APPENDIX I

HYDROLOGY AND WATER QUALITY ASSESSMENT

QUESTA ENGINEERING CORP.

Hydrology and Water Quality Assessment

for

Heritage Oaks Memorial Park

San Jose, California

Prepared for:

Denise Duffy & Associates, Inc.
Monterey, California

Prepared by:

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May 2014

Civil, Environmental & Water Resources

WATER SUPPLY ANALYSIS

FOR

HERITAGE OAKS MEMORIAL PARK

SAN JOSE, CALIFORNIA

Prepared For

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Project #1300096

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May 2014

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INTRODUCTION

This report presents an assessment of potential hydrology and water quality impacts associated with the development of the proposed Heritage Oaks Memorial Park, located off Bailey Avenue at the southern extent of the City of San Jose (**Figure 1**). This analysis was prepared by Questa Engineering under a sub-contracting agreement with Denise Duffy & Associates for incorporation into the Environmental Impact Report for the project.

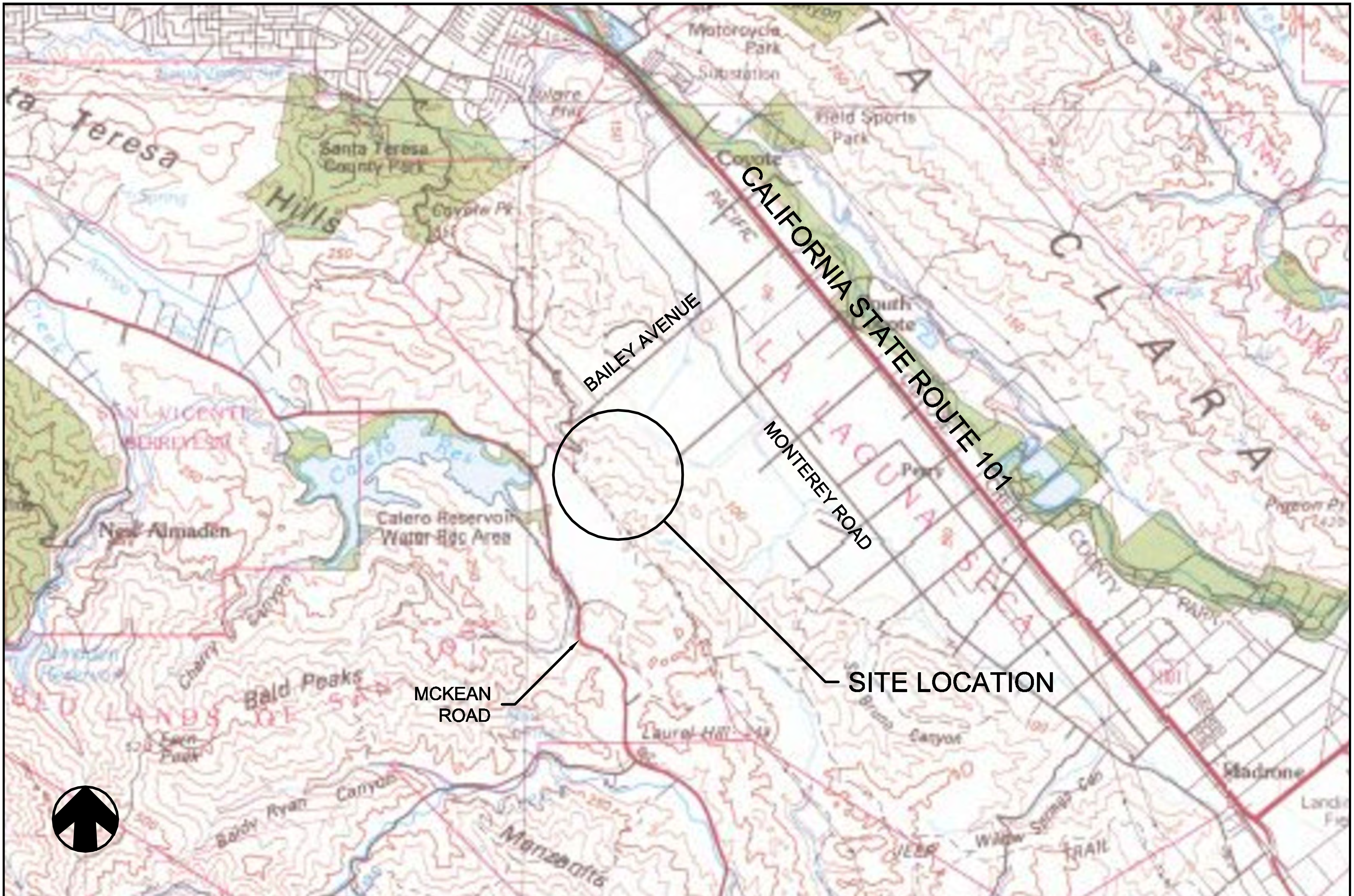
The project site lies partly within the drainage area of the Calero Reservoir, a popular recreation area and an emergency water supply source for the San Jose area, raising special concern about hydrologic and water quality effects from watershed activities. The project will involve mass grading, establishment of irrigated turf, a network of paved access roads and parking areas, administration and maintenance buildings, and an onsite well and wastewater disposal system for staff and visitors. This analysis was conducted to identify and evaluate potential hydrologic and water quality impacts associated with the construction and ongoing operation of the proposed memorial park. Issues of primary concern include changes in hydrology, soil erosion, chemical applications for turf management and non-point source runoff from parking and maintenance areas. The report includes an outline of appropriate management and mitigation measures where needed to address potentially significant impact concerns.

PROJECT SITE CONDITIONS

The overall project site ("rezone site") consists of approximately 275 acres of rolling hills located immediately south of Bailey Avenue, along either side of the watershed divide between Coyote Valley (to the east) and the Calero Reservoir area on the west (**Figure 2**). Approximately 102 acres of the project site are planned to be developed for the memorial park (cemetery). Elevations on the project site range from about 300 feet (above mean sea level, msl) along the eastern boundary (edge of Coyote Valley), to about 700 feet msl along the highest parts of the ridgeline. The site is estimated to receive average annual rainfall of about 23 inches, occurring mainly between the months of November through April. The vegetation throughout the site is primarily large expanses of grass with scattered oaks and brush. The site has historically been used for cattle grazing.

Surface Waters

Figure 2 delineates three main watershed areas for the site, labeled A, B and C. The majority of the site is encompassed by Watersheds B and C, which drain to the east via several seasonal drainages and then north through farmland via unnamed tributary drainages, eventually reaching Coyote Creek near the Metcalf Energy Center south of Metcalf Road. The most significant watercourse in the project area is a seasonal drainage in Watershed B, which originates just south of the rezone boundary and flows easterly toward Palm Avenue before turning northeast into the Coyote Valley farmland. This drainage is shown as a dashed blue-line (intermittent) stream on the U.S. Geological Survey's Morgan Hill Quadrangle (topographic map), which also shows a former stock pond located near the head of the stream, adjacent to the rezone site. There is also an active in-stream stock pond, about ¼-acre in size, located in Watershed C within the rezone site just beyond the northwest edge of the proposed cemetery boundaries near Bailey Avenue.



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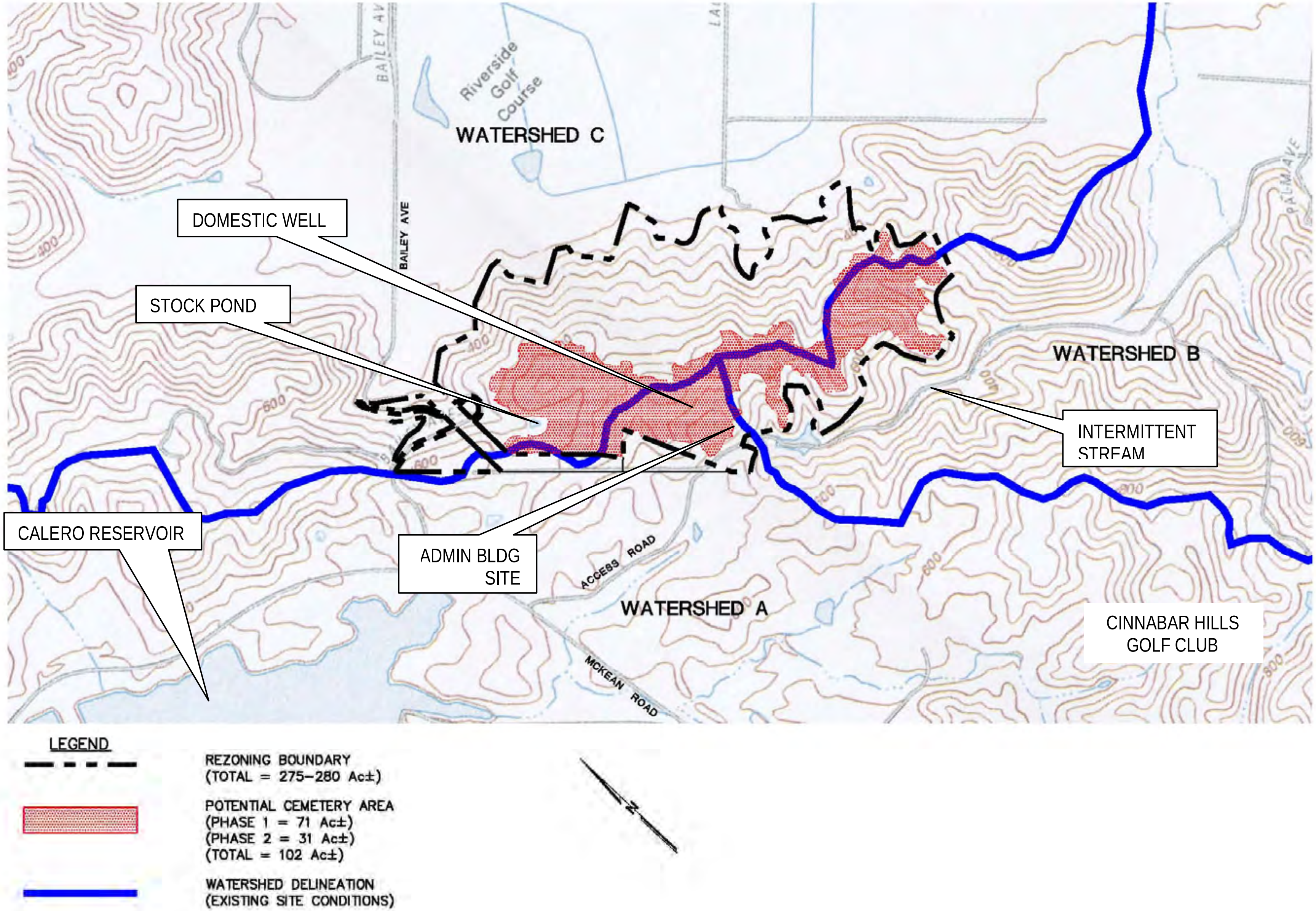
LOCATION MAP (NO SCALE)
HERITAGE OAKS MEMORIAL PARK
HYDROLOGY AND WATER QUALITY

FIGURE
1



Source: Ruth and Going, Inc.

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General Watershed Delineations

Heritage Memorial Park

FIGURE 2

Watershed A comprises the western portion of the site, which drains via swales and seasonal drainage channels that flow westerly and then north through Calero County Park and eventually enter Pine Creek Canyon (also called Calero Creek) and the east arm of Calero Reservoir near McKean Road. Watershed A encompasses about 8% of the 275-acre rezone site and about 20% of the proposed 102 acres of potential cemetery area.

Calero Reservoir, the nearest surface water body to the site, is owned and operated by the Santa Clara Valley Water District (SCVWD). It was built in 1935 and has a capacity of about 10,000 acre-feet. One of the primary purposes of the reservoir is for storage and release to downstream groundwater recharge basins operated by SCVWD. The reservoir is also part of the emergency drinking water supply for the SCVWD system. The reservoir is used for a variety of recreational activities, including motorized boats, jet skis, water skiing, sailing and fishing.

