Final Project Report

Woodacre Flats Wastewater Feasibility Study

Prepared for:

Marin County Community Development Agency
Environmental Health Services Division
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San Rafael, California 94903

By:

Questa Engineering Corporation
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Point Richmond, California 94801

QUESTA ENGINEERING CORP.

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Questa Project no. 290191

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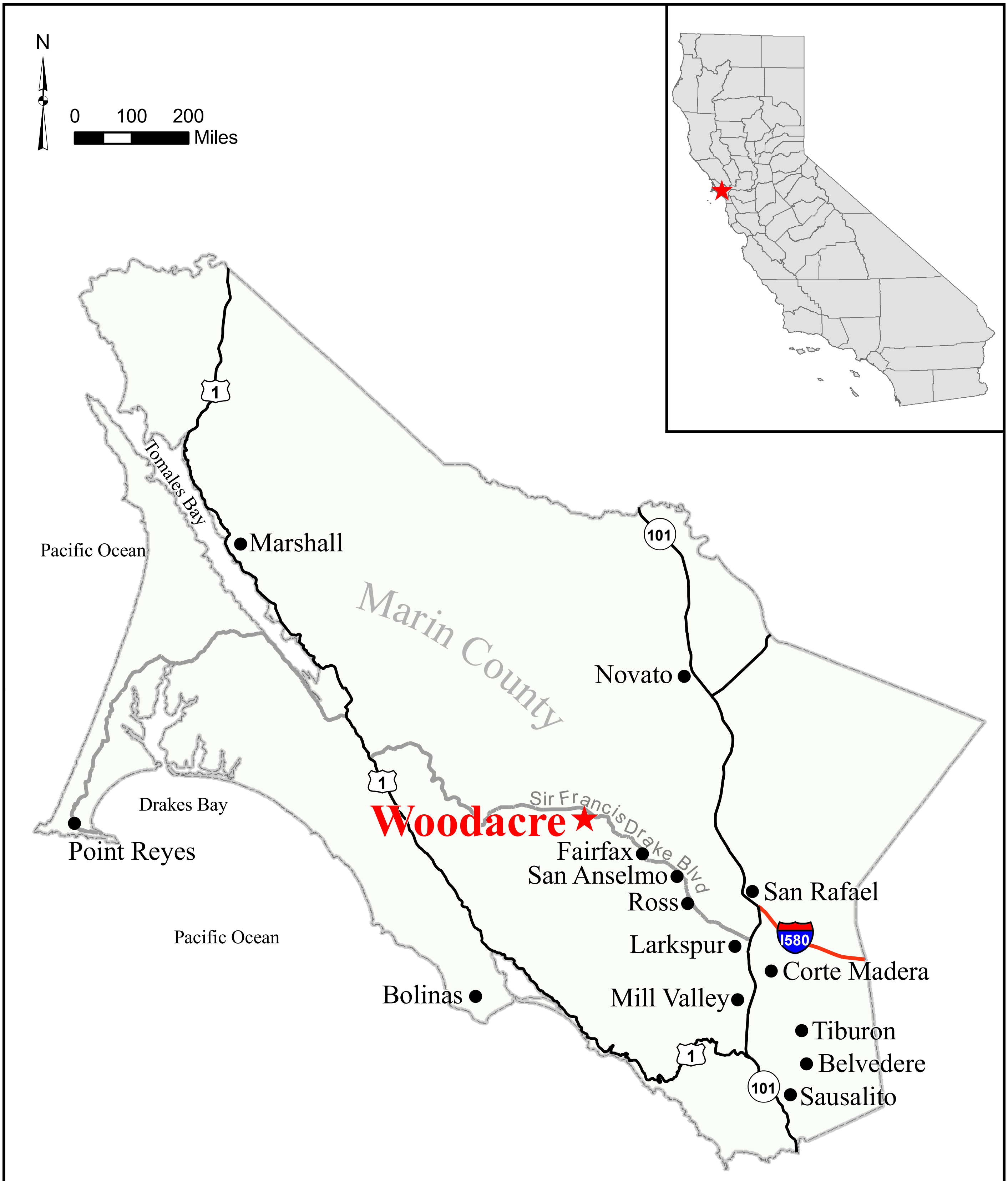
SECTION 1: INTRODUCTION AND BACKGROUND

This report presents the results of a feasibility study regarding sanitary wastewater facility improvements for the community of Woodacre located in the San Geronimo Valley in Western Marin County (**Figure 1**). The particular geographical focus of the study ("Study Area") is the low-lying and more densely developed portion of Woodacre referred to as the "Flats". The Woodacre Flats Study Area encompasses approximately 150 parcels, primarily single family residences with a small number of commercial occupancies (**Figure 2**). All properties in Woodacre Flats are dependent on individual onsite septic systems for sewage disposal, many of which are problematic and a source of public health and water quality concern. The purpose of the study was to identify, evaluate and compare various alternatives for improving wastewater treatment and disposal in the community, including options ranging from onsite septic system upgrades to community sewerage facilities.

