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FINAL

TECHNICAL MEMORANDUM NO. 5

DATE: October 19, 2005 Project No.: 423-02-03-01

TO: Don Ridenhour, Project Manager CC: WATRTAC Members

FROM: Gerry Nakano, Project Manager
JJ Westra, Project Engineer

SUBJECT: 2050 Napa Valley Water Resources Study Project
Unincorporated Area Water Supplies

Existing and future water demands of the unincorporated areas for the Napa 2050 Study Area (Study Area) were estimated in Technical Memorandum (TM) No. 3 to be approximately 39,500 and 51,500 acre-feet per year in 2000 and 2050 respectively. The actual 2050 unincorporated demands will be dependent upon water availability, climate, and marketability of wine from the Napa Valley. However, if these demands materialize, to meet these increasing unincorporated area water demands, water must be supplied from a variety of sources. The purpose of this TM is to estimate the quantity of available water supplies to meet the unincorporated area water demands in the Napa 2050 Study Area and identify potential supply deficiencies.

The following key points are a summary of the conclusions and recommendations contained in this TM regarding the unincorporated area water supplies for the Study Area:

- There appears to be insufficient perennial groundwater supplies within the Main Basin to meet the projected increase in annual water demands in the Main Basin for the years 2020 and 2050.
- Groundwater levels in the Napa Valley should continue to be monitored semi-annually by the Napa County Flood Control and Water Conservation District (District), and additional wells added to this program. These data will allow long-term hydrographs to be developed, to better track water level and basin storage volume changes over time. Additional key wells within the Napa Valley floor area should be added to this monitoring program to more accurately track groundwater conditions.
- Groundwater demands within localized areas of the Milliken-Sarco-Tulucay (MST) area exceed long-term groundwater supplies, as evidenced by the continued decline of groundwater levels in specific areas. Alternative supplies (such as recycled water or surface water for non-potable use) should be acquired and delivered to this area, in lieu of continued groundwater pumpage.

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- There is limited information in the Carneros area to accurately assess groundwater conditions. A detailed hydrogeological study similar to the MST Study should be conducted in this area, including a groundwater monitoring program, with the data reported to a central agency, such as the District.

AVAILABLE WATER SUPPLY SOURCES

Water demands in the unincorporated areas of the Study Area are generally met from five water supply sources. While groundwater is typically the main source of supply, other sources of supply could include: surface water, precipitation, recycled water and irrigation return flow.

Surface Water

The State Water Resources Control Board (SWRCB) is responsible for maintaining surface water rights in the State of California, including the Napa River and its tributaries. A SWRCB database updated in the year 2000 was obtained showing pending applications, licenses, permits and statement of diversions or use from the Napa River and its tributaries for use within Napa County. This database does not include riparian diversions from the Napa River or its tributaries. It is acknowledged that riparian stream diversions do take place, however these quantities are very difficult to quantify, and will not make a significant difference to this planning study. It is acknowledged that riparian stream diversions do take place, however these quantities are very difficult to quantify, and will not make a significant difference to this planning study. The database was then used to estimate the quantity of surface water being diverted and used for agricultural purposes, including irrigation, frost and heat protection on the Napa Valley floor.

Because the SWRCB establishes maximum values that a water right holder can divert, it is not possible to know the actual quantity of surface water diverted annually. However, the maximum agricultural diversion allowed can be estimated by summing all water right applications, licenses, permits and statement of diversions or use for both direct diversion and storage.

The Napa River is considered fully appropriated during the irrigation season. Therefore, no increase in water supply from the Napa River is anticipated through the year 2050. Water supplies available from the Napa River and its tributaries are anticipated to remain constant from 2000 through 2050.

Precipitation

While precipitation is a factor in the quantity of irrigation water required, it is not considered to be a key source of supply as evaluated in this TM. The agricultural water demands/needs calculated in this TM only consider the water supply requirements of the plants beyond normal precipitation, i.e., the water supply requirements that need to be applied through the irrigation system.

Recycled Water

Recycled water in the unincorporated areas of the Study Area is supplied from the Napa Sanitation District. Larry Walker and Associates have prepared a Draft Recycled Water Master Plan for Napa Sanitation District (NSD) in February 2005. Recycled water in 2005 is delivered to vineyards, landscape irrigation customers and the NSD disposal field. The draft Recycled Water

Master Plan anticipates the availability of highly treated recycled water supplies suitable for non-potable use ranging from 3,600-9,800 afa by the year 2020, based on six different water reuse strategies. The actual available recycled water supply, and the specific adopted water reuse strategy(s) and project(s) will depend on a variety of factors, including institutional and economical factors, among others.

Subsurface Water

In personal conversations with our agricultural irrigation specialist, several of the recently replanted vineyards in the northern Napa Valley area have installed subsurface drains to lower high groundwater tables. Some growers are now capturing and reapplying water from these subsurface drains for irrigation. For purposes of this Study, we have assumed that only a few percent of the agricultural demand is being met from this source, and this source of supply will be considered to be groundwater for this Study.

Unincorporated Water Supply Sources

Existing non-agricultural water demands are primarily met from two water supply sources: groundwater and recycled water. The rural residential water demands are generally supplied from privately owned domestic groundwater wells. Improved open space (predominately golf courses) can potentially be supplied from groundwater, recycled water or a combination of both.

The majority of the winery demand occurs during crush, where groundwater is used to wash down equipment during grape processing. Water supplies to meet crop water demands are from five water sources: groundwater, surface water, precipitation, recycled water, and irrigation return flow (captured in subsurface drains). Because the water demands in this TM only consider the amount of water applied from an irrigation system, precipitation is not included as a source in this assessment. The use of recycled water for vineyard irrigation is also somewhat limited and localized. Because subsurface irrigation return flow is essentially high groundwater, only groundwater, surface water, and recycled water are discussed in more detail below.

It is estimated that the majority of the crop water demands are met through a combination of surface water and groundwater supplies. While there are estimates of surface water diversions, the precise quantity of groundwater pumped is unknown because agricultural groundwater wells are not typically metered. However, the quantity of pumped groundwater can be estimated if the supply from each source category (except for groundwater) can be approximated. The quantity of water supplied from the groundwater basin can then be estimated if the total water demand is subtracted by the supply contributions from each of the other individual supply sources.

MAIN BASIN

The Main Basin region includes the unincorporated areas in the vicinity of Calistoga, St. Helena, Yountville, Napa and American Canyon. This section discusses water supplies for the years 2000, 2020, and 2050, groundwater trends, and perennial yield of the Main Basin.

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Main Basin Supply

Based on our previous evaluation and information provided in TM 3, water demands for the unincorporated areas of the Main Basin, which exclude the Carneros and the Milliken-Sarco-Tulucay (MST) areas are approximately 33,700 and 41,100 afa for 2000 and 2050, respectively.

<u>2000 Main Basin Supplies</u>

Crop water use in the Main Basin is approximately 87 percent (29,271 af) of the total unincorporated water demand as shown in Table 1. The remaining water demands consisting of rural residential, improved open space and winery demand make up the remaining 13 percent (4,385 af). Based on our analysis of the various available water supplies to meet this demand (discussed in the following paragraphs), the estimated water supply sources (during normal years) and percent contribution by supply source are summarized in Table 1.

Table 1. Estimated 2000 Main Basin Unincorporated Area Supply Sources

	Demands		Supplies						
			Groundwater[b]		Surface Water		Recycled Water		
	Estimated Demand, afa	Percent of Total Demand	Quantity, afa	Percent of Supply	Quantity, afa	Percent of Supply	Quantity, afa	Percent of Supply	Total Supply, afa
Rural residential	2,300	7	2,300	100	—	—	—	—	2,300
Improved open space[a]	1,111	3	326	29	—	—	785[c]	71	1,111
Winery	974	3	974	100	—	—	—	—	974
Crop water use	29,271	87	23,152	80	6,000[d]	20	115[e]	0	29,270
Total	33,656	100	28,000[f]	79	6,000	18	900	3	34,900

(a) Improved open space primarily consists of golf courses.
(b) For the purposes of this evaluation, the groundwater supply is assumed to make up the unmet demands not supplied by surface and recycled water.
(c) Based on the assumption that approximately half of the existing (2005) landscape irrigation recycled water use reported in the Napa Sanitation District Draft Recycled Water Master Plan, prepared by Larry Walker and Associates, February 2005, (reduced to account for the year 2000 groundwater offset) is available for delivery to the Main Basin.
(d) Based on normal year hydrologic conditions (76 percent of wet year supply of 7,900 afa).
(e) Based on existing vineyard recycled water use as reported in the Napa Sanitation District Draft Recycled Water Master Plan, prepared by Larry Walker and Associates, February 2005.
(f) The total available groundwater supply is assumed to be 28,000 afa, based on the perennial yield.

Based on this analysis, as shown on Table 1, the groundwater pumpage for non-agricultural use (rural residential and improved open space) in the Main Basin in 2000 was estimated to be approximately 2,600 af. Approximately 785 af of recycled water was estimated to be available to meet the improved open space demands.

Winery demand of approximately 975 afa is supplied in its entirety from groundwater. Crop water demand in the Main Basin in 2000 was estimated to be approximately 29,300 af, or 87 percent of the total unincorporated water demand in the Main Basin. The crop water demand is supplied from groundwater, surface water and a small amount of recycled water. According to the SWRCB database, approximately 7,900 afa could be stored from the Napa River and its tributaries to meet crop water demands in the Main Basin during a wet year. During normal year hydrologic conditions, the surface water supply is assumed to be 76 percent of the wet year supply, or 6,004 afa. Water supplies available from the Napa River and its tributaries are anticipated to remain constant from 2000 to 2050. The remaining crop water demand of 23,152 af is assumed to come from the groundwater basin.

<u>2020 Main Basin Supply</u>

The estimated 2020 unincorporated water demands in the Main Basin are approximately 36,400 afa. Table 2 provides a summary of the estimated water supply sources and the percent contribution by each supply source to meet this demand in year 2020. Rural residential demands slightly increased corresponding to an increased in rural residential groundwater pumping. Improved open space demands remain the same yet, the amount of recycled water is projected to increase to this category. Approximately 80 percent of the improved open space is anticipated to be supplied from recycled water reducing the improved open space dependence on groundwater.

The winery demands in 2020 are continued to be entirely supplied from groundwater. The quantities of water supplied from surface water to meet crop water demands are anticipated to remain unchanged because the Napa River is fully appropriated. The quantity of recycled water used is anticipated to increase slightly as it becomes more available and more readily acceptable, but is only expected to supply approximately one percent of the total crop water demand, estimated to be approximately 200 afa. Therefore, it was assumed that the increase in crop water demand would have to be met from increased groundwater pumpage up to the perennial yield of the groundwater basin. A detailed discussion of the perennial yield is in the perennial yield section of this TM. Unincorporated demands currently exceed the supplies by approximately 1,340 afa as shown in Table 2. <u>An additional supply of approximately 1,340 afa is required to meet the projected 2020 unincorporated water demands under normal year surface water deliveries.</u>

Table 2. Estimated 2020 Main Basin Unincorporated Area Supply Sources

	Demands		Supplies						
			Groundwater[b]		Surface Water		Recycled Water		
	Estimated Demand, afa	Percent of Total Demand	Quantity, afa	Percent of Supply	Quantity, afa	Percent of Supply	Quantity, afa	Percent of Supply	Total Supply, afa
Rural residential	2,420	7	—	—	—	—	—	—	—
Improved open space[a]	1,111	3	—	—	—	—	865[c]	—	—
Winery	1,022	3	—	—	—	—	—	—	—
Crop water use	31,863	87	—	—	6,000[e]	25	207[c]	—	—
Total	36,416	100	28,000[d]	80	6,000[e]	17	1,072	3	35,070

[a] Improved open space primarily consists of golf courses.
[b] For the purposes of this evaluation, groundwater is assumed to make up the unmet demands not supplied by surface and recycled water, up to the estimated perennial yield of the Main Basin.
[c] Assumed constant growth from 2000-2050.
[d] Limited to estimated perennial yield of the Main Basin at 28,000 afa.
[e] Based on normal year hydrologic conditions (76 percent of wet year supply of 7,900 afa).

2050 Main Basin Supply

The estimated 2050 unincorporated water demands in the Main Basin are approximately 41,100 afa. Table 3 provides a summary of the estimated water supply sources and the percent contribution by each supply source to meet this demand in year 2050. Rural residential demands slightly increased corresponding to an increased in rural residential growth. Improved open space demands remain the same yet the amount of recycled water is projected to increase to this category. Approximately 90 percent of the improved open space is anticipated to be supplied from recycled water, thus continuing to reduce this category’s dependence on other supply sources.

The winery demands in 2050 are projected to be entirely supplied from groundwater. The quantities of water supplied from surface water to meet crop water demands are anticipated to remain constant, because the Napa River is fully appropriated. The quantity of recycled water used is anticipated to increase slightly as it becomes more available and more readily acceptable, but is only expected to supply only one percent of the total crop water demand, estimated to be approximately 500 afa. Therefore, it was assumed that the increase in agricultural water demand could be supplied from the groundwater basin up to the perennial yield of the Main Basin. As previously stated, the perennial yield is discussed in greater detail in the perennial section of this TM. Unincorporated demands have continued to increase from 2020 and supplies have not sufficiently increased to the extent the demands have. Table 3 shows that estimated demands exceed projected supplies by approximately 5,640 afa under normal year surface water deliveries.