Ground Water

To the east of the site the Coyote Valley sub-basin is a major source groundwater for Santa Clara County. However, beneath the project site and surrounding hills, ground water resources are limited primarily to water that occurs in discontinuous fracture zones in the rocks of the underlying Franciscan formation. There is no defined groundwater basin; although the small alluvial valleys in the Franciscan formation have limited shallow groundwater reservoirs. Residences and agricultural operations in the area rely on groundwater wells for water supply; there are no major water well supplies in the area. A well was installed on the property in 2003 in anticipation of ultimately providing a source of potable water. The well was tested and capped at the time of installation. It is currently inactive, but is intended to be put into service for the proposed project. The well is located near the center of project site, about 500 feet north and uphill of the proposed site for the administration building (**Figure 2**).

PROJECT FACILITIES AND OPERATIONS

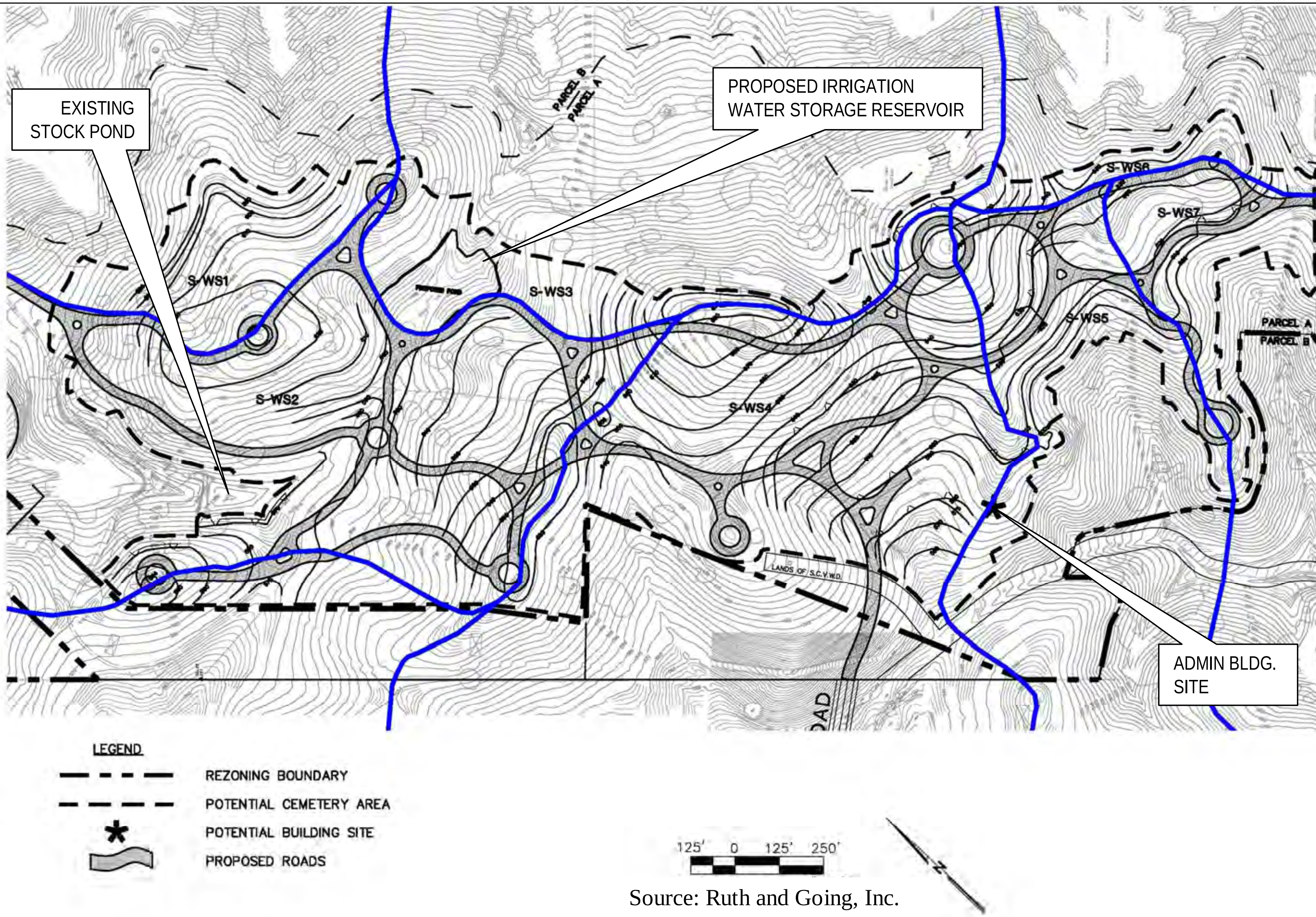
Grading

Development of the proposed cemetery will include modifications to the existing topography to create terrain more suitable for use as a memorial park. According to the conceptual grading plans prepared by the applicant's civil engineer (Ruth & Going), site development will include cuts on the order of 10 to 75 feet on the ridges and knolls and fills of 5 to 20 feet in the swales. This will result in smoothing and lowering of ground slopes throughout most of the site, typically reducing from current slopes of 18 to 20+% down to finished slopes of 10 to 15%. The conceptual plans reviewed cover work proposed for development of the northwesterly portion of the cemetery (near Bailey Avenue); however, it is anticipated that similar cut and fill grading would be undertaken throughout all of the 102-acre area planned for full build-out of the cemetery.

Figure 3 shows the conceptual grading plans and layout of key development features for the northwestern portion of the cemetery (roads, irrigation reservoir, building site, etc.).

Drainage Facilities

Surface Drains. Generally, development of the proposed memorial park would not be expected



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Conceptual Grading and Development Plan
Heritage Memorial Park

FIGURE 3

to entail the construction of any large drainage structures or features. Administration building parking lots and the network of access roads throughout the cemetery would create impervious surfaces and require appropriate drainage measures. These facilities would likely be ditches, swales and, possibly, buried storm drains which would convey runoff to the nearest defined natural drainage way or a grassed swale. Some portions of the access roads throughout the cemetery may require drainage improvements such as culverts, curbs, and inlet/outlet structures. In general, roadway drainage would be expected to be directed via sheet flow to adjacent turf areas and vegetated drainage swales.

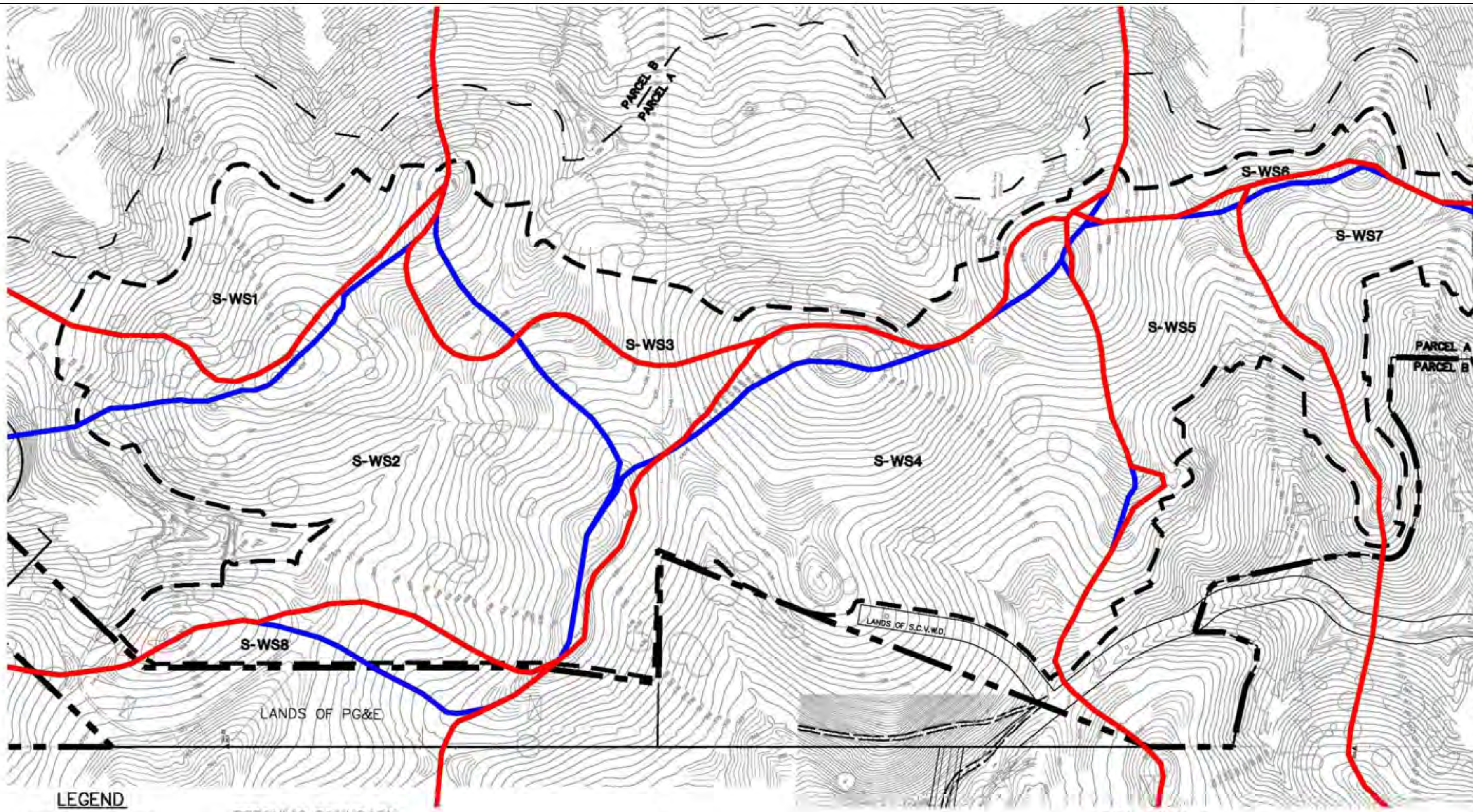
Subsurface Drains. It is anticipated that subsurface drains will be constructed beneath swale fills, in connections with building foundations and retaining walls, and at other locations where groundwater is expected or encountered during construction. Water discharged from subsurface drains will either be combined with surface drains or dispersed for absorption into down-slope vegetated areas.

Watershed/Drainage Patterns. Conceptual plans indicate that grading of the site will alter drainage patterns and sub-watershed catchment areas within some portions of the site to a small degree. For the northwestern portion of the site where initial cemetery development will take place, **Figure 4** shows a comparative delineation of sub-watershed boundaries for: (a) existing conditions (blue) and (b) proposed site conditions (red). A summary of the projected change in watershed areas for this portion of the site (provided by the project civil engineer, Ruth & Going) is presented in **Table 1**. As indicated by the totals, the project grading in the northwestern portion of the site will result in an approximate shift in drainage/watershed area of about 2.3 acres from the Coyote Valley to the Calero Reservoir watershed. This represents about a 3% change for the approximately 69 acres of cemetery area in the northwestern part of the site.

Table 1. Watershed Area Changes for Northwestern Portion of Cemetery

Sub-watershed Delineation	Existing Conditions Area (ac)	Developed Conditions Area (ac)	Net Change in Area (ac)
Watershed C			
S-WS1	7.56	5.55	(-2.01)
S-WS2	18.83	21.81	2.98
S-WS3	9.17	6.00	(-3.17)
S-WS6	2.05	1.78	(-0.27)
Totals Watershed C	**37.61**	**35.14**	**(-2.47)**
Watershed A			
S-WS4	18.73	19.91	1.18
S-WS8	0.92	2.04	1.12
Totals Watershed A	**19.65**	**21.95**	**2.30**
Watershed B			
S-WS5	7.32	7.31	(-0.01)
S-WS7	4.71	4.91	0.20
Totals Watershed B	**12.03**	**12.22**	**0.19**

The remaining portion (southeastern area) of the cemetery to be developed at full build-out consists of approximately 33 acres, all of which lies within the Coyote Valley watershed, mostly



LEGEND

REZONING BOUNDARY
(TOTAL = 275 Ac±)

POTENTIAL CEMETERY AREA
(PHASE 1 = 69 Ac±)
(PHASE 2 = 32 Ac±)
(TOTAL = 101 Ac±)

SUB-WATERSHED DELINEATION
(EXISTING SITE CONDITIONS)

SUB-WATERSHED DELINEATION
(PROPOSED SITE CONDITIONS)

125' 0 125' 250'

Source: Ruth and Going, Inc.

