WEST YOST & ASSOCIATES
Consulting Engineers


**FINAL**

**TECHNICAL MEMORANDUM NO. 3**

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

TO: Don Ridenhour, Project Manager CC: WATRTAC Members

FROM: Gerry Nakano, Project Manager
J. J. Westra, Project Engineer

SUBJECT: 2050 Napa Valley Water Resources Study
Unincorporated Water Demands

## SUMMARY OF FINDINGS/CONCLUSIONS

This TM summarizes the existing (year 2000) and projected (year 2050) unincorporated water demands within the Napa Valley 2050 Water Resources Study Area (Study Area). The unincorporated water demands include: rural residential, improved open space (golf courses), wineries and crop water demands. Unincorporated water demands are estimated to be approximately 39,500 acre-feet annually (afa) in the year 2000 and are projected to increase up to approximately 51,500 afa in the year 2050. This increase in agricultural demand is predominately a result of existing vineyards ultimately being converted to denser plantings.

The TM outlines data sources, and procedures for determining existing and future unincorporated water demands for the Study Area. Total demands currently anticipated for the Study Area are based on unit water demands for various regions and sub-regions in the Study Area.

## SUMMARY OF PROCEDURES

Unincorporated water demands discussed in this Technical Memorandum (TM) are divided into Non-agricultural and agricultural categories. Non-agricultural water demands in the unincorporated areas consist of rural residential and improved open space (golf courses). Agricultural water demands consist of winery and crop water demands. Because the majority of lands within the Study Area are vineyards, significantly more detail regarding vineyard demands are discussed in this TM.

To determine the existing (year 2000) and projected (year 2050) unincorporated water demands for the Study Area, the following methodology was employed. The rural residential population was multiplied by a per capita water demand to calculate the rural residential water demand. A rural residential growth rate of 0.25 percent per year was used to project the population. The projected population was then multiplied by the same per capita water demand to calculate the 2050 water demand. The land area of improved open space (golf courses) was multiplied by the

appropriate unit water demand factor to calculate the water demand of improved open space. Improved open space water demands were held constant in the 2050 projection.

Winery water demand was based on vineyard acres multiplied by a unit water demand factor for wineries based on vineyard acreage. Future water demands were based upon the increased number of vineyard acres planted in 2050. Potential Napa Valley irrigated agricultural land uses were grouped into three categories consisting of vineyards, non-vineyard agricultural land, and native vegetation. To determine existing water demands, land use categories were multiplied by the appropriate unit water demands based upon location and corresponding micro-climate water demands within the Napa Valley. Future crop water demands were estimated by assuming the conversion of all existing vineyards to a denser (4-foot by 6-foot) vine spacing, and the conversion of some portions of native vegetation land use areas with slopes of less than 30 percent to a dense vineyard spacing by the year 2050. All existing non-vineyard agricultural land use areas (and their corresponding higher water duty factors) were assumed to remain.

## AGRICULTURAL WATER DEMAND

The following data sources were used to calculate the agricultural water demands presented in this TM:

- Aerial photos dated August 2002
- 1999 DWR land use survey
- USGS 30 meter Digital Elevation Model data
- Personal communication with Mr. Steve Soper, Agricultural/Irrigation Consultant from *The Water Works*
- *Groundwater Resources in the Lower Milliken-Sarco-Tulucay Creeks Area, Southeastern Napa County California, 2000-2002*. Published by the U.S.G.S.

Aerial photos were taken of the Napa Valley in August 2002 were used as the basis for this analysis. These photos were used to verify land use as well as background images for various report figures.

The 1999 Land Use data was obtained from the California Department of Water Resources (DWR). Aerial photographs were used by DWR to develop the Land Use survey, taken in late June of 1999. This work was compiled with site visits by DWR staff to verify land uses. The 1999 DWR land use data was used in the Napa 2050 Study since DWR's land use survey more accurately reports land use information. These acreages are also consistent with the 1999 crop report prepared by the Napa County Agricultural Commissioner as discussed in subsequent sections. To remain consistent with future WYA TM's, the demands calculated using the 1999 DWR land use data will be referred to as 2000 water demands.

Napa County's GIS Department prepared and delivered land use data containing a complete parcel GIS database, including land use, and other data, dated April 2003. WYA attempted to use the land use database component, however this database could not be used in the assessment of

agricultural lands because entire parcels were designated as a particular land use type, even if only a small portion of that parcel contained a particular land use type.

For purposes of this study, to define the extent of the Napa Valley floor, USGS 30 meter Digital Elevation Model (DEM) data was downloaded from the California Spatial Information Library (CASIL). This data is based upon a 30-meter by 30-meter pixel grid across the entire Napa County area. The extent of the valley floor was then determined based upon aerial photos and lines of equal elevation as topography generally increases from south to north up the axis of the valley.

Percent slope for areas within the Study Area was derived from the DEM using ArcGIS Spatial Analyst Version 8.2. This software was able to calculate average slopes using the DEM data generated at the center of the 30-meter by 30-meter pixels to define areas into the following slope categories; 0-5%, 5-20%, 20-30%, and greater than 30 percent. These categories were used to define locations that could and could not be converted to vineyard lands in the future, due to the physical limitation of farm equipment to climb terrain having a slope greater than 30 percent.

