated a loss of 7,000 AF (Figure 31). In the Santa Maria Valley portion of the basin, the cumulative water budget method estimated a surplus of 5,400 AF of groundwater in storage between 1975 and 1995 and the "specific yield method" estimated a surplus of 3,000 AF (Figure 32).

The differences between the results of the two methods are believed reasonable, considering the available data. Accordingly, the amounts of the change in groundwater in storage obtained by the two methods are sufficiently in agreement not only to verify the general order of magnitude of the values derived, but also to substantiate the methods used.

An analysis of the water budgets revealed the following:

- Stream infiltration and deep percolation of precipitation are the major sources of inflow to the main Santa Maria Groundwater Basin. Inflow from these sources was significantly larger in wet years. Groundwater storage space must be available for recharge from a series of wet years to be effective; otherwise, the inflow is simply rejected and contributes to surface and subsurface outflow to the ocean.

- In dry years, urban, agricultural, and other returns help offset the lack of recharge from natural sources. In Nipomo Mesa and Santa Maria Valley, urban, agricultural, and other returns result from extractions of groundwater; in Tri-Cities Mesa - Arroyo Grande Plain, returns are also from use of surface water.

- The largest source of outflow from the main basin was agricultural extractions, followed by subsurface flow to the ocean. In the base period, about 80 percent of the agricultural extractions from the main basin are from Santa Maria Valley. Urban extractions are the major extractions in the Nipomo Mesa and Tri-Cities Mesa - Arroyo Grande Plain portions of the basin.

- In the base period, total outflows were estimated to exceed total inflows in the main basin by about 10 percent. In Tri-Cities Mesa - Arroyo Grande Plain, total inflow about equaled total outflow in the base period, while in Nipomo Mesa and Santa Maria Valley total outflow exceeded total inflow in the base period by 17 and 11 percent, respectively.

  In wet years, inflows were estimated to exceed outflows by greater than 200 percent in Nipomo Mesa and Santa Maria Valley (as much as 11,000 and 31,000 AF, respectively)