AREA TOTALS

Sub-Watershed	Existing	Proposed
S-WS1	7.56 Ac±	5.55 Ac±
S-WS2	18.83 Ac±	21.81 Ac±
S-WS3	9.17 Ac±	6.00 Ac±
S-WS4	18.73 Ac±	19.91 Ac±
S-WS5	7.32 Ac±	7.31 Ac±
S-WS6	2.05 Ac±	1.78 Ac±
S-WS7	4.71 Ac±	4.91 Ac±
S-WS8	0.92 Ac±	2.04 Ac±

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Watershed Changes

Heritage Memorial Park

FIGURE 4

Watershed B. At build-out there may be a small shift in drainage between Watersheds B and C along the ridgeline, but nothing that would affect drainage to the Calero Reservoir watershed.

Stormwater Best Management Practices. The applicant's civil engineer (Ruth & Going) has indicated the intent to implement controls in project site design, including low impact development (LID), to reduce water pollution carried in storm water runoff. This will include treatment control measures (TCMs) as appropriate based upon site specific design to achieve stormwater requirements for urban runoff pollution. Physical TCM's will vary in their appropriateness of use given the type and location of development they serve and other site specific constraints. In general, these techniques may include storage or retention, filtration, and infiltration practices. At a minimum, the following list of general guidelines addressing urban runoff pollution prevention will be considered in the specific site development plans presented for City approval. The TCM's most likely to be employed include but are not limited to:

- Site Design Measures:
    - Minimize land disturbed
    - Minimize impervious surfaces
    - Minimum-impact street or parking lot design
    - Self-treating areas
    - Self-retaining areas
    - Preserved open space
    - Use of pervious pavement materials

- Source Control Measures:
    - Beneficial landscaping (minimize irrigation, runoff, pesticides and fertilizers)
    - Storm drain labeling
    - Maintenance (pavement sweeping, catch basin cleaning, etc.)

- LID Treatment Systems:
    - In-ground detention and infiltration system
    - Biotreatment basins

Irrigation System and Storage Reservoir

The primary use of water for the project will be for irrigation of the cemetery lawns and other landscaping. Pursuant to an agreement with the SCVWD, the applicant proposes to obtain non urban sourced water (untreated) from the Cross Valley Pipeline that runs roughly along the western boundary of the proposed rezone site. The terms and conditions of the agreement are formalized in a 2005 Memorandum of Understanding (MOU) between the applicant and SCVWD. The MOU allows for the project to obtain water from the existing turn-out valve that serves the Cinnabar Hills Golf Club. From that point the water would be piped to one or more storage reservoirs on the project site (roughly 1 to 1.5 acres area), and from there fed into the irrigation system. The reservoir(s) would also provide storage of the required volume of water for fire suppression. The tentative location of a water storage reservoir in the northern portion of the site is indicated to be near the ridgeline within Sub-watershed S-WS3 (Watershed C), as shown in **Figure 3**.

Other non-urban sourced water supplies that may also be used in the future include: (1) well water from adjoining applicant-owned lands in the Coyote Valley (vicinity of Laguna Ave and Santa Teresa Blvd.); and (2) recycled water from the regional recycled water distribution system, if extended to the project site from its current terminus near the Metcalf Energy Center.

The applicant proposes to install a computerized irrigation controller, utilizing real-time climatic information to regulate and optimize irrigation water use. The system would include an onsite weather station that would collect and feed data into the computer. The computer would then determine the proper amount of water required for each part of the site and activate the appropriate sprinkler heads. In this way irrigation water application rates are adjusted automatically so that little or no runoff from the turf grass areas occurs. The irrigation system may also be used to apply fertilizer and pesticides at a controlled rate, if selected grasses within burial areas require such application.

REGULATORY REQUIREMENTS

National Pollutant Discharge Elimination System

National Pollutant Discharge Elimination System (NPDES) is a permitting process to comply with EPA regulations (Section 402) of the Clean Water Act. The intent of the permitting process is to control sources of discharge pollutants into U.S. water systems (i.e. rivers, lakes, bays, etc.).

In California, the State Water Resources Control Board (SWRCB) implements Clean Water Act requirements through an NPDES General Permit for Discharges of Stormwater Associated with Construction Activity ("*NPDES General Construction Permit*"). Construction projects, such as Heritage Oaks Memorial Park, that would disturb more than one-acre of land are required to file with the SWRCB a Notice of Intent for compliance with the NPDES General Construction Permit, along with preparation and implementation of a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP is to include site specific best management practices (BMPs) to control erosion and sediment runoff and protect water quality during construction. BMPS are also to be implemented for post-construction water quality control.

All San Francisco Bay Area municipalities and flood control agencies that discharge directly to the San Francisco Bay share a *Municipal Regional Stormwater NPDES Permit (MRP)*, issued by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) and currently effective until October 14, 2014. This shared permit was developed following an earlier joint NPDES Permit to an association of municipalities and agencies called the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCCVRPPP). The SCVRPPP allows Santa Clara County, the Santa Clara Valley Water District and 13 municipalities in the County, including San Jose, to meet the NPDES Permit requirements jointly in order to allow collaboration and the sharing of resources on projects of mutual benefit.

Provision C.3 of the MRP requires development projects, such as Heritage Oaks Memorial Park, that create, add or replace 10,000 square feet or more of impervious surface area to control post-development stormwater runoff through source control, site design and treatment control

BMPs. Most regulated projects require the management of stormwater runoff using Low Impact Design (LID) measures. The LID strategy manages stormwater runoff as close to the source as possible by incorporating a variety of natural and built features to reduce the rate of surface runoff, filter pollutants from runoff, facilitate the infiltration of water into the ground surface, and re-use water on site, and can include such technologies as bio-treatment and evapotranspiration.

The MRP also includes controls for hydromodification, defined as any watershed changes in stormwater runoff characteristics resulting from changes in land use conditions (e.g., urbanization). Such land use changes could include increasing impervious surfaces that may increase peak runoff flow, volume and duration which in turn may cause erosion, sediment-related pollution or other impacts to local creeks, streams, rivers or other water bodies. The Heritage Oaks project proposes grading and construction of impervious surfaces that will be considered hydromodification.

City of San Jose Policies

The City of San Jose's Post-Construction Urban Runoff Policy 6-29 was adopted to establish an implementation framework, consistent with Provision C.3 of the MRP. In addition to requiring all new and redevelopment projects to implement post-construction BMPs and Treatment Control Measures (TCMs), the policy establishes specific design standards for post-construction TCMs for projects that create, add or replace 10,000 square feet or more of impervious surfaces. The City's Post-Construction Hydromodification Management Policy 8-14 was adopted to establish an implementation framework for projects that are subject to hydromodification controls in the MRP.

ENVIRONMENTAL ISSUES

The hydrological and water quality issues related to the construction and operation of the proposed cemetery and related site improvements at the project site fall into five basic categories: (1) hydromodification; (2) soil erosion; (3) stormwater runoff quality; (4) landscape/turf fertilizers; and (5) pesticides.

Hydromodification

The term "hydromodification" refers to changes in the natural hydrologic processes and runoff characteristics caused by urbanization or other land use changes that can result in increased stream flows, changes in sediment transport, reduced groundwater replenishment, and associated effects on water resources, ecological systems and the landscape. The development and operation of the proposed cemetery will constitute a change in land use and raise potential hydromodification issues which are reviewed here.

Specific aspects of the project that will alter the hydrological conditions include: (1) grading and re-contouring of the terrain along with changes in site runoff patterns and drainage/catchment areas; (2) conversion of the vegetation from grazed pasture to irrigated, managed turf grass; (3) application of irrigation water; (4) impervious areas created by access roads, parking areas and buildings; (5) onsite reservoir(s) for storage and regulation of irrigation water; (6) onsite groundwater well for potable water supply; and (7) onsite wastewater disposal system. The hydromodification issues of potential concern raised by these various changes include: (a) peak stormwater flows; (b) overall watershed runoff and recharge conditions.

Peak Stormwater Flows. Peak stormwater flows are influenced by: (1) the "runoff coefficient", which is a function of land use and soil surface conditions; (2) intensity of rainfall, which is partially influenced by the speed of runoff ("time of concentration"), and is a function of the slope and length of the drainage path; and (3) the size of the contributing drainage area. Procedures for determining peak runoff for small watersheds (<200 acres in size) combine these various factors in the equation below, known as the Rational Method:

$$Q = CIA$$

Where:
Q = peak rate of runoff in cubic feet per second (cfs)
C = runoff coefficient, based on land surface conditions
I = storm intensity, inches per hour, for a given storm frequency (e.g., 10-yr, 100-yr etc.)
A = drainage area, in acres

Since the project occupies a ridge location, with surface drainage flowing in multiple directions, effects on peak stormwater flows were reviewed by examining proposed changes in the above factors for each of the individual sub-watersheds, rather than for the project site as a whole.

- **Runoff Coefficient, C**. The project will have the beneficial effect of converting a substantial amount of land from grazed open space to irrigated turf, which will tend to absorb more rainfall and slow the rate of water runoff. On the other hand the project will include construction of a network of roads and other impervious surfaces, contributing to a higher rate of runoff in those areas. Utilizing the guidelines and criteria in the Santa Clara County Drainage Manual (2007) and information presented in the conceptual development plans for the northeastern portion of the cemetery, composite runoff coefficients (i.e., weighted average values) were calculated for all of the sub-watershed areas for developed conditions. The runoff coefficient (C value) for existing conditions (open space) is estimated to be 0.35, per Table B-1 of the County Drainage Manual. For developed conditions a value of 0.30 (parks) was assigned for the cemetery turf and other vegetated areas of the cemetery. A value of 0.85 (paved/impervious areas) was assigned to all roads, parking and building areas. This value for impervious areas does not account for various measures (e.g., infiltration, detention, etc.) the applicant intends to incorporate in the project site design; therefore the calculations should be understood to represent the theoretical maximum change that could occur, if not mitigated. The results are presented in **Table 2,** along with the supporting assumptions regarding the location and amount of impervious areas, derived through inspection of the preliminary plans.

  Development of the remaining portion (southeastern area) of the 102-acres of cemetery at full build-out would be expected to have effects represented by those estimated for the adjacent sub-watersheds WS6 and WS7. These sub-watersheds have similar hydrological conditions and, assuming comparable grading, drainage and road network, the effect would range from a decrease in runoff coefficient to a small increase amenable to mitigation through sheet flow dispersion of road runoff.

- **Rainfall Intensity, I**. The proposed plans for re-contouring and lowing of the slope gradient over a substantial part of the cemetery area will tend to slow down the rate of water flow over the land surface. This will theoretically lengthen the time of concentration and reduce the rainfall intensity values for use in the Rational Method. However, the reduction in the rate of water flow is likely to be so small as to have an insignificant impact on runoff calculations. Therefore, for most of the cemetery site, this factor is judged to remain unchanged, which is a conservative (safe) assumption.

- **Drainage Area, A.** As previously discussed under ***Drainage Facilities***, the project grading will alter drainage patterns and sub-watershed catchment areas within some portions of the site. The net changes in drainage area from **Table 1** are listed also in **Table 2**.

Notes and recommendations regarding assessment of the overall effect on peak storm flow are provided in the right-hand column in **Table 2,** and discussed below.

- **Watershed C**, draining to Coyote Valley, may experience a decrease in peak storm flow from three of the four sub-watersheds (WS1, WS3 and WS6) as a result of a reduction in drainage area and lower runoff coefficient. In Sub-watershed WS2, the drainage area will be increased by about three (3) acres and the runoff coefficient is projected to increase slightly from 0.35 to 0.38. Peak storm flow generated in this part of the cemetery will be increased. However, the flows would be immediately captured and detained in the existing ¼-acre stock pond, which lies in the Rezone site just outside the proposed cemetery boundary. Areas below the stock pond and further downstream outside the Rezone site would not be impacted by the higher runoff from WS2.

- **Watershed A,** draining to the Calero Reservoir watershed, may experience higher peak storm flow due to an approximate 2.3-acre increase in drainage area along with the effects of impervious areas, including roads and a portion (assumed 50%) of the administration building and parking areas. Peak runoff calculations for the portion of WS4 encompassing the administration building area should be prepared based on specific site development plans for this area, which are currently not available. Increases in peak runoff in sub-watershed WS8 would be small and mitigated to a large extent by dispersing road runoff via sheet flow to adjacent turf areas. However, the preliminary grading plans indicate a doubling of the drainage area for this small sub-basin; therefore a detailed runoff analysis should be completed as part of the final grading and drainage plan.