Woodacre lies in the Lagunitas Creek watershed, which is tributary to Tomales Bay. The Lagunitas Creek watershed and Tomales Bay are impaired water bodies for pathogens (bacteria) and nutrients, and have been listed as such in accordance with Section 303(d) of the Federal Clean Water Act. The watershed, including the Woodacre area, contains various known and potential sources of pathogens and other pollutants that affect stream water quality via runoff. Faulty onsite wastewater systems, especially for properties located in close proximity to streams, have been identified as one of the sources contributing to the water quality impairment (San Francisco Bay RWQCB, March 2005).

Over the past several years, the Marin County Community Development Agency (CDA) has undertaken various activities to improve onsite wastewater system management practices throughout the County, and particularly in the Tomales Bay and Lagunitas Creek watersheds. During the period of January 2004-August 2005 and subsequently in the winter of 2007-2008, a voluntary septic system inspection program was conducted in the County. This work was funded through grants received from the State Water Resources Control Board and the California Coastal Commission, and was termed the "Septic Matters Program". The overall goal of the program was to provide community education to homeowners through the completion of free and confidential third-party inspection and testing of septic systems.

A large percentage of the inspections (62 out of 135) under the Septic Matters Program were conducted in Woodacre as a result of local encouragement to participate in the program. The inspections in Woodacre revealed many instances of marginal soils, high groundwater conditions, old and undocumented systems, gray water discharges, and a preponderance of small, "overdeveloped" lots, with minimal area provided for adequate onsite wastewater disposal. Overall, these inspections showed marginal to unacceptable operating conditions for about one-half to two-thirds of the septic systems inspected in the Woodacre area. During this same time frame, stream water quality testing in the Woodacre area by the Tomales Bay Watershed Council showed elevated concentrations of bacteria, nutrients and other constituents commonly associated with domestic wastewater discharges.



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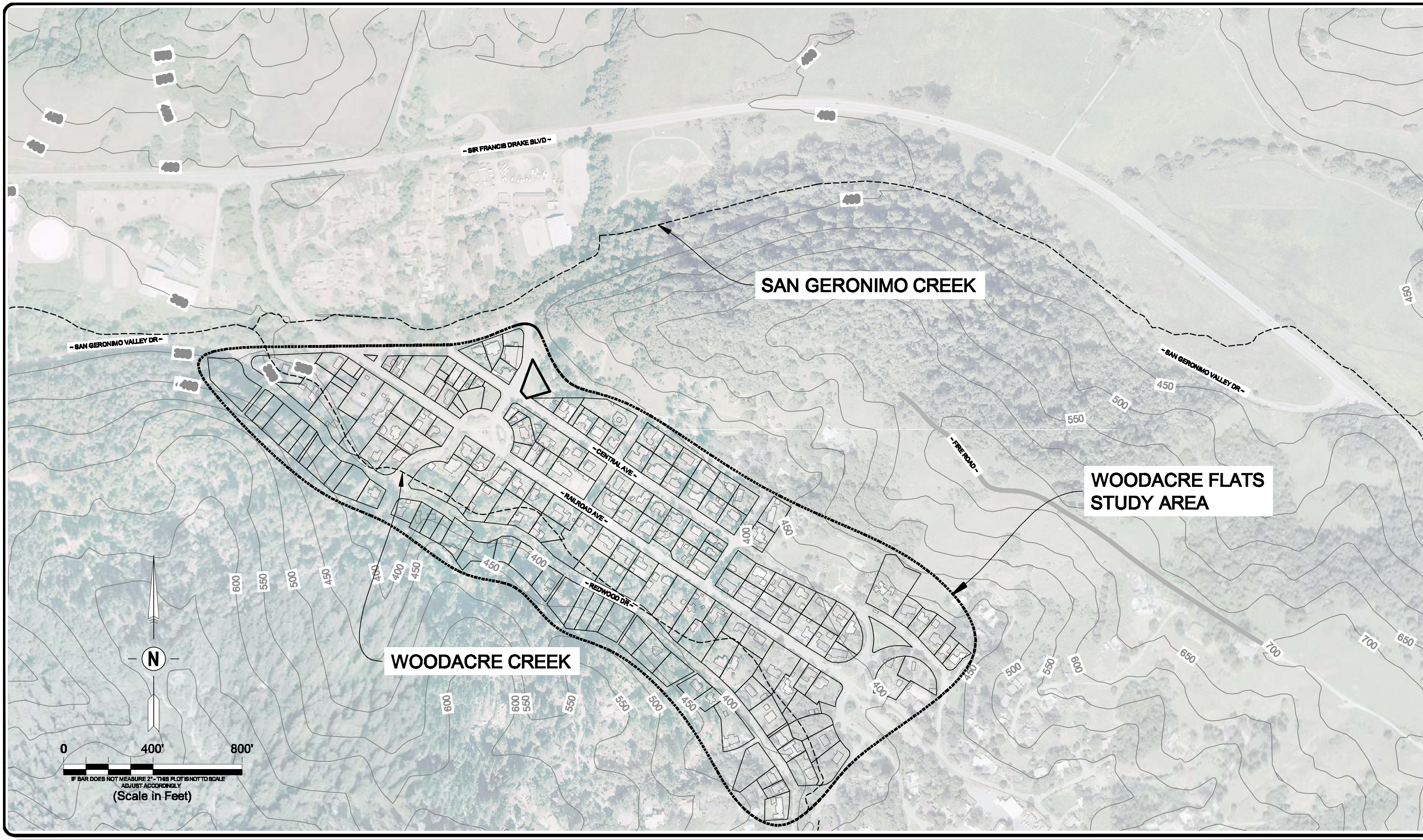
Woodacre Flats Wastewater Feasibility Study
Woodacre, Ca