FIGURE 30 - COMPARISON OF CUMULATIVE SURPLUS/DEFICIENCY WITH CHANGE IN STORAGE
TRI-CITIES MESA - ARROYO GRANDE PLAIN

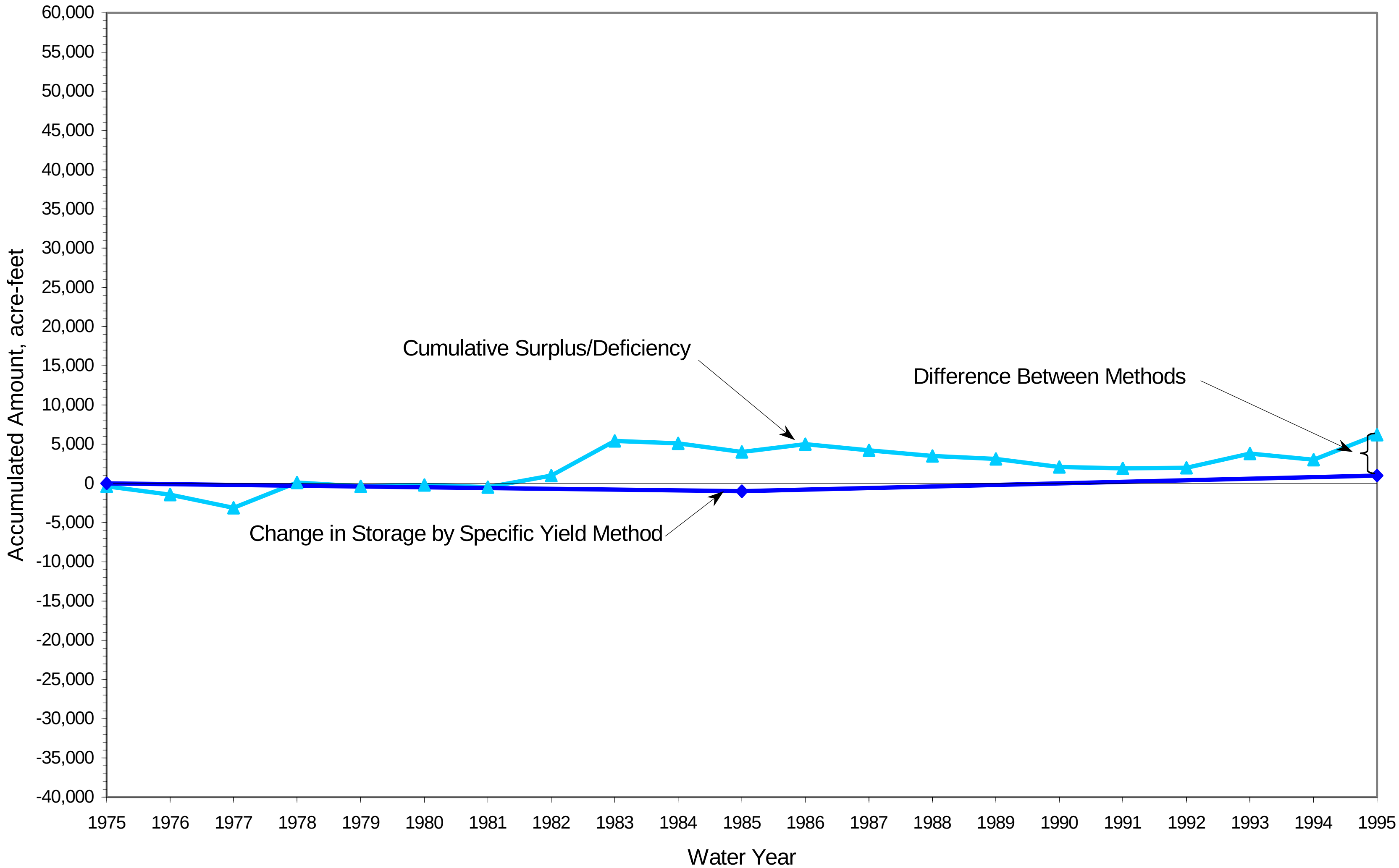