- **Watershed B**, draining to Coyote Valley in the direction of Palm Avenue, may experience an increase in peak storm runoff due to a small increase in drainage area and an increase in the composite runoff coefficient due to the impervious surfaces associated with a portion of the administration building and parking facilities. Peak runoff calculations for WS5, the sub-watershed areas expected to have the greatest potential runoff changes, should be prepared based on specific site development plans for this area, which are currently not available. Increases in peak runoff in sub-watershed WS8 would be small and could be mitigated dispersing road runoff via sheet flow to adjacent turf areas or vegetated buffers wherever practicable.

- **Future Build-out.** Development of the remaining portion (southeastern area) of the 102-acres of cemetery at full build-out would be expected to have effects represented by those estimated for the adjacent sub-watersheds WS6 and WS7. These sub-watersheds have similar hydrological conditions and, assuming comparable grading, drainage and road network, the effect would range from a decrease in peak runoff to a small increase that would be amenable to mitigation through sheet flow dispersion of road runoff to adjacent turf areas or vegetated buffers where practicable.

Table 2. Projected Changes in Drainage Characteristics Affecting Peak Runoff[a]

Sub-watershed Delineation	Net Change in Drainage Area[b] (ac)	Roads		Other Imperv. Surfaces (ac)	Composite Runoff Coefficient C Value[c]	Net Effect on Peak Storm Flow and Recommendations
		%	(ac)			
Watershed C						
WS1	(-2.01)	0.00	0.00	0	0.30	Decrease
WS2	2.98	0.15	3.27	0	0.38	Increase mitigated by detention effect of existing stock pond in adjacent Rezone open space
WS3	(-3.17)[d]	0.00	0.00	0	0.30	Decrease
WS6	(-0.27)	0.00	0.00	0	0.30	Decrease
Sub-total C	**(-2.47)**		**3.27**	**0**	**0.35**	Decrease
Watershed A						
WS4	1.18	0.12	2.39	1.0	0.39	Increase; detailed analysis required
WS8	1.12	0.13	0.27	0	0.37	Increase may be mitigated by sheet flow dispersal of road runoff; detailed analysis required
Sub-total A	**2.30**		**2.66**	**1.0**	**0.39**	Increase if not mitigated; detailed analysis required
Watershed B						
WS5	(-0.01)	0.13	0.95	1.0	0.45	Increase, detailed analysis required
WS7	0.20	0.17	0.85	0	0.39	Increase mitigated by sheet flow dispersal of road runoff
Sub-total B	**0.19**		**1.80**	**1.0**	**0.43**	Increase if not mitigated; detailed analysis required

[a] Analysis for northwestern portion of the cemetery only; results for WS6 and WS7 estimated to be representative of effects of development of remaining (southeastern) portion of cemetery at full build-out.
[b] Per Table 1
[c] Existing C value estimated to be 0.35 (open space, Hydrologic Soil Group C)
[d] The 1.25-acre irrigation storage reservoir planned to be located in this WS3 will act as a retention facility for rainwater, further reducing the amount of land contributing to runoff in this sub-watershed.

In summary, the project will project will have no significant impact on peak storm runoff flows to downstream areas, except potentially for Sub-watersheds WS4, WS5 and WS8. For these areas, the combination of increased drainage area and introduction of new impervious surfaces has the potential to cause increases in peak storm runoff. Runoff analysis should be completed for these three sub-watersheds, in accordance with procedures and criteria in the Santa Clara County Drainage Manual, and based on specific site development plans. The analysis should account for any self-mitigating measures included in the site design, demonstrating no resultant increases in peak storm runoff from the developed project conditions. As recommended elsewhere in this report (under Watershed Analysis and Stormwater Runoff Quality topics), a potentially viable mitigation measure for peak runoff flows not identified in the applicant's preliminary plan, is to install stormwater interceptor tank and pump facilities that can capture, contain and route excess runoff into the onsite irrigation storage reservoir(s).

Watershed Analysis. The land use changes and water use activities associated with the proposed cemetery will affect the rainfall-runoff and groundwater recharge characteristics within the project site. The potential effects are long-term, cumulative changes, rather than storm-related, and can be best understood and analyzed through the construction of a watershed-based water balance model. The water balance is basically an input-output model that accounts for all key sources of inflow and outflow of water within the project site, the main factors in this case being rainfall, applied irrigation water, runoff, evapotranspiration, and deep percolation/recharge. Although relatively small, the effects of subsurface drainage beneath fill areas, well water pumping, onsite wastewater disposal, irrigation storage reservoir(s), were also included in the analysis.

<u>Methodology and Assumptions</u>. The water balance is first constructed for existing land use conditions, and then modified to incorporate the proposed development conditions, with the aim of quantifying cumulative changes in runoff and groundwater recharge volumes due to the project. For this analysis, the water balance was done for average annual conditions, and was constructed to reflect conditions in each of the eight sub-watersheds in the northwestern portion of the project, as identified the applicant's preliminary development plan. Calculation worksheets and supporting reference data are provided in **Attachment A**. The assumptions and calculation steps are described below.

- **Rainfall.** Average monthly and annual rainfall for the project area are as follows:

Average Monthly Rainfall (in)												**Average Annual Rainfall (in)**
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	
4.94	5.06	3.63	1.40	0.54	0.10	0.00	0.03	0.18	1.01	2.37	4.01	**23.27**

Source: The Weather Channel: http://www.weather.com/weather/wxclimatology/monthly/graph/1780:19

- **Runoff.** Monthly and annual runoff depths (converted to volumes) were estimated using the Natural Resource Conservation Service (NRCS) Curve Number Method. This involves assigning a "Curve Number" or "CN" value (similar to runoff coefficient) based on the soil and land use conditions; determining runoff-off volumes (by CN) for a range of typical storm amounts (e.g., 0.5 to 2.5 inches) per published NRCS tables; tallying the results to estimate rainfall-runoff percentages; and finally applying the results to average monthly rainfall totals (above) to produce estimates of monthly and annual monthly runoff by CN value.

CN values were determined as follows:

- A CN of 79 was selected for existing conditions, based on guidelines for grassland/rangeland, "fair" conditions, and Hydrologic Soil Group C (per published Soil Survey).

- For developed conditions, a CN of 74 was assigned, applicable to parks and cemeteries in "good" condition for the same hydrologic soil group.

- The network of paved roads was accounted for by considering them to be "unconnected impervious areas", with runoff directed primarily as sheet flow across the land surface before entering the drainage system. The NRCS guidelines provide a formula to adjust the CN value based on the percentage of unconnected impervious areas, which was applied to each sub-watershed based on the amount of road surfaces per the conceptual development plan (see **Table 2** above). From the calculations the CN value was determined to increase from 74 to 77 as a result of the road network, and this was assigned to the entire drainage area in the affected sub-watersheds (WS2, WS4, WS5, WS7 and WS8).

- The estimated 2 acres of impervious area associated with the administrative building and parking area was assigned a CN of 98 per NRCS guidelines, which, as previously noted, was assumed to be split equally between WS4 and WS5.

- **Evapotranspiration.** Evapotranspiration estimates for the project area were obtained from the California Irrigation Management Information System (CIMIS) using the maps prepared by the University of California, Davis, and the California Department of Water Resources. A copy of the map and reference data is included in **Attachment A**. The monthly CIMIS reference evapotranspiration data selected for the project area were the published rates for CIMIS Zone 3, Coastal Valleys.

  "Reference evapotranspiration (ETo)" is a term used to estimate the evapotranspiration rate of a reference crop expressed in either inches or millimeters. The reference crop used for the CIMIS program is grass, which is closely clipped, actively growing, completely shading the soil, and well watered. The adjusted evapotranspiration values following the Landscape Coefficient Method, as described in the University of California Cooperative Extension Leaflet 21943 "Estimating Water Requirements of Landscape Plantings". This is an adjustment to reflect the localized conditions and vegetation selection. For this analysis an average landscape coefficient (multiplier) of 0.6 was determined, based on assumption of: (a) 0.6 Species factor for warm-season turf grass, drought tolerant; (b) 1.0 Density factor for average conditions; and (c) 1.0 Microclimate factor for average conditions. The composite landscape coefficient is the product of these three factors. The same landscape coefficient determined for turf grass was applied for the native grassland under existing conditions.

- **Applied irrigation water and Seepage Losses.** The average rate of applied irrigation water for the proposed cemetery lawns was estimated to be approximately 1.6 acre-feet per year per acre based on an irrigation water balance analysis detailed in the "Water Supply Analysis" report by Questa (April 2014). Total volume of water is this rate multiplied times the amount of area to be irrigated. Estimates were made of the approximate amount of irrigated lawns in each sub-watershed based on the applicant's conceptual plans for the northwestern portion of the project site. An estimate of 75% was assigned to all sub-watersheds, except WS3 and WS6 on the eastern side of the ridgeline, which were estimated to be 50% and 30%, respectively. For the northwestern portion of the cemetery the overall percentage devoted to irrigated turf was estimated to be about 48 acres, roughly 70% of the cemetery (northwestern portion). At full build-out the estimated amount of irrigated turf is about 75 acres, roughly 74% of the total cemetery area.

  "Seepage losses" from applied irrigation water represent the amount of water that percolates past the root zone due to inefficiencies in exactly matching the plant water requirements. A 10% factor was used to estimate these losses, meaning that 90% of the applied irrigation water is taken up by plant evapotranspiration, and the balance percolates through the soil eventually becoming part of the groundwater recharge. This reflects a relatively high level of irrigation efficiency, which is achievable with a well-managed computer-aided control system, as proposed.

- **Sub-surface Drains for Fill Areas.** Per geotechnical recommendations (Earth Systems Pacific, April 2014), sub-surface drains will be installed beneath the engineered fill areas of the cemetery. These drains will act to intercept a portion of the water percolating beneath the cemetery (e.g., from rainwater or irrigation seepage losses), and route the water (by gravity flow) for discharge to the surface. This will have the effect of returning some of the percolating recharge water back to the surface water runoff regime. To account for this, we determined the approximate area of fills in each sub-watershed and assumed these sub-surface drains would intercept and divert approximately 10% of the percolating recharge water within the determined fill areas. Depending on final project grading plans, this flow may be very amenable to dispersal to vegetated areas, percolation somewhere else on the site, or collection for other onsite uses. However, for our impact analysis, we calculated the resulting flow from these sub-drains as an addition to the annual volume of runoff from the project site.

- **Onsite Water Well Pumping.** Per findings and recommendations of the Water Supply Analysis (Questa Engineering, April 2014), the onsite water well will be used to extract approximately 2.0 acre-feet per year of groundwater to meet the projected domestic water demands at project build-out. In the water balance, this groundwater extraction was subtracted from the estimated annual groundwater recharge volume for sub-basin WS4, where the well is located.

- **Onsite Wastewater Disposal.** Per findings and recommendations of the Wastewater Disposal Investigation (Questa Engineering, April 2014), the maximum daily wastewater flow at build-out is projected to be approximately 1,300 gpd. The average daily flow is estimated to be about two-thirds of the maximum, which equates to roughly to 870 gpd, or about 1.0 acre-feet per year. This value was incorporated in the water balance as additional groundwater recharge occurring in Sub-watershed WS6, where the proposed onsite wastewater disposal field is planned to be located.

- **Irrigation Storage Reservoir(s).** The conceptual project plans show a proposed irrigation storage reservoir, approximately 1.25 acres in size, located in Sub-watershed WS3. It is assumed the reservoir will retain all direct rainfall within the area of the reservoir; therefore in the water balance it is treated as a reduction in land area in WS3, contributing neither to rainfall-runoff or groundwater recharge.

Results. Results of the water balance analysis are summarized in **Table 3**, showing a comparison of the estimated annual runoff and groundwater recharge volumes for existing conditions and projected build-out conditions. The results are presented for each of the eight sub-watersheds, for each of the three general watersheds (A, B and C), and for the project site as a whole. A discussion of the key findings follows.

