Appendix F
Beneficial Use Evaluation Technical Memorandum

CH:CDM

Santa Monica Bay Beaches Wet Weather Bacteria TMDL Implementation Plan

Technical Memorandum Task 5: Beneficial Use Evaluation

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1.0 Introduction

1.1 Background

The CH:CDM team is assisting Jurisdiction groups 2 and 3 in developing an Implementation Plan to address the requirements of the Santa Monica Bay (SMB) Beaches Wet Weather Bacteria Total Maximum Daily Load (TMDL). This TMDL sets a limit on wet weather bacteria exceedance days per year based on monitoring at the SMB beaches. Agencies in Jurisdiction groups 2 and 3 include the Cities of Los Angeles, Santa Monica, and El Segundo; the County of Los Angeles, and Caltrans. Jurisdictions 2 and 3 have selected to pursue an integrated water resources approach to meet the requirements of the TMDL. One of the criteria of the integrated approach outlined in the TMDL is to include beneficial use elements in the implementation plan. The purpose of this technical memorandum (TM) is to evaluate the beneficial use opportunities for wet weather runoff within the Jurisdiction 2 and 3 subwatersheds.

1.2 Scope

This beneficial use evaluation builds on previous and ongoing regional runoff and recycled water planning efforts conducted by the CH:CDM team and the City of Los Angeles in preparing the Integrated Resources Plan (IRP). The City of Los Angeles is thus far managing the dry weather runoff portion of this TMDL through diversions to the wastewater system, and through the Santa Monica Urban Runoff Recycling Facility (SMURRF), which treats and beneficially reuses dry weather runoff. For the Jurisdiction 2 and 3 areas, this evaluation will identify specific direct reuse or groundwater recharge opportunities that could be met with captured and treated wet weather runoff within the SMB beaches watersheds. Seasonal storage requirements will be discussed. Where possible, other pollutants of concern that could be abated as a result of implementing reuse or recharge opportunities will be identified. Although this evaluation focuses on beneficial use of wet weather runoff, the overall detailed

Implementation Plan may include runoff management options or facilities that have additional capacity to manage dry weather runoff as well. To that end, this evaluation presents steps towards total runoff management solutions for the SMB watersheds.

In preparing for the Implementation Plan, the hydrologic analysis task estimated that the total volume of wet weather runoff from Jurisdictions 2 and 3 is 174 million gallons for a target storm event of 0.45 inches. The 0.45 inch rainfall is targeted because based on analysis of 50 years of precipitation data, managing storms up to and including 0.45 inches will maintain exceedances to 17 days or less each year, over 90 percent of the time. Some of the 174 million gallons of runoff volume could be managed through on-site or "localized" source control solutions that retain and infiltrate or evapotranspirate wet weather runoff and reduce the volume entering the storm drain system. The rest would be captured and managed "regionally"; that is, either diverted to the wastewater system, treated and discharged; or treated and retained for beneficial use. This evaluation identifies potential quantities of runoff that can be managed through local or regional beneficial use options. Local beneficial use opportunities evaluated herein include:

- Cisterns, for on-site collection and direct reuse of runoff, and
- On-site infiltration projects.

Regional beneficial use opportunities evaluated herein include:

- Regional surface groundwater recharge to enhance water supply,
- Groundwater injection to create a salt water intrusion barrier and/or enhance water supply, and
- Regional capture and reuse as irrigation or other non-potable supply.

2.0 Land Use Analysis

2.1 Methodology

The approach to evaluating beneficial use options involves identifying potential locations for the implementation of beneficial use opportunities at both local and regional levels, and estimating the amount of wet weather runoff that could be managed by those beneficial use options. The potential for beneficial use is related to land uses since certain land uses offer more potential for reuse, for example, landscape irrigation for golf courses and parks. Therefore, the first part of this analysis requires creating a map that shows the spatial distribution of land uses in Jurisdictions 2 and 3, and the second part involves determining the size of these land use areas. The spatial distribution of the land uses is used to determine the applicability of the beneficial use option to that land use. The size of each land use category is used to estimate the amount of runoff that could be managed by the beneficial use option applicable to that land use.

Southern California Association of Governments (SCAG) land use data from year 1999 was used to create the land use map. On this map, Santa Monica Bay watershed data was overlain to show the boundaries of seven subwatersheds that are within Jurisdictions 2 and 3. The boundaries of Jurisdictions 2 and 3, and highways and freeways were added for reference.

The SCAG land use data is divided into 133 land uses, which were grouped into fifteen categories for simplification. The fifteen categories include:

- Single family residential
- Multiple family residential
- Commercial
- Public
- Religious
- Educational
- Industrial
- Transportation
- Mixed urban/construction
- Golf courses and cemeteries
- Inland parks
- Beach parks
- Wild life preserves
- Open space and recreation
- Natural open space.

Jurisdiction 2 consists of the following six coastal subwatersheds :

- Castle Rock
- Santa Ynez Canyon
- Pulga Canyon
- Santa Monica Canyon
- Venice Beach
- Dockweiler

Jurisdiction 3 consists of the Santa Monica subwatershed. Figure 1 shows the distribution of fifteen land use areas within the seven subwatersheds in Jurisdictions 2 and 3.

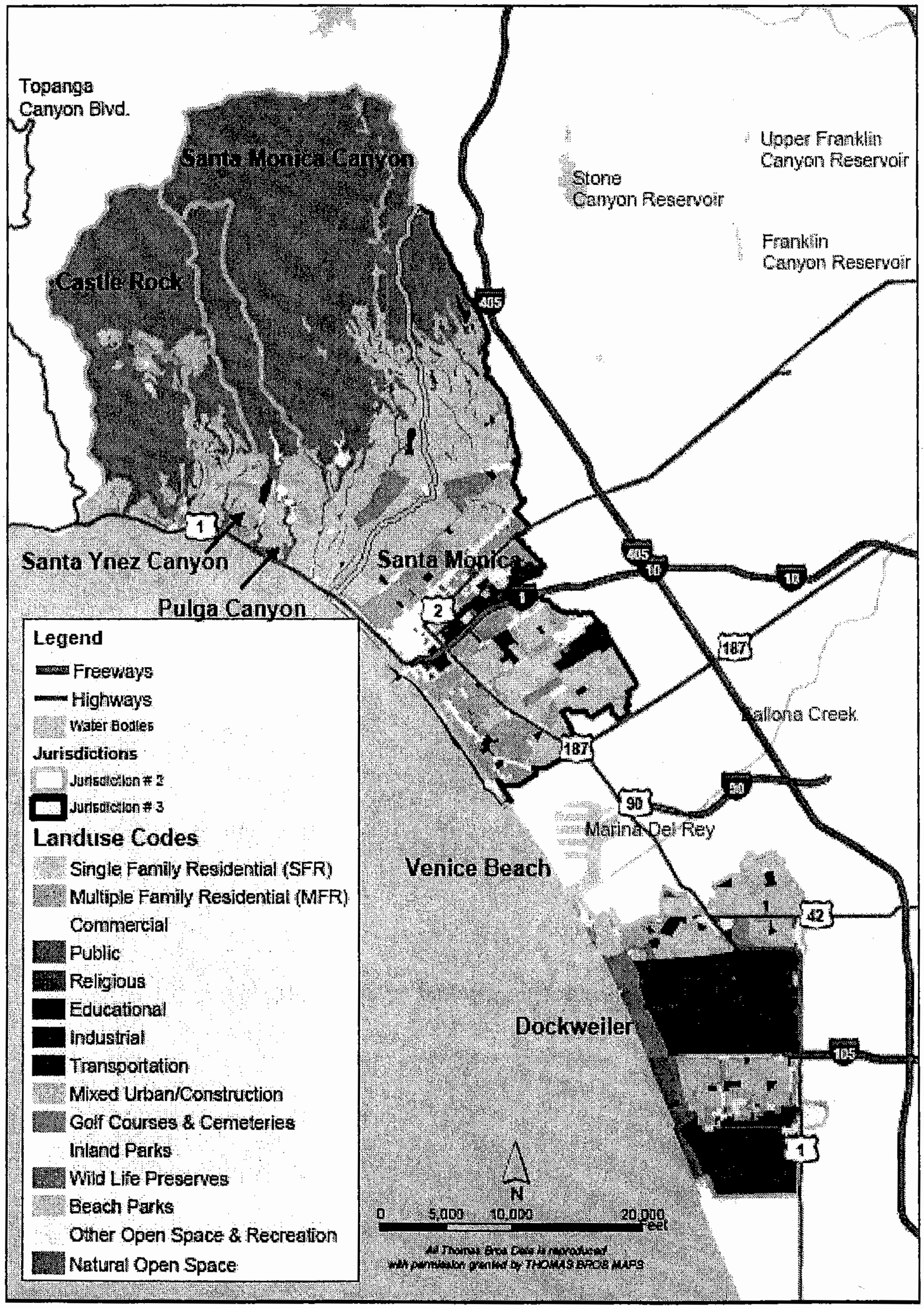

Figure 1. Jurisdictions 2 and 3 Subwatersheds and Land Use

2.2 General Characteristics of Subwatersheds

As seen on Figure 1, Castle Rock, Pulga Canyon and Santa Monica Canyon subwatersheds are mostly natural open space, some parts of which are undeveloped rocky mountainous areas. Therefore, runoff from these subwatersheds is expected to have a substantially lower relative contribution from urban sources of bacteria as compared to the other watersheds.

In contrast, Dockweiler and Santa Monica subwatersheds are more urbanized, with large percentages of transportation, residential and commercial land uses. The runoff from these subwatersheds is predominantly from urban sources. Santa Ynez Canyon subwatershed consists of relatively equal proportions of urban and non-urban land use areas, and Venice Beach subwatershed consist mainly of beach park land use.

Table 1 following, shows the areas of each land use for each subwatershed.

Table 1

Land Use Area Per Subwatershed in Jurisdictions 2 and 3

Land Use Category	Castle Rock (Acres)	Dockweiler (Acres)	Pulga Canyon (Acres)	Santa Monica Canyon (Acres)	Santa Ynez Canyon (Acres)	Venice Beach (Acres)	J2 Total (Acres)	Santa Monica/ J3 Total (Acres)	J2 and J3 Total (Acres)
Single Family Residential	572	1,401	334	1,983	557	0	4,848	3,631	8,479
Multi-Family Residential	114	376	18	45	66	9	629	1,983	2,612
Commercial	21	271	54	38	18	0	402	1,006	1,408
Government Only	0	2	2	0	0	0	4	22	26
Public (w/o Government)	26	227	1	5	0	0	259	48	307
Religious	2	6	2	0	0	0	10	9	19
Educational	10	184	38	35	7	0	274	265	539
Industrial	3	1,118	7	0	0	0	1,127	315	1,442
Transportation	0	2,049	0	0	0	0	2,049	231	2,280
Mixed Urban/Construction	95	270	0	10	55	0	430	25	455
Golf Courses & Cemeteries	0	73	0	156	0	0	230	232	461
Inland Parks	14	81	27	38	0	0	160	149	308
Wild Life Preserves	0	317	0	0	0	0	317	0	317
Beach Parks	30	313	28	38	26	99	533	253	786
Open Space & Recreation	5	25	0	0	0	0	30	0	30
Natural Open Space	4,090	153	1,473	7,777	496	0	13,989	983	14,972
Water	1	14	0	0	0	0	15	0	15
Total	**4,982**	**6,879**	**1,984**	**10,125**	**1,226**	**109**	**25,305**	**9,152**	**34,457**

3.0 Local (On-Site) Reuse Opportunities

Local (on-site) reuse opportunities evaluated include:

- Irrigation use of roof runoff captured via cisterns
- On-site infiltration of runoff

3.1 Cisterns

Rain barrels and cisterns are low-cost water conservation devices that can be used to reduce runoff volume and, for smaller storm events, delay and reduce the peak runoff flow rates. They divert and store runoff from impervious roof areas. This stored runoff can provide a source of chemically untreated 'soft water' for gardens and compost, free of most sediment and dissolved salts. Because residential irrigation can account for up to 40 percent of domestic water consumption, water conservation measures such as rain barrels can be used to reduce the demand on the municipal water system, especially during the hot summer months.

Individual cisterns can be located beneath each downspout, or the desired storage volume can be provided in one large, common cistern that collects rainwater from several sources. Pre-manufactured residential-use cisterns come in sizes ranging from 100 to 10,000 gallons.

Use of rain barrels and cisterns in urban and suburban areas is being encouraged in a number of jurisdictions across North America. In the City of Toronto, Canada, a citywide Rain Barrel Program was initiated in 1996 in which the residents have access to free downspout disconnection by a City contractor. City residents, while not offered any direct financial incentives, are educated on the economic and environmental advantages rain barrels and downspout disconnection will have for them, such as helping to keep the beaches of Lake Ontario clean. Locally, TreePeople has installed cistern collection systems at select demonstration sites (e.g., Hall House) and have been developing models for their effectiveness.

3.1.1 Analysis of Cistern Option

The cistern analysis consisted of estimating the amount of wet weather runoff volume managed on-site by cistern systems ranging in size from 60 to 10,000 gallons. Similar to the analysis performed in the IRP, the following assumptions were used in this analysis (refer to Appendix A for more detailed information):

- Potential sites for implementation of cisterns are single family and multi-family residences, schools, government, and public facilities. The areas of these land uses were estimated based on land use data as shown in Table 2.
- **Cistern size** - It was assumed that 1,000 gallon cisterns would be installed at single family residences and 10,000 gallon cisterns would be installed at the other sites.

Table 2

Runoff Managed with Cistern Installation

Land Use	Total Area (acre)	% Roof Shadow %	Average Annual Rainfall (in/yr)	% Capture	Cistern Size (gallon)	% Effectiveness (efficiency)	Runoff Managed		
							100% Installation (ac-ft/yr)	5% Installation (ac-ft/yr)	10% Installation (ac-ft/yr)
Single Family Residential	8,500	23%	14.95	90%	1,000	40%	877	43.8	87.7
Multi Family Residential	2,600	41%	14.95	90%	10,000	60%	717	35.9	71.7
Educational	540	50%	14.95	90%	10,000	60%	182	9.1	18.2
Government and Public	330	61%	14.95	90%	10,000	60%	135	6.8	13.5
Total	**11,970**						**1,911**	**95.6**	**191.1**

- Commercial/industrial areas were excluded due to the low percentage of green space that would require irrigation. Recreational areas and cemeteries were excluded due to the low percentage of rooftop areas.

- **Roof shadow** - Only the rainfall on rooftops would be captured as runoff. The runoff from other sources (for example, driveways, parking areas) will not be captured due to variable water quality. The estimated percent rooftop areas ('roof shadow') for each land use are shown in Table 2. These values were estimated for different land uses based on an analysis of representative parcels.

- **Percent Capture** -Up to 90 percent of rooftop runoff could be captured by cisterns (based on TreePeople model) if volume is available (see below).

- The captured runoff would be used for irrigation only, which suggests that treatment of the collected water would not be required. The cisterns would not be emptied other than to meet irrigation needs.

- Irrigation would be initiated 2 days after a rainfall event with total rainfall greater than 0.1 inches, and stopped 1 day before a subsequent rainfall event.

- It is assumed that the cisterns are emptied at a typical daily rate of irrigation, which is 135 gallons per day for a single family residential lot, and 250 gallons per day for a multi-family residential lot (Vickers, 2001 and AWWA, 1995).

- Irrigation would occur efficiently with negligible excess runoff.

Not all of the rainfall that is collected can be used for irrigation. If the rainfall occurs when the cistern is full, it will be discharged to the local stormwater collection system. Another option besides releasing overflow runoff to the stormwater collection system is to combine the cistern with an overflow connection to an adjacent infiltration pit. This would allow for storage of water for irrigation during dry weather and infiltration during wet weather.