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Table 3. Estimated 2050 Main Basin Unincorporated Water Supply Sources

	Demands		Supplies						
			Groundwater[b]		Surface Water		Recycled Water		
	Estimated Demand, afa	Percent of Total Demand	Quantity, afa	Percent of Supply	Quantity, afa	Percent of Supply	Quantity, afa	Percent of Supply	Total Supply, afa
Rural residential	2,750	7	—	—	—	—	—	—	—
Improved open space[a]	1,111	3	—	—	—	—	1,000[c]	—	—
Winery	1,100	3	—	—	—	—	—	—	—
Crop water use	36,187	88	—	—	6,000[f]	—	500[d]	—	—
Total	41,148	100	28,000[e]	79	6,006[f]	17	1,500	4	35,500

(a) Improved open space primarily consists of golf courses.
(b) For the purposes of this evaluation, groundwater is assumed to make up the unmet demands not supplied by surface and recycled water, up to the estimated perennial yield of the Main Basin.
(c) For planning purposes, WYA assumed recycled water supply is increased to 1,000 afa.
(d) For planning purposes, WYA assumed recycled water supply is increased to 500 afa.
(e) Groundwater demand is limited by perennial yield of the Main Basin (28,000 afa).
(f) Based on normal year hydrologic conditions (76 percent of wet year supply of 7,900 afa).

Groundwater Trends

Because groundwater will be heavily relied upon to meet the identified increasing agricultural demands created by vineyard densification and acreage expansions, an evaluation of historic increases in agricultural demand (based on increased vineyard acreages) and potential groundwater basin impacts (water level changes due to increased pumpage), was conducted. The Napa County Agricultural Commissioner prepares an annual crop report for Napa County. Total vineyard acreages from 1975 to 2002 for Napa County, which includes bearing and non-bearing vineyards, are shown on Figure 1. From 1975 to 2003 vineyard acreages increased by approximately 18,800 acres or 675 acres per year within Napa County, and from 1998 to 2003 vineyard acreage has increased at a rate of approximately 1,675 acres per year.

Groundwater Hydrographs

The California Department of Water Resources (DWR) measures groundwater wells throughout the State. The online database was searched for groundwater information in the Napa Valley. Spring depths to groundwater measurements from 1975 to 2002 were plotted for four key wells located throughout the Valley as shown on Figure 2. Only spring groundwater measurements were plotted because they represent the maximum groundwater elevation for the given year. Typically groundwater elevations recover to their annual maximum level after the winter rainfall, prior to the occurrence of increased groundwater pumping. Annual calendar year rainfall was also plotted on these graphs to show the potential effects that rainfall recharge could have on groundwater basin water levels. Groundwater elevations for these key wells are shown on Figures 3 through 10, and discussed below.

Figure 3 shows spring depth to groundwater measurements near the City of Calistoga. Groundwater levels indicate that groundwater conditions have been relatively stable for the last 25 years, and extremely stable since 1989 (15 years). Depth to water is approximately ten feet below the land surface. Figure 4 presents a plot of the change in groundwater elevations (from spring to spring) in the Calistoga area, compared to both annual rainfall and increasing total planted vineyard acreages in the Napa Valley (shown on the lower horizontal scale). The graphic clearly shows that; (1) water levels are extremely stable, even though vineyard acreages have nearly doubled and that groundwater pumpage had to increase to provide supply for these vineyard acreage expansions, and (2) water levels do not necessarily decline during lower rainfall drought periods (1987 to 1992).

Based on this data, there are no long-term effects of increased agricultural demands in the Calistoga area. The horizontal axis of Figure 4 shows increased vineyard acreages compared to annual changes in groundwater levels. As the vineyard acreage increases, the demands on the groundwater basin are expected to increase since it is assumed that increased water demands would be supplied from the groundwater basin. Since depth to groundwater remains fairly stable in the area, it appears that there is sufficient groundwater supplies in the area to meet existing agricultural demands.

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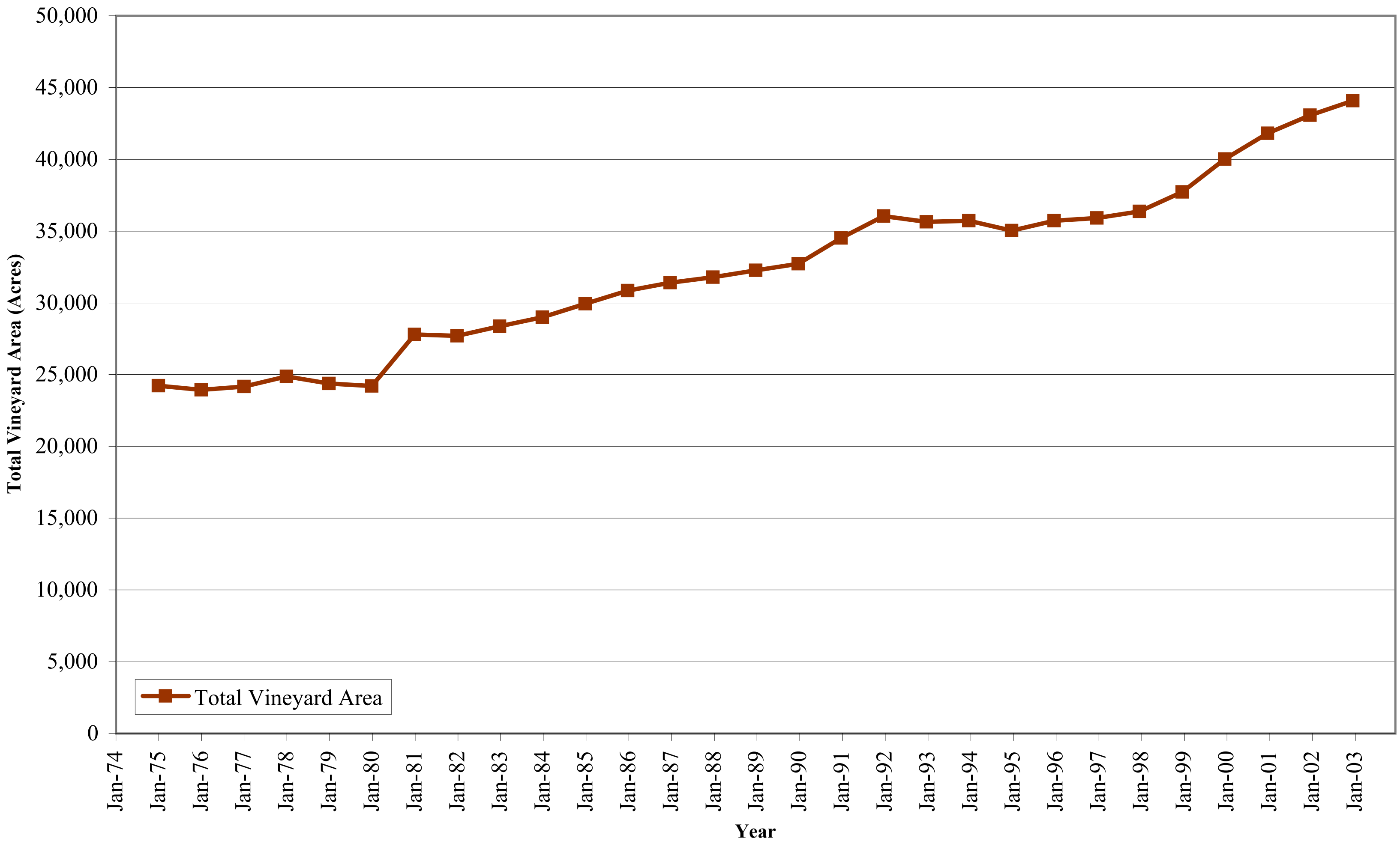
Figure 1. Napa Valley Wine Grape Acreages
Napa County Agricultural Crop Report (1975-2003)



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vineyard acreages.xls.xls; fig 1
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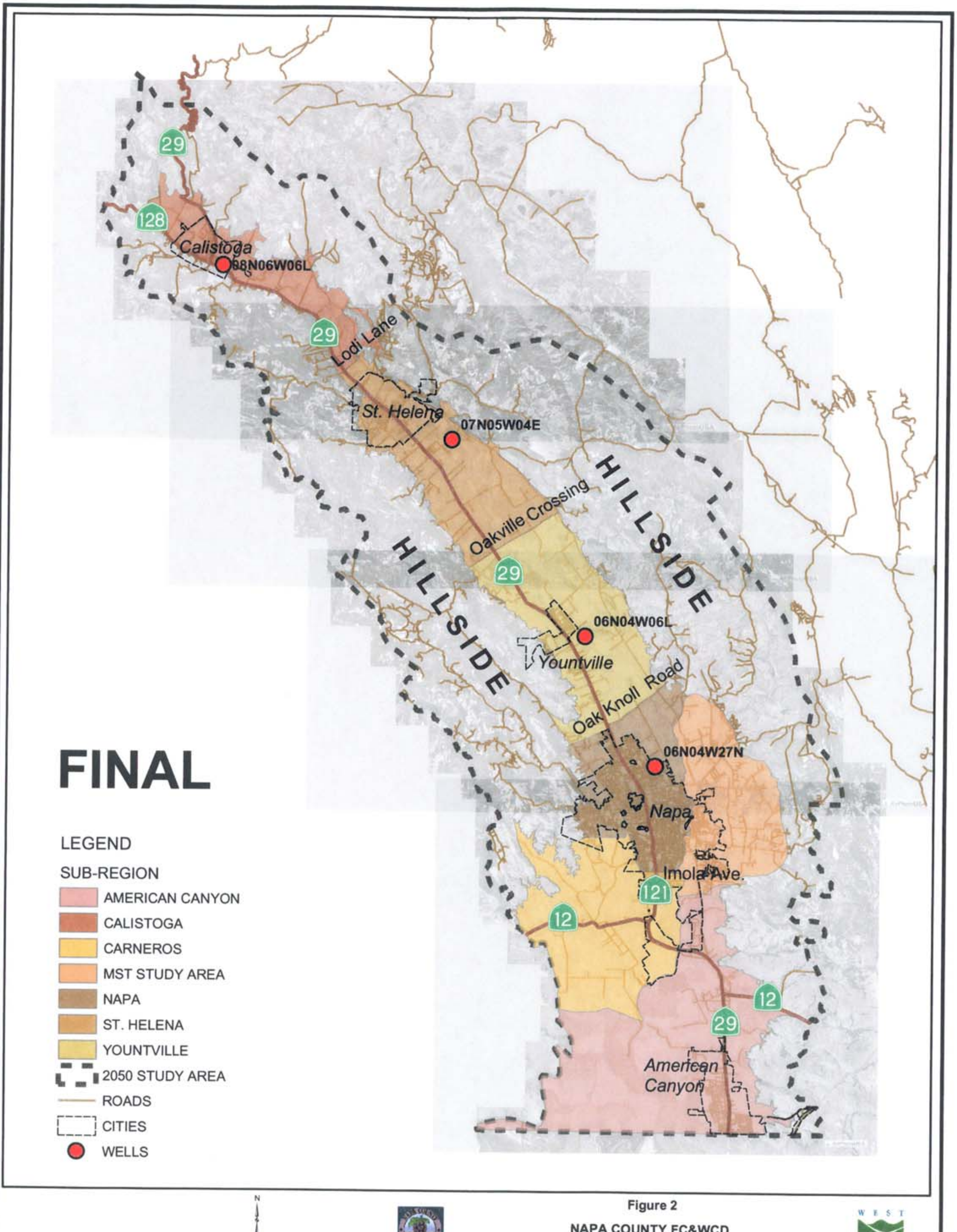
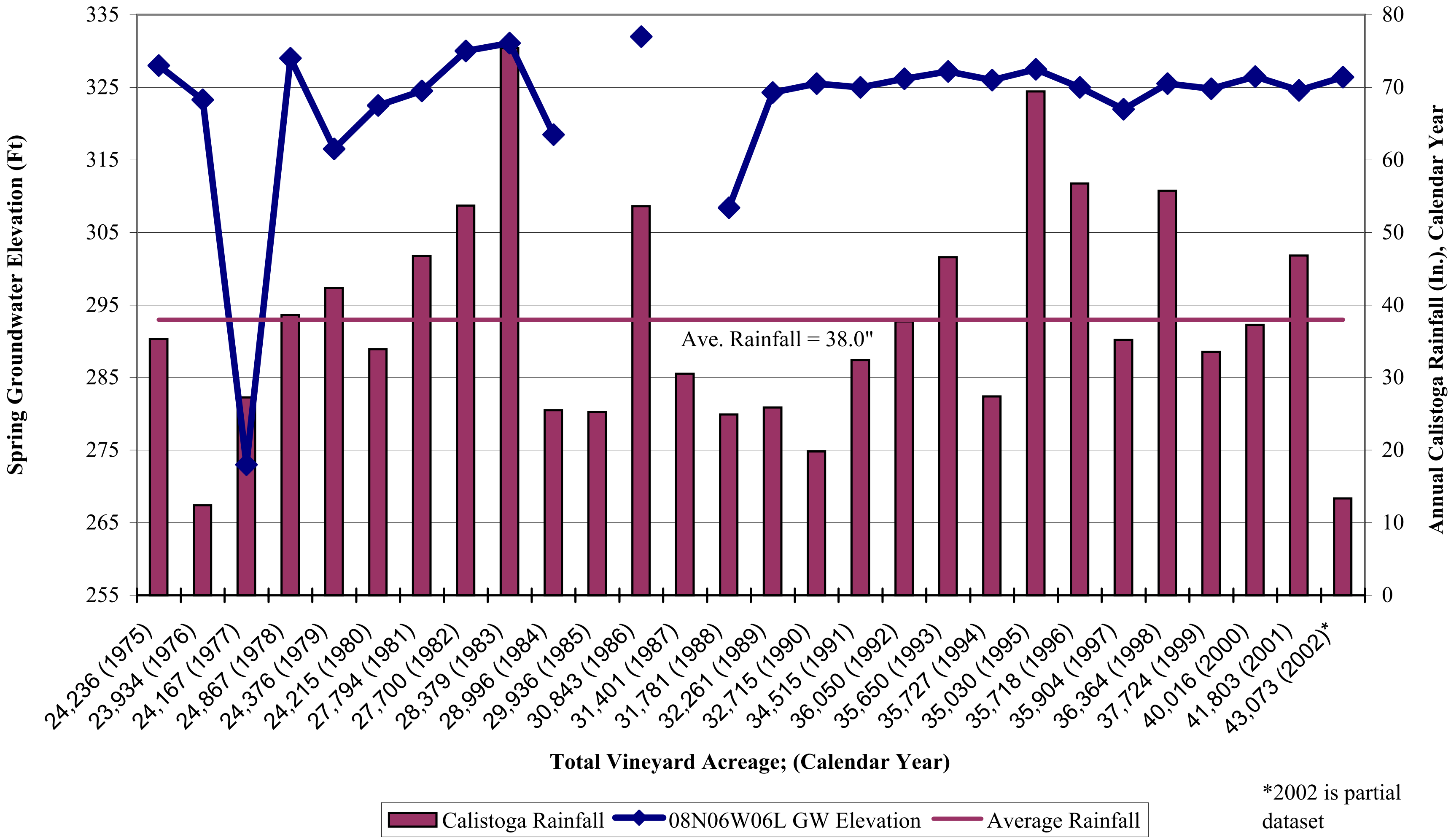