FIGURE 31 - COMPARISON OF CUMULATIVE SURPLUS/DEFICIENCY WITH CHANGE IN STORAGE
NIPOMO MESA

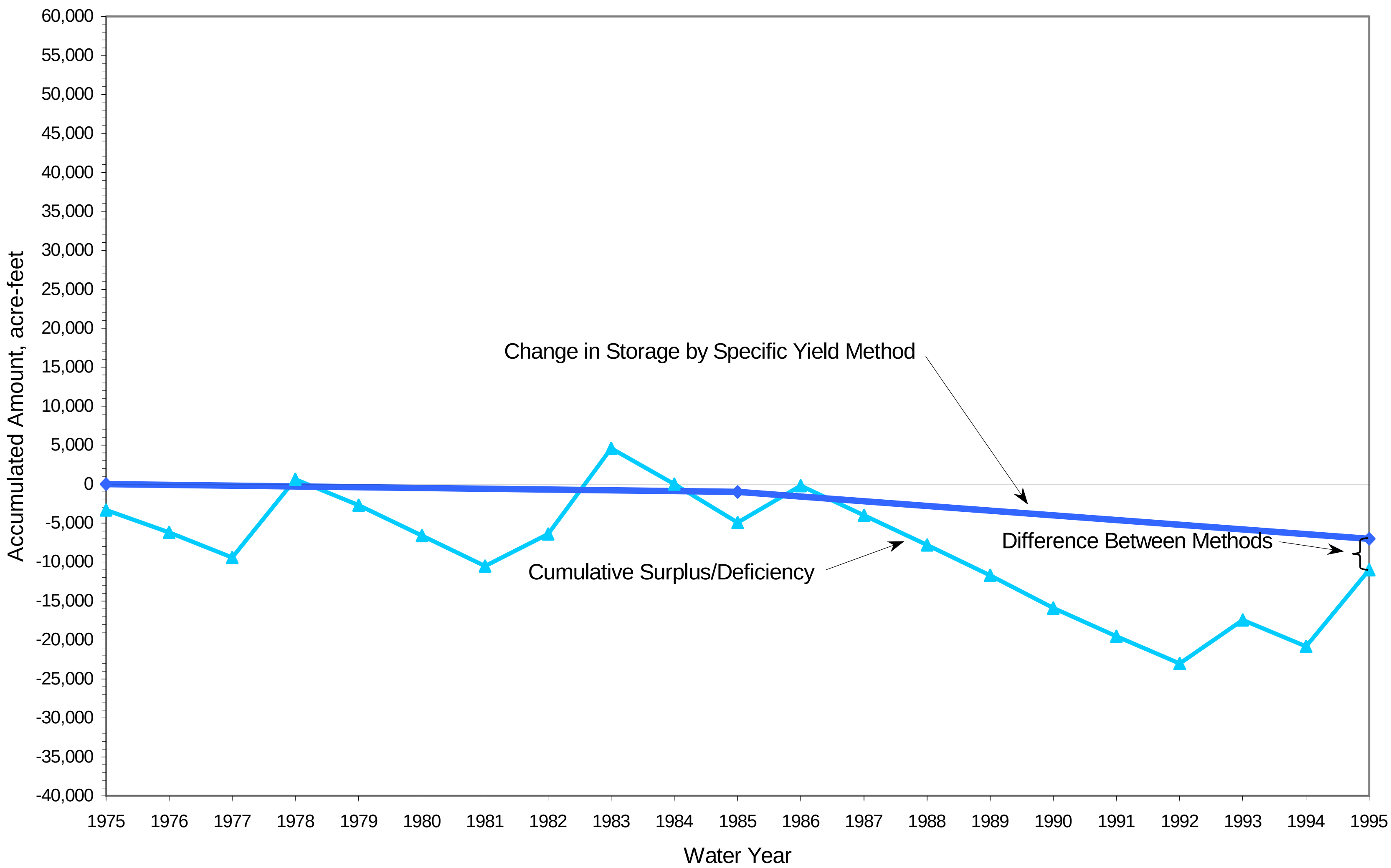
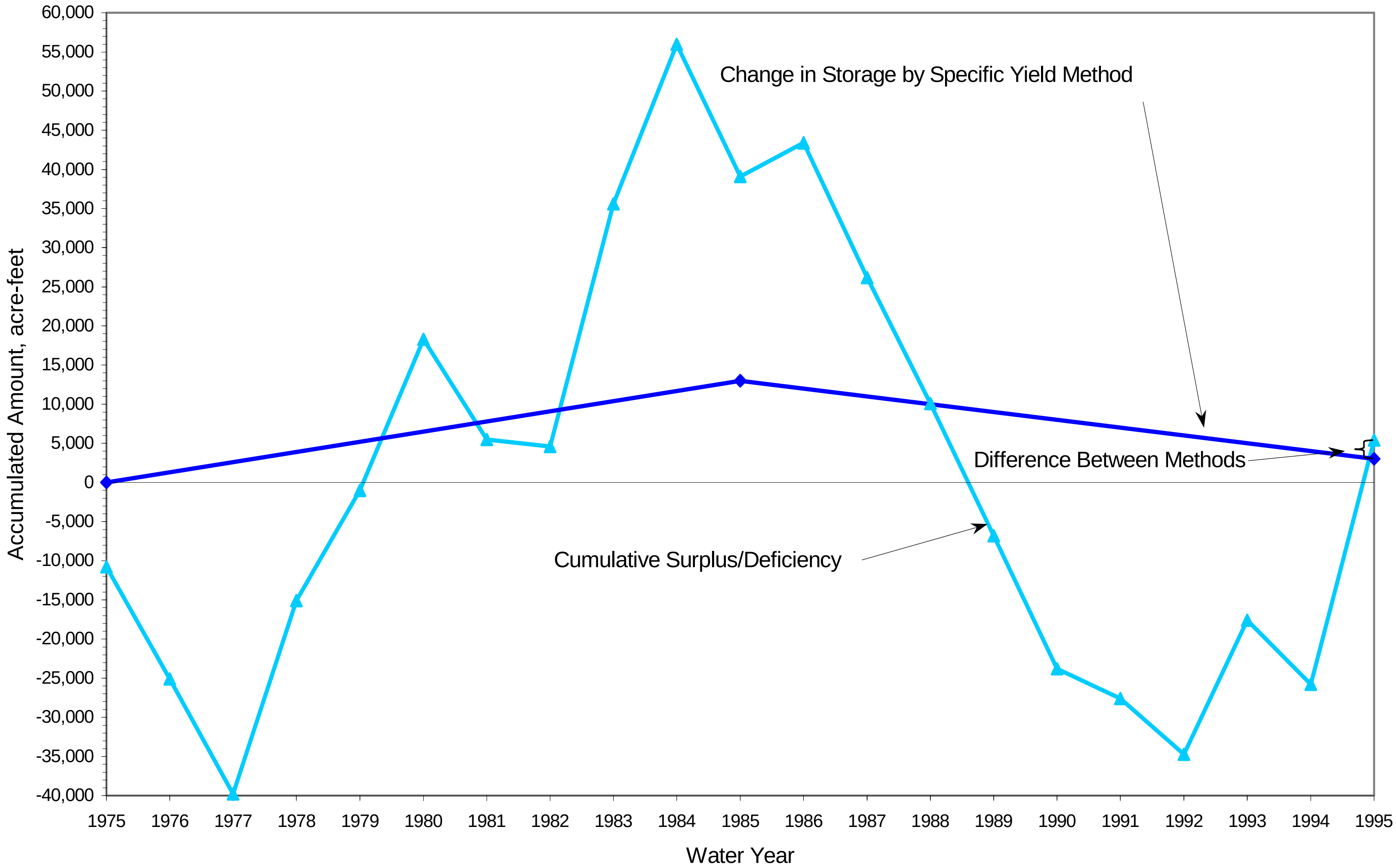