The **effectiveness** of a cistern is dependent on cistern size, roof area, landscape area, rainfall amount, and rainfall interval. The roof area and rainfall amount determines the rate at which the cistern fills, and the landscape area determines the rate at which the cistern empties. The duration between rainfall events reflects how full the cistern is before the rainfall event. The rainfall amount determines how full the cistern is after the rainfall event. The cistern size reflects how often the system reaches capacity and must route rainfall to the collection system.

Therefore, the effectiveness of a cistern can be estimated based on past rainfall history and assumed land use characteristics (i.e., roof area to landscape area ratio). The **percent effectiveness** of each cistern size and land use type was estimated based on the TreePeople model and the daily rainfall data from January 1990 to December 2001 at the Los Angeles International Airport rainfall gauge. Using this continuous simulation approach, it was estimated that a 1,000 gallon cistern would be 40 percent efficient in retaining collected rainwater for single family residences and 21 percent efficient for multifamily homes. It was estimated that a 10,000 gallon cistern would be 85 percent efficient in retaining collected rainwater for single family residences and 60 percent efficient for multifamily homes. It was assumed that schools, government, and public facilities have a similar ratio of irrigation area to rooftop area as do multifamily residences and should thus have similar efficiencies.

This analysis calculates the amount of runoff that could be beneficially used by cisterns by comparing it to the total annual rainfall for the Jurisdiction 2/3 area. The annual rainfall for developed areas of Jurisdiction 2/3 is estimated at 14.95 inches per year. (The annual rainfall of 14.95 inches per year is based on an average of National Weather Service Data). No adjustments to the annual precipitation were made for elevation (as was done in the task 4 TM), because the LAX rain gauge was considered to be representative of the coastal developed elevation at which cisterns would likely be installed.

Based on these estimates and assumptions, the amount of long-term average annual runoff that could be managed by installing cisterns was estimated for each land use type. A summary of this analysis is presented Table 2, and an example calculation for single family residential land use is included below.

Single Family Residential:

Roof area = Total area * % Roof shadow
= 8,500 acre * 23%
= 1,955 acre

Roof runoff captured per year = Roof area * Annual rainfall * % Capture
= 1,955 acre * 14.95 in/yr * 90%
= 2,192 ac-ft/yr

Runoff used for irrigation per year = Roof runoff captured * % Effectiveness
= 2,192 ac-ft/yr * 40% (assuming 1,000 gallon size cisterns)
= 877 ac-ft/yr

Runoff managed by cisterns = 877 ac-ft/yr (with 100% installation)
= 43.8 ac-ft/yr (with 5% installation)
= 87.7 ac-ft/yr (with 10% installation)

Multi Family Residential, Educational, Government and Public Land use:

Assume 10,000 gallon size cisterns and 60% effectiveness

Based on our analysis, if cisterns are installed at all residential, school, government, and public facilities within Jurisdictions 2 and 3, the maximum amount of wet weather runoff that could be beneficially used is approximately 1,911 AF per year. However, 100 percent installation is not feasible. Assuming a 5 to 10 percent level of installation, it is estimated that approximately 96 to 191 AF of wet weather runoff per year could be beneficially used for irrigation via cisterns.

How does this amount compare to the total quantity of runoff? The total wet weather runoff generated within Jurisdictions 2 and 3 from a long-term average annual rainfall is approximately 15,440 AF per year. Therefore, it is estimated that approximately 0.6 to 1.2 percent of the total annual wet weather runoff could be managed if cisterns are installed at 5 to 10 percent of all residential, school, government, and public facilities. Although by itself, the cistern option will not manage sufficient quantities of runoff to eliminate the need for other runoff management options, it should be encouraged due to its positive effect from a water conservation standpoint.

3.2 On-Site Infiltration

On-site infiltration involves capturing runoff at the site where it is generated and storing it in a basin or structural feature of some type where it can infiltrate to the local groundwater. While it reduces the amount of runoff from a site, it does not store the runoff for on-site irrigation use as with rain barrels and cisterns. Types of on-site infiltration Best Management Practices (BMPs) include porous pavement, infiltration trenches and swales, French drains, and dry wells.

Infiltrating runoff requires that the soils be permeable enough to allow percolation into the underlying groundwater basin in a reasonable time and without excessive mounding or surfacing. Since the groundwater aquifer under Jurisdictions 2 and 3 is largely confined, it is unlikely that there is significant opportunity for groundwater recharge through on-site infiltration projects. There is the potential, however, for some runoff to infiltrate into the top layers of soil, where it will reduce the overall runoff volume leaving the site. Sandy or sandy loam soils have the highest percolation rates (infiltration capacity). Clay soils tend to have the lowest infiltration capacity. The clay in poorly draining soils quickly expands when wet and prevents further percolation. The relative compaction of topsoil at a given site would also need to be considered on a project-specific basis as excessive compaction could limit permeability.

Much of the area within Jurisdictions 2 and 3 has predominantly clay soils that do not permit extensive infiltration. The types of soil within the Santa Monica Bay area were identified based on data provided by the Los Angeles County Department of Public Works hydrology GIS database. This data consists of charts of runoff coefficients (Cu) versus rainfall intensity for 172 soil types and the geographic distribution of these soil types throughout the County. This data was merged with jurisdiction boundaries to develop a geographic distribution of soil types within the study area.

A chart of runoff coefficient versus rainfall intensity represents the fraction of rainfall that would run off from a plot of undeveloped land with a specific soil as a function of rainfall intensity in inches per hour. A high runoff coefficient would indicate that very little of the water infiltrates into the soil at that rainfall intensity. A low fraction would indicate that the soil permits good infiltration at that rainfall intensity.

A plot of the curves for three different soils types included in the County's database is presented in Figure 2. Soil Number 18 is considered to have a good infiltration capacity. As can be seen in the plot, the Cu is relatively low at all levels of rainfall intensity. At rainfall intensities less than 3 inches per hour, essentially all of the rainfall that falls onto a plot with Soil Number 18 will percolate into the soil. At a rainfall intensity of 2 inches per hour on a one-acre plot with this soil type, 48,900 gallons/hour (90 percent) of water would percolate and only 5,400 gallons/hour (10 percent) would drain from the site. At a rainfall intensity of 10 inches per hour, 86,600 gallons/hour (32 percent) would percolate and 185,000 gallons/hour (68 percent) would drain from the site.

At the other extreme, Soil Number 9 is considered to have a poor infiltration capacity. At a rainfall intensity of 2 inches per hour on a one-acre plot with this soil type, only 13,600 gallons/hour (25 percent) would percolate and 40,700 gallons/hour would drain from the site. At a rainfall intensity of 10 inches per hour, only 5,400 gallons/hour (2 percent) would percolate and 266,000 gallons/hour (98 percent) would drain from the site. Less water is percolated at the higher intensity because the clayey soil expands more quickly with higher rainfall intensity.

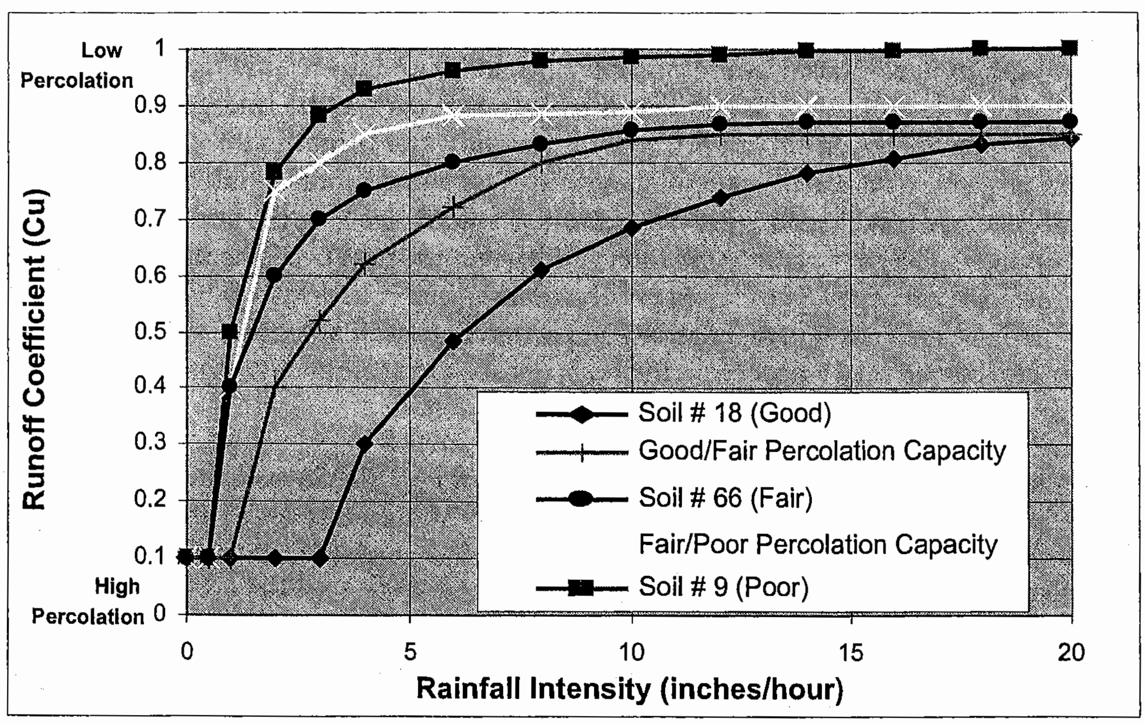

Figure 2. Surface Soil Analysis

Based on a visual inspection of the plots, a soil was classified as having a good infiltration capacity if it has a Cu of less than 0.4 at a rainfall intensity of 2 inches per hour and less than 0.85 at a rainfall intensity of 10 inches per hour. A soil was classified as having a fair infiltration capacity if it has a Cu of less than 0.75 at a rainfall intensity of 2 inches per hour and less than 0.9 at a rainfall intensity of 10 inches per hour. Other soils were classified as having a poor infiltration capacity. The curves separating the good and fair regimes and the fair and poor regimes are also plotted on Figure 2.

It is assumed for this study that only soils with a good infiltration capacity would support effective use of infiltration as a method of on-site control, that is, may achieve reductions in runoff volume. Areas with a fair infiltration capacity may sustain infiltration source control measures without serious flooding under many but not all rainfall intensities but would be at risk for serious flooding under some rainfall conditions and is therefore not recommended. Areas with poor infiltration capacity would incur serious flooding under almost all rainfall conditions.

The distribution of soil types throughout the Santa Monica Bay Area was obtained from the County's Hydrology GIS. A summary of the rating of each soil type located in the City is presented in Appendix B. A plot of the distribution of the good, fair, and poor infiltration capacities of the soils types throughout the Santa Monica Bay area is presented in Figure 3.

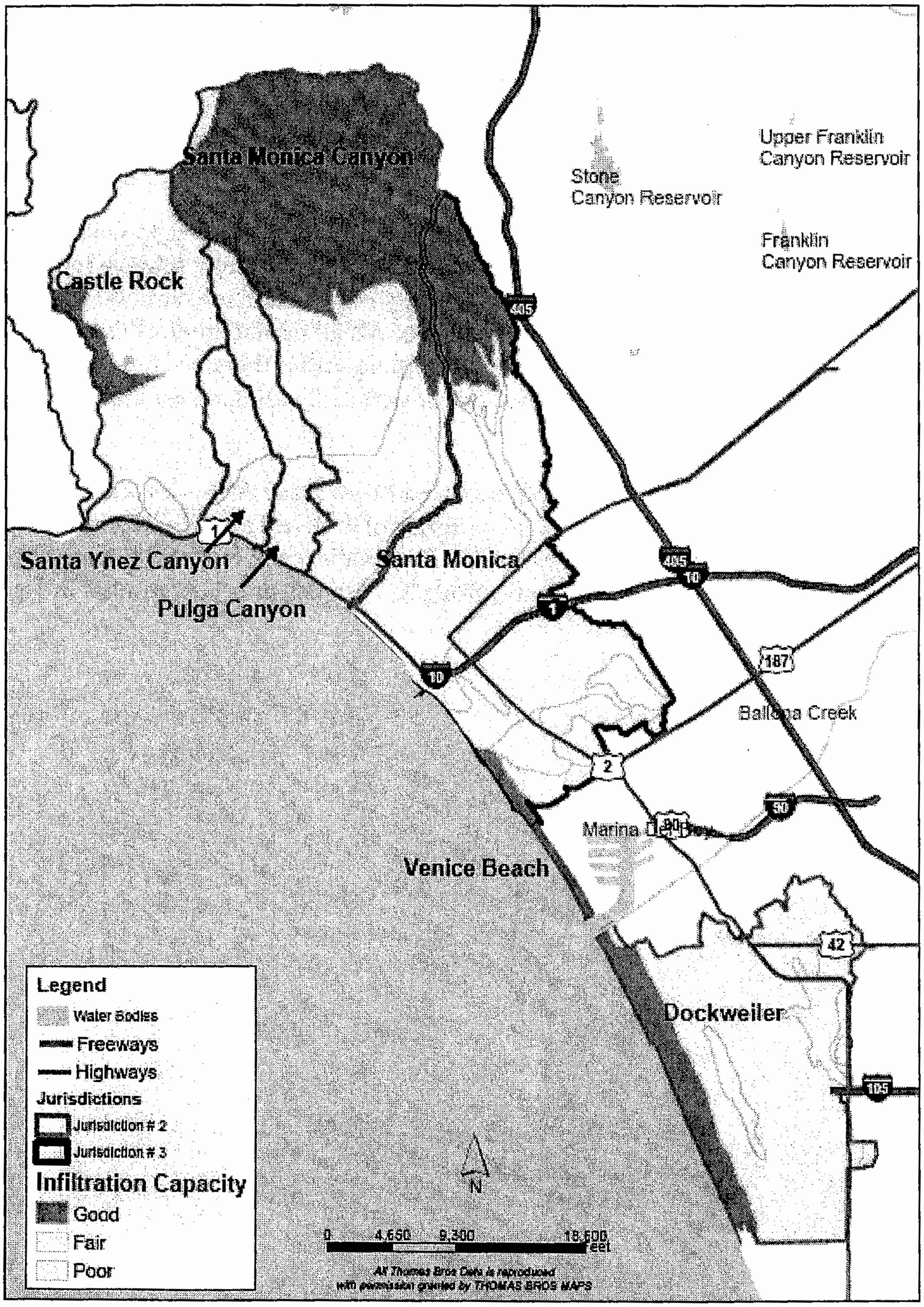

Figure 3. Soil Infiltration Capabilities

Table 3 summarizes the distribution of soil types throughout the Jurisdiction 2 and 3 area. As can be seen in Table 3, there are approximately 9,000 acres of land with soils having a good infiltration capacity within the Santa Monica Bay area, about 11,500 acres of land with soils having a fair infiltration capacity, and about 13,800 acres of land with soils having a poor infiltration capacity.

Of the 9,000 acres of soil with good infiltration capacity, much of this area is either along the coastal sands or in the steep, mountainous terrain of the Santa Monica Canyon. The steep, mountainous terrain is not appropriate for on-site infiltration projects because there is no development or urban land use that generates runoff; and these areas are too far upstream of the desired runoff concentration points. The coastal sand areas, however, may provide opportunities for localized infiltration and treatment systems. Other limitations may be significant along the coast, including lack of available space and shallow groundwater, but the soils should not be ruled out as possible treatment areas to remove bacteria, and may provide some incremental savings in total runoff volume to be managed.