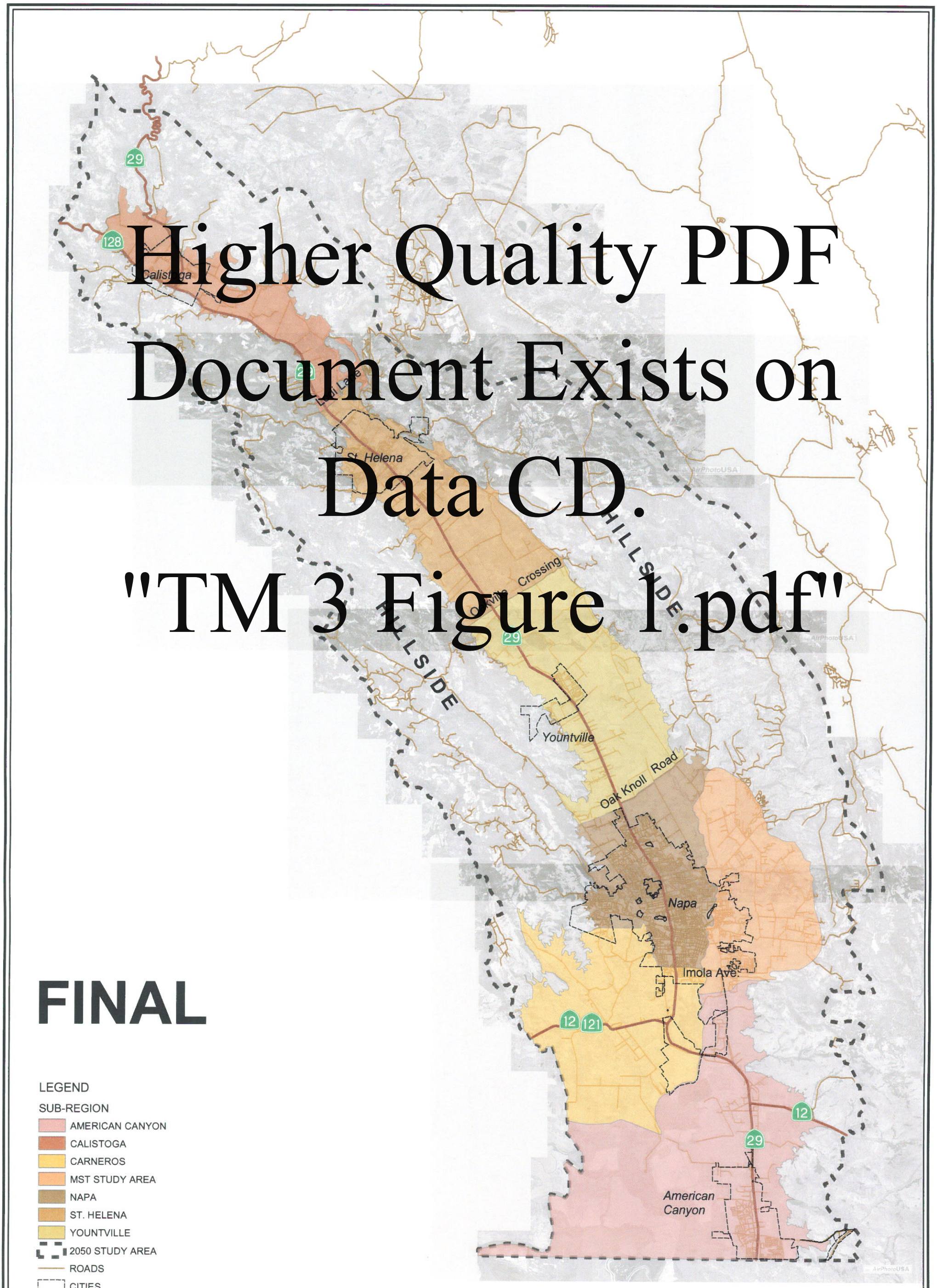
Mr. Steve Soper from *The Water Works* was consulted regarding crop water demands within the Study Area. Discussions were based upon Mr. Soper's knowledge of the Napa Valley. Various topics of discussion included: water demand factors, existing and future agricultural patterns, and identification of various micro-climate locations. Mr. Soper's discussion with other growers and vineyard managers in the Napa Valley verified the water use factors discussed in this TM.

## PROCEDURES

Based upon discussions with Mr. Soper the Study Area was divided up into eight sub-regions. The sub-regions were based upon several factors that included: micro-climate, land use, geological features, appellations, and landmarks. The eight sub-regions are described in Table 1 and are spatially shown in Figure 1.

**Table 1. Sub-region Description**

| Sub-region Number | Sub-region Name | Sub-region Description |
|---|---|---|
| 1 | Calistoga | North Study Area Boundary south to Lodi Lane |
| 2 | St. Helena | Lodi Lane south to Oakville Crossing |
| 3 | Yountville | Oakville Crossing south to Oak Knoll Road |
| 4 | Napa | Oak Knoll Road south to Imola Avenue |
| 5 | MST Study Area | Napa River east to Base of Howell Mountains |
| 6 | Carneros | Based upon the Carneros Appellation |
| 7 | American Canyon | Imola Avenue south to Napa County Line |
| 8 | Hillside | Outside of valley floor yet inside 2050 Study Area |




# FINAL

LEGEND

SUB-REGION

- AMERICAN CANYON
- CALISTOGA
- CARNEROS
- MST STUDY AREA
- NAPA
- ST. HELENA
- YOUNTVILLE
- 2050 STUDY AREA
- ROADS
- CITIES

NOTE:
-

N

0 1 2 Miles

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**Figure 1**

**NAPA COUNTY FC&WCD**
**2050 NAPA VALLEY WATER RESOURCES STUDY**
**VALLEY SUB-REGIONS**

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The hillside sub-region is not included in the water demand analysis section of this TM. Generally, the cost of installing water system infrastructure from the valley floor area to these more remote hillside areas will be uneconomical and more localized water supplies will have to be developed if these areas are to become irrigated agricultural area. Therefore, water demands for the hillside sub-region would not be supplied from the groundwater basin beneath the Napa Valley floor, and this sub-region water demand were not considered in this Study Area.

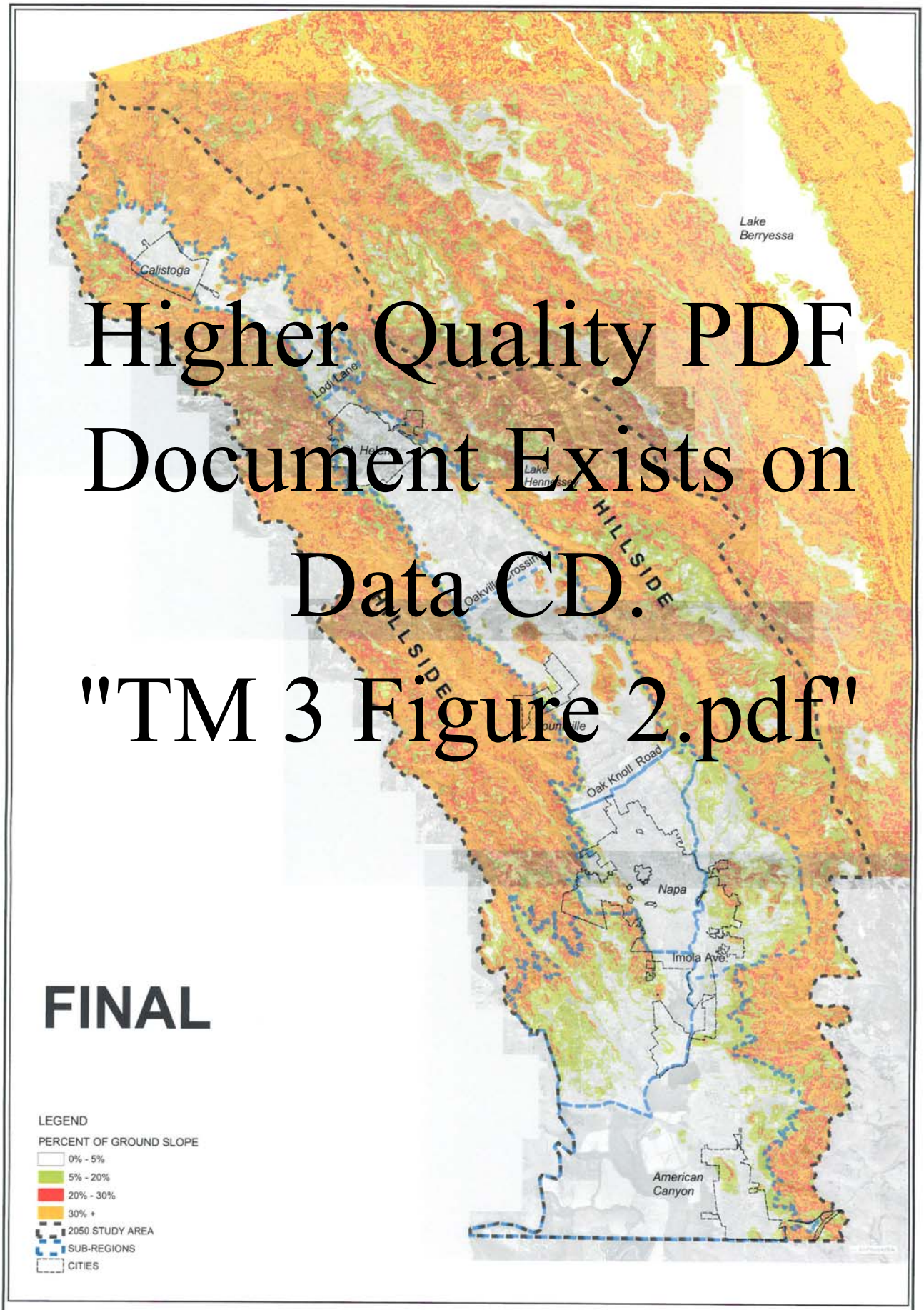
The various land use categories from the 2000 DWR land use survey were analyzed using ArcGIS for each sub-region. The various land uses were grouped into three basic categories: existing vineyards, existing non-vineyard agricultural lands and native vegetation. Non-vineyard agricultural lands consisted of: Subtropical (citrus), Deciduous Trees (apples, cherries, etc), Truck Crops (lettuce, melons, onions, etc), Pasture, Idle Lands and Grain (wheat, barley, etc). Each of the three basic land use categories were multiplied by a water duty factor to determine crop water demand. Because the water demand for existing non-vineyard agricultural lands is actually greater than the water demand if these lands were to be converted to vineyards, for the purposes of this Study, it was assumed that these areas would remain non-vineyard agricultural into the future.