Figure 1
Location Map



WOODACRE FLATS
WASTEWATER FEASIBILITY STUDY

WOODACRE, CALIFORNIA

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WOODACRE FLATS STUDY AREA

FIGURE 2

In response to these surveys a local community organization, Woodacre Flats Wastewater Group (WFWG), was formed to work with the CDA to initiate a review of the septic system and water quality findings and seek funding to investigate possible corrective strategies. The County applied for and received grant monies from the US EPA which, in combination with County and locally-raised money, provided sufficient funding to undertake a wastewater feasibility study to evaluate needs and methods for correcting faulty septic systems within the Woodacre Flats area.

In February 2010, the Marin County Board of Supervisors contracted with Questa Engineering Corporation to conduct a wastewater feasibility study of the Woodacre Flats area, which is the subject of this report. The specific objective of the study was to identify, evaluate and compare potential wastewater treatment and disposal alternatives for the community. The evaluation was to include review and comparison of facility needs, regulatory requirements, environmental considerations, and construction, operation and maintenance costs amongst the different alternatives, with the aim of identifying an "apparent best alternative". At a minimum, the range of alternatives was to include: (a) "No Project" (i.e., status quo); (b) upgrading and management of existing onsite systems; and (c) development of a community wastewater collection, treatment and disposal system for the area.

In terms of the organization of this report, following the Introduction and Executive Summary, background information on the general study area conditions, existing wastewater practices and concerns are covered in **Sections 3** and **4**. **Section 5** describes the boundaries and wastewater characteristics of the service area covered by the study. The project alternatives for wastewater collection, treatment and disposal facilities are presented and described in **Section 6**, including facility requirements and estimated costs for construction and ongoing operation and maintenance. This is followed by a comparative analysis and review of the alternatives in **Section 7,** including identification of the "apparent best alternative". **Section 8** addresses management requirements and alternatives for the Woodacre Flats Study Area.

SECTION 2: EXECUTIVE SUMMARY

INTRODUCTION

In February 2010 the County of Marin contracted with Questa Engineering Corporation to conduct a wastewater feasibility study for the community of Woodacre, focusing specifically on The Woodacre Flats study area encompasses approximately 150 parcels, primarily single family residences with a small number of commercial occupancies. The purpose of the study was to identify, evaluate and compare various alternatives for improving wastewater treatment and disposal in the community, including options ranging from onsite septic system upgrades to community sewerage facilities.