FIGURE 32 - COMPARISON OF CUMULATIVE SURPLUS/DEFICIENCY WITH CHANGE IN STORAGE
SANTA MARIA VALLEY



and up to about 150 percent in Tri-Cities Mesa - Arroyo Grande Plain (up to about 4,000 AF). The gains in groundwater in storage help to offset succeeding dry year deficiencies.

In dry years, total outflows exceeded total inflows. In Tri-Cities Mesa - Arroyo Grande Plain, losses in groundwater in storage were relatively small, less than 2,000 AF, because of estimated subsurface inflow and stream infiltration from Lopez Reservoir releases. Dry year deficiencies in Nipomo Mesa were estimated to be up to about 5,000 AF and are lessened by subsurface inflow from Santa Maria Valley. In Santa Maria Valley, dry year deficiencies were estimated to be as high as about 17,000 AF, although conservation releases from Twitchell Reservoir can offset reduced inflows in dry years (as occurred in 1984, which had estimated total inflow exceeding total outflow).

- The 2010 and 2020 water budgets are based on projected land use changes and associated changes in water demands and on the base period, which represents long-term average hydrologic conditions through water year 1995. The surpluses/deficiencies represent the possible amount of change of groundwater in storage that could take place, if the hydrologic base period conditions of this study prevailed that year.

  The projected deficiencies in the 2010 and 2020 water budgets for Tri-Cities Mesa - Arroyo Grande Plain, Nipomo Mesa, and Santa Maria Valley (1,300, 3,800, and 2,000 AF in 2020, respectively) represent the potential losses in groundwater in storage if hydrologic base period conditions occurred in those years. The projected deficiencies would amount to about one-tenth of a foot decline in groundwater levels in 2020 over the entire Tri-Cities Mesa - Arroyo Grande Plain and Santa Maria Valley portions of the basin and two-tenths of a foot decline in groundwater levels in 2020 over the entire Nipomo Mesa portion of the basin.