Native vegetation was classified within Napa Valley. Native vegetation was not shown for those areas with slopes greater than 30 percent for clarity purposes, as these slopes are steeper than existing farm equipment can climb. Native vegetation consists of trees and grasses that occur naturally within the Napa County. This land is not irrigated and survives off of natural precipitation.

Areas of native vegetation were overlaid with the percent slope map shown in Figure 2 to identify areas of native vegetation which are growing on slopes of less than 30 percent. It is significant to note that 30 percent slope criteria is the theoretical maximum land slope on which vineyards can presently be planted on within Napa County. (There are several county ordinances that prohibit the conversion of land greater than 30 percent to vineyards, and it is extremely difficult for vineyard equipment to climb a 30 percent slope). For the purposes of this Study, it was assumed that the estimated acreage of native vegetation less than 30 percent slope would be converted to vineyards by the year 2050.

The DWR land use survey which contained the native vegetation land use category also had to be adjusted in several areas. One area was the Napa County airport which was classified as native vegetation. Because one of the purposes of the 2050 Study is to project the number of acres of native vegetation that could be converted to vineyards in the future and since there is little potential for the airport to convert to an irrigated agricultural area, this area was not considered as land that was available for conversion to vineyards by the year 2050.

A second example would be the northern portions of the Napa River. While it would be correct to classify the Napa River as native vegetation, this land cannot be converted to vineyards in the future. These land types were removed from the database as possible future vineyard sites. Approximately 7,700 acres originally classified as native vegetation was not considered to be available for conversion in our water demand calculations. The net of these calculations produce a total native vegetation acreage of approximately 30,400 acres.




Higher Quality PDF Document Exists on Data CD.

"TM 3 Figure 2.pdf"

Existing and future water demands for vineyards were assigned for each of the various sub-regions. The unit water demands were based upon discussion with Mr. Soper. Total unit water demands for vineyards included heat and frost protection. The average vine spacing for existing vineyards was six feet by ten feet, which results in 726 vines per acre. Vine densification was assumed to occur in the future, and future vine spacing was assumed to average four feet by six feet, which results in a density of 1,815 vines per acre.

Vines planted at a density of 726 vines per acre are irrigated from 100 to 250 gallons per vine per year, while vines planted at a density of 1,815 vines per acre are irrigated at 100 to 110 gallons per vine per year (depending on micro-climate location).

For existing non-vineyard irrigated agricultural lands, no distinction was made between actual crop types. The acreages were summed together and an average unit water demand of three acre-feet per acre per year was assigned to this category. Because the water demand on existing non-vineyard irrigated agricultural land is actually greater than the water demand if these lands were to be converted to vineyards, for the purposes of this Study, it was assumed that these area would remain irrigated non-vineyard agricultural land into the future.

Total crop water use for the Study Area was calculated by multiplying the unit water demands by the total number of acres in each sub-region and then summing all of the sub-region demands. Future water demands were calculated in a similar manner. It was assumed the existing vineyards planted at 726 vines per acre and native vegetation existing on slopes of less than 30 percent would be converted to vineyards, at a density of 1,815 vines per acre by the year 2050.

## NON-AGRICULTURAL WATER DEMANDS

Non-agricultural water demands in the unincorporated areas of the Study Area consist of rural residential and improved open space. The rural residential population is primarily contained in the communities of Angwin and Deer Park and on the Napa Valley floor, outside of the incorporated areas. The improved open space areas consist of cemeteries, golf courses and public institutions.

### Rural Residential

The Napa Valley rural residential population is spread throughout the County, but is found in greater concentration in the communities of Angwin and Deer Park, both located north of St. Helena. As of the 2000 Census, there were 3,148 residents of Angwin, and 1,433 residents of Deer Park, for a total of 4,581 for the two communities. The 1990 Census and the 1980 Census indicated a population of 5,328 and 4,980, respectively for the two communities. The 1991 Study estimated a County rural residential total population of approximately 23,300 persons as of 1990.

The Study Area for this project includes Deer Park, but does not include Angwin or the rural areas around Lake Berryessa. The total rural population within the current project's Study Area is approximately 20,600 persons, of which approximately 13,700 live on the valley floor, 4,800 live in the Milliken-Sarco-Tulucay region north and east of Napa as reported by the 2002 USGS MST study, and 2,100 live in the Carneros region west of Napa. A unit water use factor of 150 gallons

per capita per day was assigned to rural residential areas. The estimated water demands for these residents are summarized in Table 2.

**Table 2. Estimated Existing and Projected Rural Residential Water Demand**

| Region | 2000 | | 2020 | | 2050 | |
|---|---|---|---|---|---|---|
| | Population | Water Demand, afa[(a)] | Population | Water Demand, afa | Population | Water Demand, afa |
| Main Basin[(b)] | 13,700 | 2,300 | 14,430 | 2,420 | 15,520 | 2,750 |
| MST[(c)] | 4,800 | 800 | 5,045 | 850 | 5,440 | 960 |
| Carneros[(d)] | 2,100 | 350 | 2,200 | 370 | 2,380 | 420 |
| Total | 20,600 | 3,450 | 21,675 | 3,640 | 23,340 | 4,130 |

[(a)] Water demand assumes a water use factor of 150 gallons per capita per day.
[(b)] Main Basin includes the valley floor.
[(c)] MST (Milliken-Sarco-Tulucay) is the lower watersheds of those creeks, north and east of Napa.
[(d)] Carneros is the region west of Napa that drains into the Carneros Creek.

A rural residential growth rate of 0.25 percent per year was used to project water demands to 2050 although between the 1990 and 2000 census years, the rural residential population actually decreased by approximately 0.25 percent per year.

**Improved Open Space**

Improved open space consists of cemeteries, golf courses and public institutions although the primary land use in this category in the unincorporated portions of the Napa Valley is golf courses. Chardonnay Vineyard golf course and Eagle Vines golf course are the only improved open space areas identified in the unincorporated areas of the Main Basin. The two golf courses identified in the MST region are Silverado and Napa Valley Country Club, and the improved open space area is taken directly from the 2002 USGS MST study. The only golf course in the Carneros region is the privately owned Vineyard Knolls golf club.