Figure 2

NAPA COUNTY FC&WCD
2050 NAPA VALLEY WATER RESOURCES STUDY
HYDROGRAPH LOCATIONS

3/30/05

Figure 3. Spring Groundwater Elevation
Well 08N06W06L near City of Calistoga (1975-2002)
Ground Surface Elevation = 335ft MSL



*2002 is partial dataset

J:e/423/TM5
vineyard acreages.xls, 08N06W06L chart Elevation
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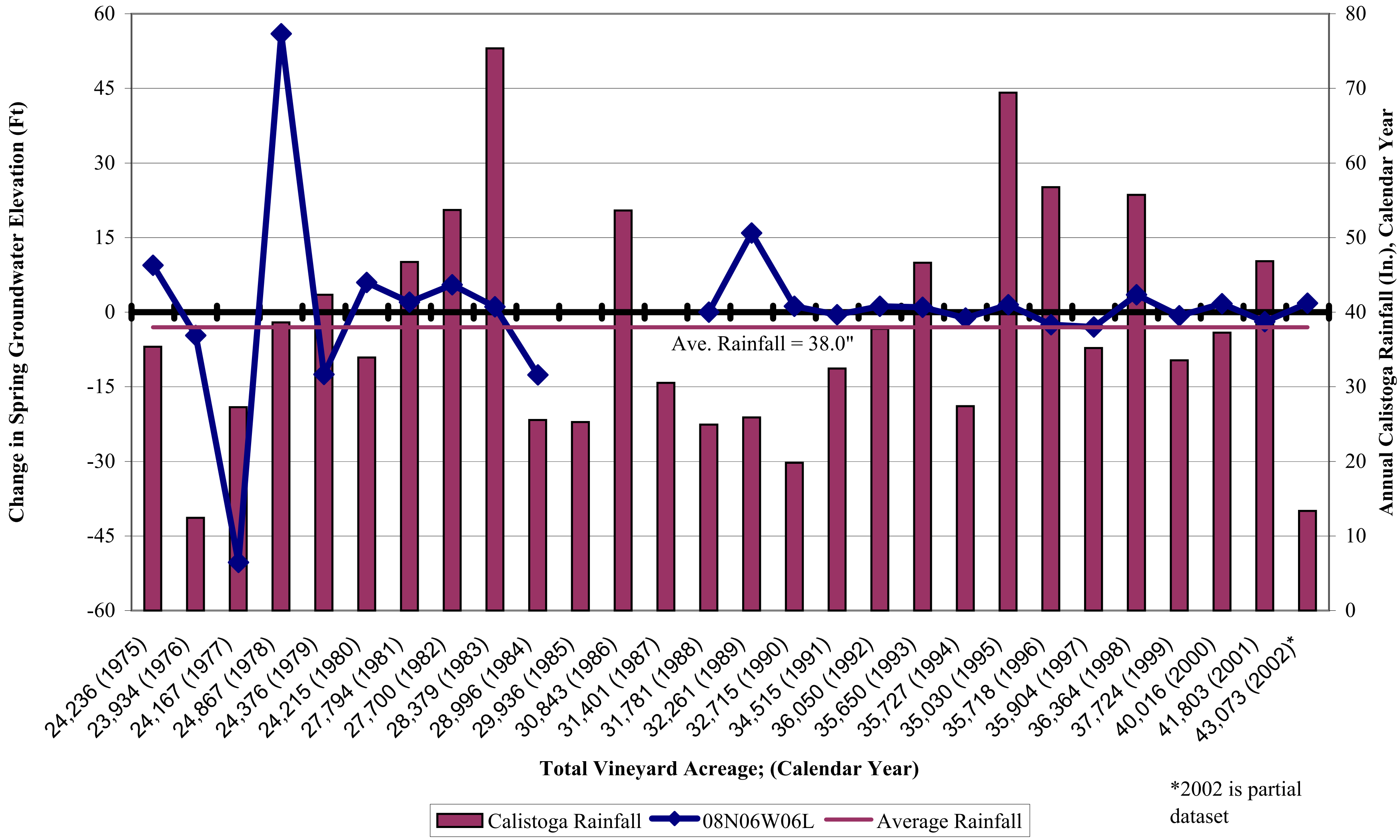
Figure 4. Change in Spring Groundwater Elevation
Well 08N06W06L near City of Calistoga (1975-2002)



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vineyard acreages.xls, 08N06W06L chart
Last Revised 10/27/04

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Water level trend data as shown on Figure 5 for a well in the St. Helena area tells a similar story. Long-term groundwater levels again remain fairly constant, with water levels typically about five feet below ground surface over this entire time period. With only a few exceptions, annual groundwater levels rarely vary by more than a foot or two. The exceptions begin to occur when precipitation is below normal as shown in Figure 6. From 1988 to 1994 when precipitation was near or below average, and irrigated acreages in the valley was below 35,000 acres, spring to spring groundwater levels remained fairly constant. However, after the irrigated acreages expanded beyond 35,000 acres valley-wide, annual groundwater level fluctuations increased and decreased over a larger range, varying between plus or minus 16 to 18 feet. These larger changes in groundwater levels appear to correspond with changes in precipitation. The lower than normal rainfall periods correspond to lower groundwater levels and conversely, higher than normal rainfall corresponds to higher groundwater levels. Although the data is rather limited, this possible pattern of increased sensitivity between annual rainfall and annual (spring) water levels maybe due to the increased agricultural use of the groundwater basin in this area of the valley (irrigated acreages are now over 43,000 acres). However, the data shows no long-term water level declines as the basin responds very quickly to recharge opportunities, indicating that groundwater supplies are adequate to meet the agricultural demands.

Figure 5. Annual Spring Groundwater Elevation
Well 07N05W04E near City of St. Helena (1975-2002)
Ground Surface Elevation = 175 ft MSL