Table 3

Infiltration Capacity of Soils in the Santa Monica bay Area

Subwatershed	Good (Acres)	Fair (Acres)	Poor (Acres)	Total (Acres)
Castle Rock	505	4,477	--	4,982
Santa Ynez Canyon	--	1,226	--	1,226
Pulga Canyon	285	1,699	--	1,984
Santa Monica Canyon	5,660	4,112	353	10,125
Santa Monica	1,462	20	7,670	9,152
Venice Beach	109	--	--	109
Dockweiler	1,045	--	5,834	6,879
Total	**9,066**	**11,534**	**13,857**	**34,457**

4.0 Regional Reuse Opportunities

Regional reuse opportunities evaluated include:

- Regional surface groundwater recharge to enhance water supply,
- Groundwater injection to create a salt water intrusion barrier and/or enhance water supply, and
- Regional capture and reuse as irrigation or other non-potable supply.

4.1 Regional Groundwater Recharge

4.1.1 Groundwater Basins

Jurisdictions 2 and 3 lie on the Coastal Plain groundwater basin, which consists of five different groundwater sub-basins as shown in Figure 4:

- Central
- Hollywood
- La Habra
- Santa Monica
- West Coast Basins

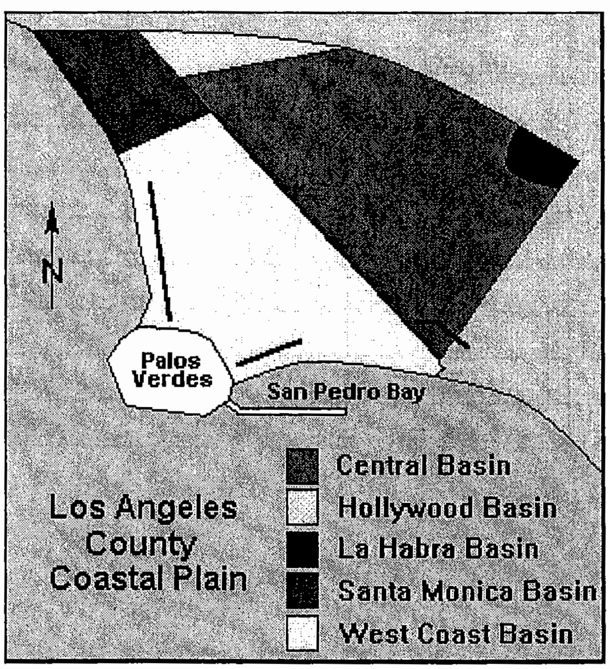

Figure 4. Los Angeles County Coastal Plain Groundwater Basins[1]

[1] Source: www.ladpw.org

Dockweiler subwatershed lies on the north end of West Coast Basin, and other subwatersheds of Jurisdictions 2 and 3 lie on Santa Monica Basin. The West Coast Basin underlies 140 square miles of the Coastal Plain, extending from the Pacific Ocean east to the Newport-Inglewood fault zone. The northern boundary of the West Coast Basin is the Ballona escarpment, and the southern boundary is the ocean.

The Santa Monica Basin underlies 50 square miles of the northwestern part of Coastal Plain. It extends from the Pacific Ocean on the west to the Inglewood fault on the east. The basin is bounded by impermeable bedrock of the Santa Monica Mountains on the north and by the Ballona escarpment on the south.

4.1.2 Surface Groundwater Recharge

The Santa Monica Basin and portion of the West Coast Basin that underlie the Jurisdiction 2 and 3 areas contain mostly confined or semi-confined alluvial aquifers. Because of this, large-scale regional recharge projects, or spreading grounds, will not be an effective means of managing runoff. On the other side of the Santa Monica Mountains, opportunity exists in the San Fernando Valley for expanding or adding new spreading grounds; however, managing runoff volume by building conveyance facilities to transport wet weather runoff outside of the Jurisdiction 2/3 area and to higher elevations in the Valley is not a desirable option for several reasons. In addition to the high cost of new conveyance infrastructure, the San Fernando Valley area has its own regulatory responsibilities regarding increasing capture and groundwater recharge of runoff. Use of Jurisdiction 2/3 runoff would not be as efficient as use of local runoff supplies, and therefore, is not considered a likely opportunity.

As discussed in Section 3.2, there may be very localized opportunities, particularly in the coastal sand areas to consider infiltration projects that may function largely as treatment options, without necessarily effectively recharging the groundwater basins.

4.1.3 Groundwater Injection

Groundwater injection is a method of groundwater recharge at regional level that not only augments groundwater supplies, but also often serves an additional purpose of protecting the groundwater against seawater intrusion. The water (generally imported and/or reclaimed supplies) injected through a series of injection wells creates a pressure ridge that impedes the inland movement of the salt water front, and maintains protective groundwater elevations in the aquifers. For this evaluation, groundwater injection is explored as a means to manage wet weather runoff.

The Los Angeles County Department of Public Works has created three barrier projects to halt seawater intrusion into the basins where they are exposed to the ocean: West Coast Basin Barrier Project (WCBBP), Dominguez Gap Barrier Project (DGBP), and Alamitos Barrier Project (ABP). Of these projects, WCBBP is the only project of interest because it is located closest to Jurisdictions 2 and 3, and it injects reclaimed water mixed with imported water.

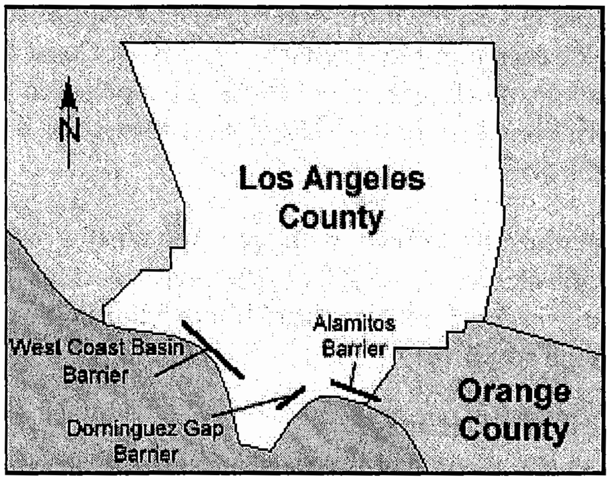

Figure 5. Los Angeles County Seawater Barrier Projects[2]

The WCBBP currently injects approximately 17.5 mgd of water (50% imported, and 50% recycled) into the aquifers of the West Coast Basin. The reclaimed water used in WCBBP is advanced treated effluent from the West Basin Water Recycling Plant (WBWRP) in the City of El Segundo, which is owned and operated by the West Basin Municipal Water District.

The existing Barrier Treatment process at the WBWRP treats secondary effluent from Hyperion Wastewater Treatment Plant, and produces 7.5 mgd of recycled water that is subsequently blended with imported water and injected into West Basin aquifer through West Basin Barrier Project. After the completion of the WBWRP Expansion, the new Barrier Water Treatment System will produce 12.5 mgd of recycled water. The new Barrier Treatment process includes pre-treatment by microfiltration (MF) followed by RO, hydrogen peroxide addition, and ultraviolet (UV) treatment. The WBWRP Expansion is part of an effort to provide up to 100% recycled water to the Barrier (17.5 mgd) in the near future.

Injection of wet weather runoff in an independent system similar to West Basin, which consists of treatment at WBWRP and injection at WCBBP, is theoretically possible, but is not feasible due to the variable quality, quantity and overall lack of reliability of wet weather runoff as a source, as well as the extensive permitting and operational issues.

West Basin is an efficient system because it reserves a consistent quantity of secondary effluent from Hyperion, and has designed tertiary treatment systems to effectively treat that quantity. Furthermore, since the quality of the Hyperion effluent is consistent, it can be effectively treated. Unlike the secondary effluent of Hyperion, wet weather runoff has a more variable water quality, which can make effective tertiary treatment difficult and could produce poor quality effluent if it were the primary source.

From a quantity perspective, Hyperion effluent is available in abundant supply year-round, whereas wet weather runoff is available only during wet weather and in variable quantity.

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2 Source: www.ladpw.org

As an independent project, to procure and treat the volume of wet weather runoff to be managed, and then inject it throughout the year, expensive plants would need to be constructed to treat and store the wet weather runoff during the wet weather months.

While stormwater quality is variable, most of the constituents in runoff are similar to or better than those in secondary effluent. In particular, total dissolved solids (TDS) are much lower, and therefore the runoff could have value as a supplemental, low TDS source water that could, under the right conditions, be blended with Hyperion effluent as a feed to the West Basin Plant. For smaller local watersheds, if runoff could be captured to meet the TMDL requirement and blended, it may be worthwhile to explore the concept of supplying runoff as a low cost, low TDS source of supplemental supply to the West Basin Project. This would require careful review of the water quality issues, as well as contractual agreements in place between all parties.

4.2 Reuse as Non-Potable Supply for Irrigation or Other Uses

The City of Los Angeles Department of Water and Power (DWP) and the City of Santa Monica provide water to users within Jurisdiction 2 and 3 and are thus responsible for coordinating recycled water supplies to potential customers. As part of the IRP, the DWP is currently developing a water recycling master plan. The considerations used in developing the master plan include possible modifications, expansions, or additions to the City's wastewater and stormwater conveyance and treatment facilities. The primary focus is utilizing recycled water for traditional irrigation use. A GIS based model was developed that took geographic features and major infrastructure characteristics into consideration in the routing of conceptual pipelines.

The City of Santa Monica already provides recycled water to local customers from the Santa Monica Urban Runoff Recycling Facility (SMURRF). The facility treats dry-weather urban runoff water that previously was discharged into the Santa Monica Bay through storm drains. A summary of the existing DWP and City of Santa Monica recycled water demands and analysis of potential customers and demands within Jurisdiction 2/3 is presented in this section. After the demands are located and quantified, the results are reviewed to determine whether wet weather runoff is appropriate as an additional or independent source of non-potable supply.

4.2.1 Identifying Potential DWP Irrigation Demands

Within Jurisdictions 2 and 3, recycled water is currently produced from Hyperion effluent and treated and delivered through the West Basin Water Recycling Plant at approximately 34,350 acre-feet/year (Source: IRP Recycled Water Volume). Expanding DWP's recycled water system to include reuse of wet weather runoff depends on several factors including economics, water quality regulations, and public acceptance. Though there may be the high potential for recycled water use in the City, it would not be economically feasible to provide treated runoff to all potential users. Reuse of runoff would require not only capture, storage, and treatment systems; but also construction of pipelines and pump stations to distribute treated runoff to DWP's water customers. In addition, most water customers do not have dual plumbing systems—meaning separate pipelines for potable and non-potable uses, such as irrigation. Therefore, retrofits for the plumbing system are needed. This can be very expensive depending on the plumbing layout of the water customers.

As part of the IRP recycled water planning, a model was developed to identify additional DWP recycled water customers. The criteria and assumptions used in the model were reviewed in the context of potential applicability to wet weather runoff, and are summarized as follows:

- *Size of potential water demand per customer* – by focusing on larger water customers first, smaller customers along the routes can be economically added later.
- *Type of water use* – landscape irrigation usually requires less cost (from a treatment standpoint) and regulatory hurdles; whereas industrial use may very likely require advanced treatment (such as MF/RO)
- *Proximity to existing recycled water system* – those potential customers nearest to potential recycled water supplies and existing recycled water pipelines would be the most cost-effective to develop because of the lower distribution cost (pipelines and pump stations)
- *Willingness to use recycled water* – not all potential water customers have a desire to use recycled water; and many base the decision to use such water on costs and/or reliability—meaning in most cases DWP must provide proper incentives.

To estimate the potential for recycled water use within Jurisdictions 2 and 3, DWP's largest water customers were identified using billing records. These customers were generally those that used more than 890 gallons per day (or approximately 1 acre-foot per year).

DWP uses billing rate codes to identify certain customers. Single-family residential rate codes were excluded from this search as they would be too expensive to connect to the recycled water system during this first phase. All rate codes that were identified as irrigation meters were considered excellent potential recycled water users as they already had separate irrigation (non-potable) plumbing systems.

The rate codes for commercial customers were inspected more closely to determine the likelihood of accepting recycled water. Most of these other customers could use recycled water to meet landscaping water needs and were thought to be high potential recycled water users, even though they would most likely require retrofitting to create a separate plumping system for non-potable uses.

Those customers identified as industrial were assumed to have little irrigation demand potential—but instead could use recycled water for process use (i.e., cooling towers or recirculation systems). However, those industrial customers that manufactured foods, beverages, or pharmaceuticals were not considered as potential recycled water users as it was assumed that these customers would have more difficulty in accepting recycled water.

In addition to DWP's current customers, future customers were added to the potential users list. These future customers included new schools that are currently planned to be constructed by the Los Angeles Unified School District, and new parks planned by the Los Angeles Department of Recreation and Parks.

DWP's potential recycled water customers were plotted on a map using GIS (see Figure 6). As a result of this evaluation, Jurisdictions 2 and 3 were found to have a total potential demand of 3,490 acre-feet/year. The complete listing of these demands is in Appendix C. Note that the City of Santa Monica is not included in Figure 6 because the model analyzed DWP's service area only. The City of Santa Monica's potential recycled water demands are evaluated separately in Section 4.2.2.

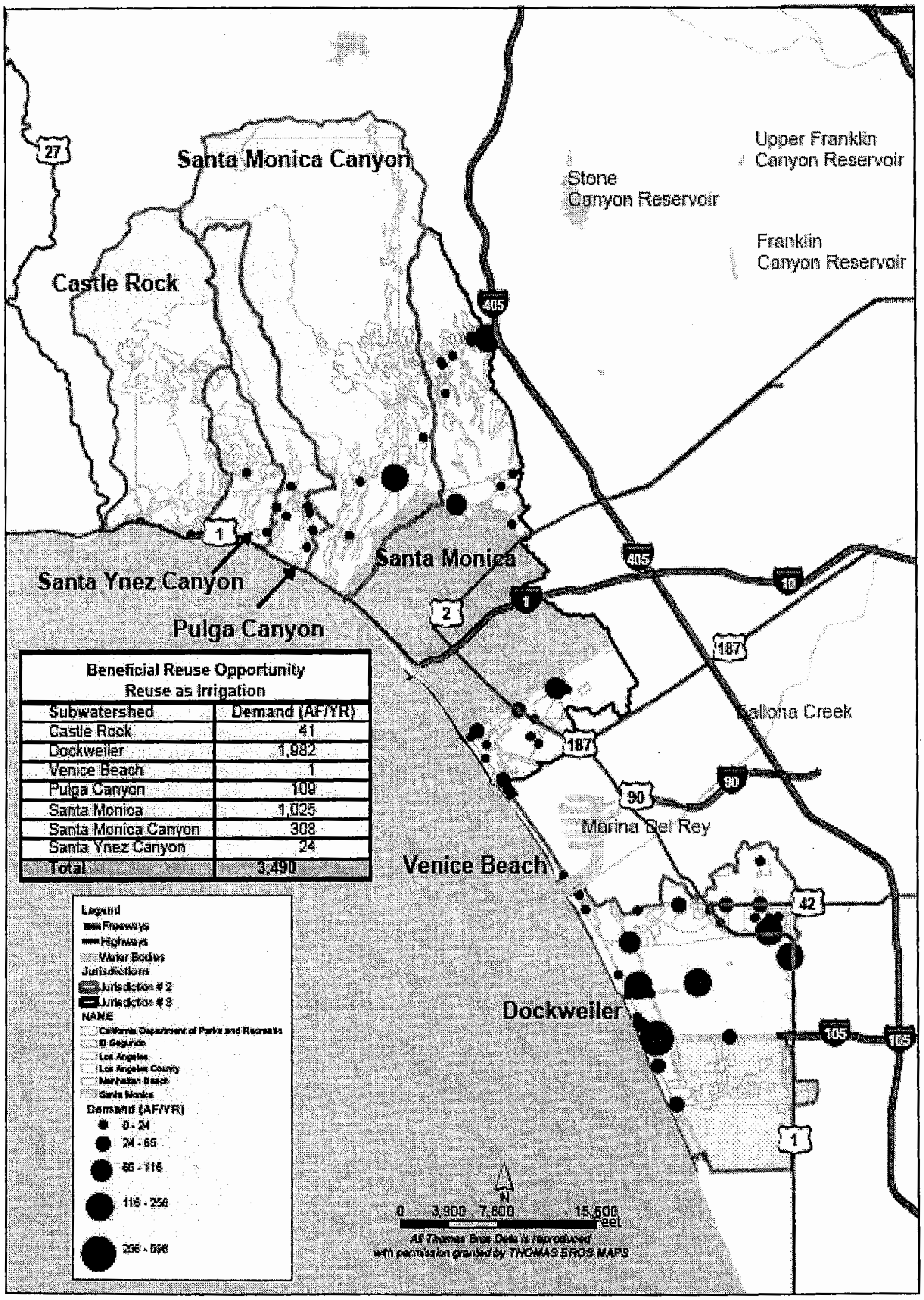

Figure 6. DWP Service Area: Irrigation Demand Points[3]

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[3] Source: Los Angeles Department of Water and Power, IRP Recycled Water Planning

4.2.2 Identifying Potential City of Santa Monica Irrigation Demands

Santa Monica's SMURRF facility, with a peak average design capacity of 500,000 gallons per day, is currently producing about 329 AF/year of treated dry weather urban runoff (about 300,000 gpd). The total estimated demand for the recycled water from this facility in 2004 is 49 AF/year. With additional connections to the SMURRF distribution system being constructed or proposed, it is estimated that 199 AF/year of recycled water demand would be serviced by SMURRF by 2005. For the purposes of this study, it will be assumed that the remaining 130 AF/year of SMURRF capacity must be used before a market exists for reuse of treated wet weather runoff. A summary of Santa Monica's recycled water demand from SMURRF is presented in Table 4.