- In Tri-Cities Mesa - Arroyo Grande Plain, the projected increase in urban extractions (190 percent from 1995 to 2020), which will account for about 50 percent of the outflow, is the major factor contributing to the projected deficiencies. Reductions in subsurface outflow to the ocean, which accounts for about 35 percent of total outflow, will likely offset future negative imbalances between inflow and outflow and loss of groundwater in storage. Also, recharge enhancement of Arroyo Grande Creek could increase stream infiltration amounts and potentially offset future deficiencies. However, if in the future, subsurface outflow to the ocean is not of sufficient quantity for the freshwater head to counterbalance the greater density of sea water, sea water intrusion of the groundwater basin could occur.

- In Nipomo Mesa, the projected increase in urban extractions (about 215 percent from 1995 to 2020), which will account for 60 percent of the outflow, is the major factor contributing to projected deficiencies. Reductions in subsurface outflows to the ocean and to Tri-Cities Mesa - Arroyo Grande Plain and increased subsurface inflow from Santa Maria Valley will likely offset future negative imbalances between inflow and outflow, reducing the projected amount of loss in groundwater in storage. Subsurface outflow to the ocean was only 600 AF in the base period (seven percent of total outflow) and reductions in this outflow would need to be small because of the concern regarding sea water intrusion, as mentioned above.

- In Santa Maria Valley, the projected deficiencies are not the result of future increased extractions (extractions were projected to increase only 200 AF between 1995 and 2020). Projected subsurface outflows are substantial (6,200 AF to the ocean and 2,300 AF to Nipomo Mesa) from this portion of the basin. Potential future deficiencies will likely be offset by reduced subsurface outflow to the ocean, which accounts for about 30 percent of the total outflow in the future. However, if in the future, subsurface outflow to Nipomo Mesa increases above the projected amount of 2,300 AF, water budgets for this portion of the basin could show larger deficits (loss of groundwater in storage). The same concern regarding sea water intrusion, as mentioned above, applies.

  Also, estimated stream infiltration over the base period was low because of five years with little or no stream infiltration (estimated stream infiltration over the study period was 1,700 AF more than in the base period). Silt accumulation in Twitchell Reservoir has significantly reduced its storage capacity and effectiveness in augmenting groundwater recharge. Restoration and maintenance of the storage capacity of the reservoir could improve future recharge amounts from the Santa Maria River to the groundwater basin.

Dependable Yield and Overdraft

Dependable Yield. The dependable yield of a groundwater basin is the average quantity of water that can be withdrawn from the basin over a period of time (during which water supply conditions approximate average conditions) without resulting in adverse effects, such as sea water intrusion, subsidence, permanently lowered groundwater levels, or degradation of water quality. Dependable yield is determined for a specified set of conditions and any changes in those conditions require a new calculation.

For this study, the estimates of dependable yield are based on the hydrologic equation for the 1984 through 1995 base period and for the 1975 through 1995 study period and were determined by two methods: the dependable yield may be equal to the average annual inflow minus the natural outflow, or it may be equal to the average annual extractions plus or minus the change in the amount of groundwater in storage.[9] The estimates of dependable yield for each portion of the main basin are given in Table 29.

[9]The methodology used and the accuracy of the assumptions for the components of the hydrologic equation were discussed earlier in this chapter.

TABLE 29
ESTIMATES OF DEPENDABLE YIELD, MAIN SANTA MARIA GROUNDWATER BASIN
In acre-feet

	Average Annual Inflow Minus Natural Outflow		Average Annual Extractions Plus Change in Storage	
Division Within Main Groundwater Basin	Base Period*	Study Period**	Base Period*	Study Period**
Tri-Cities Mesa - Arroyo Grande Plain	4,000	4,400	4,100	4,200
Nipomo Mesa	4,900	5,000	4,700	4,800
Santa Maria Valley	10,300	12,900	11,900	12,800

*The base period is water years 1984 through 1995.
**The study period is water years 1975 through 1995.