Due to the amount of improved open space compared to other areas, discussed in more detail in subsequent sections of the TM, the unit water demands are not based upon micro-climates and are assigned a constant unit water demand of 4 af/ac as used in the 2002 USGS MST Study. Due to the cost of land, it is assumed that these golf courses would not expand and the areas are held constant under future conditions. The estimated existing and projected improved open space is shown in Table 3.

**Table 3. Estimated Existing and Projected Improved Open Space Water Demand**

| Region | 2000 | | 2020 | | 2050 | |
|---|---|---|---|---|---|---|
| | Area, ac | Water Demand, afa[(a)] | Area, ac | Water Demand, afa[(a)] | Area, ac | Water Demand, afa[(a)] |
| Main Basin[(b)] | 278 | 1,111 | 278 | 1,111 | 278 | 1,111 |
| MST[(c)] | 391 | 1,564 | 391 | 1,564 | 391 | 1,564 |
| Carneros[(d)] | 24 | 96 | 24 | 96 | 24 | 96 |
| Total | 693 | 2,771 | 693 | 2,771 | 693 | 2,771 |

[(a)] Water demand assumes a water use factor of 4 acre-feet annually per acre.
[(b)] Main Basin includes the valley floor.
[(c)] MST (Milliken-Sarco-Tulucay) is the lower watersheds of those creeks, north and east of Napa.
[(d)] Carneros is the region west of Napa that drains into the Carneros Creek.

## AGRICULTURAL WATER DEMANDS

The primary agricultural water demands in the Napa Valley are vineyard related. Agricultural water demands consist of winery and crop water demands. Because the Napa Valley is extensively irrigated, significantly more detail regarding crop water demand is presented in the following section of this TM.

### Winery Water Demand

Winery water demands for the unincorporated areas of the County were calculated by WYA using the Final Environmental Impact Report for the Napa County Winery Definition Ordinance (LSA Associates December 1989), the Napa County Wine Industry Growth Master Environmental Assessment, Part III Industry Projections (Agland Investment Services, Inc., December 1989), information provided by growers, and WYA estimates of projected vineyard areas as discussed in the following section.

In the above referenced documents, winery growth was projected to the year 2010. Continuing the projected growth through the year 2050 resulted in unreasonably high estimates of winery water demand. It is generally believed that the winery growth cannot exceed vineyard production due to the Winery Definition Ordinance, which limits the amount of wine grapes that a winery can import and still claim to be a “Napa Valley” wine. Under the Winery Definition Ordinance, a “Napa Valley” winery can import up to 25 percent of the wine grapes used in the production of the wine.

Therefore, WYA calculated an estimated gross unit water demand for wineries. This estimate takes into consideration historical winery water demands that, prior to the Winery Definition Ordinance, allowed greater than 25 percent of the grapes used in a “Napa Valley” label to be imported from outside the County. Thus, the projected water demands could be considered to be

conservative. Because the only parameter related to wine production and winery water use that was projected to the year 2050 was vineyard acreages, WYA normalized the current winery water demand per vineyard acre by using the following factors calculated from data in the Winery Ordinance Environmental Impact Report:

- Tons of grapes per acre
- 25 percent imported grapes
- Gallons of wine per ton of grapes
- Gallons of water per gallon of wine

WYA found the total projected winery water demand is considerably smaller than the water demand required to irrigate the actual vineyards, or the M&I water demand (discussed in TM 2). Therefore, any variability in the winery water demand calculations will essentially be inconsequential to the total Napa Valley water supply and demand situation.

WYA calculated the approximate winery water demand to be 12,350 gallons per year per acre of vineyard, which is larger than the more typical factor of approximately 7 gallons of water demand per gallon of bottled wine.

Although wineries are not necessarily located adjacent to the respective vineyard, it was assumed winery water demands would be proportional to the amount of vineyards planted in each sub-region.

The estimated area of vineyards and the estimated existing and projected winery water demands are shown in Table 4.

**Table 4. Estimated Existing and Projected Winery Water Demand**

| Region | 2000 Vineyard Area, ac | 2000 Winery Demand, afa | 2020 Vineyard Area, ac | 2020 Winery Demand, afa | 2050 Vineyard Area, ac | 2050 Winery Demand, afa |
|---|---|---|---|---|---|---|
| Main Basin | 25,689 | 974 | 26,970 | 1,022 | 29,012 | 1,100 |
| MST | 2,301 | 87 | 2,640 | 99 | 3,134 | 119 |
| Carneros | 6,823 | 259 | 7,345 | 278 | 8,203 | 311 |
| Total | 34,813 | 1,319 | 36,919 | 1,400 | 40,349 | 1,530 |

Crop Demands

The Napa Valley floor was subdivided into seven sub-regions. The Main Basin consists of sub-regions 1-4 and sub-region 7 as previously shown in Figure 1. The MST Study Area and the Carneros area are sub-regions 5 and 6, respectively. Existing and projected crop water demands are discussed in the following section.

*Existing Crop Water Demands*

Areas of cropped lands were calculated using 2000 DWR land use survey as shown in Figure 3. There were approximately 34,800 acres of vineyards and approximately 2,200 acres of non-vineyards grown within the valley floor including MST and Carneros areas as shown in Table 5. All types of vineyards such as, bearing, non-bearing, black, and white vine varieties were accounted for. It was assumed that the existing vineyards were planted on an average spacing of six feet by ten feet, which equates to 726 vines per acre.