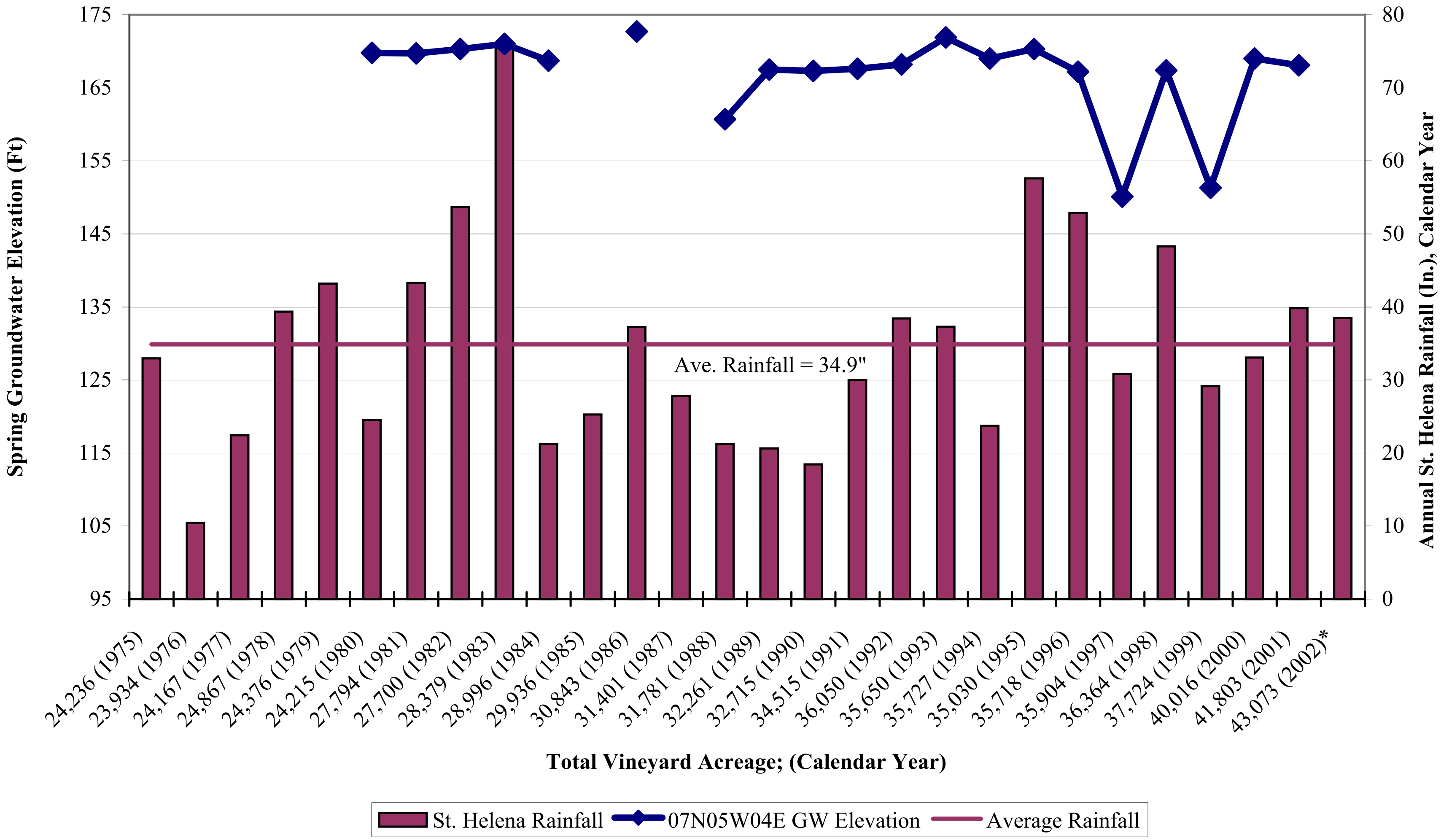

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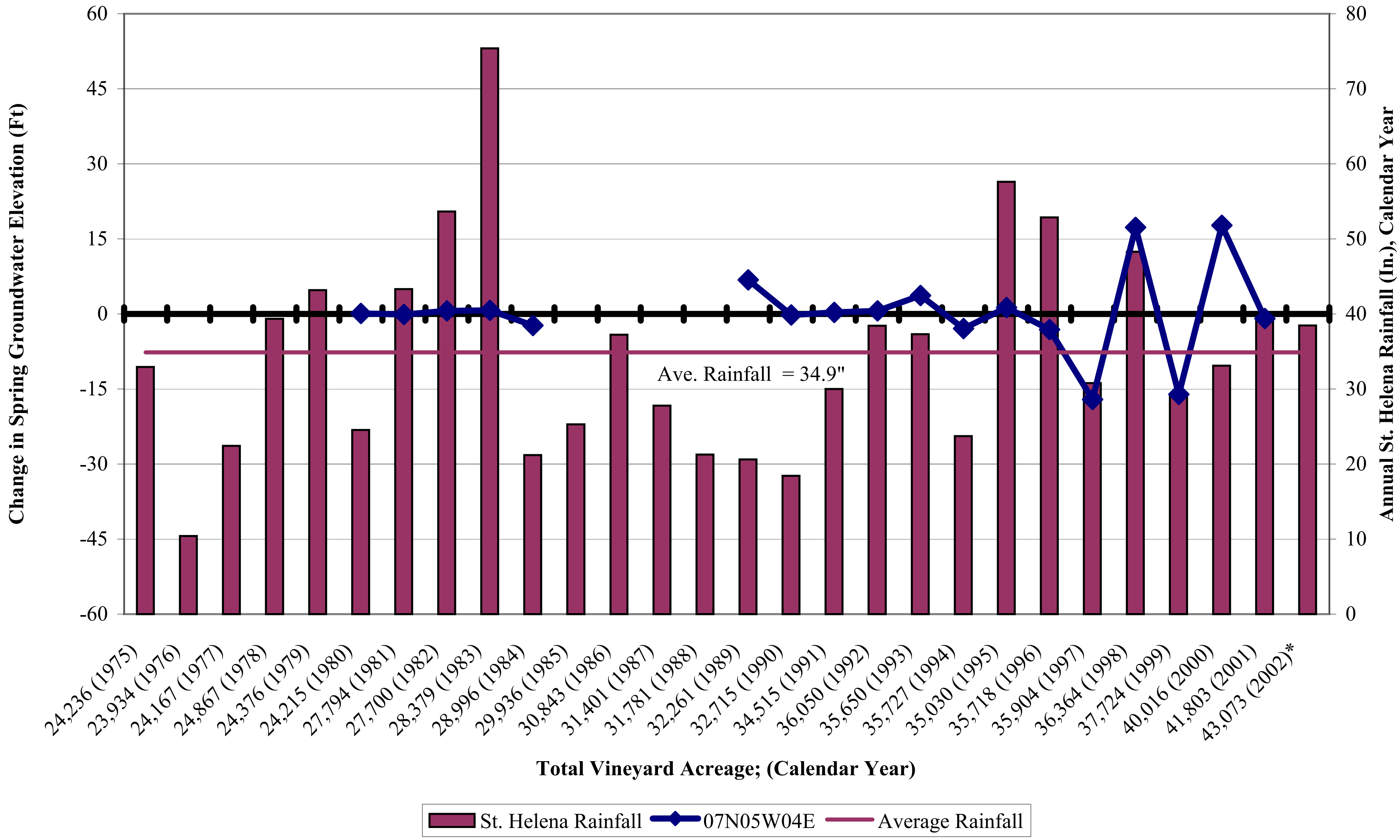
Figure 6. Annual Change in Spring Groundwater Elevation
Well 07N05W04E near City of St. Helena (1975-2002)



Figures 7 and 8 present annual groundwater level data for a well near the Town of Yountville. Groundwater trends are similar to the two previously discussed areas with one minor difference, groundwater levels (as shown in Figure 7) are typically ten feet below ground surface in this area, compared to five feet below ground surface in the Calistoga and St. Helena areas. The groundwater levels in this area also do not tend to vary and react to the annual precipitation as the key well in the St. Helena area did. Water levels appear to be constant and stable, even during significant drought periods. As shown in Figure 8, in the year 2001 groundwater levels do drop approximately 25 feet below ground surface. This decline in groundwater level occurs in a wet year. Precipitation for this year is of similar quantity as the previous and subsequent years where the groundwater levels remained at ten feet below ground surface, leading one to suspect that maybe the water level measurement from 2001 is not a true static reading, possibly reflective of a recently turned off pump. Long-term groundwater levels indicate that there is sufficient groundwater supplies to meet existing groundwater demands in this area, even with the increasing vineyard acreages being irrigated.

Figure 9 presents annual groundwater level data for a well near the City of Napa. This data differs from the previously evaluated water level hydrograph data because it shows two distinct groundwater level baseline periods. The first period occurred from 1978 to 1986, with groundwater levels at approximately ten feet below the ground surface. A second groundwater baseline level occurred starting in 1987, extending to 2002. Groundwater levels during this period were slightly lower, averaging about 20 feet below ground surface during this period. However, it should be noted that although water levels are currently about 20 feet below the ground surface, the data does not show a long-term decline in spring groundwater levels. Sporadic groundwater level data for this well is actually available back to the 1930's. As shown on Figure 9, spring groundwater elevations were measured at approximately 17 and 20 feet below ground surface in 1930 and 1932, respectively. Using these years as a start of the baseline data, it would appear that the groundwater levels recovered during the 1978-1986 time period, due to a number of significantly wet years, and have now returned to 1930 levels. This indicates that the groundwater basin is capable of sustaining the demands based on the annually available recharge quantities, even under the increasing irrigation demands of expanding acreages (as shown on Figure 10).

Overall, groundwater levels throughout the valley appear to be stable. The significant increase in irrigated vineyard acreage in the Napa Valley has had almost no effect on the groundwater basin. There appears to be increased seasonal water level variations (seasonal spring to fall water level changes) probably caused by increased seasonal use of groundwater basin storage. However, long-term water levels are still steady, indicating that groundwater pumpage is not exceeding long-term annual recharge. The one note of caution is for the southern portion of the valley. Even though there appears to be sufficient supplies in the southern portions of the Napa Valley, additional pumpage from the groundwater basin in this area (even seasonally), may allow saline groundwater to migrate and intrude into the higher quality groundwater supplies further northward in the Napa Valley.

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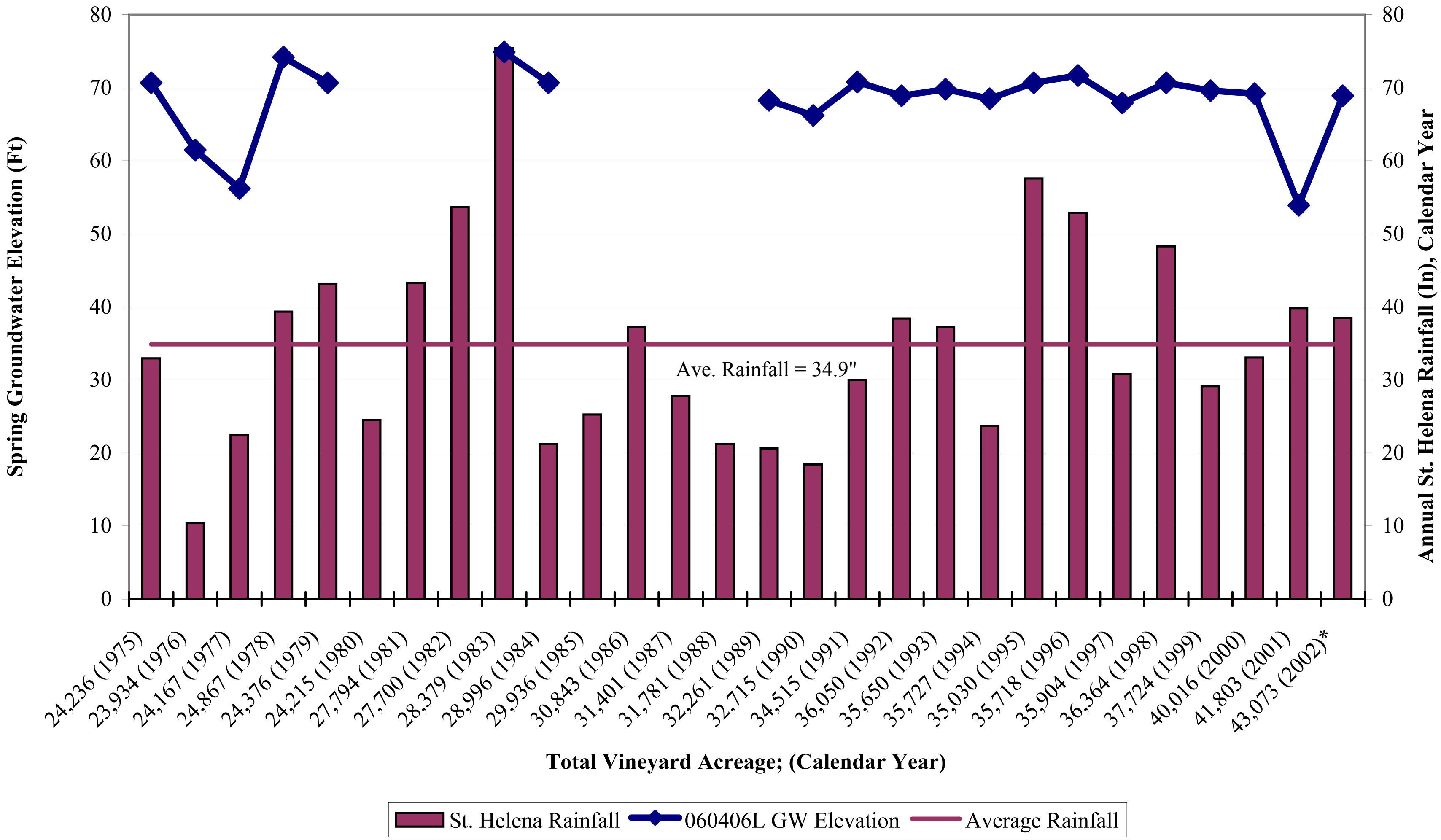
Figure 7. Annual Spring Groundwater Elevation
Well 06N04W06L near Town of Yountville (1975-2002)
Ground Surface Elevation = 80 ft MSL



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vineyard acreages.xls, 060406L chart elevation
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Figure 8. Annual Change in Groundwater Elevation
Well 06N04W06L near Town of Yountville (1975-2002)