Table 4

SMURRF Recycled Water Demands[4]

	Demand (AF/year)
Estimated Total 2003-2005	49
Under Construction or Pending (on-line by June 30, 2004)	126
Proposed for 2004/05 (on-line by June 30, 2005)	23
Total Annual Demand	**199**
Total Annual Plant Capacity for SMURRF (300,000 gpd)	**329**

In addition to SMURRF's recycled water demand estimated above, potential irrigation demand in the City of Santa Monica was estimated using the City's water demand data. The account types of the City's water users were analyzed using selection criteria similar to DWP's to identify customers that could potentially use recycled water to meet their irrigation use demand. However, the IRP model, which considers geographic features and major infrastructures to determine which customers are in locations where a recycled water distribution system would be economically viable, was not used for the users serviced by the City of Santa Monica. Therefore, the selection method for the potential recycled water users for irrigation use within the City of Santa Monica was less selective than the method used for DWP's service area.

The potential recycled water users for irrigation use in the City of Santa Monica consisted largely of City parks and open spaces, government and public facilities, schools, and commercial landscape. The residential users were excluded because the cost of connecting to the recycled water system would be too high. There were no large industrial users in the City of Santa Monica service area. The current and future users of SMURRF recycled water (199 AF/year) were excluded from the list of potential irrigation demand and counted separately. Also, all water users with irrigation demand less than 1 AF/year were excluded.

4 Source: City of Santa Monica Water Resources-Utility Department

Using these criteria, the total estimated irrigation demand in the City of Santa Monica was estimated to be approximately 305 AF/year. It is assumed that all potential recycled water users serviced by the City of Santa Monica are located within the Santa Monica subwatershed. The detailed list of potential recycled water demand for irrigation use in Santa Monica is included in Appendix C.

4.2.3 Reuse of Runoff as Irrigation Supply

When DWP and Santa Monica service area are combined, the estimated total irrigation water demand within Jurisdictions 2 and 3 is approximately 3,795 AF/year as summarized in Table 5. The demands are broken down by subwatershed and type of demand. A more detailed list of potential irrigation users within Jurisdictions 2 and 3 is included in Appendix C.

Table 5

Jurisdictions 2 and 3 Irrigation Demand (AF/YR)

	Castle Rock	Santa Ynez Canyon	Pulga Canyon	Santa Monica Canyon	Santa Monica	Venice Beach	Dockweiler	Total
Airport	--	--	--	--	3	--	992	995
Commercial/Private	27	24	18	--	676	--	30	775
Country Clubs/ Cemeteries	--	--	--	256	116	--	--	372
Government/Public	14	--	--	--	95	1	74	184
Hyperion WWTP	--	--	--	--	--	--	713	
Parks & Recreation	--	--	51	35	404	--	77	567
Schools	--	--	40	17	36	--	96	189
Total (AF/YR)	**41**	**24**	**109**	**308**	**1,330**	**1**	**1,982**	**3,795**

It should be noted that although Table 5 provides an estimate of the total irrigation demand in Jurisdiction 2 and 3, not all areas are appropriate to use runoff as a source of supply. The DWP has current plans to meet the recycled demand in the Dockweiler region with new pipelines serving the Playa and Westchester areas. Because of this, wet weather runoff would not be considered a suitable source of supply for areas south of Santa Monica. The DWP does not have current plans, however, to supply areas north of Santa Monica with additional recycled water, so it may be appropriate to consider treated wet weather runoff as a source of supply for these subwatersheds. The demands in the northern subwatersheds are described below.

Castle Rock – There are three potential recycled water users located along the coast of Castle Rock subwatershed, one of which is the Los Angeles County (14 AF/year demand). Of the remaining two commercial/private users, one (14 AF/year demand) is a likely potential recycled water user, because it already has separate irrigation (non-potable) plumbing system.

Santa Ynez Canyon – There is only one potential recycled water user within Santa Ynez Canyon subwatershed, located in Pacific Palisades, which is a religious facility with 24 AF/year of irrigation demand.

Pulga Canyon – The irrigation demand within Pulga Canyon subwatershed comes from a commercial facility, City parks, and a school in Pacific Palisades. The school in Pacific Palisades has an estimated demand of 40 AF/year.

Santa Monica Canyon – The largest irrigation water user in Santa Monica Canyon subwatershed is a country club that uses approximately 256 AF/year for landscape irrigation. Other users include State and City parks, and a school in Los Angeles.

Santa Monica – The list of potential recycled water users within the Santa Monica subwatershed are derived from the water demand data of DWP and City of Santa Monica. It was estimated that approximately 676 AF/year of demand is accounted for by irrigation users from the commercial/private sector. The largest commercial/private user is a museum with 424 AF/year, and the second largest is a country club with religious facility with 43 AF/year. Approximately 70% of the commercial/private sector irrigation demand is derived from these two users. A country club is accounted for separately, and it has approximately 116 AF/year of demand. In addition, there are approximately 18 government/public irrigation users, three of which have demand greater than 10 AF/year. Approximately 12 parks owned by the City of Los Angeles, and approximately 50 parks, recreation areas, and open spaces owned by the City of Santa Monica were identified for potential irrigation demand. Of these, approximately nine had irrigation demand greater than 10 AF/year. Four schools were identified as potential irrigation users.

Where wet weather runoff may be used to meet irrigation demands, the irrigation demands divided by the supply of runoff is used to quantify the beneficial use potential. Table 6 presents the maximum potential irrigation demand in the northern subwatersheds along with the total target runoff volume generated from each subwatershed. For this example, the total target runoff volume is equal to the amount of annual runoff managed by capturing storms up to and including 0.45 inches. As discussed in the IRP Runoff Volume Interim Deliverable (Section 4.3.4), this quantity is approximately 25 percent of the total annual runoff volume, as illustrated in Figure 7. The runoff volumes for each subwatershed were calculated using runoff coefficients from the Draft Hydrologic Study Technical Memorandum for the SMB Implementation Plan project, and assuming an average of 14.95 inches of rainfall per year.

Table 6

Theoretical Beneficial Use Potential

Subwatershed	Potential Irrigation Demand (AF/YR)	0.45" Target Runoff Volume (AF/YR) (25% of annual ave. rainfall)	Beneficial Use Potential (%)
Castle Rock	41	264	16%
Santa Ynez Canyon	24	118	20%
Pulga Canyon	109	124	88%
Santa Monica Canyon	308	536	57%
Santa Monica	1330	1,482	90%
Venice Beach	1	8	13%
Total	**1,813**	**2,532**	**72%**

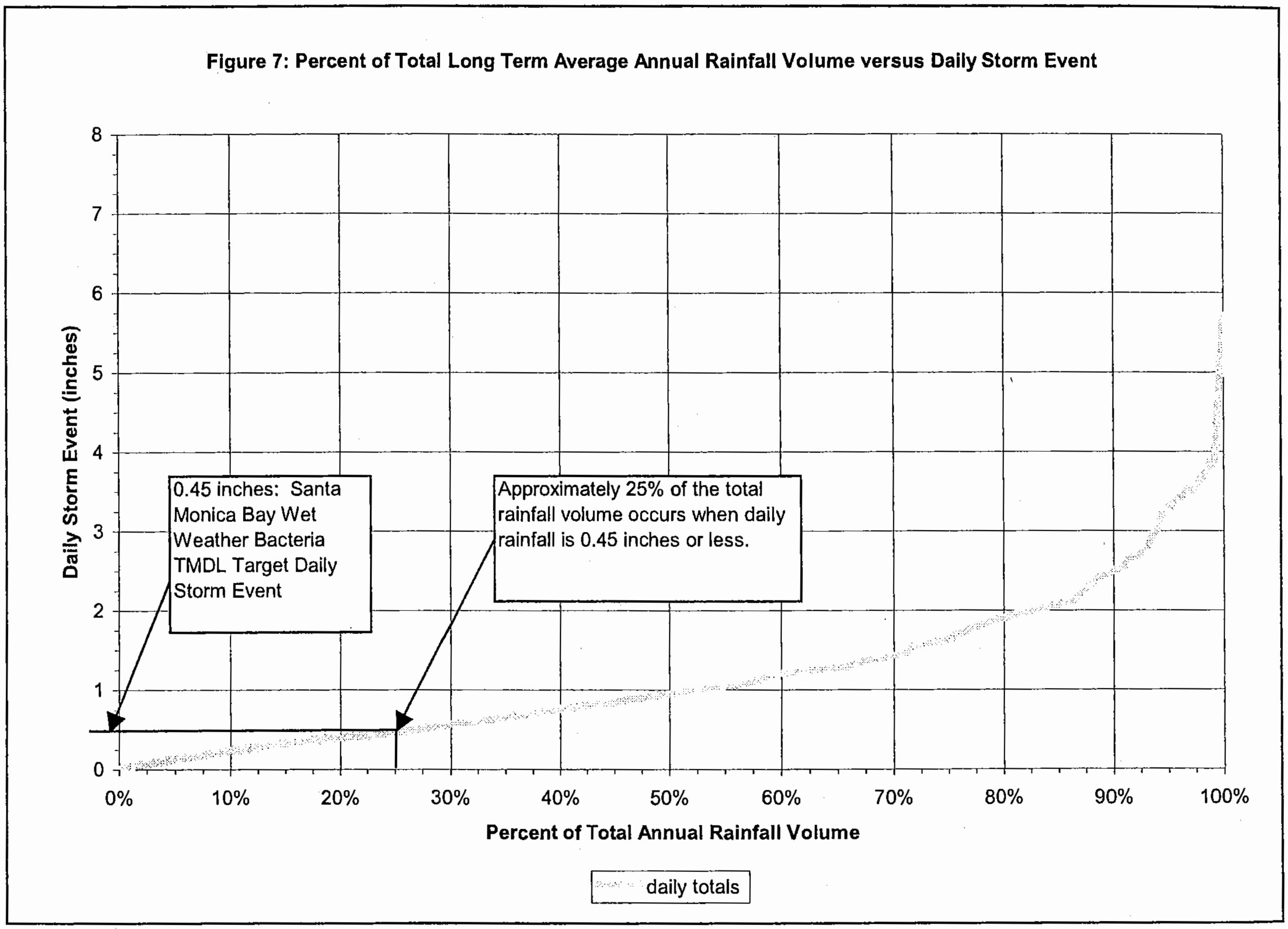

Figure 7: Percent of Total Long Term Average Annual Rainfall Volume Versus Daily Storm Event

As shown in Table 6, if 100 percent of the identified irrigation demands in the northern subwatersheds were met exclusively with stored and treated wet weather runoff, it would be theoretically possible to beneficially use approximately 72 percent of the total target runoff volumes.

Two types of beneficial use projects emerge, based on the level of treatment required for the end-use customer. Generally, the demands identified will require treatment to Title 22 Standards to assure a level of water quality consistent with public health goals. This applies for schools, golf courses, larger parks and public facilities, and any end-use that would distribute treated runoff through a sprinkler system.

There may be smaller, localized opportunities to capture and store runoff, and provide a lower level of treatment before the runoff can be reused on-site. This would require careful management and non-traditional means of irrigation. For this type of project, an underground storage area of, for example, 20 x 20 x 8 feet would be excavated and lined.

Treatment may be required to remove trash, oil, and grease. Wet weather runoff would be directed to the underground system by either conveyance piping or infiltration of the surface soil, or a combination of both. The runoff is stored in the underground system, and can then be pumped and used for on-site irrigation. Each system would have to be designed and sized to collect and treat runoff from either on-site or additional street areas, and stored underground in a system sized to appropriately handle a percentage (perhaps 80% as an upper limit) of the irrigation demand.

In both cases, if wet weather runoff is to be beneficially used as irrigation supply, seasonal storage will be necessary. This is because the demand for irrigation water occurs during dry weather, whereas the runoff is available during wet weather. For each of the individual irrigation demands identified, seasonal storage could be sized to capture and store a volume of runoff that, when reused, would offset a percentage of the total irrigation demand at that location. Storage and treatment could be grouped together by subwatershed, to treat the runoff in a neighborhood or regional SMURRF-type urban runoff treatment facility.

5.0 Conclusions

This evaluation explores the opportunities to beneficially use wet weather runoff by various methods. Regarding on-site opportunities, cisterns and other on-site infiltration type projects were evaluated. Installing cisterns at residences, schools, and government and public facilities (in perhaps a limited capacity where runoff would not need treatment) will beneficially use runoff, but the quantifiable gains will be slight. The analysis herein estimates that if 5% to 10% installation is achieved, approximately 0.6 to 1.2 percent of the total annual wet weather runoff could be managed via cisterns. As a stand-alone option, cisterns will not eliminate the need for other runoff management options, but their installation should be encouraged.

In addition to cisterns as on-site solutions, the opportunities for on-site infiltration projects to manage runoff were investigated by analyzing surface soil characteristics in the Jurisdiction 2 and 3 areas. On a large scale, areas with sufficient infiltration capacity to achieve reductions in runoff volume were not found. Areas along the coastal sands, however, may provide opportunities for localized infiltration and treatment systems. These areas should not be ruled out as possible treatment areas to remove bacteria, and may provide some incremental savings in total runoff volume to be managed. Overall, implementing on-site opportunities alone will not be sufficient to manage the target runoff volumes.

Regionally, existing groundwater injection projects were evaluated to determine if runoff could be an additional source of supply. For smaller local watersheds, runoff may be a viable, low cost, low TDS source of supplemental supply to the West Basin Project.

Reuse of runoff as irrigation supply was evaluated, particularly in areas where there are no current plans to supply additional recycled water. Irrigation demands for the Jurisdiction 2 and 3 areas were estimated. From a theoretical point of view, if it were possible to capture, store, treat (in a facility similar to a SMURRF for wet weather), and distribute wet weather runoff to meet 100 percent of these demands, 72 percent of the total target runoff volumes could be beneficially used.