Table 3. Water Balance Analysis Results

Sub-Watershed ID	Rainfall – Runoff(ac-ft/yr)			Groundwater Recharge (ac-ft/Yr)		
	Existing Conditions	Proposed Project Conditions	Net Change	Existing Conditions	Proposed Project Conditions	Net Change
Watershed C						
WS-1	1.78	0.98	(-0.80)	6.34	5.61	(-0.73)
WS-2	4.43	4.79	+0.36	15.79	21.19	+5.40
WS-3	2.15	0.74	(-1.41)	7.69	4.81	(-2.88)
WS-6	0.48	0.26	(-0.22)	1.72	2.73	1.01
Sub-Total	**8.84**	**6.77**	**(-2.07)**	**31.53**	**34.33**	**+2.80**
Watershed A						
WS-4	4.40	5.74	+1.34	15.70	16.14	+0.44
WS-8	0.22	0.45	+0.23	0.77	1.98	+1.21
Sub-Total	**4.62**	**6.19**	**+1.57**	**16.47**	**18.13**	**+1.65**
Watershed B						
WS-5	1.72	2.82	+1.10	6.14	6.06	(-0.08)
WS-7	1.11	1.08	(-0.03)	3.95	4.77	+0.82
Sub-Total	**2.83**	**3.90**	**+1.07**	**10.09**	**10.83**	**+0.74**
Project Site Total	**16.29**	**16.86**	**+0.57**	**58.09**	**63.28**	**+5.19**

- **Annual Runoff.**
  - The northwestern portion of the project site is estimated to produce a net reduction in surface runoff to Coyote Valley (Watersheds B and C) of approximately 1 acre-ft per year, with an increase of 1 acre-ft occurring in Watershed B, and a 2 acre-ft decrease in Watershed C.
  - Annual runoff to the Calero Reservoir (Watershed A) is estimated to increase by about 1.6 acre-ft, the majority coming from sub-watershed WS4, which will encompass portions of the administration building and associated parking areas.
  - For the project site as a whole, the development of the northwestern portion of the cemetery (per conceptual plans) indicates a net increase in annual runoff of approximately 0.6 acre-ft.
  - The additional runoff from the project is attributable principally to the impervious surfaces associated with the administration building and associated parking, indicating the need for inclusion of retention measures in the stormwater BMPs for the project.
  - The proposed network of access roads throughout the cemetery, if handled primarily by sheet flow dispersal across adjacent turf and other vegetated areas, will be self-mitigating and will not contribute to increased surface water runoff from the site compared to existing conditions.
- **Annual Groundwater Recharge.**
  - The northwestern portion of the project site is estimated to produce a net increase in groundwater recharge in all three general watersheds (A, B, and C) and for the project site as a whole.
  - The net increase in groundwater recharge is estimated to be about 5.2 acre-ft per year, with about 85% occurring in the areas tributary to Coyote Valley, and 15% to the Calero Reservoir side.
- **Future Build-out.** Development of the remaining portion (southeastern area) of the 102-acres of cemetery at full build-out would be expected to have effects represented by those estimated for the adjacent sub-watersheds WS6 and WS7. These sub-watersheds have similar hydrological conditions and, assuming comparable grading, drainage and road network, the watershed effects would be a small decrease in annual runoff volumes and a small increase in annual groundwater recharge volumes, all within the Coyote Valley watershed. There would be no effect on the Calero Reservoir watershed from this remaining build-out of the cemetery.

Recommendations

- Where practicable, direct runoff from paved access paths to "sheet flow" across turf areas for absorption and to slow the rate of runoff;

- Where practicable, direct water from sub-drains (beneath engineered fills) to turf areas or other vegetated areas for absorption and to slow the rate of runoff;

- For the administration building and parking areas, consider amongst the potential stormwater BMPs the option of installing facilities to capture, contain and route excess runoff into the onsite irrigation storage reservoir(s). This may, for example, be accomplished with one or more stormwater interceptors, lift station and piping to pump the collected runoff to the irrigation storage reservoir or combined with the pump system taking water diverted from the Cross Valley Pipeline.

Soil Erosion

Construction of the cemetery will require earthwork for roads, building pad(s), pipelines, pond(s), and mass grading to re-contour large portions of the site to accommodate the planned cemetery uses. Some portions of the project site are gently sloping meadows; but most of the site is moderately to steeply sloping terrain, with intervening swales. Consequently, construction work and project design must pay careful attention to potential erosion hazards.

Soil erosion can cause numerous types of impacts. Eroded soil contains nitrogen, phosphorus, and other nutrients. When carried into water bodies, these nutrients can stimulate algae growth that reduce water clarity, deplete oxygen and create odors. The greatest soil erosion hazard would exist during and immediately following the initial major grading and construction activities. However, the full extent of the cemetery will be built-out over a long period of time, with excavation and grading work expected to occur off-and-on with each expansion phase. Once grading and site development is completed in each area, there should be minimal threat of erosion and sediment discharges to downstream water bodies, due to the addition and maintenance of turf grass and other landscaping and native re-vegetation in areas of soil disturbance.

Recommendations. Erosion and sedimentation impacts from the construction of the proposed cemetery and support facilities are expected to be confined predominantly to the construction phases of the project. Construction-related erosion and sedimentation may be mitigated by the implementation of the following measures:

- For each phase of work, the cemetery grading plan should conform to all drainage and erosion control standards adopted by the City of San Jose. The standards should include measures such as: (a) restricting grading to the dry season, except under specific conditions granted by the City; (b) protecting all finished graded slopes from erosion through re-vegetation, drainage diversion and other appropriate methods; (c) protecting any downstream storm drainage inlets from sedimentation; and (d) as applicable, use of silt fencing, straw bales and wattles, erosion control blankets, mulch and reseeding, and temporary sedimentation basins to retain sediment on the project site.

- The project applicant shall apply for and receive the applicable permits under the National Pollutant Discharge Elimination System (NPDES), including preparation and updating of required Stormwater Pollution Prevention Plans (SWPPP).

- After construction is completed for each phase of work, all drainage facilities should be inspected for accumulated sediment. Where sediment has accumulated, these drainage structures should be cleared of debris and sediment.

Stormwater Runoff Quality

The development of the proposed cemetery will involve the construction of roads and parking areas, as well as equipment storage and maintenance washing, as part of the normal day-to-day operations. Runoff from these vehicle areas can be expected to contain non-point pollution similar to that from urban areas. The type of pollutants contained in street/parking lot runoff include oil and grease, heavy metals, other petroleum derivatives coming from engine drippings and wearing of tires, brake linings and asphalt pavement. Some amount of general litter and debris can also be anticipated; paint and solvent residue associated with maintenance activities could be present in the maintenance area or around construction work.

If allowed to be washed directly into the local drainages, these surface contaminants could be detectable downstream in the seasonal drainages leading to Calero Reservoir on the west and Coyote Creek on the east. However, the impact on these downstream receiving water bodies would likely be small to negligible. Nevertheless, any additional non-point pollution threats to the watershed and reservoir must be controlled and minimized.

Recommendations: Although details have not been provided, the applicant has indicated the intention to consider and incorporate, as appropriate, various stormwater quality management measures, including:

- Minimum-impact street and parking lot design
- Cluster structures/ pavement
- Self-treating areas
- Self-retaining areas
- Storm drain labeling
- Pavement sweeping, catch basin cleaning, etc.
- In-ground detention and infiltration system
- Biotreatment basins

Based on our assessment of the site conditions and preliminary plans, management measures that should be given high priority to avoid adverse stormwater runoff effects from the memorial park include:

- Wherever practicable, channel site runoff through grass-lined, permeable drainage swales, in lieu of direct piping to one of the existing drainageways.

- Disperse the drainage from roads and parking areas as sheet flow to adjacent turf and vegetated buffer areas.

- Provide containment dikes around and, possibly, covering over maintenance areas where the potential for oil, grease and fuel spillage is high.

- Routinely police the grounds to collect litter and other debris that could be washed into the local drainages.

- Evaluate and include, as appropriate, stormwater interceptor tanks in selected locations to serve several potential purposes: (a) reduction of peak runoff flows from impervious areas; (b) capture and retention of pollutants that might be washed from parking area surfaces during the "first flush" period of a storm and unanticipated off-season rain showers; and (c) a means for retaining and incorporating excess runoff water into the onsite storage reservoir and turf irrigation system.

Landscape/Turf Fertilizers

The cemetery lawns will be fertilized as part of regular turf maintenance. Using golf course fairway turf as a guideline, typical yearly application rates of 3 lbs./1,000 sq.ft. would be anticipated. Nitrogen is the primary fertilizing agent and is of potential water quality concern for downstream surface waters (i.e., Calero Reservoir) and groundwater that may be used for drinking water supplies.

Surface Water Impacts. A variety of factors control nitrogen transport from turf areas to surface waters, including climate, rainfall intensity and duration, soil texture, management practices, plant uptake ability, volatilization, and soil moisture conditions.

The greatest concern is that of nitrogen fertilizer being transported by surface runoff from the area of application before it is absorbed and utilized by the vegetation. The majority of nitrogen that is transported to surface water sources consists of sediment-bound nitrogen (Balogh and Walker, 1992). The increased nitrogen delivered to a surface water body can serve as a nutrient enrichment, causing stimulation of aquatic growth and, possibly, increased eutrophication of the water body. Management factors such as application rates, timing of application, the form of application, and amount of irrigation all contribute to nitrogen's ability to move from the area of application into ground or surface waters. Irrigation and subsequent soil moisture levels have to be monitored and kept as low as possible to reduce the likelihood of seepage losses. The amount and timing fertilization is important to maximize plant uptake and minimize the potential for surface runoff. The amount of irrigation and subsequent soil moisture levels are important to reduce potential leaching of nitrogen.

The layout the cemetery should avoid the placement of irrigated turf where unfiltered runoff can directly enter any of the seasonal drainages on or immediately downstream of the site. Using intervening buffer areas of native grasses will greatly reduce the potential for runoff of residual nitrogen from fertilizer applications.

Groundwater Impacts. Nitrogen is the primary component of turf grass fertilizer and poses potential groundwater quality concerns to the extent that there is excess nitrogen that is not utilized by the vegetation. Nitrogen losses to sub-soils and groundwater are in the form of nitrate which can contribute to human health problems (in drinking water) and general degradation of water quality. Nitrogen loss to groundwater occurs once nitrogen that is not taken up by the plant, absorbed by the soil, or volatilized has seeped past the root zone of the turf grass, and slowly migrates to groundwater. At normal fertilizer rates, cemetery lawns are not as susceptible to potential leaching as, for instance, more intensively managed turf such as golf course tees and greens. However, given the large amount of land coverage with turf, the potential nitrate leaching effects requires evaluation and management.

The potential for groundwater nitrate effects can be evaluated through a simplified chemical/water mass balance as described here. Using an estimated annual nitrogen application rate of 3 lbs/1,000 sq.ft. for cemetery lawns, and a total of approximately 75 acres of irrigated turf at build-out, the projected total annual amount of fertilizer application would be:

Total Annual Nitrogen Applied = (75 acres)*(43,560 ft^2/acre) @ 3 lbs/1,000 ft^2 = 9,800 lbs/yr

Under good turf fertilizer management practices, 90 percent (8,820 lbs) of the applied nitrogen will go to plant uptake and denitrification in the soil (Petrovic, 1990); the remaining 10 percent (980 lbs) would be expected to leach downward to the groundwater. Since the turf areas would be spread throughout the approximately 102 acres of cemetery area, the long-term effect on groundwater quality can be estimated as the weighted average or combined effect of percolating recharge water and fertilizer leachate over the 102-acre area. Note, this does not include the approximately 175 acres of open space area (mostly on the eastern side of the project site), which would have a diluting effect on the resulting groundwater nitrate concentration for areas of the site draining toward Coyote Valley. From the water balance analysis presented previously, the average annual groundwater recharge for the site, due to rainfall percolation and irrigation seepage losses, is estimated to be approximately 0.91 acre-ft/yr per acre (63 ac-ft per 69 acres). The combined nitrate-nitrogen percolate concentration (N_C) is calculated as shown below.

$$N_C = N_L / (8.34)(R)$$

where:
N_C = resultant nitrate concentration in groundwater beneath the site (as N, in mg/l)
R = million gal per yr recharge = (0.91 ft)(102 ac)(325,851 million gal/ac-ft) = 30.25mill gal
N_L = nitrogen leached, in lbs/year = 980 lbs.
8.34 = units conversion factor

Substituting the assumed and calculated values:

N_C = 980/ (8.34) (30.25) = 3.88mg/l, NO_3-N

This calculation shows a predicated measurable rise in the groundwater-nitrate concentration immediately beneath the cemetery. This concentration would be expected to be found in groundwater in the deeper fracture zones of the Franciscan formation beneath the site. The concentration would still be well below the NO_3-N drinking water limit of 10 mg/l and, therefore, would not pose a threat to any existing or potential uses of groundwater around or downgradient of the project site.