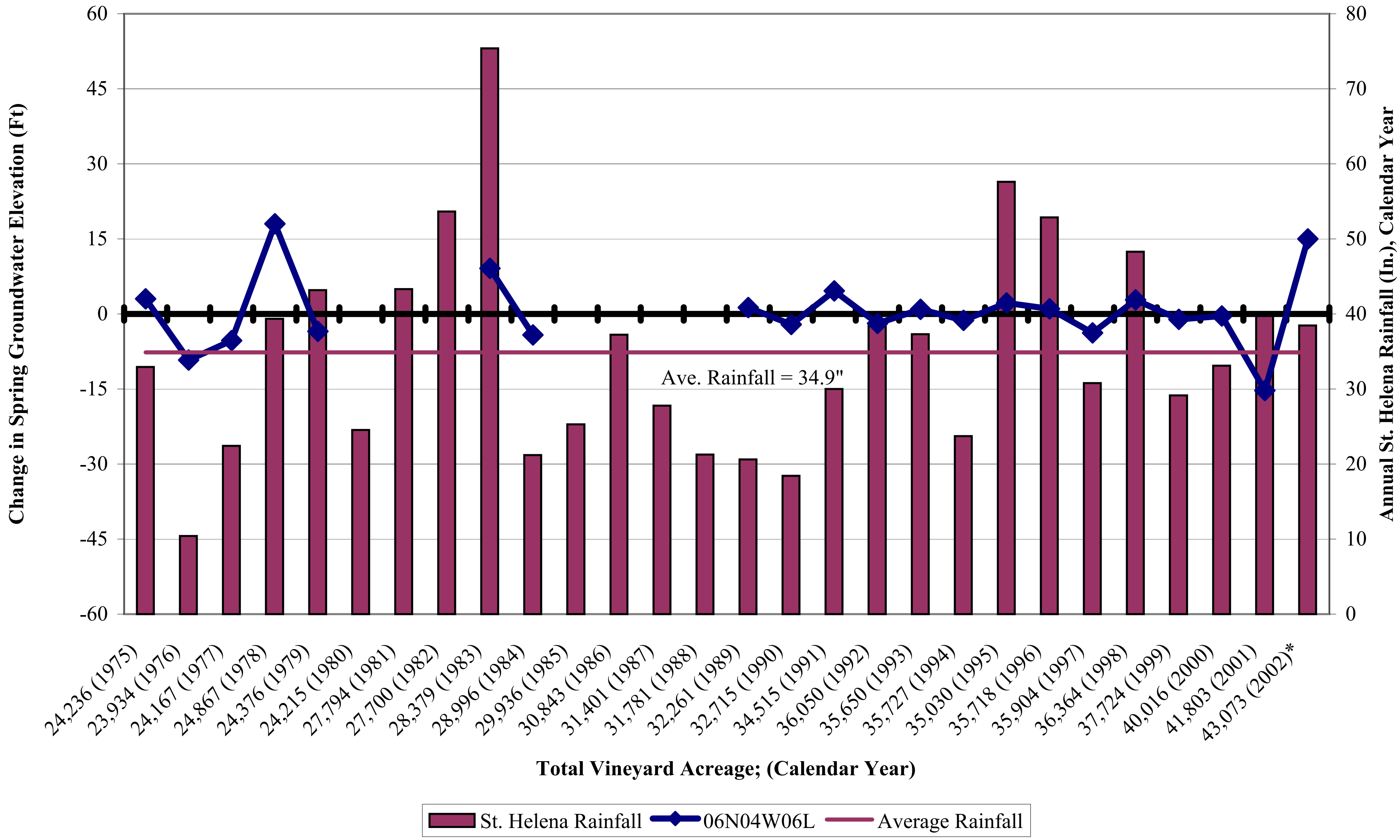

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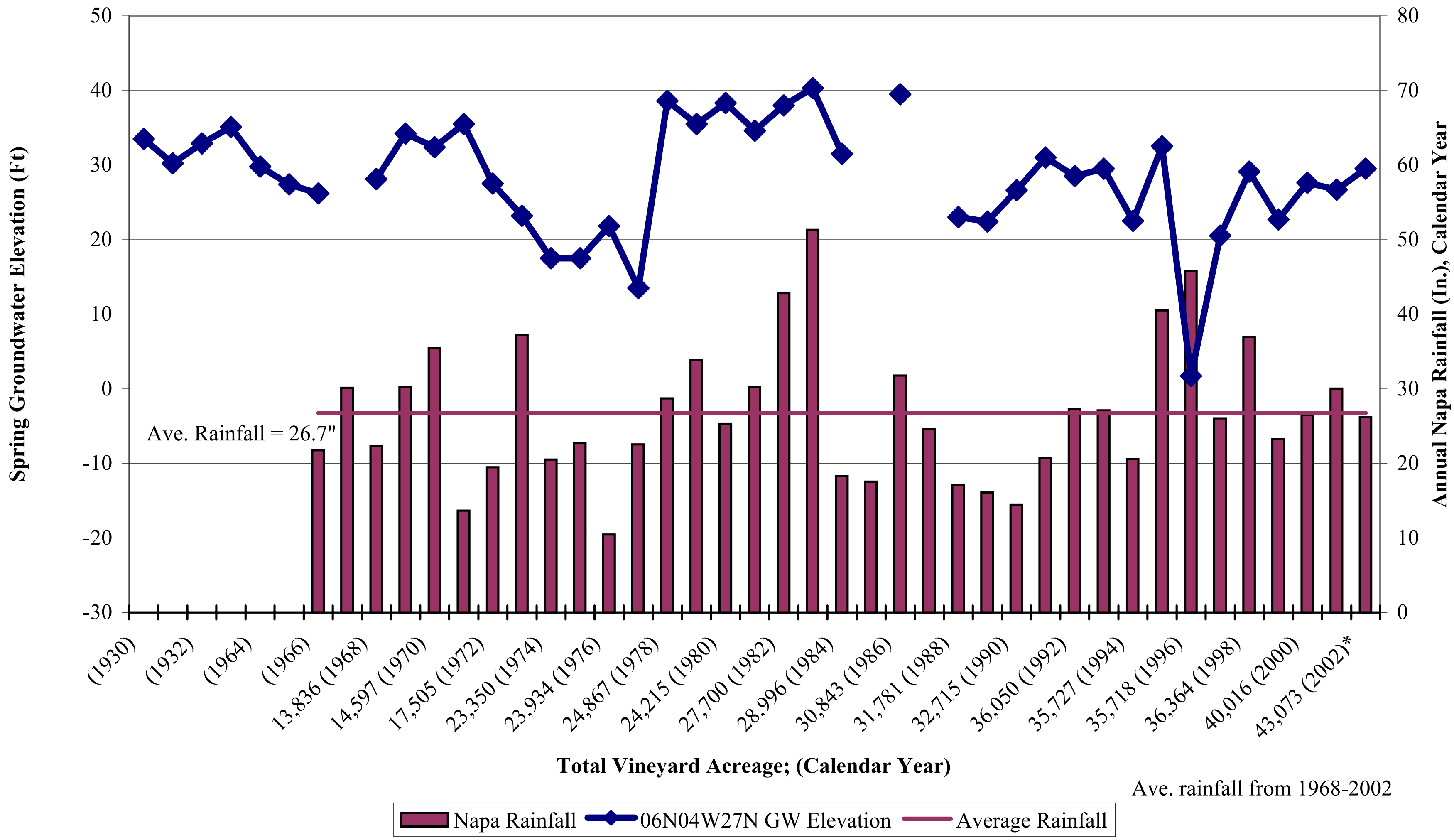
Figure 9. Spring Groundwater Elevation
Well 06N04W27N near City of Napa (1930-2002)
Ground Surface Elevation = 50 ft MSL



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vineyard acreages.xls, 060427N chart elevation
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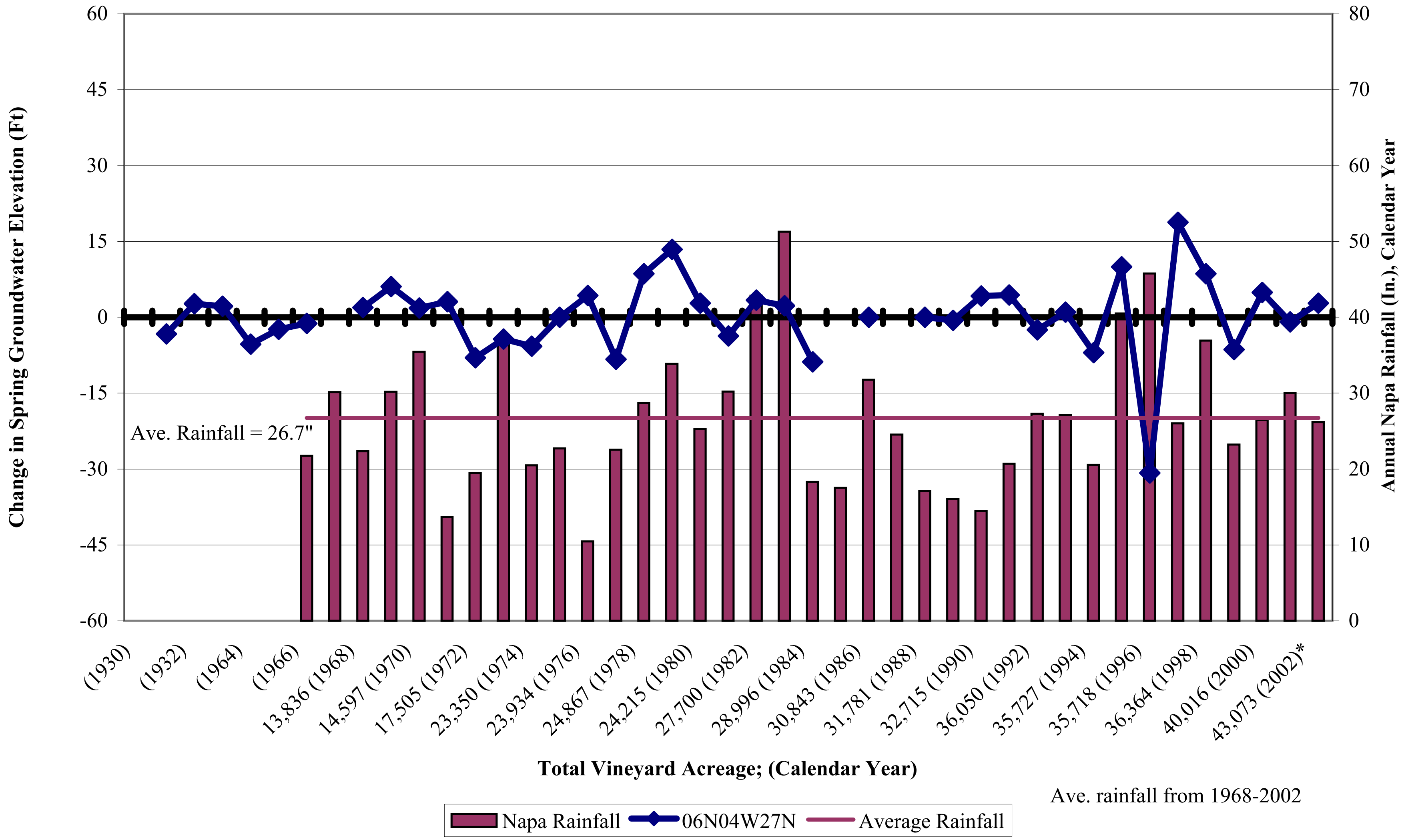
Figure 10. Annual Change in Spring Groundwater Elevation Well 06N04W27N near City of Napa (1930-2002)



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Perennial Yield

From Table 1, we have estimated that the 2000 unincorporated groundwater demand in the Main Basin is approximately 26,750 afa in normal years and our analysis of available hydrologic data demonstrates that groundwater levels have remained stable throughout the Main Basin. Since there is no observed long-term decline in groundwater levels, and groundwater levels annually return to their historic levels, the existing groundwater pumpage of approximately 26,750 afa is within the annual perennial yield of the groundwater basin (another way to state this is that the perennial yield of the Main Basin is slightly more than 26,750).

The 1991 James Montgomery study for the Napa Valley conservatively estimated the perennial yield of the entire Napa Valley (includes both the northern and southern Napa sub-areas, including the MST groundwater basin) at 27,900 afa. As discussed in more detail in the next section, if the approximately 6,000 afa perennial yield of the MST basin is deducted from the 27,900 afa, the perennial yield of the main valley area is approximately 21,900 afa

The United States Geological Survey (USGS) in the 1973 report of *the Groundwater Hydrology of Northern Napa Valley, California* estimated that the groundwater basin north of Oak Knoll Road could yield approximately 24,000 afa without a significant decline in groundwater elevations. If one were to adjust this number to account for additional yield for those areas south of Oak Knoll, several thousand additional acre-feet of basin yield would be available. Therefore, based on the three different and independent methodologies (references) presented above which were used to estimate the perennial yield of the Main Basin, for the purposes of this study, we will adopt a perennial yield estimate of 28,000 afa for the Main Basin.

Present depth to groundwater measurements in the Napa Valley floor typically vary between 5 and 20 feet below ground surface, and annual groundwater level measurements indicate water levels to be very stable, indicating that the groundwater basin is not in an overdrafted condition.

As presented in Tables 2 and 3, we have estimated that the 2020 and the 2050 unincorporated water demands in the Main Basin will probably exceed supplies during normal climatic conditions. This increase in demand is most likely due to vineyard densification and some increases in irrigated acreages. Using these estimates, it appears that the perennial yield of the groundwater basin alone cannot supply the difference between estimated demands and supplies in and beyond the year 2020 during normal climatic conditions.

In 1960, the USGS published *Geology and Groundwater in Napa and Sonoma Valleys, Napa and Sonoma Counties*, Water Supply Paper (WSP) 1495. This report identified groundwater storage in the northern Napa Valley (north of Oak Knoll Road) to be approximately 245,000 acre-feet, and an additional 60,000 acre-feet of storage available in the southern Napa Valley, for a total storage of about 300,000 acre-feet.

Assuming that the annual perennial yield of the Main Basin is approximately 28,000 afa, and the available storage in the Main Basin is 245,000 af, then approximately ten percent of the groundwater basin's available storage capacity is being utilized for "working storage" or seasonal use. However, this also means that 90 percent of the available storage, or over 200,000 af of water in the groundwater basin is not being utilized, and is available for drought protection and/or emergency use. If groundwater is used to supply the difference between demands and the available surface and recycled supplies in 2050 during normal water years, the Main Basin would need to supply approximately 33,640 af per year, or approximately 5,640 af/yr beyond the estimated available perennial yield of the basin.

This analysis demonstrates two key points:

1. The projected demand increase on the Main Basin due to growth in the unincorporated areas will probably exceed the annual perennial yield (recharge) capability of the groundwater basin. If these demands (and corresponding groundwater withdrawals beyond the perennial yield) occur, water levels will begin to decline, as the available basin storage is slowly depleted.
2. If annual demands (withdrawals or pumpage) from the Main Basin can be maintained at or below the perennial yield of the basin, then the storage capacity of the Main Basin (approximately 200,000 af, excluding the seasonal storage), is a valuable groundwater resource that could be further utilized to the benefit of all Napa County residents, particularly during periods of drought and/or other emergency conditions. During periods of wet or above normal rainfall conditions, the groundwater basin will be recharged and storage conditions will return to pre-drought levels.

It should be noted that these estimates of perennial basin yield, future projected agricultural demands and basin storage capacity are based upon the best information currently available, and are appropriate for initial planning level estimates. However, additional, detailed groundwater basin studies and continued groundwater level monitoring should be conducted to verify and refine these planning level estimates. Groundwater levels on at least a semi-annual basis (spring and fall) should continue to be made, and an updated, comprehensive groundwater basin study should also be undertaken to confirm annual pumpage quantities, identify annual recharge quantities and locations, and estimate groundwater storage within the basin.

MILLIKEN-SARCO-TULUCAY SUBBASIN AREA

The 42 square mile Milliken-Sarco-Tulucay Groundwater (MST) watershed area has been extensively studied by the USGS, with particular focus on a 15 square mile area called the Lower MST area (MST Area), located east of the City of Napa. A detailed study of the MST Area was conducted by the USGS in 1977 and again in 2000-2002. The 2002 Lower MST study concluded that the groundwater demand in portions of the MST study area is currently exceeding supplies.

The MST groundwater basin is at least partially separated from the Napa Valley groundwater basin by the Soda Creek Fault. The groundwater basin, therefore, has characteristics separate from the larger Napa Valley groundwater basin.

MST Supply

The existing unincorporated water demand estimated for the MST Area (discussed in more detail in TM 3) for the year 2000 is approximately 3,300 afa and is projected to increase to 4,600 afa by the year 2050. The Lower MST Study (conducted by the USGS) estimated water demands for rural residential, improved open space and vineyards for 2002 and made no estimates of projected water demands. Improved open space has the greatest demands in the MST Area for the year 2000 requiring

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an estimated 47 percent of the total demand. Crop water use by the year 2050 has supercedes improved open space and requires an estimated 43 percent of the total demand.