Recommendations regarding beneficial use options vary for different subwatersheds or regional areas. In the South (Dockweiler subwatershed), it does not make sense to develop independent injection or direct reuse options, because there are already systems in place that are set up to treat and recycle water for these end-uses. It would not be practical to duplicate treatment or distribution systems or try to deliver to the same customers. Hence, in the South, the most likely beneficial use option is to consider runoff as a supplemental source for injection at West Basin. North of Santa Monica, there are no current plans to use local recycled water to meet irrigation demands, so it does become a viable option to use treated runoff to meet these demands. This can be accomplished by collecting and storing runoff seasonally, and then treating it (in SMURRF-type regional facilities) for irrigation use. In addition, there may be more localized opportunities to meet smaller irrigation demands through on-site storage and reuse at end-uses that may not require the same high level of treatment.

In summary, although there is some opportunity to beneficially use wet weather runoff through local and regional solutions, even full implementation of these options would not eliminate the need for other management options. These options, including treatment and discharge, and diversions to the wastewater system will be addressed in upcoming technical memoranda (Tasks 6 and 7). The options presented in these tasks will be combined to create several alternatives for managing the wet weather runoff volume.

6.0 References

City of Los Angeles Integrated Resources Plan Facilities Plan Interim Deliverable. Volume 2 Recycled Water Management, August 2003. Prepared by CH:CDM and City of Los Angeles Department of Public Works, Bureau of Sanitation.

City of Los Angeles Integrated Resources Plan Facilities Plan Interim Deliverable. Volume 3 Runoff Management, August 2003. Prepared by CH:CDM and City of Los Angeles Department of Public Works, Bureau of Sanitation.

Groundwater and Surface Water in Southern California: A Guide to Conjunctive Use. October 2000. Prepared by Montgomery Watson, Water Education Foundation, and Association of Ground Water Agencies.

Santa Monica Bay Beaches Wet Weather Bacteria TMDL Implementation Plan. Task 4 Technical Memorandum, Hydrologic Analysis, March 2004. Prepared by CH:CDM and City of Los Angeles Department of Public Works, Bureau of Sanitation.

Santa Monica Bay Beaches Wet Weather Bacteria TMDL.

Cistern Model. TreePeople. 2003

Appendices

APPENDIX A

Table 1. Assumptions used for Cistern Analysis

Data from 2000 UWMP (in DWP Service Area)					
	Year				
	2000	2005	2010	2015	2020
Daily Water Use/Household					
SFR (gal/day)	389	394	393	396	394
MFR (gal/day)	234	245	246	248	243

Water Usage[1]	
	Outdoor Use (gal/day)
Irrigation	
SFR - 35% of Total Usage (gal/day/bldg)	135
MFR - 15% of Total Usage (gal/day/bldg)	250
Notes:	
1. Vickers. Water Use and Conservation (2001).	

Runoff Coefficients[2]		
	Impervious Ratio	Runoff Coefficient
SFR	0.39	0.43
MFR	0.75	0.70
2. Watershed Protection Division, Pollutant Load Model (landuse from SCAG)		

APPENDIX A

Table 1. Assumptions used for Cistern Analysis (Cont'd)

Makeup of the Average Single Family Residence Lot					
Assume :					
Resdential Lots are 85 feet wide.					
Residential Lot is 85 feet deep		7,225 SF		0.17 acres	
Sidewalk and tree lane is 8 feet wide		680 SF		0.02 acres	
Half of steet is 10 feet wide		850 SF		0.02 acres	
		8,755 SF		**0.201 acres**	
Impervious Portions					
Assume:					% of total SFR Area
Roof Shadow			2,000 SF		23%
Driveway	16' x 25'		400 SF		5%
Sidewalk 4 feet wide			340 SF		4%
Half of steet is 10 feet wide			850 SF		10%
			3,590 SF		41%

Makeup of the Average Multi Family Residence Lot				
Assume:				
MFR Lots are 100 feet wide.				
Lot is 100 feet deep	10,000 SF		0.23 acres	
Sidewalk and tree lane is 8 feet wide	800 SF		0.02 acres	
Half of steet is 15 feet wide	1500 SF		0.03 acres	
	12,300 SF		**0.282 acres**	
Impervious Portions				
Assume				% of total MFR Area
Roof Shadow		5,000 SF		41%
Parking Lot		2,340 SF	23' x 100'	19%
Sidewalk and tree lane is 4 feet wide		400 SF		3%
Half of steet is 15 feet wide		1500 SF		12%
		9,240 SF		75%

Approach for Cistern Analysis.
Used the rainfall data at LAX from January 1990 to December 2001.
There were 658 rain events during this period.
Of these events, 375 were very small (0.00 to 0.1 inches of total rainfall). These evetns were deleted from the database.
The largest was 3.5 inches on 3 January 1995.
It was assumed that 90% of the rain falliing onto a roof would be captured (per TREE people web site information).
It was assumed that irrigation would be stopped one day before a storm and could be started 2 days after a storm.

APPENDIX A Table 2. Example Calculation for the Cistern Analysis Single Family Residence										
								If Stored 1,000 Gallons		
	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 2,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
1	1	2	1990	0.11	123			0	123	
2	1	13	1990	0.22	247	11	8	0	247	123
3	1	14	1990	0.25	281	1	0	247	527	0
4	1	16	1990	0.37	415	2	0	527	942	0
5	1	30	1990	0.10	112	14	11	0	112	942
6	2	4	1990	0.32	359	4	1	0	359	112
7	2	16	1990	0.35	393	12	9	0	393	359
8	2	17	1990	1.88	2109	1	0	393	1000	0
9	4	4	1990	0.16	180	47	44	0	180	1000
10	4	30	1990	0.12	135	26	23	0	135	180
11	5	28	1990	0.77	864	28	25	0	864	135
12	1	3	1991	0.66	741	189	186	0	741	864
13	1	4	1991	0.38	426	1	0	741	1000	0
14	1	9	1991	0.32	359	5	2	730	1000	270
15	2	27	1991	1.60	1795	48	45	0	1000	1000
16	2	28	1991	0.93	1043	1	0	1000	1000	0
17	3	1	1991	0.72	808	3	0	1000	1000	0
18	3	4	1991	0.10	112	3	0	1000	1000	0
19	3	13	1991	0.14	157	9	6	190	347	810
20	3	18	1991	0.68	763	5	2	77	840	270
21	3	19	1991	0.23	258	1	0	840	1000	0
22	3	20	1991	0.52	583	1	0	1000	1000	0
23	3	25	1991	0.48	539	5	2	730	1000	270
24	3	26	1991	0.70	785	1	0	1000	1000	0
25	3	27	1991	0.35	393	1	0	1000	1000	0
26	7	8	1991	0.10	112	101	98	0	112	1000
27	12	8	1991	0.27	303	150	147	0	303	112
28	12	27	1991	0.84	942	19	16	0	942	303
29	12	28	1991	0.47	527	1	0	942	1000	0
30	12	29	1991	1.07	1201	1	0	1000	1000	0
31	12	30	1991	0.12	135	1	0	1000	1000	0
32	1	3	1992	0.39	438	4	1	865	1000	135
33	1	5	1992	0.84	942	2	0	1000	1000	0
34	1	7	1992	0.37	415	2	0	1000	1000	0
35	2	6	1992	0.80	898	29	26	0	898	1000
36	2	7	1992	0.51	572	1	0	898	1000	0
37	2	9	1992	0.19	213	2	0	1000	1000	0
38	2	10	1992	0.60	673	1	0	1000	1000	0
39	2	11	1992	0.57	640	1	0	1000	1000	0
40	2	12	1992	1.38	1548	1	0	1000	1000	0
41	2	13	1992	0.20	224	1	0	1000	1000	0
42	2	15	1992	0.38	426	2	0	1000	1000	0
43	3	1	1992	0.10	112	16	13	0	112	1000
44	3	2	1992	1.28	1436	1	0	112	1000	0
45	3	3	1992	0.34	381	1	0	1000	1000	0
46	3	6	1992	0.52	583	3	0	1000	1000	0

APPENDIX A Table 2. Example Calculation for the Cistern Analysis Single Family Residence								If Stored 1,000 Gallons		
	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 2,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
47	3	20	1992	1.04	1167	14	11	0	1000	1000
48	3	21	1992	0.23	258	1	0	1000	1000	0
49	3	22	1992	0.71	797	1	0	1000	1000	0
50	3	26	1992	0.10	112	4	1	865	977	135
51	3	27	1992	0.56	628	1	0	977	1000	0
52	3	31	1992	0.13	146	4	1	865	1000	135
53	4	1	1992	0.18	202	0	0	1000	1000	0
54	7	12	1992	0.28	314	101	98	0	314	1000
55	10	21	1992	0.24	269	99	96	0	269	314
56	10	30	1992	0.21	236	9	6	0	236	269
57	12	4	1992	0.21	236	34	31	0	236	236
58	12	6	1992	0.64	718	2	0	236	954	0
59	12	7	1992	1.71	1919	1	0	954	1000	0
60	12	11	1992	0.12	135	4	1	865	1000	135
61	12	17	1992	0.18	202	6	3	595	797	405
62	12	27	1992	0.54	606	10	7	0	606	797
63	12	29	1992	0.74	830	2	0	606	1000	0
64	1	2	1993	0.44	494	4	1	865	1000	135
65	1	6	1993	3.23	3624	4	1	865	1000	135
66	1	7	1993	1.26	1414	1	0	1000	1000	0
67	1	10	1993	0.23	258	3	0	1000	1000	0
68	1	12	1993	0.73	819	2	0	1000	1000	0
69	1	13	1993	0.93	1043	1	0	1000	1000	0
70	1	14	1993	0.28	314	1	0	1000	1000	0
71	1	15	1993	1.18	1324	1	0	1000	1000	0
72	1	16	1993	0.51	572	1	0	1000	1000	0
73	1	17	1993	0.36	404	1	0	1000	1000	0
74	1	18	1993	1.03	1156	1	0	1000	1000	0
75	1	30	1993	0.41	460	12	9	0	460	1000
76	2	7	1993	2.42	2715	7	4	0	1000	460
77	2	8	1993	0.32	359	1	0	1000	1000	0
78	2	18	1993	1.29	1447	10	7	55	1000	945
79	2	19	1993	0.34	381	1	0	1000	1000	0
80	2	20	1993	0.41	460	1	0	1000	1000	0
81	2	23	1993	0.22	247	3	0	1000	1000	0
82	2	26	1993	0.34	381	3	0	1000	1000	0
83	3	25	1993	1.04	1167	29	26	0	1000	1000
84	3	26	1993	0.30	337	1	0	1000	1000	0
85	3	27	1993	0.30	337	1	0	1000	1000	0
86	3	28	1993	0.19	213	1	0	1000	1000	0
87	6	5	1993	0.74	830	67	64	0	830	1000
88	11	11	1993	0.24	269	156	153	0	269	830
89	11	29	1993	0.26	292	18	15	0	292	269
90	11	30	1993	0.41	460	1	0	292	752	0
91	12	11	1993	0.46	516	11	8	0	516	752
92	12	14	1993	0.38	426	3	0	516	942	0

APPENDIX A

Table 2. Example Calculation for the Cistern Analysis

Single Family Residence

								If Stored 1,000 Gallons		
	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 2,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
93	1	24	1994	0.33	370	41	38	0	370	942
94	2	3	1994	0.28	314	9	6	0	314	370
95	2	4	1994	0.37	415	1	0	314	729	0
96	2	6	1994	0.12	135	2	0	729	864	0
97	2	7	1994	0.99	1111	1	0	864	1000	0
98	2	17	1994	1.26	1414	10	7	55	1000	945
99	2	20	1994	1.22	1369	3	0	1000	1000	0
100	3	19	1994	0.24	269	29	26	0	269	1000
101	3	24	1994	0.66	741	5	2	0	741	269
102	4	9	1994	0.19	213	15	12	0	213	741
103	4	25	1994	0.18	202	16	13	0	202	213
104	10	4	1994	0.14	157	159	156	0	157	202
105	11	8	1994	0.19	213	34	31	0	213	157
106	11	10	1994	0.38	426	2	0	213	640	0
107	12	12	1994	0.46	516	32	29	0	516	640
108	12	24	1994	0.57	640	12	9	0	640	516
109	1	3	1995	0.75	842	10	7	0	842	640
110	1	4	1995	3.50	3927	1	0	842	1000	0
111	1	7	1995	1.29	1447	3	0	1000	1000	0
112	1	8	1995	0.38	426	1	0	1000	1000	0
113	1	10	1995	2.93	3287	2	0	1000	1000	0
114	1	11	1995	0.17	191	1	0	1000	1000	0
115	1	12	1995	0.37	415	1	0	1000	1000	0
116	1	14	1995	0.12	135	2	0	1000	1000	0
117	1	20	1995	0.14	157	6	3	595	752	405
118	1	23	1995	1.16	1302	3	0	752	1000	0
119	1	24	1995	1.04	1167	1	0	1000	1000	0
120	1	25	1995	0.81	909	1	0	1000	1000	0
121	2	8	1995	0.12	135	13	10	0	135	1000
122	2	13	1995	0.16	180	5	2	0	180	135
123	2	14	1995	0.26	292	1	0	180	471	0
124	3	2	1995	0.16	180	18	15	0	180	471
125	3	3	1995	0.10	112	1	0	180	292	0
126	3	4	1995	0.19	213	1	0	292	505	0
127	3	5	1995	1.89	2121	1	0	505	1000	0
128	3	10	1995	1.67	1874	5	2	730	1000	270
129	3	11	1995	0.75	842	1	0	1000	1000	0
130	3	21	1995	0.50	561	10	7	55	616	945
131	3	23	1995	0.38	426	2	0	616	1000	0
132	4	16	1995	0.69	774	23	20	0	774	1000
133	5	15	1995	0.61	684	29	26	0	684	774
134	6	15	1995	0.24	269	30	27	0	269	684
135	6	16	1995	0.36	404	1	0	269	673	0
136	11	1	1995	0.10	112	135	132	0	112	673
137	12	12	1995	0.53	595	41	38	0	595	112
138	12	13	1995	0.82	920	1	0	595	1000	0

APPENDIX A Table 2. Example Calculation for the Cistern Analysis Single Family Residence											
								If Stored 1,000 Gallons		
	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 2,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
139	12	23	1995	0.80	898	10	7	55	953	945
140	1	16	1996	0.23	258	24	21	0	258	953
141	1	19	1996	0.15	168	3	0	258	426	0
142	1	21	1996	0.18	202	2	0	426	628	0
143	1	27	1996	0.10	112	6	3	223	336	405
144	1	31	1996	1.25	1403	4	1	201	1000	135
145	2	3	1996	0.29	325	2	0	1000	1000	0
146	2	19	1996	0.57	640	16	13	0	640	1000
147	2	20	1996	1.90	2132	1	0	640	1000	0
148	2	21	1996	0.78	875	1	0	1000	1000	0
149	2	25	1996	0.20	224	4	1	865	1000	135
150	2	27	1996	0.37	415	2	0	1000	1000	0
151	3	4	1996	0.80	898	7	4	460	1000	540
152	3	12	1996	0.26	292	8	5	325	617	675
153	3	13	1996	0.19	213	1	0	617	830	0
154	4	17	1996	0.31	348	34	31	0	348	830
155	10	30	1996	1.44	1616	193	190	0	1000	348
156	11	21	1996	1.44	1616	21	18	0	1000	1000
157	11	22	1996	0.37	415	1	0	1000	1000	0
158	12	9	1996	1.36	1526	17	14	0	1000	1000
159	12	10	1996	0.79	886	1	0	1000	1000	0
160	12	11	1996	0.64	718	1	0	1000	1000	0
161	12	22	1996	0.17	191	11	8	0	191	1000
162	12	27	1996	1.46	1638	5	2	0	1000	191
163	1	1	1997	0.14	157	5	2	730	887	270
164	1	2	1997	0.43	482	1	0	887	1000	0
165	1	3	1997	0.10	112	1	0	1000	1000	0
166	1	12	1997	1.20	1346	9	6	190	1000	810
167	1	15	1997	0.79	886	3	0	1000	1000	0
168	1	21	1997	0.46	516	6	3	595	1000	405
169	1	22	1997	0.23	258	1	0	1000	1000	0
170	1	23	1997	0.30	337	1	0	1000	1000	0
171	1	25	1997	0.92	1032	2	0	1000	1000	0
172	1	26	1997	0.44	494	1	0	1000	1000	0
173	9	25	1997	0.27	303	239	236	0	303	1000
174	11	10	1997	0.78	875	45	42	0	875	303
175	11	13	1997	0.40	449	3	0	875	1000	0
176	11	26	1997	0.79	886	13	10	0	886	1000
177	11	30	1997	0.58	651	4	1	751	1000	135
178	12	5	1997	0.92	1032	5	2	730	1000	270
179	12	6	1997	1.54	1728	1	0	1000	1000	0
180	12	7	1997	0.29	325	1	0	1000	1000	0
181	12	18	1997	1.22	1369	11	8	0	1000	1000
182	1	3	1998	0.22	247	16	13	0	247	1000
183	1	4	1998	0.41	460	1	0	247	707	0
184	1	9	1998	1.70	1907	5	2	437	1000	270