**Table 5. Existing Crop Water Demands**

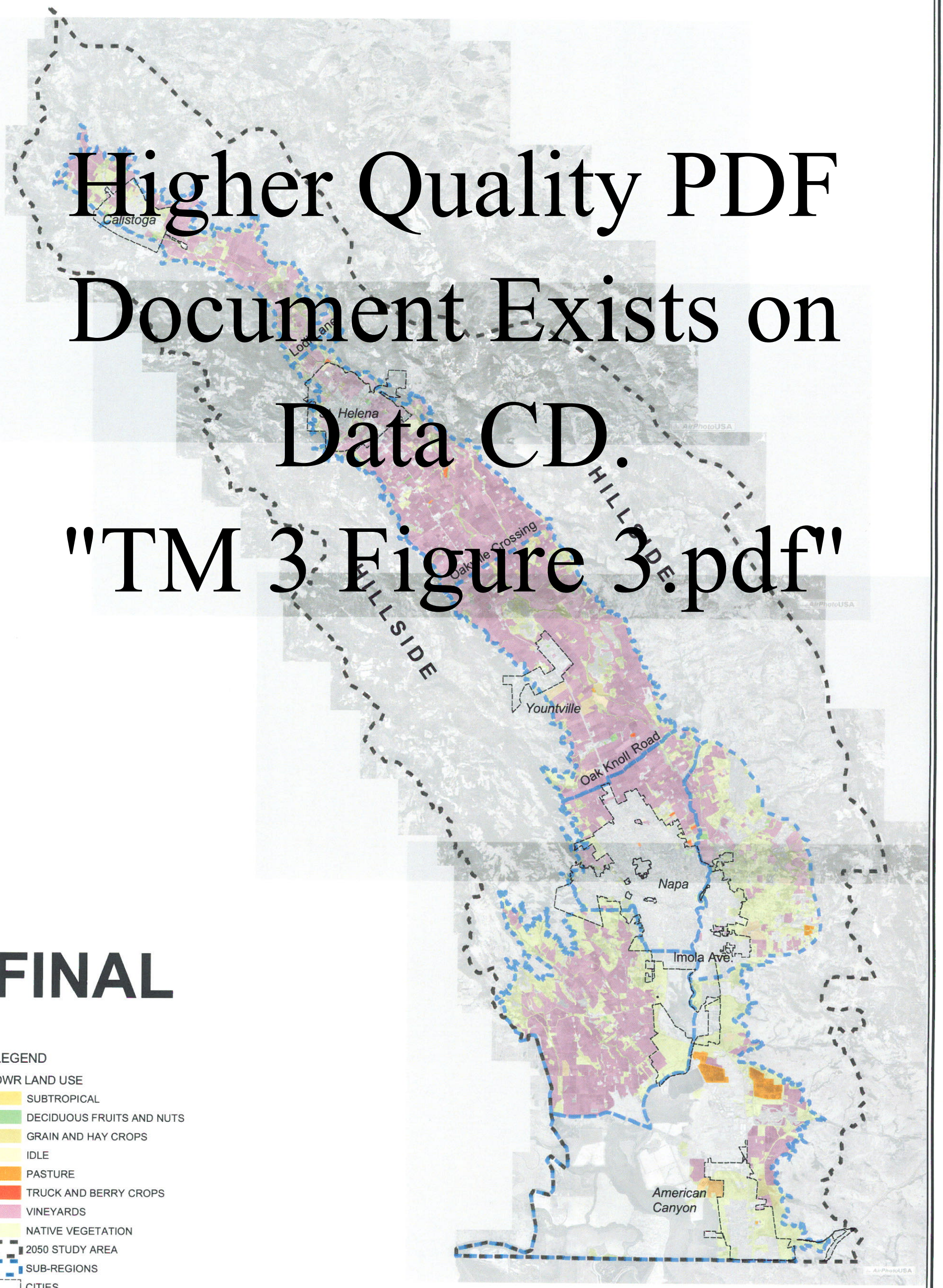
| (1) Sub-region Number | (2) Sub-region Name | (3) Annual Water Duty, gallons per vine | (4) Frost and Heat Protection, af/ac | (5) Annual Total Water Duty, af/ac | (6) Vineyard Area, ac[(a)] | (7) Non-Vineyard Agricultural Area, ac[(b)] | (8) Total Annual Crop Water Demand, afa |
|---|---|---|---|---|---|---|---|
| 1 | Calistoga | 250 | 0.5 | 1.06 | 4,051 | 108 | 4,606 |
| 2 | St. Helena | 200 | 0.5 | 0.95 | 8,519 | 197 | 8,647 |
| 3 | Yountville | 200 | 0.5 | 0.95 | 9,083 | 573 | 10,308 |
| 4 | Napa | 150 | 0.5 | 0.83 | 2,615 | 79 | 2,419 |
| 5 | MST Study Area | 100 | 0.0 | 0.22 | 2,301 | 116 | 862 |
| 6 | Carneros | 100 | 0.0 | 0.22 | 6,823 | 107 | 1,842 |
| 7 | American Canyon | 100 | 0.0 | 0.22 | 1,422 | 991 | 3,291 |
| Total | | — | — | — | 34,813 | 2,173 | 31,975 |

(a) Average vine spacing 6'x10' or 726 vines per acre.
(b) Annual water duty of non-vineyard agricultural areas in 3 af/ac.

The Napa County Agricultural Commissioner prepares an annual crop report for Napa County. Total vineyard acreages from 1975 to 2003 for Napa County which included bearing and non-bearing vineyards are shown in Figure 4. From 1975 to 2003 vineyard acreages increased by approximately 19,800 acres or 700 acres per year within Napa County. From 2000 to 2003 vineyard acreage has increased at a rate of 1,350 acres per year. Vineyard yields from 1985 to 2003 have declined from approximately 4.0 to 3.3 tons per acre, respectively. This decrease in yield is due to cultural practices and is discussed in the projected 2050 crop water demands section.

Non-vineyard agricultural lands within the valley floor were grouped together as previously discussed to determine their water use. The total irrigated area is approximately 2,200 acres within the valley floor including MST and Carneros areas.

Areas of native vegetation on a slope of less than 30 percent were also calculated. There are approximately 30,400 acres of native vegetation on less than 30 percent slope within the Study Area. Of this 30,400 acre area, only about 5,500 acres is considered to be convertible to vineyards. This reduction was due to existing (non-compatible) land usage, (i.e. airport area, etc.), surrounding land uses, and proximity to rivers and streams. Figure 5 shows the areas of irrigated acreage (all existing agricultural lands) and non-irrigated lands (native vegetation) in the Study Area.




# FINAL

LEGEND

DWR LAND USE

- SUBTROPICAL
- DECIDUOUS FRUITS AND NUTS
- GRAIN AND HAY CROPS
- IDLE
- PASTURE
- TRUCK AND BERRY CROPS
- VINEYARDS
- NATIVE VEGETATION
- 2050 STUDY AREA
- SUB-REGIONS
- CITIES

NOTE:

- Land use data source is: California Dept. of Water Resources, 1999 Land Use Survey.