STUDY AREA CHARACTERISTICS

The Woodacre Flats study area comprises a portion of the unincorporated community of Woodacre, located in the eastern end of the San Geronimo Valley in western Marin County. Woodacre Flats encompasses primarily the low-lying valley portions of the community, including an area of roughly 75 acres.

Woodacre lies within the watershed of Woodacre Creek, a year-round stream which drains into San Geronimo Creek, then Lagunitas Creek, and eventually into Tomales Bay. Woodacre Creek flows through the study area parallel to Redwood Drive, in a southeast-to-northwest direction. Woodacre Creek receives surface runoff and drainage from several small tributary branches and a network of storm drainage channels in the community.

The terrain within the Flats is mostly flat to gently sloping, generally from the southeast to the northeast at a gradient of approximately 2 to 5 percent. The surrounding upland portions of Woodacre occupy much steeper terrain, which drains through the Flats.

Geologically, the Woodacre Flats study area consists of a valley with ridges rising up on both the northeast and southwest sides, and at the southeasterly end. Along the western side, the ridge is formed mainly of sandstone. In contrast, the eastern ridge (Fire Road area) and the uplands in the southern end of the valley consist of Franciscan Melange (serpentine, greenstone, chert, shale and sandstone) in a clayey/shale matrix.

Clayey soils from ridges have washed into the valley, creating mostly clayey soil with interspersed gravel lenses in the Woodacre Flats area. The soils are deep in some areas, but are generally somewhat poorly to very poorly drained, with seasonal groundwater levels less than 3 feet from ground surface. Deeper, sandy alluvial soils occur along the drainageways.

EXISTING WASTEWATER DISPOSAL PRACTICES

There are no public sewers serving the Woodacre area or other communities in the San Geronimo Valley. All property owners rely on individual septic systems for sanitary waste treatment and disposal. This typically includes a septic tank for collection and settling of solids, with some type of leaching system for disposal (percolation) of the liquid into the soil. Most of the properties in the area were developed prior to the adoption of current County Codes. Gravity systems are most common, although more recent development has included the use of advanced systems installations, such as mounded and pressure distribution disposal fields and advanced treatment units.

There are many existing septic systems in Woodacre Flats with unknown construction features that likely are of an antiquated or questionable design that differs significantly from modern codes and practices. Less than half of the developed properties have septic system permit information on file with Marin County EHS. In 2004-2005 voluntary (confidential) septic system inspections conducted as part of a County-wide outreach effort ("Septic Matters Program") found roughly two-thirds of the systems inspected in Woodacre to have marginal to unacceptable operating conditions due to many of the following conditions and factors:

- System age, pre-dating modern standards and codes
- Small systems, undersized for current uses
- Additional living units, placing increased demand on sewage disposal systems
- Small parcel size with high intensity of development and limited remaining area for sewage disposal
- Restricted access to yard areas for system maintenance and repair
- Unpermitted repairs and greywater systems
- Shallow depth to groundwater, including seasonal saturation at or near ground surface
- Shallow soils and marginal soil permeability
- Close proximity to streams and local drainages

File and field reviews conducted as part of the current wastewater feasibility study revealed information consistent with the above findings.

Water quality sampling of Woodacre Creek and local storm drains in recent years has shown elevated levels of coliform bacteria, nitrate, ammonia and surfactants, in some cases exceeding receiving water quality standards. These influences on water quality may be attributable to the high density of older septic systems combined with the difficult drainage and soil conditions in Woodacre, especially in the Flats. Impacts on water quality locally can be carried downstream to San Geronimo Creek, Lagunitas Creek and eventually to Tomales Bay, which is designated as an impaired water body in regard to pathogens (bacteria) and nutrient levels. Septic systems in the Tomales Bay watershed are a potential contributor to the water quality impairment. The RWQCB and Marin County EHS are committed to eliminating faulty septic systems and implementing various onsite wastewater management programs and projects to address the water quality concerns in the Tomales Bay watershed.

SERVICE AREA

Wastewater improvement projects are normally planned and developed around a given geographical area termed the “service area”. The service area provides the basis for estimating wastewater facility requirements, project alternatives and costs. Delineating the service area is often an iterative process, whereby initial boundaries are assumed for feasibility analysis, and subsequently adjusted in response to findings, recommendations and other factors. This is the case for this study of Woodacre.