APPENDIX A Table 2. Example Calculation for the Cistern Analysis Single Family Residence								If Stored 1,000 Gallons		
	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 2,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
185	1	13	1998	0.15	168	4	1	865	1000	135
186	1	19	1998	0.14	157	6	3	595	752	405
187	1	29	1998	0.83	931	10	7	0	931	752
188	2	2	1998	0.56	628	3	0	931	1000	0
189	2	3	1998	3.08	3456	1	0	1000	1000	0
190	2	6	1998	1.38	1548	3	0	1000	1000	0
191	2	7	1998	1.22	1369	1	0	1000	1000	0
192	2	8	1998	0.47	527	1	0	1000	1000	0
193	2	14	1998	2.09	2345	6	3	595	1000	405
194	2	16	1998	0.18	202	2	0	1000	1000	0
195	2	17	1998	0.29	325	1	0	1000	1000	0
196	2	19	1998	0.77	864	2	0	1000	1000	0
197	2	21	1998	0.13	146	2	0	1000	1000	0
198	2	22	1998	1.02	1144	1	0	1000	1000	0
199	2	23	1998	1.80	2020	1	0	1000	1000	0
200	2	24	1998	0.52	583	1	0	1000	1000	0
201	3	5	1998	0.11	123	11	8	0	123	1000
202	3	6	1998	0.19	213	1	0	123	337	0
203	3	13	1998	0.47	527	7	4	0	527	337
204	3	14	1998	0.20	224	1	0	527	752	0
205	3	25	1998	1.39	1560	11	8	0	1000	752
206	3	28	1998	0.28	314	3	0	1000	1000	0
207	3	31	1998	0.68	763	3	0	1000	1000	0
208	4	3	1998	0.12	135	2	0	1000	1000	0
209	4	11	1998	0.74	830	8	5	325	1000	675
210	5	2	1998	0.11	123	21	18	0	123	1000
211	5	4	1998	0.34	381	2	0	123	505	0
212	5	5	1998	0.46	516	1	0	505	1000	0
213	5	6	1998	0.22	247	1	0	1000	1000	0
214	5	12	1998	0.67	752	6	3	595	1000	405
215	5	13	1998	0.59	662	1	0	1000	1000	0
216	11	8	1998	1.20	1346	175	172	0	1000	1000
217	11	28	1998	0.49	550	20	17	0	550	1000
218	12	1	1998	0.17	191	3	0	550	741	0
219	12	6	1998	0.39	438	5	2	471	908	270
220	1	20	1999	0.23	258	45	42	0	258	908
221	1	25	1999	0.40	449	5	2	0	449	258
222	1	26	1999	0.30	337	1	0	449	785	0
223	1	31	1999	0.19	213	5	2	515	729	270
224	2	4	1999	0.19	213	3	0	729	942	0
225	2	5	1999	0.13	146	1	0	942	1000	0
226	2	9	1999	0.17	191	4	1	865	1000	135
227	3	9	1999	0.15	168	30	27	0	168	1000
228	3	15	1999	0.66	741	6	3	0	741	168
229	3	20	1999	0.30	337	5	2	471	807	270
230	3	25	1999	0.88	987	5	2	537	1000	270

APPENDIX A Table 2. Example Calculation for the Cistern Analysis Single Family Residence								If Stored 1,000 Gallons		
	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 2,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
231	4	6	1999	0.42	471	11	8	0	471	1000
232	4	7	1999	0.30	337	1	0	471	808	0
233	4	11	1999	1.35	1515	4	1	673	1000	135
234	6	2	1999	0.48	539	51	48	0	539	1000
235	11	8	1999	0.27	303	156	153	0	303	539
236	1	25	2000	0.61	684	78	75	0	684	303
237	1	30	2000	0.18	202	5	2	414	616	270
238	2	10	2000	0.31	348	10	7	0	348	616
239	2	12	2000	0.51	572	2	0	348	920	0
240	2	13	2000	0.39	438	1	0	920	1000	0
241	2	14	2000	0.17	191	1	0	1000	1000	0
242	2	16	2000	0.54	606	2	0	1000	1000	0
243	2	20	2000	0.66	741	4	1	865	1000	135
244	2	21	2000	1.18	1324	1	0	1000	1000	0
245	2	23	2000	0.73	819	2	0	1000	1000	0
246	2	27	2000	0.17	191	4	1	865	1000	135
247	3	3	2000	0.29	325	6	3	595	920	405
248	3	5	2000	1.14	1279	2	0	920	1000	0
249	3	8	2000	0.88	987	3	0	1000	1000	0
250	4	17	2000	1.32	1481	39	36	0	1000	1000
251	4	18	2000	0.56	628	1	0	1000	1000	0
252	10	11	2000	0.11	123	173	170	0	123	1000
253	10	26	2000	0.17	191	15	12	0	191	123
254	10	27	2000	0.19	213	1	0	191	404	0
255	10	29	2000	0.59	662	2	0	404	1000	0
256	1	8	2001	0.23	258	40	37	0	258	1000
257	1	10	2001	2.09	2345	2	0	258	1000	0
258	1	11	2001	0.95	1066	1	0	1000	1000	0
259	1	12	2001	0.47	527	1	0	1000	1000	0
260	1	24	2001	0.28	314	12	9	0	314	1000
261	1	26	2001	0.66	741	2	0	314	1000	0
262	2	10	2001	0.33	370	14	11	0	370	1000
263	2	11	2001	0.10	112	1	0	370	482	0
264	2	12	2001	1.95	2188	1	0	482	1000	0
265	2	13	2001	1.61	1806	1	0	1000	1000	0
266	2	19	2001	0.24	269	6	3	595	864	405
267	2	23	2001	0.17	191	4	1	729	920	135
268	2	24	2001	0.27	303	1	0	920	1000	0
269	2	25	2001	1.85	2076	1	0	1000	1000	0
270	2	26	2001	0.40	449	1	0	1000	1000	0
271	2	27	2001	0.25	281	1	0	1000	1000	0
272	3	5	2001	0.66	741	8	5	325	1000	675
273	3	6	2001	0.49	550	1	0	1000	1000	0
274	4	7	2001	0.48	539	31	28	0	539	1000
275	4	20	2001	0.54	606	13	10	0	606	539
276	11	12	2001	0.35	393	202	199	0	393	606

APPENDIX A
Table 2. Example Calculation for the Cistern Analysis
Single Family Residence

	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 2,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	If Stored 1,000 Gallons		
								Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
277	11	24	2001	0.60	673	12	9	0	673	393
278	11	29	2001	0.30	337	5	2	403	740	270
279	12	2	2001	0.10	112	3	0	740	852	0
280	12	3	2001	0.13	146	1	0	852	998	0
281	12	14	2001	0.23	258	11	8	0	258	998
282	12	29	2001	0.32	359	15	12	0	359	258
283	12	30	2001	0.10	112	1	0	359	471	0
				TOTAL	189,102				TOTAL	75,915

APPENDIX A
Table 3. Example Calculation for the Cistern Analysis
Multi Family Residence

	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 5,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	If stored 10,000 Gallons: Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
1	1	2	1990	0.11	309			0	309	
2	1	13	1990	0.22	617	11	8	0	617	309
3	1	14	1990	0.25	701	1	0	617	1318	0
4	1	16	1990	0.37	1038	2	0	1318	2356	0
5	1	30	1990	0.10	281	14	11	0	281	2356
6	2	4	1990	0.32	898	4	1	31	928	250
7	2	16	1990	0.35	982	12	9	0	982	928
8	2	17	1990	1.88	5273	1	0	982	6255	0
9	4	4	1990	0.16	449	47	44	0	449	6255
10	4	30	1990	0.12	337	26	23	0	337	449
11	5	28	1990	0.77	2160	28	25	0	2160	337
12	1	3	1991	0.66	1851	189	186	0	1851	2160
13	1	4	1991	0.38	1066	1	0	1851	2917	0
14	1	9	1991	0.32	898	5	2	2417	3315	500
15	2	27	1991	1.60	4488	48	45	0	4488	3315
16	2	28	1991	0.93	2609	1	0	4488	7097	0
17	3	1	1991	0.72	2020	3	0	7097	9116	0
18	3	4	1991	0.10	281	3	0	9116	9397	0
19	3	13	1991	0.14	393	9	6	7897	8289	1500
20	3	18	1991	0.68	1907	5	2	7789	9697	500
21	3	19	1991	0.23	645	1	0	9697	10000	0
22	3	20	1991	0.52	1459	1	0	10000	10000	0
23	3	25	1991	0.48	1346	5	2	9500	10000	500
24	3	26	1991	0.70	1964	1	0	10000	10000	0
25	3	27	1991	0.35	982	1	0	10000	10000	0
26	7	8	1991	0.10	281	101	98	0	281	10000
27	12	8	1991	0.27	757	150	147	0	757	281
28	12	27	1991	0.84	2356	19	16	0	2356	757
29	12	28	1991	0.47	1318	1	0	2356	3675	0
30	12	29	1991	1.07	3001	1	0	3675	6676	0
31	12	30	1991	0.12	337	1	0	6676	7013	0
32	1	3	1992	0.39	1094	4	1	6763	7856	250
33	1	5	1992	0.84	2356	2	0	7856	10000	0
34	1	7	1992	0.37	1038	2	0	10000	10000	0
35	2	6	1992	0.80	2244	29	26	3500	5744	6500
36	2	7	1992	0.51	1431	1	0	5744	7175	0
37	2	9	1992	0.19	533	2	0	7175	7708	0
38	2	10	1992	0.60	1683	1	0	7708	9391	0
39	2	11	1992	0.57	1599	1	0	9391	10000	0
40	2	12	1992	1.38	3871	1	0	10000	10000	0
41	2	13	1992	0.20	561	1	0	10000	10000	0
42	2	15	1992	0.38	1066	2	0	10000	10000	0
43	3	1	1992	0.10	281	16	13	6750	7031	3250
44	3	2	1992	1.28	3590	1	0	7031	10000	0
45	3	3	1992	0.34	954	1	0	10000	10000	0
46	3	6	1992	0.52	1459	3	0	10000	10000	0

APPENDIX A Table 3. Example Calculation for the Cistern Analysis Multi Family Residence								If stored 10,000 Gallons		
	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 5,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
47	3	20	1992	1.04	2917	14	11	7250	10000	2750
48	3	21	1992	0.23	645	1	0	10000	10000	0
49	3	22	1992	0.71	1992	1	0	10000	10000	0
50	3	26	1992	0.10	281	4	1	9750	10000	250
51	3	27	1992	0.56	1571	1	0	10000	10000	0
52	3	31	1992	0.13	365	4	1	9750	10000	250
53	4	1	1992	0.18	505	0	0	10000	10000	0
54	7	12	1992	0.28	785	101	98	0	785	10000
55	10	21	1992	0.24	673	99	96	0	673	785
56	10	30	1992	0.21	589	9	6	0	589	673
57	12	4	1992	0.21	589	34	31	0	589	589
58	12	6	1992	0.64	1795	2	0	589	2384	0
59	12	7	1992	1.71	4797	1	0	2384	7181	0
60	12	11	1992	0.12	337	4	1	6931	7267	250
61	12	17	1992	0.18	505	6	3	6517	7022	750
62	12	27	1992	0.54	1515	10	7	5272	6787	1750
63	12	29	1992	0.74	2076	2	0	6787	8863	0
64	1	2	1993	0.44	1234	4	1	8613	9847	250
65	1	6	1993	3.23	9060	4	1	9597	10000	250
66	1	7	1993	1.26	3534	1	0	10000	10000	0
67	1	10	1993	0.23	645	3	0	10000	10000	0
68	1	12	1993	0.73	2048	2	0	10000	10000	0
69	1	13	1993	0.93	2609	1	0	10000	10000	0
70	1	14	1993	0.28	785	1	0	10000	10000	0
71	1	15	1993	1.18	3310	1	0	10000	10000	0
72	1	16	1993	0.51	1431	1	0	10000	10000	0
73	1	17	1993	0.36	1010	1	0	10000	10000	0
74	1	18	1993	1.03	2889	1	0	10000	10000	0
75	1	30	1993	0.41	1150	12	9	7750	8900	2250
76	2	7	1993	2.42	6788	7	4	7900	10000	1000
77	2	8	1993	0.32	898	1	0	10000	10000	0
78	2	18	1993	1.29	3618	10	7	8250	10000	1750
79	2	19	1993	0.34	954	1	0	10000	10000	0
80	2	20	1993	0.41	1150	1	0	10000	10000	0
81	2	23	1993	0.22	617	3	0	10000	10000	0
82	2	26	1993	0.34	954	3	0	10000	10000	0
83	3	25	1993	1.04	2917	29	26	3500	6417	6500
84	3	26	1993	0.30	842	1	0	6417	7259	0
85	3	27	1993	0.30	842	1	0	7259	8100	0
86	3	28	1993	0.19	533	1	0	8100	8633	0
87	6	5	1993	0.74	2076	67	64	0	2076	8633
88	11	11	1993	0.24	673	156	153	0	673	2076
89	11	29	1993	0.26	729	18	15	0	729	673
90	11	30	1993	0.41	1150	1	0	729	1879	0
91	12	11	1993	0.46	1290	11	8	0	1290	1879
92	12	14	1993	0.38	1066	3	0	1290	2356	0

APPENDIX A
Table 3. Example Calculation for the Cistern Analysis
Multi Family Residence