The above calculation is based solely on consideration of the fertilizer nitrate load. Although small, the project will also contribute nitrate through the onsite wastewater disposal system for the administration building staff and visitors. The combined effect from both of these nitrate sources is considered here. In the combined nitrate loading analysis, the above mass balance equation is modified to include the annual wastewater nitrate load, N_{LW} (in lbs. of N), and the average annual wastewater flow, W, into the soil (in million gallons). The revised formula and calculations are as follows:

$N_C = N_L + N_W/(8.34)\ (R + W)$

where, in addition to N_C, N_L, R and 8.34 from above:

W = average annual wastewater discharge volume = 1.0 ac-ft/yr = 0.325 million gallons
N_W = annual nitrogen wastewater loading = $(8.34)(0.325)(N_E)(1 - d)$
N_E = 30 mg/l, average nitrogen content of secondary treated effluent
d = 0.10, assumed denitrification rate in soils
$N_W = (8.34)(0.325)(30)(1 - 0.10) = 73$ lbs/year

Substituting the assumed and calculated values:

$N_C = (980 + 73)/\ (8.34)(30.25 + 0.325) = 1{,}053/(8.34)(30.58) =$ 4.13 mg/l, NO_3-N

This analysis shows that the wastewater disposal system for the project will add about 5 percent additional nitrate over that contributed by the cemetery turf fertilizer applications. The overall loading effect will still remain well below the drinking water limit of 10 mg/l, NO_3-N. Also, as noted previously, this analysis does not include the diluting effects of rainfall-recharge from the 175 acres of open space mostly on the east side of the project site, which will substantially reduce the resultant groundwater nitrate concentrations for the portions of the project site that drain toward Coyote Valley. For further discussion of the wastewater disposal facilities and the basis for the nitrate loading assumption, please refer to the separate "Wastewater Facilities Analysis" for the project, prepared by Questa Engineering (April 2014).

Current Agricultural Use. Currently the property is used for grazing of cattle. Animal wastes contain significant amounts nitrogen which, like fertilizers, are available for leaching into the soil and groundwater or runoff into surface streams. The nitrate loading to the watershed depends upon the: (a) size, number and diet of the animals; (b) the intensity of grazing and animal confinement facilities; and, (c) proximity and accessibility of the animals to drainage channels or water bodies. No attempt has been made to measure or estimate the nitrate loading effects of the existing/historical agricultural use of the property for grazing. However, it is appropriate to note that this agricultural use of the property represents an existing source of nitrate loading to the both the Coyote Valley and Calero Reservoir watersheds that would be eliminated as a result of the proposed project.

Recommendations. The following management practices are recommended for consideration to minimize the transport of fertilizers from the cemetery turf areas into local drainages and downstream receiving waters, as well as to minimize nitrate additions to ground water.

- The applicant should prepare a nitrogen control plan which incorporates the following: (a) determination of appropriate fertilizer application rates based upon site specific soil testing and plant requirements; and, (b) annual accounting of nitrogen application to the turf areas for comparison with optimum rates.

- Application rates of fertilizers should be monitored closely and adjusted as necessary to not exceed the turf grass assimilation capacity. This could include testing of the soils under the lawns periodically to determine proper nitrogen application rates and to monitor any potential excess nitrogen buildup within the soil.

- The nitrogen fertilizer should be the slow release or less soluble form, whenever possible.

- Irrigation of the turf areas should be limited to the calculated evapotranspiration rate, plus any mineral dilution requirement, as appropriate. Excessive irrigation and soil moisture should be avoided. This will reduce potential leaching to the subsoil as well as reduce potential surface runoff from irrigation application.

- The timing of fertilizer application should coincide with the period of greatest plant uptake and avoid periods of potential runoff-rainfall events.

- Where practicable, water collected from sub-drains (beneath engineered fills) should be directed to turf areas or other vegetated areas, rather to surface drainage systems, for further absorption and uptake of any residual nitrate concentrations in the collected groundwater.

Pesticides

Pesticides (including insecticides, herbicides, and fungicides) contain a variety of chemicals used to control pests, insects and weeds. They are commonly used in a variety of applications in areas with green spaces, including the maintenance of cemetery lawns. By nature, pesticides are poisonous, and while they can be safely used if manufacturers' usage directions are followed, they can, if mismanaged, seep into surface water and ground water supplies. Heavy rains can wash pesticides from plants and soil. This can, in turn, run off into streams. Pesticides can leach into the soil if plants are watered or rainfall occurs soon after application. They can be difficult and expensive to remove, and, if inhaled or consumed, be hazardous to human health. The synthetic organic chemicals in pesticides have been linked to serious health problems, including cancer, liver and kidney damage, reproductive difficulties, and nervous system effects (U.S. EPA, 2001)

It is anticipated that pesticides may be used from time-to-time for maintenance of lawns at the proposed memorial park. These chemicals are applied selectively and much less frequently than fertilizers - usually no more than once or twice per year. The pesticides and herbicides typically used on park lawns are not highly mobile nor persistent; they dissipate rapidly as a result of volatilization, photodegradation, microbial action, hydrolysis and soil absorption.

Surface Water Impacts. The principal threat to water quality from pesticides/herbicide use on the proposed cemetery project site would most likely occur in the event of: (a) a significant rainfall event immediately following chemical application; or, (b) spillage in the area where the chemicals are handled and/or stored. There could be a potentially significant impact on surface water quality of downstream drainages that lead to either Coyote Valley or Calero Reservoir, if either of the above events were to occur.

Groundwater Impacts. Pesticide movement to groundwater is generally associated with the following conditions:

- coarse alluvial soils which may have inter-bedded fine grain materials;
- excessive quantities of irrigation water or other sources;
- unconfined aquifers with a depth to water table less than thirty feet;
- extensive or concentrated pesticide applications occurring over many years; and
- pesticides that are highly persistent and mobile in the soil-water systems.

The proposed cemetery will be located on moderately to slowly permeable soils, weathered from sandstone, shale and chert. The site does not contain any areas of highly permeable soils, typically associated with alluvial deposits. Based on information from well drilling, groundwater on the site occurs in the fractured bedrock, at depths on the order of 50 to 100 feet below ground surface.

Cemetery irrigation will be controlled by an automated system that is specifically designed to prevent excessive watering and minimize runoff from the site. Because irrigation will be held to a minimum, the amount of excess irrigation water lost to groundwater will also be minimal. This will significantly reduce the potential for pesticides to be transported to groundwater.

Pesticide use on cemetery lawns is relatively small compared with agricultural operations. Usually pesticide application is conducted only once or twice per year. The pesticides which are in common use on lawns are not very persistent. They breakdown or decompose quickly through several mechanisms such as photodegradation, soil adsorption, hydrolysis, and volatilization (i.e., evaporation). Residues are usually undetectable one to two weeks after application.

The pesticide use on the cemetery should not have any adverse impact on groundwater quality beneath the site if proper application and handling practices are observed.

Recommendations. The following management practices are recommended for consideration to minimize the transport of pesticides from cemetery turf or maintenance areas into local drainages and downstream receiving waters, as well as to minimize possible leaching to ground water.

<u>Design</u>

- Provide vegetated buffers adjacent to all turf areas where maintenance pesticides may be used. The vegetated buffers would be intended to receive and filter runoff and prevent chemical releases to drainage channels or other surface water features.

- Where practicable, outfalls from sub-drains installed in connection with fill construction should be routed and located to disperse the water into vegetated buffer areas, irrigation ponds, or similar absorption or containment areas, avoiding discharge directly into seasonal drainage channels or storm drainage facilities.

Operations

- Pesticides should be handled, applied, and disposed of by a licensed spray technician.

- Only approved and legal chemicals should be used. All county, state, and federal guidelines must be strictly adhered to regarding storage, handling, and application of pesticides.

- Only proper equipment should be used for application. This equipment should be maintained and in proper calibration.

- A controlled and designated area/facility should be used for the proper mixing and loading of pesticides into application equipment. The facility should consist of an impermeable pad with controlled and contained drainage, and should be at least 50 feet from open ditches, ponds or other water bodies. Rinse water should properly stored and hauled for disposal at an approved facility.

- Selection of pesticides should be based on the ability to achieve treatment goals and criteria to minimize off-site movement. Selection of less toxic, less mobile, and less persistent pesticides should be a priority management criterion.

- Pesticide applications should be carefully timed and combined with other pest management practices; pests should be accurately identified and pesticide applications made only when necessary, using the least amount required.

- Pesticides should not be applied when soil moisture is high during the rainy season. Applications should be restricted prior to any anticipated late or early season storm events to preclude potential impacts from runoff.

- Irrigation applications should be consistent with turf grass evapotranspiration requirements. Over-watering should be avoided.

SUMMARY AND CONCLUSIONS

This analysis was conducted to identify and evaluate potential hydrologic and water quality impacts associated with the construction and ongoing operation of the proposed Heritage Memorial Park in San Jose, California. Issues of primary concern addressed include changes in hydrology (hydromodification), soil erosion, stormwater runoff contaminants from parking and maintenance areas, and fertilizer and pesticide applications for turf management.

Specific aspects of the project that will alter the hydrological conditions include: (1) grading and re-contouring of the terrain along with changes in site runoff patterns and drainage/catchment areas; (2) conversion of the vegetation from grazed pasture to irrigated, managed turf grass; (3) application of irrigation water; (4) impervious areas created by access roads, parking areas and buildings; (5) onsite reservoir(s) for storage and regulation of irrigation water; (6) onsite groundwater well for potable water supply; and (7) onsite wastewater disposal system.

Potential impacts were evaluated quantitatively through the application of standard Santa Clara County runoff procedures, construction of an annual water balance analysis, and water-chemical nitrogen mass balance analysis. Based on the results of these analyses combined with review of baseline hydrological conditions, proposed development activities, and the range of available design and operational measures to be included in project implementation, we conclude that all contemplated hydrological and water quality impacts of the project can be adequately managed and mitigated onsite.

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Attachment A
Water Balance Calculations and Reference Information

Water Balance by Watershed

Heritage Oaks Memorial Park

Sub-Watershed ID	Existing Conditions						Proposed Condtions																		
	Area (acres)	CN Value	Annual Runoff		Annual Recharge		Area (acres)	% Sub-drained Fills	% Imperv	Building Site Acres	Subdrain Return Flow	Pond Area	CN Value	Annual Runoff		Annual Recharge									
			Inches	Ac-ft	Inches	Ac-ft								Inches	Ac-ft	Rainfall Recharge (inches)	Rainfall Recharge (ac-ft)	% Irrigated	Building Site Acres	Irrigated Acres	Inches Irrig.	Irrig. Ac-ft	Seepage Losses (ac-ft)	Wastewater (-Well Water) (ac-ft)	Net Recharge (ac-ft)
East Side																									
WS-1	7.56	79	2.82	1.78	10.06	6.34	5.55	0.30	0	0.00	0.17	0	74	1.75	0.98	11.06	5.12	0.75	0.00	4.16	19.14	6.64	0.66	0.00	5.61
WS-2	18.83	79	2.82	4.43	10.06	15.79	21.81	0.20	15	0.00	0.43	0	77	2.40	4.79	10.46	19.01	0.75	0.00	16.36	19.14	26.09	2.61	0.00	21.19
WS-3	9.17	79	2.82	2.15	10.06	7.69	6.00	0.10	0	0.00	0.05	1.25	74	1.75	0.74	11.06	4.38	0.50	0.00	3.00	19.14	4.79	0.48	0.00	4.81
WS-6	2.05	79	2.82	0.48	10.06	1.72	1.78	0.00	0	0.00	0.00	0	74	1.75	0.26	11.06	1.64	0.30	0.00	0.53	19.14	0.85	0.09	1.00	2.73
Total	**37.61**			**8.84**		**31.53**	**35.14**				**0.65**				**6.78**		**30.14**			**24.05**		**38.37**	**3.84**	**1.00**	**34.33**
West Side - A																									
WS-4	18.73	79	2.82	4.40	10.06	15.70	19.91	0.30	15	1.00	0.56	0	77	2.40	5.74	10.46	16.48	0.75	1.00	13.93	19.14	22.22	2.22	-2.00	16.14
WS-8	0.92	79	2.82	0.22	10.06	0.77	2.04	0.20	15	0.00	0.04	0	77	2.40	0.45	10.46	1.78	0.75	0.00	1.53	19.14	2.44	0.24	0.00	1.98
Total	**19.65**			**4.62**		**16.47**	**21.95**				**0.60**				**6.19**		**18.26**		**1.00**	**15.46**		**24.66**	**2.47**	**-2.00**	**18.13**
East Side - B																									
WS-5	7.32	79	2.82	1.72	10.06	6.14	7.31	0.25	15	1.00	0.16	0	77	2.40	2.82	10.46	5.50	0.75	1.00	4.48	19.14	7.15	0.71	0.00	6.06
WS7	4.71	79	2.82	1.11	10.06	3.95	4.91	0.20	15	0.00	0.10	0	77	2.40	1.08	10.46	4.28	0.75	0.00	3.68	19.14	5.87	0.59	0.00	4.77
Total	**12.03**			**2.83**		**10.09**	**12.22**				**0.25**				**3.90**		**9.78**		**1.00**	**8.17**		**13.02**	**1.30**	**0.00**	**10.83**
Grand Total	**69.29**			**16.28**		**58.09**	**69.31**				**1.51**				**16.87**		**58.19**		**2.00**	**47.68**		**76.05**	**7.61**	**-1.00**	**63.28**