N

0 1 2 Miles

3/30/05

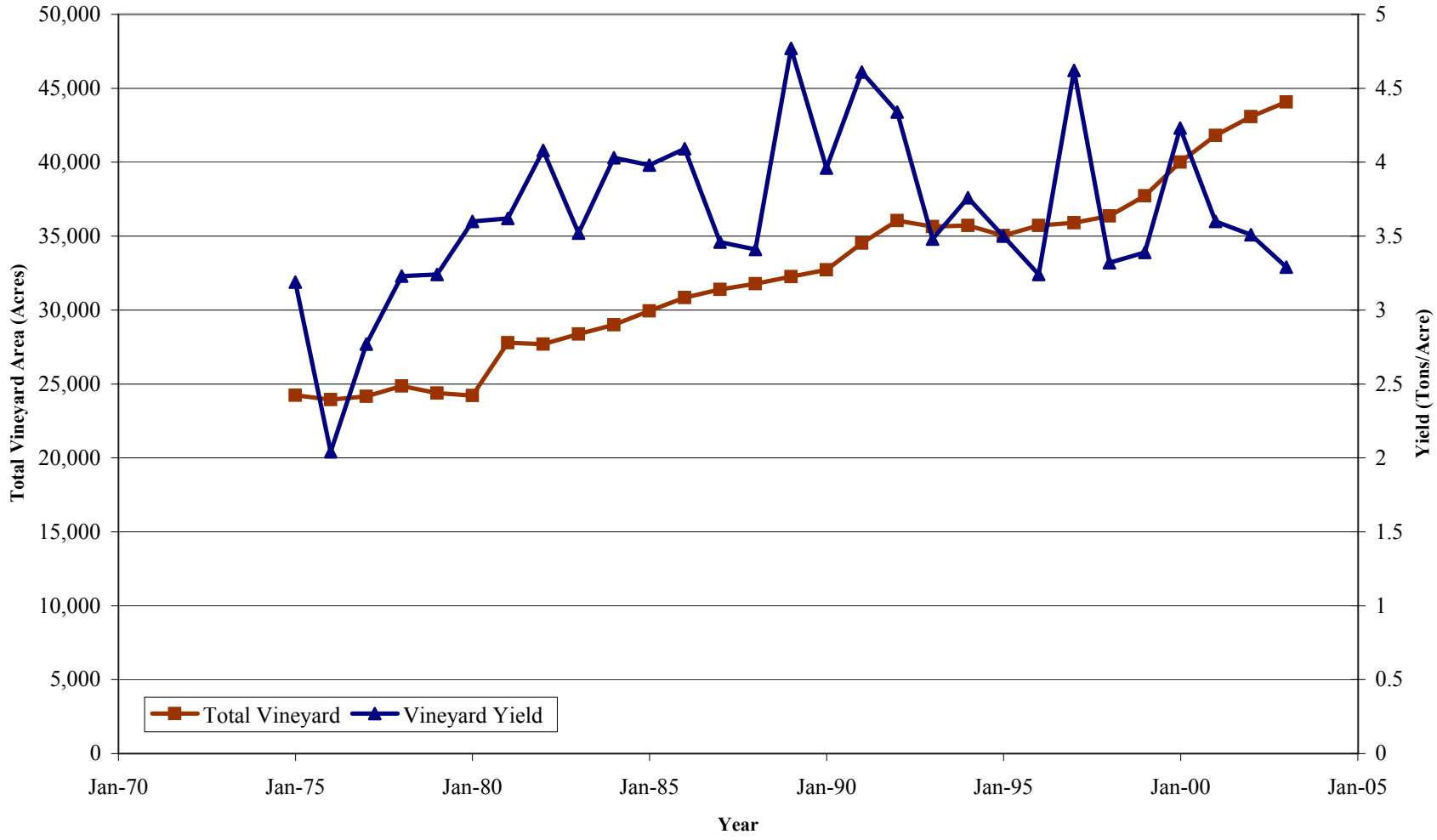
**Figure 3**

**NAPA COUNTY FC&WCD**

**2050 NAPA VALLEY WATER RESOURCES STUDY**
**AGRICULTURAL LAND USE**

WEST YOST & ASSOCIATES

**Figure 4. Napa Valley Wine Grape Acreages**
Napa County Agricultural Crop Report (1975-2003)

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vineyard acreages.xls; yield
Last Revised: 4/7/2005

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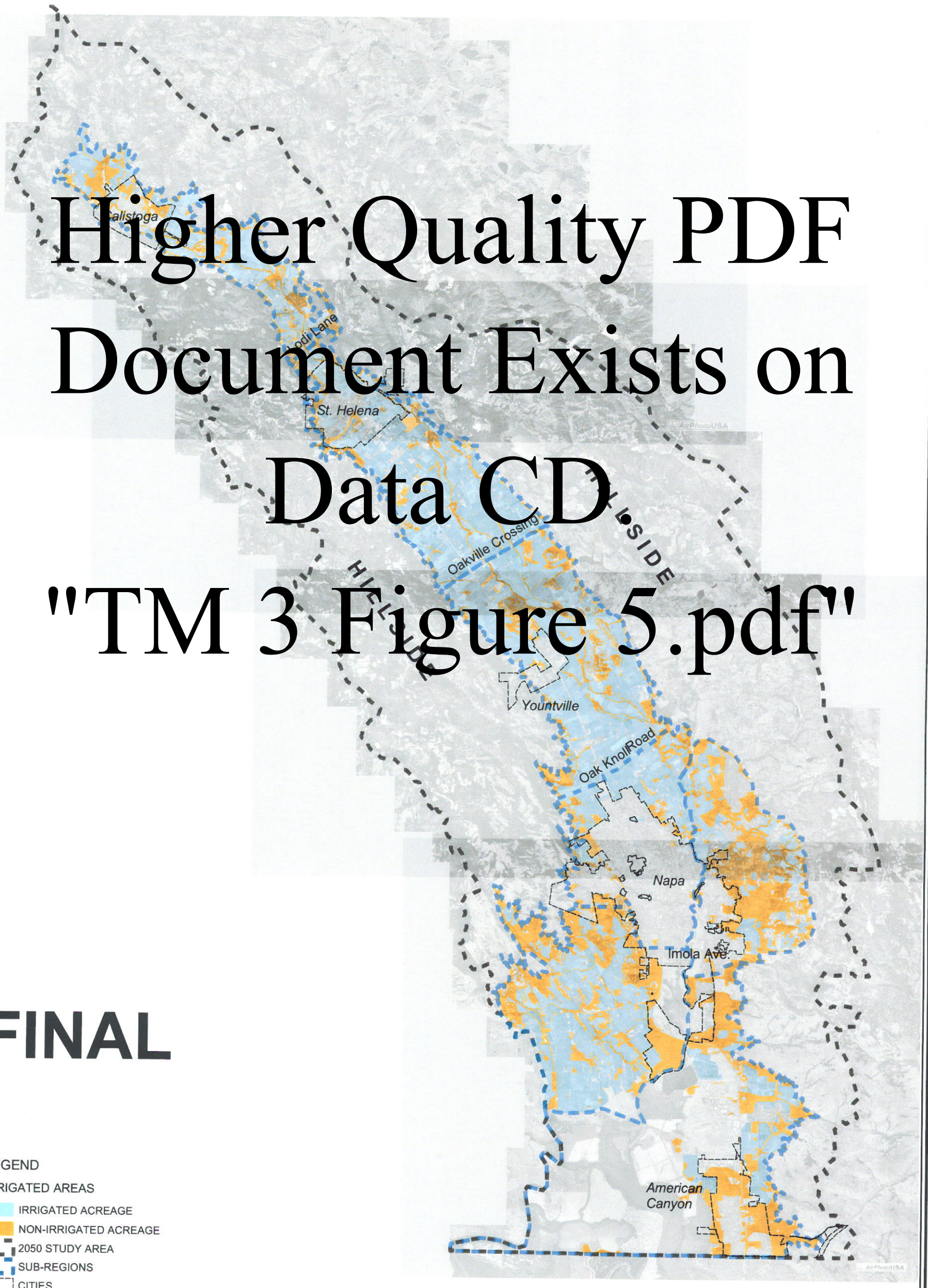


LEGEND

IRRIGATED AREAS

- IRRIGATED ACREAGE
- NON-IRRIGATED ACREAGE
- 2050 STUDY AREA
- SUB-REGIONS
- CITIES

NOTE:

- Land use data source is: California Dept. of Water Resources, 1999 Land Use Survey.

N

0 1 2 Miles

3/30/05

**Figure 5**

**NAPA COUNTY FC&WCD**

**2050 NAPA VALLEY WATER RESOURCES STUDY**

**IRRIGATED AREAS**

WEST YOST & ASSOCIATES

Unit water demands ranged from 250 gallons per vine (gpv) in the northern portions of Napa Valley, to 100 gpv in the southern portions of Napa Valley as shown in Table 5. San Pablo Bay has a direct influence on the climate of the American Canyon and adjacent areas, but does not influence the northern portions of the Napa Valley. This results in a hotter and dryer micro-climate in these northerly sub-regions, and thus a higher unit water demand. Conversely, since San Pablo Bay influences the southern Napa Valley the climate is more moderate which results in lower unit water demand.