	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 5,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	If stored 10,000 Gallons Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
93	1	24	1994	0.33	926	41	38	0	926	2356
94	2	3	1994	0.28	785	9	6	0	785	926
95	2	4	1994	0.37	1038	1	0	785	1823	0
96	2	6	1994	0.12	337	2	0	1823	2160	0
97	2	7	1994	0.99	2777	1	0	2160	4937	0
98	2	17	1994	1.26	3534	10	7	3187	6721	1750
99	2	20	1994	1.22	3422	3	0	6721	10000	0
100	3	19	1994	0.24	673	29	26	3500	4173	6500
101	3	24	1994	0.66	1851	5	2	3673	5525	500
102	4	9	1994	0.19	533	15	12	2525	3057	3000
103	4	25	1994	0.18	505	16	13	0	505	3057
104	10	4	1994	0.14	393	159	156	0	393	505
105	11	8	1994	0.19	533	34	31	0	533	393
106	11	10	1994	0.38	1066	2	0	533	1599	0
107	12	12	1994	0.46	1290	32	29	0	1290	1599
108	12	24	1994	0.57	1599	12	9	0	1599	1290
109	1	3	1995	0.75	2104	10	7	0	2104	1599
110	1	4	1995	3.50	9818	1	0	2104	10000	0
111	1	7	1995	1.29	3618	3	0	10000	10000	0
112	1	8	1995	0.38	1066	1	0	10000	10000	0
113	1	10	1995	2.93	8219	2	0	10000	10000	0
114	1	11	1995	0.17	477	1	0	10000	10000	0
115	1	12	1995	0.37	1038	1	0	10000	10000	0
116	1	14	1995	0.12	337	2	0	10000	10000	0
117	1	20	1995	0.14	393	6	3	9250	9643	750
118	1	23	1995	1.16	3254	3	0	9643	10000	0
119	1	24	1995	1.04	2917	1	0	10000	10000	0
120	1	25	1995	0.81	2272	1	0	10000	10000	0
121	2	8	1995	0.12	337	13	10	7500	7837	2500
122	2	13	1995	0.16	449	5	2	7337	7785	500
123	2	14	1995	0.26	729	1	0	7785	8515	0
124	3	2	1995	0.16	449	18	15	4765	5214	3750
125	3	3	1995	0.10	281	1	0	5214	5494	0
126	3	4	1995	0.19	533	1	0	5494	6027	0
127	3	5	1995	1.89	5301	1	0	6027	10000	0
128	3	10	1995	1.67	4684	5	2	9500	10000	500
129	3	11	1995	0.75	2104	1	0	10000	10000	0
130	3	21	1995	0.50	1403	10	7	8250	9653	1750
131	3	23	1995	0.38	1066	2	0	9653	10000	0
132	4	16	1995	0.69	1935	23	20	5000	6935	5000
133	5	15	1995	0.61	1711	29	26	435	2147	6500
134	6	15	1995	0.24	673	30	27	0	673	2147
135	6	16	1995	0.36	1010	1	0	673	1683	0
136	11	1	1995	0.10	281	135	132	0	281	1683
137	12	12	1995	0.53	1487	41	38	0	1487	281
138	12	13	1995	0.82	2300	1	0	1487	3787	0

APPENDIX A
Table 3. Example Calculation for the Cistern Analysis
Multi Family Residence

								If stored 10,000 Gallons		
	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 5,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
139	12	23	1995	0.80	2244	10	7	2037	4281	1750
140	1	16	1996	0.23	645	24	21	0	645	4281
141	1	19	1996	0.15	421	3	0	645	1066	0
142	1	21	1996	0.18	505	2	0	1066	1571	0
143	1	27	1996	0.10	281	6	3	821	1101	750
144	1	31	1996	1.25	3506	4	1	851	4358	250
145	2	3	1996	0.29	813	2	0	4358	5171	0
146	2	19	1996	0.57	1599	16	13	1921	3520	3250
147	2	20	1996	1.90	5330	1	0	3520	8849	0
148	2	21	1996	0.78	2188	1	0	8849	10000	0
149	2	25	1996	0.20	561	4	1	9750	10000	250
150	2	27	1996	0.37	1038	2	0	10000	10000	0
151	3	4	1996	0.80	2244	7	4	9000	10000	1000
152	3	12	1996	0.26	729	8	5	8750	9479	1250
153	3	13	1996	0.19	533	1	0	9479	10000	0
154	4	17	1996	0.31	870	34	31	2250	3120	7750
155	10	30	1996	1.44	4039	193	190	0	4039	3120
156	11	21	1996	1.44	4039	21	18	0	4039	4039
157	11	22	1996	0.37	1038	1	0	4039	5077	0
158	12	9	1996	1.36	3815	17	14	1577	5392	3500
159	12	10	1996	0.79	2216	1	0	5392	7608	0
160	12	11	1996	0.64	1795	1	0	7608	9403	0
161	12	22	1996	0.17	477	11	8	7403	7880	2000
162	12	27	1996	1.46	4095	5	2	7380	10000	500
163	1	1	1997	0.14	393	5	2	9500	9893	500
164	1	2	1997	0.43	1206	1	0	9893	10000	0
165	1	3	1997	0.10	281	1	0	10000	10000	0
166	1	12	1997	1.20	3366	9	6	8500	10000	1500
167	1	15	1997	0.79	2216	3	0	10000	10000	0
168	1	21	1997	0.46	1290	6	3	9250	10000	750
169	1	22	1997	0.23	645	1	0	10000	10000	0
170	1	23	1997	0.30	842	1	0	10000	10000	0
171	1	25	1997	0.92	2581	2	0	10000	10000	0
172	1	26	1997	0.44	1234	1	0	10000	10000	0
173	9	25	1997	0.27	757	239	236	0	757	10000
174	11	10	1997	0.78	2188	45	42	0	2188	757
175	11	13	1997	0.40	1122	3	0	2188	3310	0
176	11	26	1997	0.79	2216	13	10	810	3026	2500
177	11	30	1997	0.58	1627	4	1	2776	4403	250
178	12	5	1997	0.92	2581	5	2	3903	6483	500
179	12	6	1997	1.54	4320	1	0	6483	10000	0
180	12	7	1997	0.29	813	1	0	10000	10000	0
181	12	18	1997	1.22	3422	11	8	8000	10000	2000
182	1	3	1998	0.22	617	16	13	6750	7367	3250
183	1	4	1998	0.41	1150	1	0	7367	8517	0
184	1	9	1998	1.70	4769	5	2	8017	10000	500

APPENDIX A
Table 3. Example Calculation for the Cistern Analysis
Multi Family Residence

	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 5,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	If stored 10,000 Gallons Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
185	1	13	1998	0.15	421	4	1	9750	10000	250
186	1	19	1998	0.14	393	6	3	9250	9643	750
187	1	29	1998	0.83	2328	10	7	7893	10000	1750
188	2	2	1998	0.56	1571	3	0	10000	10000	0
189	2	3	1998	3.08	8639	1	0	10000	10000	0
190	2	6	1998	1.38	3871	3	0	10000	10000	0
191	2	7	1998	1.22	3422	1	0	10000	10000	0
192	2	8	1998	0.47	1318	1	0	10000	10000	0
193	2	14	1998	2.09	5862	6	3	9250	10000	750
194	2	16	1998	0.18	505	2	0	10000	10000	0
195	2	17	1998	0.29	813	1	0	10000	10000	0
196	2	19	1998	0.77	2160	2	0	10000	10000	0
197	2	21	1998	0.13	365	2	0	10000	10000	0
198	2	22	1998	1.02	2861	1	0	10000	10000	0
199	2	23	1998	1.80	5049	1	0	10000	10000	0
200	2	24	1998	0.52	1459	1	0	10000	10000	0
201	3	5	1998	0.11	309	11	8	8000	8309	2000
202	3	6	1998	0.19	533	1	0	8309	8842	0
203	3	13	1998	0.47	1318	7	4	7842	9160	1000
204	3	14	1998	0.20	561	1	0	9160	9721	0
205	3	25	1998	1.39	3899	11	8	7721	10000	2000
206	3	28	1998	0.28	785	3	0	10000	10000	0
207	3	31	1998	0.68	1907	3	0	10000	10000	0
208	4	3	1998	0.12	337	2	0	10000	10000	0
209	4	11	1998	0.74	2076	8	5	8750	10000	1250
210	5	2	1998	0.11	309	21	18	5500	5809	4500
211	5	4	1998	0.34	954	2	0	5809	6762	0
212	5	5	1998	0.46	1290	1	0	6762	8053	0
213	5	6	1998	0.22	617	1	0	8053	8670	0
214	5	12	1998	0.67	1879	6	3	7920	9799	750
215	5	13	1998	0.59	1655	1	0	9799	10000	0
216	11	8	1998	1.20	3366	175	172	0	3366	10000
217	11	28	1998	0.49	1374	20	17	0	1374	3366
218	12	1	1998	0.17	477	3	0	1374	1851	0
219	12	6	1998	0.39	1094	5	2	1351	2445	500
220	1	20	1999	0.23	645	45	42	0	645	2445
221	1	25	1999	0.40	1122	5	2	145	1267	500
222	1	26	1999	0.30	842	1	0	1267	2109	0
223	1	31	1999	0.19	533	5	2	1609	2142	500
224	2	4	1999	0.19	533	3	0	2142	2675	0
225	2	5	1999	0.13	365	1	0	2675	3039	0
226	2	9	1999	0.17	477	4	1	2789	3266	250
227	3	9	1999	0.15	421	30	27	0	421	3266
228	3	15	1999	0.66	1851	6	3	0	1851	421
229	3	20	1999	0.30	842	5	2	1351	2193	500
230	3	25	1999	0.88	2468	5	2	1693	4161	500

APPENDIX A Table 3. Example Calculation for the Cistern Analysis Multi Family Residence								If stored 10,000 Gallons		
	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 5,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
231	4	6	1999	0.42	1178	11	8	2161	3339	2000
232	4	7	1999	0.30	842	1	0	3339	4181	0
233	4	11	1999	1.35	3787	4	1	3931	7718	250
234	6	2	1999	0.48	1346	51	48	0	1346	7718
235	11	8	1999	0.27	757	156	153	0	757	1346
236	1	25	2000	0.61	1711	78	75	0	1711	757
237	1	30	2000	0.18	505	5	2	1211	1716	500
238	2	10	2000	0.31	870	10	7	0	870	1716
239	2	12	2000	0.51	1431	2	0	870	2300	0
240	2	13	2000	0.39	1094	1	0	2300	3394	0
241	2	14	2000	0.17	477	1	0	3394	3871	0
242	2	16	2000	0.54	1515	2	0	3871	5386	0
243	2	20	2000	0.66	1851	4	1	5136	6987	250
244	2	21	2000	1.18	3310	1	0	6987	10000	0
245	2	23	2000	0.73	2048	2	0	10000	10000	0
246	2	27	2000	0.17	477	4	1	9750	10000	250
247	3	3	2000	0.29	813	6	3	9250	10000	750
248	3	5	2000	1.14	3198	2	0	10000	10000	0
249	3	8	2000	0.88	2468	3	0	10000	10000	0
250	4	17	2000	1.32	3703	39	36	1000	4703	9000
251	4	18	2000	0.56	1571	1	0	4703	6273	0
252	10	11	2000	0.11	309	173	170	0	309	6273
253	10	26	2000	0.17	477	15	12	0	477	309
254	10	27	2000	0.19	533	1	0	477	1010	0
255	10	29	2000	0.59	1655	2	0	1010	2665	0
256	1	8	2001	0.23	645	40	37	0	645	2665
257	1	10	2001	2.09	5862	2	0	645	6508	0
258	1	11	2001	0.95	2665	1	0	6508	9172	0
259	1	12	2001	0.47	1318	1	0	9172	10000	0
260	1	24	2001	0.28	785	12	9	7750	8535	2250
261	1	26	2001	0.66	1851	2	0	8535	10000	0
262	2	10	2001	0.33	926	14	11	7250	8176	2750
263	2	11	2001	0.10	281	1	0	8176	8456	0
264	2	12	2001	1.95	5470	1	0	8456	10000	0
265	2	13	2001	1.61	4516	1	0	10000	10000	0
266	2	19	2001	0.24	673	6	3	9250	9923	750
267	2	23	2001	0.17	477	4	1	9673	10000	250
268	2	24	2001	0.27	757	1	0	10000	10000	0
269	2	25	2001	1.85	5189	1	0	10000	10000	0
270	2	26	2001	0.40	1122	1	0	10000	10000	0
271	2	27	2001	0.25	701	1	0	10000	10000	0
272	3	5	2001	0.66	1851	8	5	8750	10000	1250
273	3	6	2001	0.49	1374	1	0	10000	10000	0
274	4	7	2001	0.48	1346	31	28	3000	4346	7000
275	4	20	2001	0.54	1515	13	10	1846	3361	2500
276	11	12	2001	0.35	982	202	199	0	982	3361

APPENDIX A

Table 3. Example Calculation for the Cistern Analysis

Multi Family Residence

	Month	Day	Year	Storm Total (inch)	Volume 90% Capture on 5,000 SF Roof (Gal)	Total Days Between Storms (days)	Irrigation Days Between Storms (days)	If stored 10,000 Gallons Water Stored Just Before Storm (gal)	Water Stored Just After Storm (gal)	Amount of Water Irrigated (gal)
277	11	24	2001	0.60	1683	12	9	0	1683	982
278	11	29	2001	0.30	842	5	2	1183	2025	500
279	12	2	2001	0.10	281	3	0	2025	2305	0
280	12	3	2001	0.13	365	1	0	2305	2670	0
281	12	14	2001	0.23	645	11	8	670	1315	2000
282	12	29	2001	0.32	898	15	12	0	898	1315
283	12	30	2001	0.10	281	1	0	898	1178	0
				TOTAL	**472,755**					**284,676**

APPENDIX A				
Table 4.Cistern Effectiveness per Cistern Size				
Cistern Size	**Single Family**		**Multi Family**	
	Amount of Water Irrigated (gal)	**% Effectiveness**	**Amount of Water Irrigated (gal)**	**% Effectiveness**
60	8,040	4%	8,040	2%
165	21,311	11%	22,110	5%
350	38,770	21%	45,051	10%
1,000	**75,915**	**40%**	**101,353**	**21%**
1,800	97,599	52%	149,594	32%
2,000	101,089	53%	158,883	34%
5,000	133,705	71%	228,562	48%
10,000	**163,087**	**86%**	**284,676**	**60%**
90% Roof Runoff Capture	***189,102 gal***		***472,755 gal***	

APPENDIX A

Table 5. Runoff Managed with Cistern Installation

Land Use	Total Area (acre)	% Roof Shadow %	Average Annual Rainfall (in/yr)	% Capture	Cistern Size (gallons)	% Effectiveness	Runoff Managed		
							100% Installation (MG/yr)	5% Installation (MG/yr)	10% Installation (MG/yr)
Single Family Residential	8,500	23%	14.95	90%	1,000	40%	286	14.3	28.6
Multi Family Residential	2,600	41%	14.95	90%	10,000	60%	234	11.7	23.4
Educational	540	50%	14.95	90%	10,000	60%	59	3.0	5.9
Government and Public	330	61%	14.95	90%	10,000	60%	44	2.2	4.4
Total	**11,970**						**623**	**31.1**	**62.3**