Water Balance Analysis - Heritage Oaks Memorial Park
(ETo Climate Zone 3; CN 74)

Month	1 Ave Precip. (in/month)	2 Average Runoff Rate	3 Runoff	4 Available Precip.	5 Potential ET (in/month)	6 Adjusted ET (in/month)	7 Excess Water Percolation to
Jan	4.94	0.10	0.49	4.45	1.86	1.12	3.33
Feb	5.06	0.10	0.51	4.55	2.24	1.34	3.21
Mar	3.63	0.05	0.18	3.45	3.72	2.23	1.22
Apr	1.40	0.02	0.03	1.37	4.80	2.88	0.00
May	0.54	0.00	0.00	0.54	5.27	3.16	0.00
Jun	0.10	0.00	0.00	0.10	5.70	3.42	0.00
Jul	0.00	0.00	0.00	0.00	5.58	3.35	0.00
Aug	0.03	0.00	0.00	0.03	5.27	3.16	0.00
Sep	0.18	0.00	0.00	0.18	4.20	2.52	0.00
Oct	1.01	0.02	0.02	0.99	3.41	2.05	0.00
Nov	2.37	0.05	0.12	2.25	2.40	1.44	0.81
Dec	4.01	0.10	0.40	3.61	1.86	1.12	2.49
Total	**23.27**		**1.75**	**21.52**	**46.31**	**27.79**	**11.06**

Notes:

1. Ave monthly precip for Calero Reservoir Park (Weather Channel)
2. "Available Precip" equal to ave monthly precip minus estimated runoff rate (percent);
3. Reference ETo obtained from CIMIS for Zone 3, Coastal Valleys
4. Potential ET adjusted with 0.6 Landscape Coefficient multiplier for warm-season turf grass and ave conditions

Water Balance Analysis - Heritage Oaks Memorial Park
(ETo Climate Zone 3; CN 77)

Month	1 Ave Precip. (in/month)	2 Average Runoff Rate	3 Runoff	4 Available Precip.	5 Potential ET (in/month)	6 Adjusted ET (in/month)	7 Excess Water Percolation to
Jan	4.94	0.13	0.64	4.30	1.86	1.12	3.18
Feb	5.06	0.13	0.66	4.40	2.24	1.34	3.06
Mar	3.63	0.08	0.29	3.34	3.72	2.23	1.11
Apr	1.40	0.04	0.06	1.34	4.80	2.88	0.00
May	0.54	0.00	0.00	0.54	5.27	3.16	0.00
Jun	0.10	0.00	0.00	0.10	5.70	3.42	0.00
Jul	0.00	0.00	0.00	0.00	5.58	3.35	0.00
Aug	0.03	0.00	0.00	0.03	5.27	3.16	0.00
Sep	0.18	0.00	0.00	0.18	4.20	2.52	0.00
Oct	1.01	0.04	0.04	0.97	3.41	2.05	0.00
Nov	2.37	0.08	0.19	2.18	2.40	1.44	0.74
Dec	4.01	0.13	0.52	3.49	1.86	1.12	2.37
Total	**23.27**		**2.40**	**20.87**	**46.31**	**27.79**	**10.46**

Notes:

1. Ave monthly precip for Calero Reservoir Park (Weather Channel)
2. "Available Precip" equal to ave monthly precip minus estimated runoff rate (percent);
3. Reference ETo obtained from CIMIS for Zone 3, Coastal Valleys
4. Potential ET adjusted with 0.6 Landscape Coefficient multiplier for warm-season turf grass and ave conditions

Water Balance Analysis - Heritage Oaks Memorial Park
(ETo Climate Zone 3; CN 79)

Month	1 Ave Precip. (in/month)	2 Average Runoff Rate (%)	3 Runoff	4 Available Precip. (in/month)	5 Potential ET (in/month)	6 Adjusted ET (in/month)	7 Excess Water Percolation to Groundwater
Jan	4.94	0.15	0.74	4.20	1.86	1.12	3.08
Feb	5.06	0.15	0.76	4.30	2.24	1.34	2.96
Mar	3.63	0.10	0.36	3.27	3.72	2.23	1.04
Apr	1.40	0.05	0.07	1.33	4.80	2.88	0.00
May	0.54	0.00	0.00	0.54	5.27	3.16	0.00
Jun	0.10	0.00	0.00	0.10	5.70	3.42	0.00
Jul	0.00	0.00	0.00	0.00	5.58	3.35	0.00
Aug	0.03	0.00	0.00	0.03	5.27	3.16	0.00
Sep	0.18	0.00	0.00	0.18	4.20	2.52	0.00
Oct	1.01	0.05	0.05	0.96	3.41	2.05	0.00
Nov	2.37	0.10	0.24	2.13	2.40	1.44	0.69
Dec	4.01	0.15	0.60	3.41	1.86	1.12	2.29
Total	**23.27**		**2.82**	**20.45**	**46.31**	**27.79**	**10.06**

Notes:

1. Ave monthly precip for Calero Reservoir Park (Weather Channel)
2. "Available Precip" equal to ave monthly precip minus estimated runoff rate (percent);
3. Reference ETo obtained from CIMIS for Zone 3, Coastal Valleys
4. Potential ET adjusted with 0.6 Landscape Coefficient multiplier for native grassland - average conditions

Adjusted CN for Unconnected Impervious Road Surface Area by Sub-watershed
Heritage Oaks Memorial Park

Sub-Watershed ID	Total Area	Measured Length of Road (lin ft)	Calculated Road Area (sq ft)	Road Area (acres)	% Impervious	Adjusted CN*
Watershed C						
WS-1	5.55	0	0	0.00	0.00	74.0
WS-2	21.81	5,835	145,875	3.35	0.15	77.5
WS-3	6.00	0	0	0.00	0.00	74.0
WS-6	1.78	0	0	0.00	0.00	74.0
Total	**35.14**	**5,835**	**145,875**	**3.35**	**0.10**	**76.2**
Watershed A						
WS-4	19.91	4,125	103,125	2.37	0.12	76.7
WS-8	2.04	450	11,250	0.26	0.13	76.9
Total	**21.95**	**4,575**	114,375	2.63	0.12	76.7
Watershed B						
WS-5	7.31	1,650	41,250	0.95	0.13	77.0
WS7	4.91	1,475	36,875	0.85	0.17	77.9
Total	**12.22**	**3,125**	**78,125**	**1.79**	**0.15**	**77.3**
Grand Total	**69.31**	**13,535**	**338,375**	**7.77**	**0.11**	**76.6**

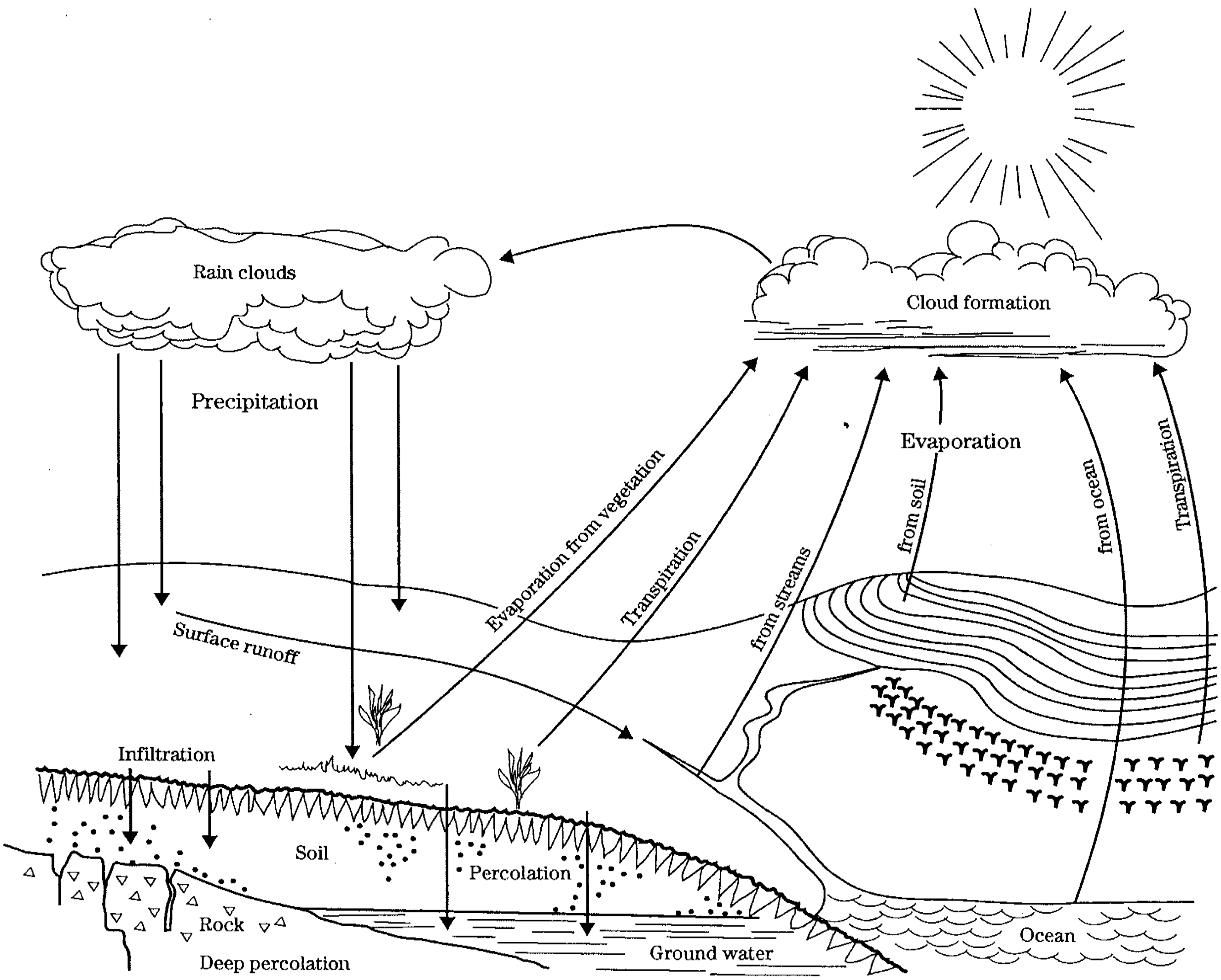
* Calculated per NRCS National Engineering Handbook, Part 630; Chapter 9 - Hydroglogic Soil-Cover Complexes; p 9-12

United States
Department of
Agriculture

**Natural
Resources
Conservation
Service**

Part 630 Hydrology
National Engineering Handbook

Chapter 9 Hydrologic Soil-Cover Complexes



(210-VI-NEH, July 2004)

Table 9–1 Runoff curve numbers for agricultural lands [1/] — Continued

Cover description: cover type	treatment [2/]	hydrologic condition [3/]	CN for hydrologic soil group: A	B	C	D
Pasture, grassland, or range-continuous forage for grazing [4/]		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
Meadow-continuous grass, protected from grazing and generally mowed for hay		Good	30	58	71	78
Brush-brush-forbs-grass mixture with brush the major element [5/]		Poor	48	67	77	83
		Fair	35	56	70	77
		Good	30 [6/]	48	65	73
Woods-grass combination (orchard or tree farm) [7/]		Poor	57	73	82	86
		Fair	43	65	76	82
		Good	32	58	72	79
Woods [8/]		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	30	55	70	77
Farmstead–buildings, lanes, driveways, and surrounding lots		---	59	74	82	86
Roads (including right-of-way):						
Dirt		---	72	82	87	89
Gravel		---	76	85	89	91

1/ Average runoff condition, and I_a=0.2s.