2000 MST Area Supplies

WYA estimated the 2000 unincorporated water demands of 3,300 afa for the MST Area as shown in Table 3. The USGS Lower MST Study estimated the total quantity of pumped groundwater to average approximately 5,330 afa with all demands being supplied from groundwater. The differences between the Lower MST study and WYA demands are discussed in TM 3. Water demands used in this TM have been calculated by WYA.

Rural residential water demands and improved open space are supplied from the groundwater basin. Improved open space has the largest water demand (1,564 afa) in the MST Area. The combined groundwater pumping of rural residential and improved open space is approximately 2,400 afa or 72 percent of the total demand in the MST Area.

Agricultural water demands consist of winery and crop water demands. Winery demands are supplied entirely from groundwater and use approximately 80 afa. A crop water demand of approximately 850 afa is supplied from surface water and groundwater, with the majority of the water supply from groundwater. Using the SWRCB database, the surface water supply is conservatively estimated at 250 afa or approximately 30 percent to the crop water demand. Surface water demand is anticipated to remain constant through the year 2050.

As shown in Table 4, groundwater supplies over 90 percent of the total water demands in the MST Area. Surface water supplies the remaining 8 percent of the unincorporated water demand.

Table 4. Estimated 2000 MST Area Unincorporated Water Supply Sources

	Demands		Supplies						
			Groundwater[b]		Surface Water		Recycled Water		
	Estimated Demand, afa	Percent of Total Demand	Quantity, afa[c]	Percent of Supply	Quantity, afa	Percent of Supply	Quantity, afa	Percent of Supply	Total Supply, afa
Rural residential	800	24	800	100	—	—	—	—	800
Improved open space[a]	1,564	47	1,564	100	—	—	—	—	1,564
Winery	87	3	87	100	—	—	—	—	87
Crop water use	862	26	612	71	250	29	—	—	862
Total	3,304	100	3,054	92	250	8	—	—	3,304

(a) Improved open space primarily consists of golf courses.
(b) For the purposes of this evaluation, groundwater is assumed to make up the unmet demands not supplied by surface and recycled water.
(c) It is unclear if the MST groundwater basin can sustain these supplies long term.

<u>2020 MST Area Supplies</u>

Total unincorporated water demand in the MST Area is anticipated to increase to approximately 3,700 afa by the year 2020 as shown in Table 5. The majority of this potential increase is from the densification of vineyard, and the conversion of native vegetation to vineyards.

Rural residential demands are anticipated to increase slightly to 850 afa (a 50 af increase) and are supplied from the groundwater basin. Improved open space demand is anticipated to remain constant in and beyond 2020. A recycled water supply of 250-1,020 afa for use in landscape irrigation (improved open space) may be available to the area according to the Draft Recycled Water Master Plan prepared by Larry Walker and Associates in February 2005. A conservative estimate for recycled water of 250 af is assumed to be used in the MST basin by 2020. This reduces the improved open space groundwater demand to approximately 1,300 afa.

Winery water demands are anticipated to increase based upon the increased acreages of vineyards. Winery water demands in 2020 are anticipated to remain on groundwater. Crop water demand is projected to increase to approximately 1,200 afa. Because surface water is considered fully appropriated, it remains at approximately 250 afa. Available recycled water supply of 170-250 afa may be available to meet crop water demands by the year 2020. A conservative estimate of 170 is used in this TM. The additional crop water demand is assumed to be supplied from the groundwater basin.

Even though water demands have increased by 400 af from 2000-2020, groundwater demands have slightly decreased as a result of the assumption that recycled water will be become available in the MST Area. Groundwater demand is anticipated to supply 82 percent (approximately 3,000 af) of the total unincorporated water demand.

Table 5. Estimated 2020 MST Area Unincorporated Water Supply Sources

	Demands		Supplies						
			Groundwater[b]		Surface Water		Recycled Water		
	Estimated Demand, afa	Percent of Total Demand	Quantity, afa[c]	Percent of Supply	Quantity, afa	Percent of Supply	Quantity, afa	Percent of Supply	Total Supply, afa
Rural residential	850	23	850	100	—	—	—	—	850
Improved open space[a]	1,564	42	1,314	100	—	—	250-1020[d]	16	1,564
Winery	99	3	99	100	—	—	—	—	99
Crop water use	1,197	32	777	65	250	21	170-250[e]	14	1,197
Total	3,710	100	3,040	82	250	7	420	11	3,710

(a) Improved open space primarily consists of golf courses.
(b) For the purposes of this evaluation, groundwater is assumed to make up the unmet demands not supplied by surface and recycled water.
(c) It is unclear if the MST groundwater basin can sustain these supplies.
(d) Available recycled water supply is anticipated to range from 250-1,020 afa as reported in the Napa Sanitation District Draft Recycled Water Master Plan, prepared by Larry Walker and Associates, February 2005. The conservative supply estimate of 250 afa of recycled water supply has been used in this table.
(e) Available recycled water supply is anticipated to range from 170-250 afa as reported in the Napa Sanitation District Draft Recycled Water Master Plan, prepared by Larry Walker and Associates, February 2005. The conservative supply estimate of 170 afa of recycled water supply has been used in this table.

2050 MST Area Supplies

Total unincorporated water demand in the MST Area is anticipated to increase to approximately 4,600 afa by the year 2050 as shown in Table 6. The majority of this potential increase is continued from the densification of vineyard and the conversion of native vegetation to vineyards.

Rural residential demands are anticipated to increase slightly to 960 afa (a 160 af increase) and be supplied from the groundwater basin. Improved open space demand is anticipated to remain constant by the year 2050. The available recycled water supply of 250-1,020 afa is anticipated to remain the same. A conservative estimate of available recycled water supply of 250 af is assumed remain available in the MST Area. The improved open space groundwater supply is approximately 1,300 afa.

Winery demands are anticipated to increase based upon the increase acreages of vineyards. Winery water demands in 2050 are anticipated to remain using groundwater. Crop water demand is projected to increase to approximately 1,500 afa. Because surface water is considered fully appropriated, it remains at approximately 250 afa. A recycled water supply of 170-250 afa may be available to meet crop water demands and conservative estimate of 170 afa is used in this TM. The additional crop water demand is assumed to be supplied from the groundwater basin. Groundwater demand is anticipated to supply 85 percent (approximately 4,900 af) of the total unincorporated water demands. Total groundwater demands in the unincorporated areas of the MST Area is 3,900 af in the year 2050.

Table 6. Estimated 2050 MST Area Water Supply Sources

	Demands		Supplies						
	Estimated Demand, afa	Percent of Total Demand	Groundwater[b] Quantity, afa[c]	Groundwater[b] Percent of Supply	Surface Water Quantity, afa	Surface Water Percent of Supply	Recycled Water Quantity, afa	Recycled Water Percent of Supply	Total Supply, afa
Rural residential	960	21	960	100	—	—	—	—	960
Improved open space[a]	1,564	34	1,314	84	—	—	250-1020[d]	16	1,564
Winery	119	3	119	100	—	—	—	—	119
Crop water use	1,958	43	1,538	79	250	13	170-250[e]	9	1,958
Total	4,601	100	3,931	85	250	5	420	9	4,591

(a) Improved open space primarily consists of golf courses.
(b) For the purposes of this evaluation, groundwater is assumed to make up the unmet demands not supplied by surface and recycled water.
(c) It is unclear if the MST groundwater basin can sustain these supplies.
(d) Available recycled water supply is anticipated to range from 250-1,020 afa as reported in the Napa Sanitation District Draft Recycled Water Master Plan, prepared by Larry Walker and Associates, February 2005. The conservative supply estimate of 250 afa of recycled water supply has been used in this table.
(e) Available recycled water supply is anticipated to range from 170-250 afa as reported in the Napa Sanitation District Draft Recycled Water Master Plan, prepared by Larry Walker and Associates, February 2005. The conservative supply estimate of 170 afa of recycled water supply has been used in this table.

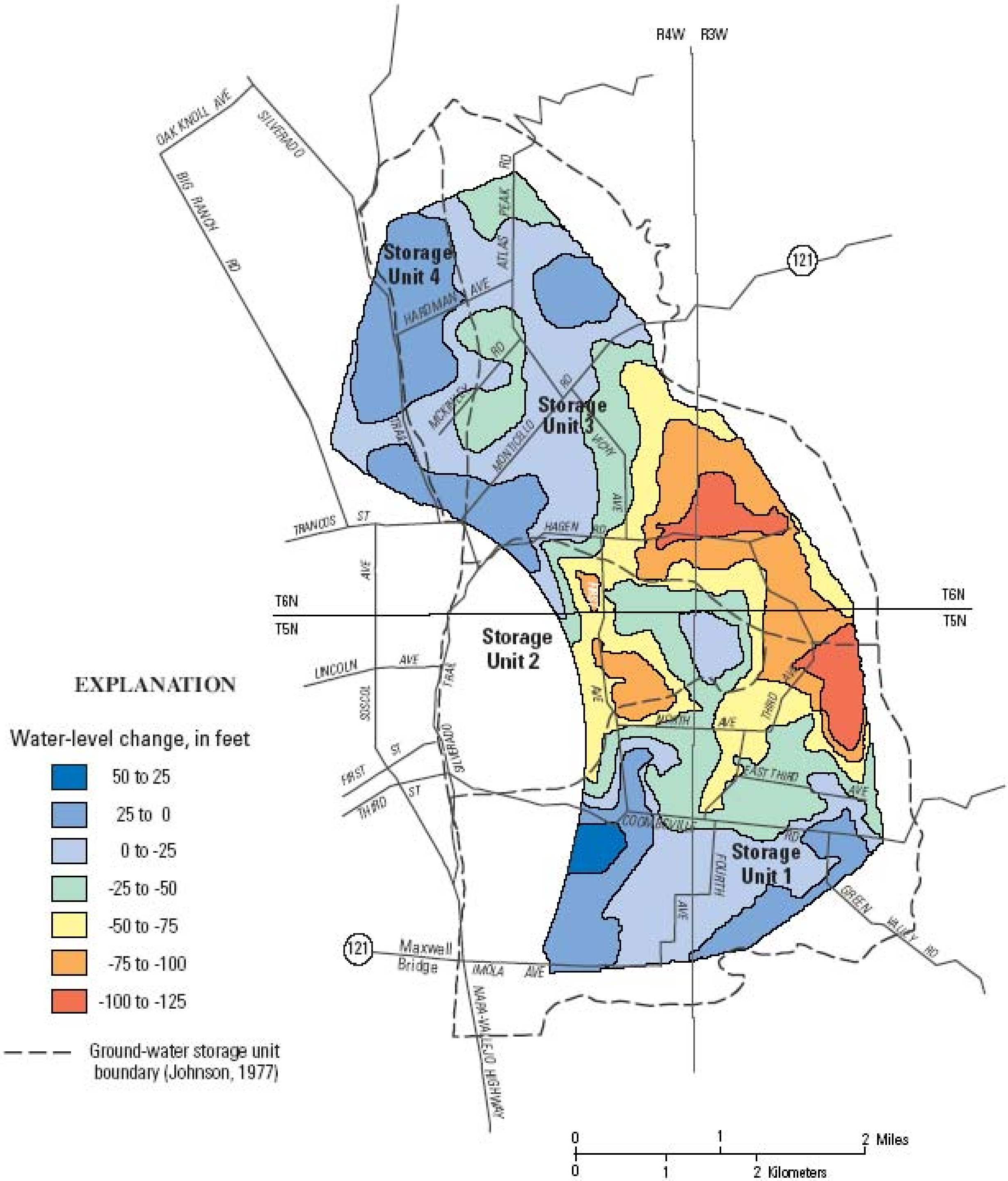
Groundwater Trends

As previously discussed, groundwater is the primary water supply in the MST area. Groundwater levels have steadily declined from 1975 to 2003 in portions of the MST basin while other areas have risen as shown in Figure 11. The rate of decline has increased from the early 1990s to early 2000s. Some areas have declined in excess of 100 feet from 1975 to 2001 and have resulted in two groundwater depressions shown in the MST area as shown in Figure 11.