APPENDIX B

Table 1. Infiltration Capacity of Soils in Jurisdictions 2 and 3

Subwatershed	Soil Type	Cu at 2 In/Hr	Cu at 10 In/Hr	Infiltration Capacity	Area (Acres)
Castle Rock	24	0.20	0.65	Good	397
Castle Rock	21	0.35	0.78	Good	106
Castle Rock	22	0.58	0.82	Fair	4,134
Castle Rock	38	0.58	0.84	Fair	165
Castle Rock	38	0.58	0.84	Fair	163
Castle Rock	23	0.58	0.85	Fair	13
Santa Ynez Canyon	22	0.58	0.82	Fair	686
Santa Ynez Canyon	23	0.58	0.85	Fair	535
Santa Ynez Canyon	22	0.58	0.82	Fair	0
Pulga Canyon	21	0.35	0.78	Good	267
Pulga Canyon	21	0.35	0.78	Good	8
Pulga Canyon	22	0.58	0.82	Fair	1,062
Pulga Canyon	23	0.58	0.85	Fair	628
Pulga Canyon	23	0.58	0.85	Fair	1
Santa Monica Canyon	21	0.35	0.78	Good	5,655
Santa Monica Canyon	22	0.58	0.82	Fair	2,138
Santa Monica Canyon	23	0.58	0.85	Fair	1,843
Santa Monica Canyon	22	0.58	0.82	Fair	117
Santa Monica Canyon	66	0.60	0.86	Fair	8
Santa Monica Canyon	22	0.58	0.82	Fair	2
Santa Monica Canyon	13	0.78	0.98	Poor	347
Santa Monica Canyon	16	0.65	0.98	Poor	1
Santa Monica	21	0.35	0.78	Good	1,275
Santa Monica	3	0.32	0.75	Good	173
Santa Monica	23	0.58	0.85	Fair	5
Santa Monica	13	0.78	0.98	Poor	2,659
Santa Monica	14	0.50	0.92	Poor	1,695
Santa Monica	16	0.65	0.98	Poor	1,080
Santa Monica	13	0.78	0.98	Poor	526
Santa Monica	13	0.78	0.98	Poor	319
Santa Monica	16	0.65	0.98	Poor	276
Santa Monica	13	0.78	0.98	Poor	259
Santa Monica	9	0.75	0.98	Poor	248
Santa Monica	12	0.90	0.98	Poor	215
Santa Monica	13	0.78	0.98	Poor	140
Santa Monica	13	0.78	0.98	Poor	118
Santa Monica	12	0.90	0.98	Poor	80
Santa Monica	17	0.85	0.98	Poor	35
Santa Monica	13	0.78	0.98	Poor	4
Santa Monica	13	0.78	0.98	Poor	1
Santa Monica	17	0.85	0.98	Poor	1
Santa Monica	16	0.65	0.98	Poor	0
Santa Monica	16	0.65	0.98	Poor	0

APPENDIX B

Table 1. Infiltration Capacity of Soils in Jurisdictions 2 and 3

Subwatershed	Soil Type	Cu at 2 In/Hr	Cu at 10 In/Hr	Infiltration Capacity	Area (Acres)
Venice Beach	3	0.32	0.75	Good	108
Dockweiler	3	0.32	0.75	Good	1,040
Dockweiler	3	0.32	0.75	Good	0
Dockweiler	10	0.40	0.90	Poor	4,899
Dockweiler	14	0.50	0.92	Poor	517
Dockweiler	14	0.50	0.92	Poor	210
Dockweiler	9	0.75	0.98	Poor	94
Dockweiler	14	0.50	0.92	Poor	42
Dockweiler	14	0.50	0.92	Poor	40
Dockweiler	10	0.40	0.90	Poor	23
Dockweiler	13	0.78	0.98	Poor	3
Dockweiler	17	0.85	0.98	Poor	1
Dockweiler	14	0.50	0.92	Poor	0

APPENDIX B

Table 2. Summary of Infiltration Capacity of Soils in Jurisdictions 2 and 3

Subwatershed	Good	Fair	Poor	Total
Castle Rock	503	4,474	-	4,977
Santa Ynez Canyon	-	1,221	-	1,221
Pulga Canyon	275	1,692	-	1,967
Santa Monica Canyon	5,655	4,108	349	10,111
Santa Monica	1,447	5	7,655	9,107
Venice Beach	108	-	-	108
Dockweiler	1,040	-	5,830	6,870
Total	**9,028**	**11,500**	**13,833**	**34,361**

APPENDIX C

Table 1. Potential Irrigtion Demand in Jursidictions 2 and 3

(Source: Los Angeles Department of Water and Power, City of Santa Monica)

CASTLE ROCK		
POTENTIAL CUSTOMER	**DEMAND (AFY)**	**DEMAND (GPM)**
COMMERCIAL/PRIVATE	13	4
COMMERCIAL/PRIVATE (MUSEUM IRRIGATION)	14	5
GOVERNMENT/PUBLIC (LA COUNTY)	14	5
TOTAL	**41**	**13**

SANTA YNEZ CANYON		
POTENTIAL CUSTOMER	**DEMAND (AFY)**	**DEMAND (GPM)**
COMMERCIAL/PRIVATE (RELIGIOUS)	24	8
TOTAL	**24**	**8**

PULGA CANYON		
POTENTIAL CUSTOMER	**DEMAND (AFY)**	**DEMAND (GPM)**
COMMERCIAL/PRIVATE (CAR WASH)	18	6
PARKS & REC (CITY LA)	19	6
PARKS & REC (CITY LA)	8	3
PARKS & REC (CITY LA)	8	3
PARKS & REC (MOUNTAINS AUTHORITY)	16	5
SCHOOL (PALISADES HIGH)	40	13
TOTAL	**109**	**36**

SANTA MONICA CANYON		
POTENTIAL CUSTOMER	**DEMAND (AFY)**	**DEMAND (GPM)**
COUNTRY CLUB	256	83
PARKS & REC (CITY LA)	17	6
PARKS & REC (STATE)	18	6
SCHOOL (PAUL REVERE JR HIGH)	17	6
TOTAL	**308**	**100**

APPENDIX C

Table 1. Potential Irrigtion Demand in Jursidictions 2 and 3

(Source: Los Angeles Department of Water and Power, City of Santa Monica)

SANTA MONICA		
POTENTIAL CUSTOMER	**DEMAND (AFY)**	**DEMAND (MG)**
AIRPORT (CITY SM)	3	1
COMMERCIAL/PRIVATE	60	20
COMMERCIAL/PRIVATE	28	9
COMMERCIAL/PRIVATE	19	6
COMMERCIAL/PRIVATE	18	6
COMMERCIAL/PRIVATE	13	4
COMMERCIAL/PRIVATE	10	3
COMMERCIAL/PRIVATE	8	3
COMMERCIAL/PRIVATE	7	2
COMMERCIAL/PRIVATE	5	2
COMMERCIAL/PRIVATE	5	1
COMMERCIAL/PRIVATE	4	1
COMMERCIAL/PRIVATE	3	1
COMMERCIAL/PRIVATE	2	1
COMMERCIAL/PRIVATE	2	1
COMMERCIAL/PRIVATE	2	1
COMMERCIAL/PRIVATE	2	1
COMMERCIAL/PRIVATE	1	0.4
COMMERCIAL/PRIVATE	1	0.4
COMMERCIAL/PRIVATE	1	0.3
COMMERCIAL/PRIVATE	1	0.3
COMMERCIAL/PRIVATE	1	0.2
COMMERCIAL/PRIVATE	1	0.2
COMMERCIAL/PRIVATE	1	0.2
COMMERCIAL/PRIVATE (CAR WASH)	15	5
COMMERCIAL/PRIVATE (HOSPITAL)	2	1
COMMERCIAL/PRIVATE (MUSEUM)	424	138
COMMERCIAL/PRIVATE (RELIGIOUS)	43	14
COUNTRY CLUB	116	38
GOVERNMENT/PUBLIC (CITY SM)	24	8
GOVERNMENT/PUBLIC (CITY SM)	10	3
GOVERNMENT/PUBLIC (CITY SM)	10	3
GOVERNMENT/PUBLIC (CITY SM)	4	1
GOVERNMENT/PUBLIC (CITY SM)	4	1
GOVERNMENT/PUBLIC (CITY SM)	3	1
GOVERNMENT/PUBLIC (CITY SM)	2	1
GOVERNMENT/PUBLIC (CITY SM)	2	1
GOVERNMENT/PUBLIC (CITY SM)	2	1
GOVERNMENT/PUBLIC (CITY SM)	2	1
GOVERNMENT/PUBLIC (CITY SM)	2	1
GOVERNMENT/PUBLIC (CITY SM)	1	0.4
GOVERNMENT/PUBLIC (CITY SM)	1	0.3
GOVERNMENT/PUBLIC (CITY SM)	1	0.3
GOVERNMENT/PUBLIC (CITY SM)	1	0.2
GOVERNMENT/PUBLIC (CITY SM)	1	0.2
GOVERNMENT/PUBLIC (CITY SM)	1	0.2
GOVERNMENT/PUBLIC (CITY SM)	1	0.2
GOVERNMENT/PUBLIC (LA COUNTY)	4	1
GOVERNMENT/PUBLIC (LA COUNTY)	1	0.3
GOVERNMENT/PUBLIC (LAC MTA)	20	7
PARKS & REC (CITY LA)	132	43
PARKS & REC (CITY LA)	42	14
PARKS & REC (CITY LA)	19	6
PARKS & REC (CITY LA)	11	4
PARKS & REC (CITY LA)	9	3
PARKS & REC (CITY LA)	8	3
PARKS & REC (CITY LA)	7	2
PARKS & REC (CITY LA)	4	1

APPENDIX C

Table 1. Potential Irrigtion Demand in Jursidictions 2 and 3

(Source: Los Angeles Department of Water and Power, City of Santa Monica)

SANTA MONICA (CONTD)		
POTENTIAL CUSTOMER	**DEMAND (AFY)**	**DEMAND (MGY)**
PARKS & REC (CITY LA)	1	0.3
PARKS & REC (CITY LA)	1	0.3
PARKS & REC (CITY LA)	1	0.3
PARKS & REC (CITY LA)	1	0.3
PARKS & REC & OPEN SPACE (CITY SM)	20	7
PARKS & REC & OPEN SPACE (CITY SM)	14	5
PARKS & REC & OPEN SPACE (CITY SM)	12	4
PARKS & REC & OPEN SPACE (CITY SM)	12	4
PARKS & REC & OPEN SPACE (CITY SM)	10	3
PARKS & REC & OPEN SPACE (CITY SM)	9	3
PARKS & REC & OPEN SPACE (CITY SM)	8	3
PARKS & REC & OPEN SPACE (CITY SM)	5	2
PARKS & REC & OPEN SPACE (CITY SM)	5	2
PARKS & REC & OPEN SPACE (CITY SM)	4	1
PARKS & REC & OPEN SPACE (CITY SM)	4	1
PARKS & REC & OPEN SPACE (CITY SM)	4	1
PARKS & REC & OPEN SPACE (CITY SM)	4	1
PARKS & REC & OPEN SPACE (CITY SM)	3	1
PARKS & REC & OPEN SPACE (CITY SM)	3	1
PARKS & REC & OPEN SPACE (CITY SM)	3	1
PARKS & REC & OPEN SPACE (CITY SM)	3	1
PARKS & REC & OPEN SPACE (CITY SM)	3	1
PARKS & REC & OPEN SPACE (CITY SM)	3	1
PARKS & REC & OPEN SPACE (CITY SM)	2	1
PARKS & REC & OPEN SPACE (CITY SM)	2	1
PARKS & REC & OPEN SPACE (CITY SM)	2	1
PARKS & REC & OPEN SPACE (CITY SM)	2	1
PARKS & REC & OPEN SPACE (CITY SM)	2	1
PARKS & REC & OPEN SPACE (CITY SM)	2	1
PARKS & REC & OPEN SPACE (CITY SM)	2	1
PARKS & REC & OPEN SPACE (CITY SM)	2	1
PARKS & REC & OPEN SPACE (CITY SM)	2	1
PARKS & REC & OPEN SPACE (CITY SM)	1	0.4
PARKS & REC & OPEN SPACE (CITY SM)	1	0.4
PARKS & REC & OPEN SPACE (CITY SM)	1	0.4
PARKS & REC & OPEN SPACE (CITY SM)	1	0.4
PARKS & REC (CITY SM)	1	0.4
PARKS & REC & OPEN SPACE (CITY SM)	1	0.4
PARKS & REC & OPEN SPACE (CITY SM)	1	0.4
PARKS & REC & OPEN SPACE (CITY SM)	1	0.3
PARKS & REC & OPEN SPACE (CITY SM)	1	0.3
PARKS & REC & OPEN SPACE (CITY SM)	1	0.3
PARKS & REC & OPEN SPACE (CITY SM)	1	0.3
PARKS & REC & OPEN SPACE (CITY SM)	1	0.3
PARKS & REC & OPEN SPACE (CITY SM)	1	0.3
PARKS & REC & OPEN SPACE (CITY SM)	1	0.3
PARKS & REC & OPEN SPACE (CITY SM)	1	0.2
PARKS & REC & OPEN SPACE (CITY SM)	1	0.2
PARKS & REC & OPEN SPACE (CITY SM)	1	0.2
PARKS & REC & OPEN SPACE (CITY SM)	1	0.2
PARKS & REC & OPEN SPACE (CITY SM)	1	0.2
PARKS & REC & OPEN SPACE (CITY SM)	1	0.2
PARKS & REC & OPEN SPACE (CITY SM)	1	0.2
PARKS & REC & OPEN SPACE (CITY SM)	1	0.2
SCHOOL (BRENYWOOD MGNT CTR)	15	5
SCHOOL (KENTER CYN)	13	4
SCHOOL (SM MALIBU UNIFIED)	6	2
SCHOOL (ST MONICAS HIGH)	3	1
TOTAL	**1,330**	**433**

APPENDIX C

Table 1. Potential Irrigtion Demand in Jursidictions 2 and 3

(Source: Los Angeles Department of Water and Power, City of Santa Monica)

VENICE BEACH		
POTENTIAL CUSTOMER	**DEMAND (AFY)**	**DEMAND (MGY)**
GOVERNMENT/PUBLIC (LA COUNTY)	1	0.3
TOTAL	**1**	**0.3**

DOWER		
POTENTIAL CUSTOMER	**DEMAND (AFY)**	**DEMAND (MGY)**
AIRPORT (CITY LA DEPT)	171	56
AIRPORT (CITY LA DEPT)	105	34
AIRPORT (CITY LA DEPT)	15	5
AIRPORT (LAX OFFSITE DEMAND #1)	250	81
AIRPORT (LAX OFFSITE DEMAND #2)	11	4
AIRPORT (LAX OFFSITE DEMAND #3)	30	10
AIRPORT (LAX UTILITY PLANT #1)	200	65
AIRPORT (LAX UTILITY PLANT #2)	200	65
AIRPORT (LAX)	6	2
AIRPORT (LAX)	3	1
AIRPORT (LAX)	1	0.3
COMMERCIAL/PRIVATE	14	4.6
COMMERCIAL/PRIVATE (HOSPITAL)	16	5
GOVERNMENT/PUBLIC (CITY LA FIRE DEPT)	31	10
GOVERNMENT/PUBLIC (LA COUNTY)	34	11
GOVERNMENT/PUBLIC (LA COUNTY)	6	2
GOVERNMENT/PUBLIC (LA COUNTY)	2	1
GOVERNMENT/PUBLIC (LA COUNTY)	1	0.3
HYPERION (CITY LA SANITATION FUND)	598	195
HYPERION (CITY LA SANITATION FUND)	65	21
HYPERION (IRRIGATION)	50	16
PARKS & REC (CITY LA)	43	14
PARKS & REC (CITY LA)	19	6
PARKS & REC (CITY LA)	6	2
PARKS & REC (CITY LA)	5	2
PARKS & REC (CITY LA)	3	1
PARKS & REC (CITY LA)	1	0.3
SCHOOL (ORV WRIGHT JR HIGH)	29	9
SCHOOL (WESTCHESTER HIGH)	67	22
TOTAL	**1,982**	**646**

APPENDIX C

Table 2. Summary of Irrigation Demand in Jurisdictions 2 and 3

	Castle Rock	Santa Ynez Canyon	Pulga Canyon	Santa Monica Canyon	Santa Monica	Venice Beach	Dockweiler	Total
Airport	--	--	--	--	3	--	992	**995**
Commercial/Private	27	24	18	--	676	--	30	**3**
Golf Courses/Country Clubs/Cemeteries	--	--	--	256	116	--	--	**32**
Government/Public	14	--	--	--	95	1	74	**184**
Hyperion WRP	--	--	--	--	--	--	713	
Parks & Recreation	--	--	51	35	404	--	77	**567**
Schools	--	--	40	17	36	--	96	**189**
Total (AFY)	**41**	**24**	**109**	**308**	**1,330**	**1**	**1,982**	**3,95**
Total (MG/YR)	***13***	***8***	***36***	***100***	***433***	***0.3***	***646***	***1,236***