Because subsurface flows to the ocean could be reduced and subsurface flows between the portions of the basin increased or decreased, the dependable yield values in Table 29 can be conservatively increased. Thus, the dependable yield for each portion of the main basin is given as a range.[10] The dependable yield is estimated to range between 4,000 and 5,600 AF for the Tri-Cities Mesa - Arroyo Grande Plain portion of the basin, between 4,800 and 6,000 AF for the Nipomo Mesa portion of the basin, and between 11,100 and 13,000 AF for the Santa Maria Valley portion of the basin.

These estimates of dependable yield for each portion of the main groundwater basin are more meaningful if they are considered as a unified whole because the estimates are directly affected by the amounts and nature of the subsurface flows occurring between portions of the basin. Thus, the dependable yield for the main Santa Maria Basin within San Luis Obispo County ranges between 19,900 and 24,600 AF.

During the course of this study, it became apparent that better data are needed to determine stream infiltration, deep percolation of precipitation, and groundwater extractions. Information is also needed that would assist in understanding the role of the Santa Maria River, Oceano, and Wilmar Avenue faults on subsurface flows. The resulting improvement in the estimated amounts of the items of water supply and use will, in turn, improve the estimates of dependable yield.

Overdraft. This report defines overdraft as the condition of a groundwater basin or subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions (California Department of Water Resources, Draft 2002). Droughts or periods of less than normal rainfall do not cause overdraft. Basically, overdraft means that extractions exceed the dependable yield of the basin.

[10]The lower value of dependable yield is the average of the two base period values given in Table 29 (rounded).

This study refrains from finding that the Santa Maria Groundwater Basin within San Luis Obispo County is currently in overdraft because of consistent subsurface outflow to the ocean and no evidence of sea water intrusion. The periodic recovery of the basin provides sufficient recharge to preclude long-term adverse conditions. The basin was estimated to have about 38,000 AF more groundwater in storage in water year 2000 than in 1975. In the Nipomo Mesa portion of the basin, the amount of groundwater in storage in 2000 was estimated to be the same as in 1975, despite the continued presence of the pumping depression in the south-central part of the mesa. Pumping depressions and declines in groundwater levels in some wells in some parts of the Nipomo Mesa portion of the basin do not imply that a condition of overdraft exists in the entire groundwater basin, but are more likely indicative of the dynamics of the groundwater system and sources of recharge in the mesa. Other recent investigations also found that the basin is not in a condition of overdraft (The Morro Group, 1990; Cleath, 1996a; Luhdorff & Scalmanini, Consulting Engineers, 1997; and Environmental Science Associates, 1998 and 2001).

The projected deficiencies in the water budgets in water years 2010 and 2020 for the three portions of the main Santa Maria Basin do not necessarily imply overdraft conditions in those years. Projected extractions are within the range of dependable yield estimates, with the exception of Nipomo Mesa in 2020. Because the basin continuously seeks a new equilibrium, reductions in subsurface outflow to the ocean and changes in subsurface flow between portions of the basin will likely compensate for projected deficiencies (loss of groundwater in storage). Such changes in subsurface flows as the basin seeks a new equilibrium will not likely result in overdraft provided that sea water intrusion and other adverse effects are avoided. However, because of the potential for adverse effects, increasing amounts of subsurface flow from the Santa Maria Valley portion of the basin into the Nipomo Mesa portion of the basin to meet projected water demands should not be used as a long-term solution to water supply needs in Nipomo Mesa. The projected deficiencies in the water budgets do indicate the need for continued planning, improved data (mentioned above in this chapter and in other chapters of this report), periodic reevaluation of the water budgets, artificial recharge programs, and expanded use of recycled water.

The groundwater basin is an area of dynamic growth, subject to constantly changing conditions, which affect water supply, use, and disposal. Human activities that can modify water supply conditions and consequently water budgets include items such as: extent of extractions, transfers of water use, increases in impermeable areas, land use changes, and alteration of groundwater hydraulic gradients. Also, because precipitation is the single most important item related to availability of water in the groundwater basin, protracted dry or wet periods will significantly affect future water supply conditions. Therefore, it needs to be recognized that any water budgets and dependable yield values will be superseded in the future as conditions change.

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