Since the climate is milder in the southern portions of the Study Area, frost and heat protection is not needed. However, frost and heat protection is needed in the northern portions of the Study Area. Approximately 0.25 acre-feet per acre were assigned individually for frost and heat protection in the northern portions of the Valley floor. This totals 0.50 acre-feet per acre for both frost and heat protection.

Total water demand, which includes applied water, frost and heat protection, range from 1.06 acre-feet per acre in the north, to 0.22 acre-feet per acre in the south as shown in Table 5.

The acreages of non-vineyard agricultural lands in the valley floor are considered to be relatively small as compared to the acreages of vineyards. Typical unit water demands for these types of crops range from two to four acre-feet per acre per year. For the purposes of the Napa 2050 Study, non-vineyard crop water demands were lumped together in a single category and assigned a unit water demand of three acre-feet per acre per year.

Native vegetation is simply grasses and trees that occur naturally within the Study Area. The water source for native vegetation is typically from rainfall. Therefore native vegetation was not assigned a unit water demand in the water demands because it is not irrigated.

The cities of American Canyon, St. Helena, and Napa supply surface water to agricultural customers within the city boundaries. The combined surface water provided to agricultural customers is approximately 1,566 afa.

Total existing annual crop water demands for the valley floor including the MST and Carneros areas were estimated to be approximately 32,000 acre-feet. This includes applied water, frost and heat protection for vineyards, and non-vineyard irrigated agricultural water demands.

*Projected 2050 crop water demands*

Projected crop water demands were estimated for the year 2050. It was assumed that by the year 2050, all existing vineyards (34,813 acres) would have been replanted at a density of 1,815 vines per acre. The existing non-vineyard agricultural areas (2,173 acres) were assumed to remain in production, and a portion of the current native vegetation acreage with less than 30 percent slope (5,536 acres) was assumed to have been planted as vineyard at a density of 1,815 vines per acre by the year 2050 as shown in Table 6.

**Table 6. Projected 2050 Crop Water Demands**

| (1) Sub-region # | (2) Sub-region Name | (3) Annual Water Duty, gallons per vine | (4) Frost and Heat Protection, af/ac | (5) Total Water Duty, af/ac | (6) Vineyard Area, ac[(a)(b)] | (7) Non-Vineyard Agricultural Area, ac[(c)] | (8) Adjusted Native Vegetation Less Than 30 Percent Slope, ac | (9) Total Crop Water Demand, afa |
|---|---|---|---|---|---|---|---|---|
| 1 | Calistoga | 110 | 0.5 | 1.11 | 4,051 | 108 | 401 | 5,278 |
| 2 | St. Helena | 110 | 0.5 | 1.11 | 8,519 | 197 | 312 | 10,418 |
| 3 | Yountville | 110 | 0.5 | 1.11 | 9,083 | 573 | 590 | 12,482 |
| 4 | Napa | 100 | 0.5 | 1.06 | 2,615 | 79 | 233 | 3,248 |
| 5 | MST Study Area | 100 | 0.0 | 0.56 | 2,301 | 116 | 833 | 1,958 |
| 6 | Carneros | 100 | 0.0 | 0.56 | 6,823 | 107 | 1,380 | 4,892 |
| 7 | American Canyon | 100 | 0.0 | 0.56 | 1,422 | 991 | 1,785 | 4,760 |
| Total | | — | — | — | 34,813 | 2,173 | 5,536 | 43,037 |

(a) Average vine spacing 4'x6' or 1,815 vines per acre.
(b) All existing vineyard is converted to denser planting by 2050.
(c) Existing non-vineyard irrigated agricultural areas assumed to continue to be planted "as is," with current water demands.

Unit water demands per vine ranged from 110 gpv in the north to 100 gpv in the south, as shown in Table 6. The per vine water demands were reduced in the denser plantings as growers desire to further stress the vines, and increase the intensity of the fruit. Even though the amount of water per vine is reduced by almost half in the northern portions of the valley floor, annual water demand on a per acre basis has increased to 1.11 acre-feet per acre due to the large number of vines per acre. The unit water demands based on an acre foot per acre basis has also increased in southern portions of the valley floor as a result of the denser plantings. Annual unit water demands have increased from 0.22 acre-feet per acre to 0.56 acre-feet per acre in the southern portions of the valley floor.

Unit water demands for heat and frost protection remain the same for denser plantings. A total of approximately 0.5 acre-feet per acre were assumed for both frost and heat protection.

As previously discussed approximately 30,400 acres of native vegetation area are potentially available for conversion to vineyards, this acreage quantity is larger than the additional vineyard acreage estimated by the Napa County Agricultural Commissioner. Therefore based on discussion with our agricultural consultant's knowledge and estimates of developable future vineyard areas, acreage reduction factors were applied to each sub-region as listed below:

- 40 percent of native vegetation in American Canyon would transition to vineyards
- 25 percent of native vegetation in Carneros and MST would transition to vineyards
- 20 percent of native vegetation in the remaining sub-regions would transition to vineyards

Using these percent transitions, it is anticipated that approximately 5,500 acres of native vegetation would be converted to vineyards by the year 2050. No irrigated water demands were previously associated with these native vegetation areas, prior to conversion to vineyards.

To approximate water demands for the year 2050, the total number of irrigated acres was multiplied by the total unit water demand. This resulted in a total estimated crop water demand of 43,000 acre-feet per year in year 2050, for the valley floor as shown in Table 6. This includes the replanting of:

- Existing vineyards to the denser 1,815 vines per acre
- New vineyard plantings on native vegetation areas
- Continued irrigation of non-vineyard agricultural lands

Existing water demands for the Main Basin including the MST and Carneros areas, are expected to steadily increase from the year 2000 (31,975 afa) to the year 2050 (43,037 afa). This will be an increase of approximately 11,050 acre-feet, or 34 percent as shown in Table 7.

**Table 7. Estimated Increase in Crop Water Demands for Napa Valley (2000-2050)**

| (1) Sub-region Number | (2) Sub-region Name | (3) Total 2000 Crop Water Demand, afa | (4) Total 2050 Crop Water Demand, afa | (5) 2000-2050 Increase, afa | (6) Percent Increase |
|---|---|---|---|---|---|
| 1 | Calistoga | 4,606 | 5,278 | 672 | 14.6 |
| 2 | St. Helena | 8,647 | 10,418 | 1,771 | 21 |
| 3 | Yountville | 10,308 | 12,482 | 2,174 | 21 |
| 4 | Napa | 2,419 | 3,248 | 829 | 34 |
| 5 | MST Study Area | 862 | 1,958 | 1,096 | 127 |
| 6 | Carneros | 1,842 | 4,892 | 3,050 | 166 |
| 7 | American Canyon | 3,291 | 4,760 | 1,470 | 45 |
| Total | | 31,975 | 43,037 | 11,062 | 35 |

## DISCUSSION

The 2050 Study Area is summarized into three regions so they can be compared to previously published documents. The Main Basin includes the unincorporated areas of sub-regions 1-4 and sub-region 7, while the MST and Carneros sub-regions remain in their own category.