Hydrographs

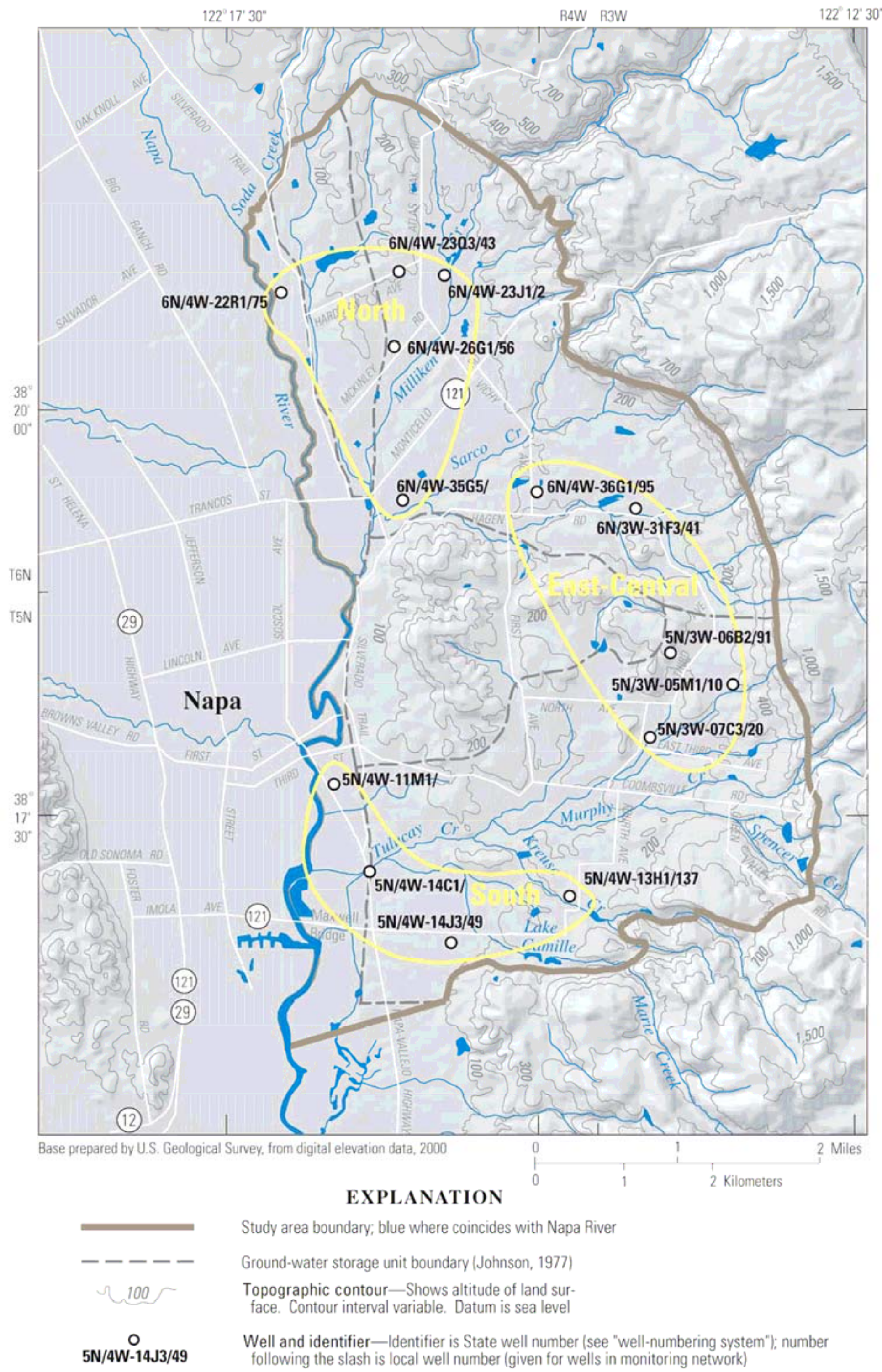
Depth to groundwater measurements from 1960 to 2002 for a number of key wells were reported in the 2002 Lower MST Study. These key wells were grouped into three subareas known as the East-Central, Northern and Southern MST areas, as shown on Figure 12. Hydrographs show spring and fall groundwater measurements and spring-to-spring measurements for these key wells are presented on Figures 13, 14 and 15, and discussed in more detail in the following sections.

Figure 11. Change in Water Levels in the lower Milliken-Sarco-Tulucay Creeks area, Southeastern Napa County, Autumn 1975 to Autumn 2001



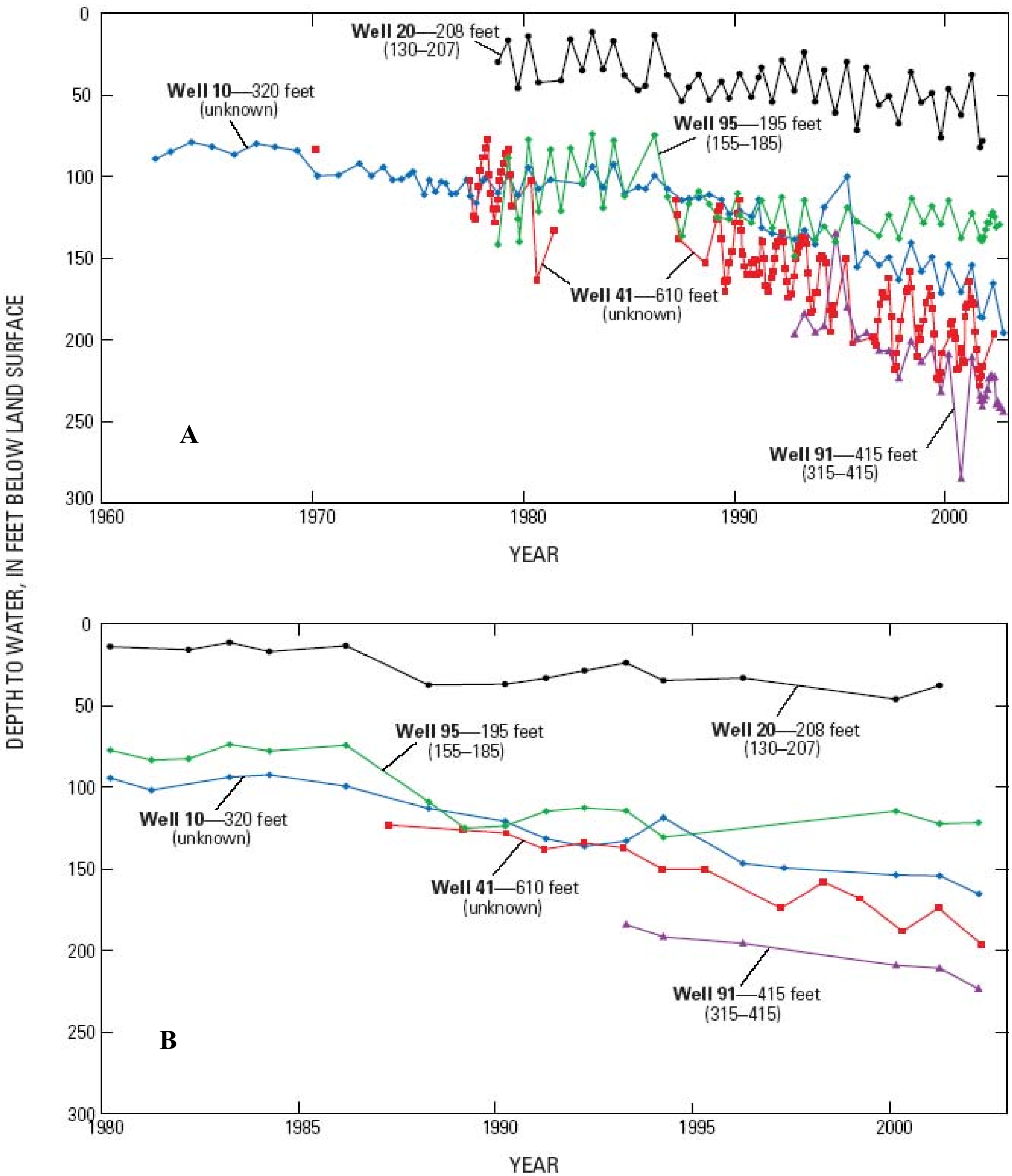
Source: USGS WRIR 03-4229

Figure 12. Map showing locations of selected wells at which periodic water levels were made in lower Milliken-Sarco-Tulucay Creeks area, Southeastern Napa County, California, early 1960s through 2002



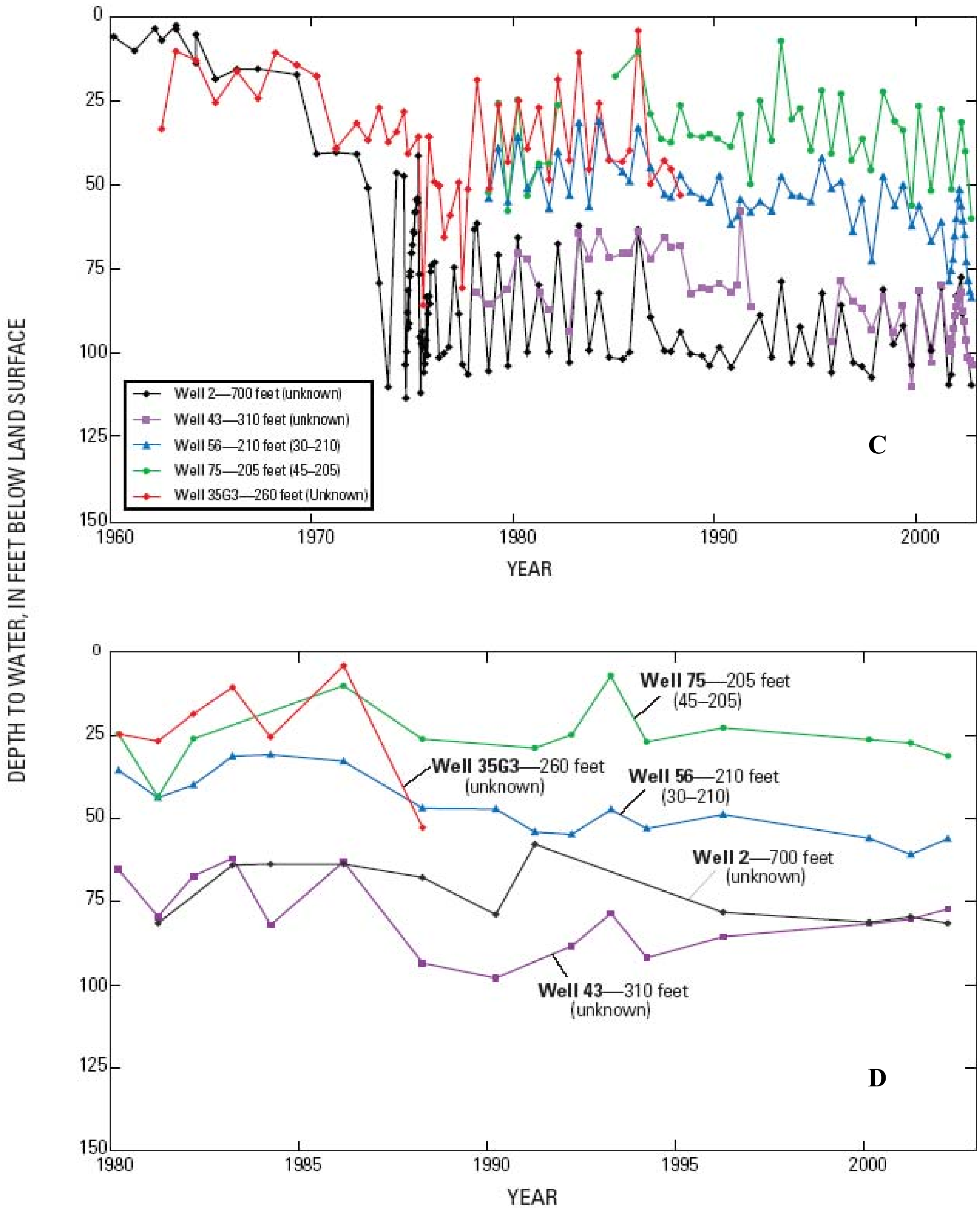
Source: USGS WRIR 03-4229

Figure 13. Graphs showing periodic water levels in selected wells in the lower Milliken-Sarco-Tulucay Creeks area, southeastern Napa County, California, early 1960s through 2002. A, east-central group, all data. B, east-central group, highest water levels measured in spring.



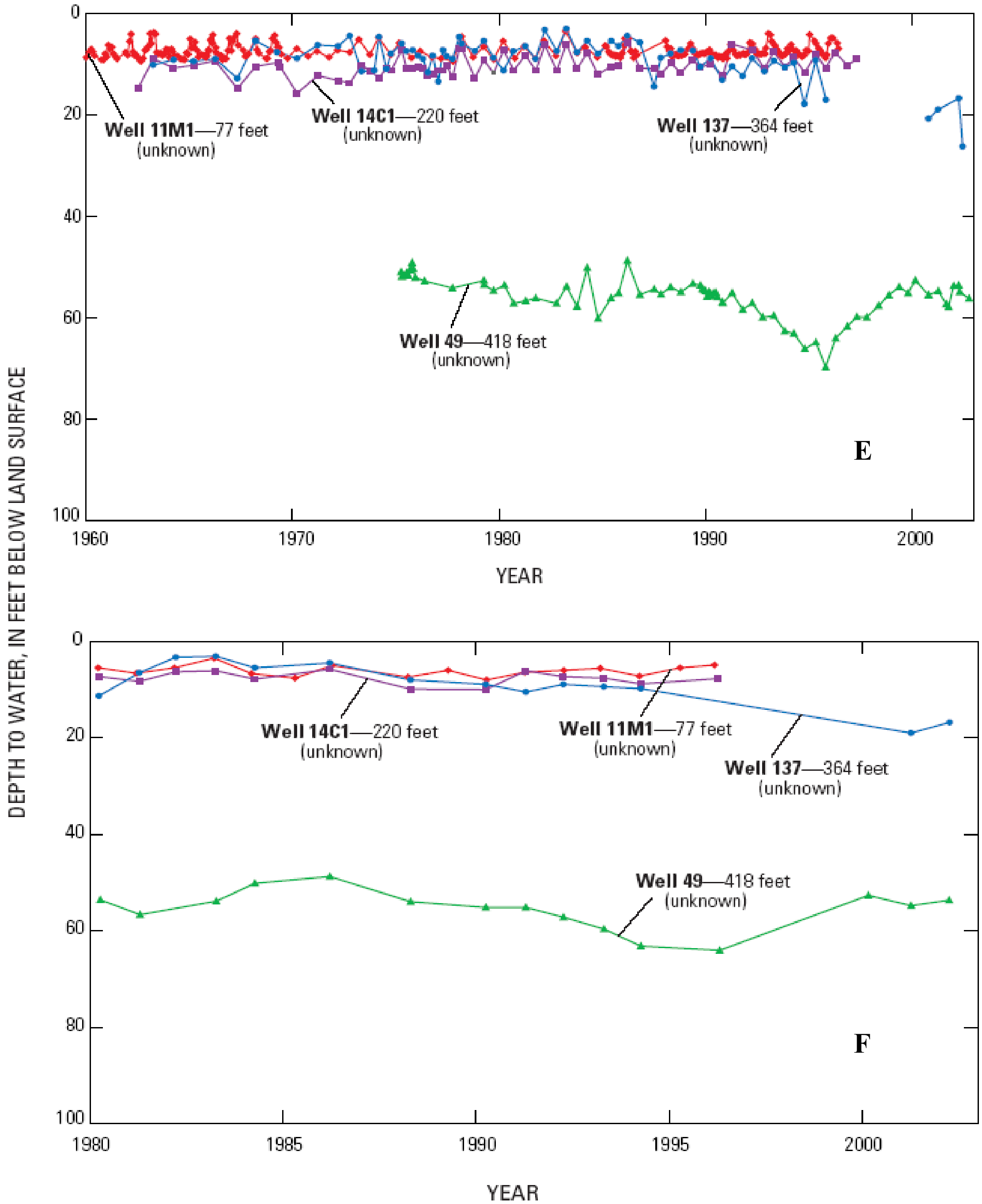
Source: USGS WRIR 03-4229

Figure 14. Graphs showing periodic water levels in selected wells in the lower Milliken-Sarco-Tulucay Creeks area, southeastern Napa County, California, early 1960s through 2002. C, north group, all data, D, north group, highest water levels measured in spring.