For the purposes of this feasibility analysis, the tentative service area boundaries were assumed to encompass the existing developed properties in the section of the community referred to as the Flats, which includes primarily low-lying properties along the following streets: Redwood Drive, Railroad Avenue, Central Avenue and Taylor Avenue. This encompasses the area of Woodacre believed to be in most need of wastewater improvements, as well as the portion of the community that has expressed the greatest amount of interest in studying possible sewerage alternatives. There are approximately 150 developed parcels in this area, largely single family residences. The study also includes information regarding the provision of wastewater service to 75% of the developed properties in the study area (112 parcels).

It is important to understand that the service area boundaries are not fixed by this study. The boundaries selected for a community wastewater project in Woodacre could be narrowed or expanded depending on the level of community interest, the alternative selected, funding sources, environmental issues, or other factors. The final decision on service area boundaries would normally occur following environmental review and in conjunction with the formation of an assessment district to develop the local financing for the project. This would entail formal public hearings and a majority vote.

ESTIMATED WASTEWATER FLOWS

Information regarding wastewater flows is important for assessing the required capacity of collection, treatment, storage and disposal facilities for community wastewater alternatives. Estimated wastewater flows for the study were developed based on the assumed number of parcels to be served, the type of development on the those parcels, and review of typical reference data and monitoring information from other small community wastewater facilities.

The Woodacre Flats service area consists mainly of single family residential parcels, with a small amount of commercial uses. The commercial uses in Woodacre are the types that generate wastewater volumes similar to or less than single family residences (e.g., offices, shops, Post Office, small apartments). Accordingly, for this feasibility study wastewater flows were estimated by applying a typical unit wastewater flow for residential use uniformly to all parcels in the service area.

Based on review of data from other small community wastewater systems, the following unit wastewater flows, in gallons per day (gpd) per single family residence (or equivalent), were determined to be appropriate for Woodacre Flats:

- Average Daily Flow: 175 gpd/parcel (for assessing storage and disposal requirements)
- Peak Daily Flow: 210 gpd/parcel (for assessing treatment requirements)

Additionally, wastewater flow estimates included an allowance of 10% for infiltration and inflow (I/I) into the sewage collections facilities if conventional gravity sewers are used. The 10% factor would not apply to pressure sewer and effluent sewer methods, which utilize small diameter piping with fused or glued joints, and do not include manholes, a major source of I/I.

The overall estimated wastewater flows generated from service to 150 parcels in the Woodacre Flats area are:

- Average Dry Weather Flow: 26,250 gpd
- Average Wet Weather Flow: 28,875 gpd (w/10% I/I factor)
- Peak Dry Weather Flow: 31,500 gpd
- Peak Wet Weather Flow: 34,650 gpd (w/10% I/I factor)

The estimated wastewater flows for a project serving 75% of the developed properties in the study area would be 75% of the above values.

PROJECT ALTERNATIVES

Project alternatives were formulated in consultation with Marin County EHS and RWQCB staff. The following community wastewater alternatives for Woodacre Flats were formulated and evaluated in this study:

- **Alternative 1 - No Project**. This would involve maintaining the status quo, where individual property owners would be responsible for maintaining and upgrading their own onsite systems, and abatement of septic system failures as directed by Marin County EHS and/or the San Francisco Bay Regional Water Quality Control Board (RWQCB). The No Project alternative is included to provide a frame of reference for evaluation of different types of wastewater improvements.

- **Alternative 2 - Onsite Wastewater Management Program**. This alternative considers the upgrade of onsite systems in conjunction with the formation of a local septic system maintenance and inspection program. The program would be operated under the authority of a wastewater maintenance district, County Service Area or similar public entity covering the boundaries of the selected service area. Financing of individual septic system improvements would be accomplished with grant assistance to bring all currently developed properties into conformance with minimum acceptable "repair" standards. No facility improvements would be provided for future development.

- **Alternative 3A, 3B and 3C - Community Leachfield**. This alternative would provide for the construction of a central wastewater collection system for the service area, leading to a community leachfield system located on nearby wooded open land. The area identified for a potential community leachfield site is a wooded knoll along the Fire Road ridgeline northeast of Woodacre on property which is part of the Dickson Ranch. Three community leachfield options utilizing this site were formulated and evaluated:

- **3A** - primary (septic tank) treatment with a shallow pressure distribution leachfield, with 100% capacity and no reserve area.
- **3B** - secondary treatment (AdvanTex filter) with a shallow pressure distribution leachfield, 100% capacity plus 100% reserve area.
- **3C** - secondary treatment (AdvanTex) with a subsurface drip dispersal leachfield, 200% capacity installed.