### Main Basin Region

The Main Basin region includes the unincorporated areas in the vicinity of Calistoga, St. Helena, Yountville, Napa and American Canyon as previously shown on Figure 1. Water demands are projected to increase by approximately 7,500 af as shown in Table 8. A significant portion (6,900 af) is the result of the increase in crop water demands. Of the 6,900 af increase, 4,226 afa is due to the conversion of existing vineyards to denser plantings. The remainder of the increase is from the conversion of native vegetation to vineyards. These potential increases in water demands are based upon the assumption that water sources are available to support this growth.

**Table 8. Estimated Main Basin Existing and Projected Water Demand**

| (1) Category | (2) 2000 Water Demand, afa | (3) 2020 Water Demand, afa | (4) 2050 Water Demand, afa |
|---|---|---|---|
| Rural Residential | 2,300 | 2,420 | 2,750 |
| Improved Open Space | 1,111 | 1,111 | 1,111 |
| Winery | 974 | 1,022 | 1,100 |
| Crop[(a)] | 29,271 | 31,863 | 36,187 |
| Total | 33,656 | 36,416 | 41,148 |

[(a)] Includes unincorporated areas of Calistoga, St. Helena, Yountville, Napa, American Canyon.

### MST Region

The concepts used by WYA to determine the unincorporated area water demands for the MST region are similar as those used in the 2002 USGS MST study. However, the unit water demands used by WYA in this TM are slightly different, as discussed below, resulting in lower water demands.

The USGS calculated rural residential water demands by averaging a land based methodology and a per capita water demand of 148 gpcd. WYA calculated rural residential demand only using 2000 census population of 4,800 persons, as presented in the USGS report, multiplied by a unit water demand of 150 gpcd.

The USGS calculated an annual water demand for the improved open space area (golf courses) of 391 acres, by multiplying this acreage by a unit water demand of 4.0 af/ac. WYA agreed with this

methodology and water demand estimate, and used the annual water demand calculation of 1,564 afa. However, the USGS did not account for winery demands in the MST area. WYA estimated existing winery demands to be approximately 87 afa.

The USGS estimated vineyard water demands by calculating vineyard areas using two different methodologies, applying two different unit water demand factors, and taking the average of the resultant values. The vineyard areas ranging from 2,369 to 2,869 acres and the USGS unit water demand factors ranged from 0.5 to 1.2 af/ac for the years 2000 and 1980, respectively. WYA calculated 2,301 acres of vineyard area and 116 acres of non-vineyards area, and multiplied these respective areas by unit water demands of 0.22 and 3.0 af/ac respectively. While the cropped areas are similar, WYA believes the lower unit water demand of 0.22 more accurately represent vineyards in the area, thus WYA water demands are lower than those presented in the USGS report. Water demands for the MST regions are shown in Table 9.

For the purposes of the 2050 Study, WYA will proceed with the unincorporated water demands used in this TM. The USGS made no estimation of projected water demands for the MST region. However, based on WYA's estimates of vineyard densification and a slight increase in rural residential water demands, water demands in the MST region have the potential to increase by approximately 1,290 af. Similar to the Main Basin region, the greatest potential increase is from increased cropped acreage. These potential increases in water demands are based upon the assumption that a water sources are available to support this growth.

**Table 9. Estimated MST Existing and Projected Water Demand**

| (1) Category | (2) 2000 Water Demand, afa | (3) 2020 Water Demand, afa | (4) 2050 Water Demand, afa |
|---|---|---|---|
| Rural Residential | 800 | 850 | 960 |
| Improved Open Space | 1,564 | 1,564 | 1,564 |
| Winery | 87 | 99 | 119 |
| Crop | 862 | 1,197 | 1,958 |
| Total | 3,313 | 3,710 | 4,601 |

**Carneros Region**

The sub-region that has the greatest potential for an increase in water demand is the Carneros sub-region. Unincorporated water demands can potentially increase by approximately 3,170 acre-feet or 45 percent by the year 2050. This increase would be predominately due to the conversion of existing vineyards to vineyards of increased density. The conversion of native vegetation to vineyards will also be a small component of this potential water demand increase.

These potential increases in unincorporated water demands are based upon the assumption that water sources are available to support this growth. Water demands are summarized in Table 10.

**Table 10. Estimated Carneros Existing and Projected Water Demand**

| (1) Category | (2) 2000 Water Demand, afa | (3) 2020 Water Demand, afa | (4) 2050 Water Demand, afa |
|---|---|---|---|
| Rural Residential | 350 | 370 | 420 |
| Improved Open Space | 96 | 96 | 96 |
| Winery | 259 | 278 | 311 |
| Crop | 1,842 | 2,723 | 4,892 |
| Total | 2,547 | 3,467 | 5,719 |

**Total unincorporated water demands**

Table 11 summarizes the previously discussed water demands for the three regions. Unincorporated water demands under existing conditions are approximately 39,500 afa. These water demands are projected to increase to approximately 51,500 afa by the year 2050, a difference of approximately 12,000 afa.

**Table 11. Estimated Unincorporated Existing and Projected Water Demand**

| (1) Category | (2) 2000 Water Demand, afa | (3) 2020 Water Demand, afa | (4) 2050 Water Demand, afa |
|---|---|---|---|
| Main Basin | 33,656 | 36,416 | 41,148 |
| MST | 3,313 | 3,710 | 4,601 |
| Carneros | 2,547 | 3,467 | 5,719 |
| Total | 39,516 | 43,593 | 51,468 |

## CONCLUSIONS

The following assumptions were used to estimate the unincorporated water demands for the Study Area evaluated in this TM:

- Rural residential demands are based upon 2000 Census data and a unit water demand of 150 gallons per person per day
- Improved open space areas (primarily golf courses) were held constant in the future and continued to be irrigated at an annual water use of four acre-feet per acre per year.
- Winery demands were calculated based upon acreages and a unit water demand of 12,350 gallons per year per acre of vineyard.
- Portions of the native vegetation occurring within the Napa Valley floor area were assumed to be planted as vineyards by 2050.
- All existing Valley floor vineyards were assumed to be replanted to denser vineyards by the year 2050.
- All existing non-vineyard, irrigated agricultural lands were assumed to continue to be irrigated at an annual water use of three acre-feet per acre per year.
- Water demands for frost and heat protection were also accounted for in the calculated water use factors.
- Available irrigable lands with slopes greater than 30 percent were not included in this analysis.

Using the above assumptions the water demands in the unincorporated areas of the Study Area are expected to reach a maximum of approximately 51,500 afa by the year 2050. This is an approximate increase of 12,000 af from the year 2000 to the year 2050.

Average vine densities in the Napa Valley appear to be increasing from approximately 726 vines per acre to 1,815 vines per acre. Current unit water demands per vine currently range from 100 to 250 gpv from the south to the north respectively, depending on microclimate. Unit water demands per vine at denser plantings decrease the unit water demand per vine to a range from 100 to 110 gpv per acre, from the south to the north respectively. With the increase in vine density and the decrease in the per vine water demand, the per acre water demand increased from 0.34 acre-feet per acre in the south to 0.05 acre-feet per acre in the north. The conversion to denser plantings in the northern portions of the valley floor have a lesser impact on water supplies than in the south.

This increase in vine density and decrease in the per vine unit water demand is a result of the Napa Valley grower's desire to increase the grape juice intensity, while still allowing for roughly the same tonnage per acre of planted vines.

The actual 2050 unincorporated water demands will be dependant upon water availability, climate, and marketability of wine from the Napa Valley, among others.

GSN/JPC:ajb