Source: USGS WRIR 03-4229

Figure 15. Graphs showing periodic water levels in selected wells in the lower Milliken-Sarco-Tulucay Creeks area, southeastern Napa County, California, early 1960s through 2002. E, south group, all data. F, south group, highest water levels measured in spring.



Source: USGS WRIR 03-4229

Groundwater trends in the East-Central MST study area have been declining significantly since the 1970s, as shown in Figure 13. All of the key wells indicate the continued decline of water levels over time, indicating that groundwater extractions in this area have continued to exceed recharge on an on-going basis.

Groundwater trends in the Northern MST study area have also declined but not to the degree of the East-Central portion of the MST study area as shown in Figure 14. Groundwater trends indicate that the majority of the water level decline occurred between the 1960s and mid 1970s. However, since the 1980s, water levels generally appear to have stabilized, and are no longer declining.

Groundwater trends in the Southern MST area are somewhat mixed, as shown on Figure 15. There are wells within particular portions of this area that have stable groundwater levels, and other wells that show slight groundwater level declines.

Perennial Yield

The long-term decline of groundwater elevations in the different MST areas is most likely a result of localized groundwater extractions exceeding annual groundwater recharge. The recent USGS Report suggests that the perennial yield of the MST watershed is in the range of 6,000 afa. The 2002 Lower MST Study (conducted by the USGS) estimated the individual components of; inflow, outflow, precipitation, surface water discharge to the Napa River and evapotranspiration from the drainage basin to develop an estimate of perennial yield for the MST watershed. However, because of the uncertainty in these estimates, this value should not be construed as the safe yield for the MST Area, and localized conditions could show significant variation in groundwater level trend data due to specific hydrogeologic conditions.

The 1977 USGS study estimated the total amount of groundwater storage in the MST Area to be approximately 195,800 acre-feet, however the usable storage was estimated to be less then 20,000 acre-feet. The 2002 Lower MST Study in which the USGS expanded the work done in 1977, believes that the 20,000 acre-feet was underestimated, however, no refinement of the usable amount of groundwater was made.

Groundwater demand is projected to be approximately 3,900 afa in the year 2050. When compared to the perennial yield of less than 6,000 afa and the declining groundwater levels in portions of the MST Area, it appears that there are localized areas where insufficient recharge and groundwater storage are available, and/or the preliminary estimates of the perennial yield of the MST Basin may be slightly high. To mitigate this situation, existing groundwater demands should be reduced by supplementing existing groundwater use with additional water supplies. Such supplies could include highly treated recycled water and/or non-potable surface water. Groundwater monitoring should also be continued in the MST study area to provide a historical indication of the effectiveness of bringing new supplies into the area.

CARNEROS SUBBASIN AREA

The Carneros subbasin area is one of the fastest growing areas in the Napa Valley, but it also has the least amount of hydrologic information. Previous studies have attempted to define water demands and supplies for this area, but because of the extremely limited data, these studies have been inconclusive at best.

The 1991 James Montgomery study estimated the safe yield of the Carneros groundwater basin to be less than 300 afa based upon the existing geologic formations. As discussed in TM 3, WYA's estimate of the current unincorporated water demand in this area is approximately 2,550 afa and is anticipated to increase to approximately 5,700 afa by the year 2050. Because of the limited data available in the Carneros areas it is difficult to know the existing condition of the Carneros groundwater basin and if the projected demands can be sustained using groundwater.

Rural residential and improved open space water demands are supplied from groundwater as shown in Tables 7, 8, and 9. Rural residential groundwater demands are currently 350 afa and projected to increase to approximately 370 and 420 afa by 2020 and 2050, respectively based upon a growth rate of 0.25 percent per year. The improved open space in Table 7, 8, and 9 consists of the privately owned Oak Knolls golf course. The water supply source for this golf course is currently unknown and is assumed to be groundwater. It is assumed that future improved open space demands will remain constant.

Winery demand in the Carneros area is approximately 250 af in the year 2000 and anticipated to increase to approximately 280 and 310 afa by the year 2020 and 2050, respectively. Winery demands are supplied from the groundwater basin.

Crop water demands are approximately 1,850 afa and are projected to 2,700 and 4,900 afa in 2020 and 2050, respectively if water supplies are available. Current irrigation supply sources include perennial streams and groundwater. Many growers have diverted surface water from various hillsides and creeks and constructed reservoirs to store this water for use during the irrigation season. Using the SWRCB database, surface water supply used for irrigation purposes is estimated to be between 800-1,200 afa. If recycled water supplies are available in the Carneros area by 2020, crop water demands could be met using a combination of ground and recycled water supplies, assuming the groundwater basin can supply the estimated demands shown in Table 8. Groundwater quantities shown in this TM for the Carneros area is for illustrative purposes only and may not be available or sustainable without further studies.

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Table 7. Estimated 2000 Carneros Water Supply Sources

	Demands		Supplies						
			Groundwater[b]		Surface Water		Recycled Water		
	Estimated Demand, afa	Percent of Total Demand	Quantity, afa[c]	Percent of Supply	Quantity, afa	Percent of Supply	Quantity, afa	Percent of Supply	Total Supply, afa
Rural residential	350	14	350	100	—	—	—	—	350
Improved open space[a]	96	4	96	100	—	—	—	—	96
Winery	259	10	259	100	—	—	—	—	259
Crop water use	1,842	72	642-1,042	35-65	800-1,200	43-65	—	—	1,842
Total	2,547	100	1,347-1,747	53-69	800-1,200	31-47	—	—	2,547

[a] Improved open space primarily consists of golf courses.
[b] Sufficient information is unavailable to determine if the groundwater supply exceeds the perennial yield of the Carneros basin.
[c] For the purposes of this evaluation, groundwater is assumed to make up the unmet demand not supplied by surface and recycled water.

Table 8. Estimated 2020 Carneros Water Supply Sources

	Demands		Supplies						
			Groundwater[b]		Surface Water		Recycled Water		
	Estimated Demand, afa	Percent of Total Demand	Quantity, afa[c]	Percent of Supply	Quantity, afa	Percent of Supply	Quantity, afa	Percent of Supply	Total Supply, afa
Rural residential	370	11	370	100	—	—	—	—	370
Improved open space[a]	96	3	96	100	—	—	—	—	96
Winery	278	8	278	100	—	—	—	—	278
Crop water use	2,723	79	0-428	0-16	8,00-1,200	43-65	1,495-2,110[d]	55-77	2,723
Total	3,467	100	744-1,172	21-34	800-1,200	23-35	1,495-2,110	43-61	3,467

[a] Improved open space primarily consists of golf courses.
[b] Sufficient information is unavailable to determine if the groundwater supply exceeds the perennial yield of the Carneros basin.
[c] For the purposes of this evaluation, groundwater is assumed to make up the unmet demand not supplied by surface and recycled water.
[d] Available recycled water supply is anticipated to range from 1,495-2,110 afa as reported in the Napa Sanitation District Draft Recycled Water Master Plan, prepared by Larry Walker and Associates, February 2005 for the Carneros area.

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Table 9. Estimated 2050 Carneros Water Supply Sources

	Demands		Supplies						
			Groundwater[b]		Surface Water		Recycled Water		
	Estimated Demand, afa	Percent of Total Demand	Quantity, afa[c]	Percent of Supply	Quantity, afa	Percent of Supply	Quantity, afa	Percent of Supply	Total Supply, afa
Rural residential	420	7	420	100	—	—	—	—	420
Improved open space[a]	96	2	96	100	—	—	—	—	96
Winery	311	5	311	100	—	—	—	—	311
Crop water use	4,892	86	1,582-2,597	32-53	800-1,200	16-25	1,495-2,110[d]	31-43	4,892
Total	5,719	100	2,409-3,424	42-60	800-1,200	14-21	1,495-2,110	26-37	5,719

[a] Improved open space primarily consists of golf courses.
[b] Sufficient information is unavailable to determine if the groundwater supply exceeds the perennial yield of the Carneros basin.
[c] For the purposes of this evaluation, groundwater is assumed to make up the unmet demand not supplied by surface and recycled water.
[d] Available recycled water supply is anticipated to range from 1,495-2,110 afa as reported in the Napa Sanitation District Draft Recycled Water Master Plan, prepared by Larry Walker and Associates, February 2005 for the Carneros area.

Although several water supply sources are available and being used in the Carneros area, it is nearly impossible to determine the quantity of water from each water supply source with any degree of certainty. With insufficient existing hydrologic information for the Carneros area available to conclusively estimate the quantity of groundwater that can be developed in this area, the following recommendations are made:

- Groundwater monitoring of key wells should be implemented to measure groundwater quantity and quality. Groundwater levels should be measured twice a year preferably spring and fall to track the minimum and maximum groundwater levels, and at least an initial set of water quality samples should be collected to determine baseline conditions.
- A groundwater study should be conducted to detail the geology, existing groundwater conditions and use, and estimate groundwater storage and availability.

ADDITIONAL INFORMATION

Many of the previous groundwater assessments for Napa County, with the exception of the MST area, have been based upon existing reports published in the 1960’s and 1970s’s. Additional geological and hydrogeological data is now available to aid in the interpretation of the groundwater basin. Groundwater levels should continue to be measured twice a year from key wells in the valley, and the program should be reviewed to possibly add additional wells to supplement existing data. To more accurately determine groundwater conditions in the Napa Valley, MST area and the Carneros area the following informational categories are recommended:

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Groundwater Pumping Data – One of most significant unknowns is the volume of pumped groundwater for agricultural use in the Napa Valley. Typically growers do not have meters on their groundwater wells and there is no requirement in the Napa Valley for the growers to report annual amounts of pumped groundwater. The installation of meters on groundwater wells is problematic, however, until meters can be installed on all major groundwater wells, an accurate assessment of the available groundwater resources in the Napa Valley will be extremely difficult to determine.

Updated Geological Information – The most recent comprehensive geological data regarding the Napa Valley groundwater basin is contained in the 1960 USGS Water Supply Paper 1495. This water supply paper uses well driller's logs prior to 1960 to develop detailed basin wide estimates of groundwater storage and perennial yield. Since this report has been published, there has been a period of over 40 years where new geological information could be available from the well drillers logs drilled from 1960 to 2004. Many of these wells could have been drilled deeper than wells in the 1960s. New wells may also be located in areas where wells had not previously been located such as the Carneros area. These additional wells logs could be analyzed to refine the work the 1960 USGS report. These well logs, if available, could be used to refine the groundwater and perennial yield estimates of the Napa Valley and Carneros groundwater basins.

Groundwater Monitoring – Groundwater level monitoring should be continued on a semi-annual basis throughout the Napa Valley. Many of the groundwater wells included in the DWR database did not have long-term groundwater measurements associated with them. Many of the well readings were discontinued for any number of reasons such as budgetary restrictions, well destruction, change of ownership, etc. Other wells contained in the database did not sufficiently or accurately represent long-term groundwater trends in the Napa Valley floor. It is difficult to accurately assess basin wide groundwater conditions based upon these wells. The wells used in this TM were chosen because they had long term water level data, and are thought to be representative of surrounding groundwater conditions.

The greatest need for additional monitoring wells is in the Carneros area. Water demands in this area are anticipated to more than double in the next forty-five years. Groundwater conditions should be established in this area prior to the potential increase in groundwater demands. By establishing groundwater levels now, the potential increased demand on the groundwater basin can be accurately assessed. Historical groundwater trends will be needed to make future groundwater management decisions.

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