2/ Crop residue cover applies only if residue is on at least 5 percent of the surface throughout the year.

3/ Hydrologic condition is based on combinations of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥20%), and (e) degree of surface toughness.

Poor: Factors impair infiltration and tend to increase runoff.
Good: Factors encourage average and better then average infiltration and tend to decrease runoff.
For conservation tillage poor hydrologic condition, 5 to 20 percent of the surface is covered with residue (less than 750 pounds per acre for row crops or 300 pounds per acre for small grain).

For conservation tillage good hydrologic condition, more than 20 percent of the surface is covered with residue (greater than 750 pounds per acre for row crops or 300 pounds per acre for small grain).

4/ Poor: < 50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

5/ Poor: < 50% ground cover.
Fair: 50 to 75% ground cover.
Good: > 75% ground cover.

6/ If actual curve number is less than 30, use CN = 30 for runoff computation.

7/ CNs shown were computed for areas with 50 percent woods and 50 percent grass (pasture) cover. Other combinations of conditions may be computed from the CNs for woods and pasture.

8/ Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed, but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 9–5 Runoff curve numbers for urban areas [1/]

Cover description cover type and hydrologic condition	Average percent impervious area [2/]	-- CN for hydrologic soil group -- A	 B	 C	 D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)		77	86	91	94

1/ Average runoff condition, and $I_a = 0.2S$.

2/ The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.

3/ CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space type.

4/ Composite CNs for natural desert landscaping should be computed using figures 9–3 or 9–4 based on the impervious area percentage (CN=98) and the pervious area CN. The pervious area CNs are assumed equivalent to desert shrub in poor hydrologic condition.

(2) Unconnected impervious areas

If runoff from impervious areas occurs over a pervious area as sheet flow prior to entering the drainage system, the impervious area is unconnected. To determine CN when all or part of the impervious area is not directly connected to the drainage system:

- use equation 9–2 or figure 9–4 if the total impervious area is less than 30 percent of the total area or
- use equation 9–1 or figure 9–3 if the total impervious area is equal to or greater than 30 percent of the total area, because the absorptive capacity of the remaining pervious areas will not significantly affect runoff.

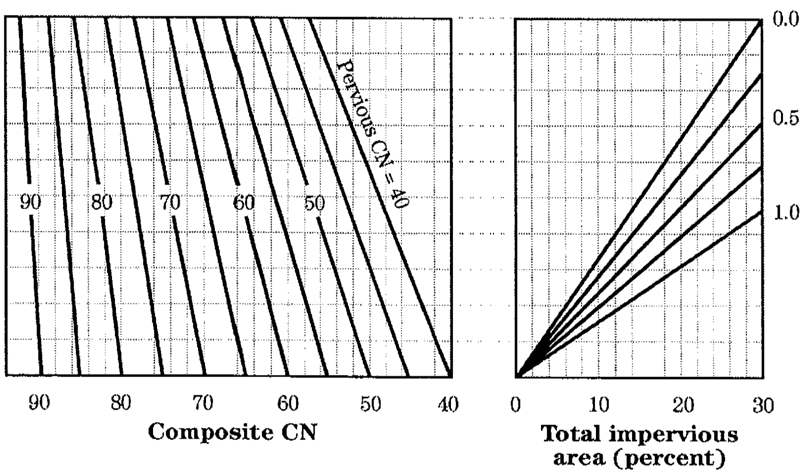
$$CN_c = CN_p + \left(\frac{P_{imp}}{100}\right)(98 - CN_p)(1 - .05R) \quad [9\text{–}2]$$

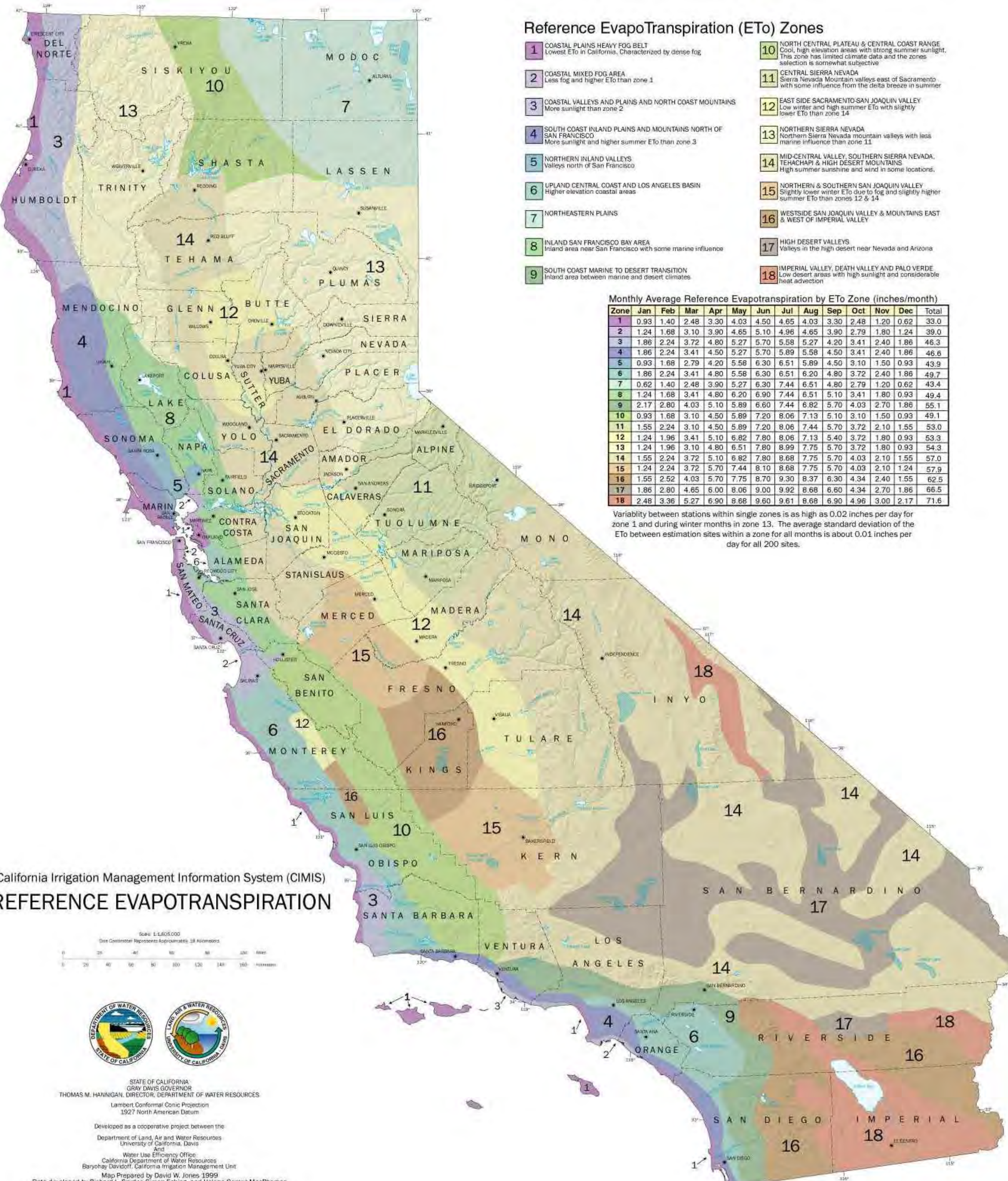
where:

CN_c = composite runoff curve number
CN_p = pervious runoff curve number
P_{imp} = percent imperviousness
R = ratio of unconnected impervious area to total impervious area

When impervious area is less than 30 percent, obtain the composite CN by entering the right half of figure 9–4 with the percentage of total impervious area and the ratio of total unconnected impervious area to total impervious area. Then move left to the appropriate pervious CN and read down to find the composite CN.

Figure 9–4 Composite CN with unconnected impervious areas and total impervious area less than 30%





Reference EvapoTranspiration (ETo) Zones

1	COASTAL PLAINS HEAVY FOG BELT Lowest ETo in California. Characterized by dense fog
2	COASTAL MIXED FOG AREA Less fog and higher ETo than zone 1
3	COASTAL VALLEYS AND PLAINS AND NORTH COAST MOUNTAINS More sunlight than zone 2
4	SOUTH COAST INLAND PLAINS AND MOUNTAINS NORTH OF SAN FRANCISCO More sunlight and higher summer ETo than zone 3
5	NORTHERN INLAND VALLEYS Valleys north of San Francisco
6	UPLAND CENTRAL COAST AND LOS ANGELES BASIN Higher elevation coastal areas
7	NORTHEASTERN PLAINS
8	INLAND SAN FRANCISCO BAY AREA Inland area near San Francisco with some marine influence
9	SOUTH COAST MARINE TO DESERT TRANSITION Inland area between marine and desert climates
10	NORTH CENTRAL PLATEAU & CENTRAL COAST RANGE Cool, high elevation areas with strong summer sunlight. This zone has limited climate data and the zones selection is somewhat subjective
11	CENTRAL SIERRA NEVADA Sierra Nevada Mountain valleys east of Sacramento with some influence from the delta breeze in summer
12	EAST SIDE SACRAMENTO-SAN JOAQUIN VALLEY Low winter and high summer ETo with slightly lower ETo than zone 14
13	NORTHERN SIERRA NEVADA Northern Sierra Nevada mountain valleys with less marine influence than zone 11
14	MID-CENTRAL VALLEY, SOUTHERN SIERRA NEVADA, TEHACHAPI & HIGH DESERT MOUNTAINS High summer sunshine and wind in some locations.
15	NORTHERN & SOUTHERN SAN JOAQUIN VALLEY Slightly lower winter ETo due to fog and slightly higher summer ETo than zones 12 & 14
16	WESTSIDE SAN JOAQUIN VALLEY & MOUNTAINS EAST & WEST OF IMPERIAL VALLEY
17	HIGH DESERT VALLEYS Valleys in the high desert near Nevada and Arizona
18	IMPERIAL VALLEY, DEATH VALLEY AND PALO VERDE Low desert areas with high sunlight and considerable heat advection

Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	33.0
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	5.58	4.50	3.41	2.40	1.86	46.6
5	0.93	1.68	2.79	4.20	5.58	6.30	6.51	5.89	4.50	3.10	1.50	0.93	43.9
6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	6.20	4.80	3.72	2.40	1.86	49.7
7	0.62	1.40	2.48	3.90	5.27	6.30	7.44	6.51	4.80	2.79	1.20	0.62	43.4
8	1.24	1.68	3.41	4.80	6.20	6.90	7.44	6.51	5.10	3.41	1.80	0.93	49.4
9	2.17	2.80	4.03	5.10	5.89	6.60	7.44	6.82	5.70	4.03	2.70	1.86	55.1
10	0.93	1.68	3.10	4.50	5.89	7.20	8.06	7.13	5.10	3.10	1.50	0.93	49.1
11	1.55	2.24	3.10	4.50	5.89	7.20	8.06	7.44	5.70	3.72	2.10	1.55	53.0
12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	53.3
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.5
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

Variablity between stations within single zones is as high as 0.02 inches per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites within a zone for all months is about 0.01 inches per day for all 200 sites.

California Irrigation Management Information System (CIMIS)

REFERENCE EVAPOTRANSPIRATION

Scale 1:1,805,000
One Centimeter Represents Approximately 18 Kilometers

STATE OF CALIFORNIA
GRAY DAVIS GOVERNOR
THOMAS M. HANNIGAN, DIRECTOR, DEPARTMENT OF WATER RESOURCES

Lambert Conformal Conic Projection
1927 North American Datum

Developed as a cooperative project between the

Department of Land, Air and Water Resources
University of California, Davis
And
Water Use Efficiency Office
California Department of Water Resources
Baryohay Davidoff, California Irrigation Management Unit

Map Prepared by David W. Jones 1999
Data developed by Richard L. Snyder, Simon Eching, and Helena Gomez-MacPherson
Background Data from Teale and USGS Sources