- **Alternative 4 – Water Recycling System at San Geronimo Golf Course**. This alternative would provide for collection, treatment, and recycling of wastewater for turf irrigation at the San Geronimo Golf Course. This would entail the construction of a central wastewater collection system in the service area (similar to Alternatives 3A, B and C), a wastewater transmission line (force main) to the San Geronimo Golf Course, a tertiary treatment plant located in golf course maintenance area, a holding pond on the golf course (near green #2) for winter storage of recycled water, and seasonal reuse of the recycled water for spray irrigation of the golf course turf grass. The wastewater would be treated to meet California State requirements for tertiary recycled water (unrestricted uses), and would be integrated into the existing golf course irrigation system to reduce the amount of raw water currently supplied from MMWD.

WASTEWATER COLLECTION ALTERNATIVES

As part of the evaluation of community wastewater facilities under Alternatives 3A, 3B, 3C and 4, the following methods of sewer collection system were analyzed and compared for applicability to Woodacre Flats:

- **Option 1 - Conventional Gravity Sewer**. In a conventional gravity sewer, untreated wastewater travels through a system of sewer pipes installed at a minimum grade to maintain gravity flow. Sewer pipes are usually six or eight-inch minimum diameter, with four-inch diameter lateral connections from buildings. Manholes provide access for maintenance and cleaning. Individual pumps may be required for buildings located downhill from the street sewer.

- **Option 2 - Pressure Sewer.** A pressure sewer consists of small diameter pipe (typically 2 to 4 inches), which is installed following the profile of the ground. In residential areas served by a pressure sewer, each home uses a small grinder pump to discharge to the main line. The pump grinds the solids in the wastewater into slurry in the manner of a kitchen sink garbage grinder.

- **Option 3 - Effluent STEP/STEG Sewer.** In effluent sewer systems primary treatment is provided at each connection by a septic tank, and only the settled wastewater is collected. The collection lines consist of small diameter pipe similar to pressure sewers (typically, 2 to 4 inches) and the pipe is installed following the profile of the ground. Where the terrain is appropriate, the septic tank effluent can be collected by gravity flow (septic tank effluent gravity, STEG). Where the terrain is flat, undulating or slopes uphill, individual pumping units (septic tank effluent pump, STEP) is used. In these cases, each connection includes one or more effluent pumps located either in the septic tank or in a separate pump chamber.

The wastewater collection systems analysis reached the following conclusions:

1) All collection methods are feasible for use in the Woodacre Flats service area, and the cost differences between the different options are relatively small.

2) Because of the terrain, a pressure sewer or STEP collection line would be the preferable option for service to properties located along Redwood Drive.

3) For the Fire Road community leachfield alternatives (#3A- #3C), effluent STEP/STEG sewers would be favored on the basis of cost and the ability to limit entry of extraneous water into the sewer system from groundwater and rainwater infiltration and inflow (I/I), which could be damaging and of significant concern for a community leachfield system.

4) For the Golf Course recycled water alternative (#4), conventional gravity sewers would be favored on the basis of cost and the compatibility of raw sewage (as compared with septic tank effluent) with the operation of a recycled water treatment system. The preferred route for a wastewater transmission line from Woodacre to the Golf Course was determined to be via Railroad Avenue and Sir Francis Drake Blvd, rather than via San Geronimo Valley Drive.

ESTIMATED PROJECT COSTS

Table 1 presents a summary of estimated capital costs and annual operation and maintenance (O&M) costs for various project alternatives to serve all 150 existing developed parcels in the Woodacre Flats study area along with the cost estimates for service to 75% of the properties in the area (112 parcels).

Table 1: Summary of Estimated Project Costs

Alternative	100% Participation (150 parcels)				75% Participation (112 parcels)			
	Capital Costs ($)		Annual O&M Costs ($)		Capital Costs ($)		Annual O&M Costs ($)	
	Total	Per Parcel	Total	Per Parcel	Total	Per Parcel	Total	Per Parcel
1 No Project	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2 Onsite Upgrades & Mgt Program	8,374,860	55,832	141,295	942	6,227,130	55,600	107,206	975
3A Fire Road Primary Treatment – PD Leachfield	5,330,130	35,534	110,000	733	4,563,000	40,741	90,970	812
3B Fire Road Secondary Treatment – PD Leachfield	5,996,610	39,777	132,770	885	5,083,260	45,386	112,420	1,004
3C Fire Road Secondary Treatment – Drip Dispersal	6,079,710	40,531	149,930	1,000	5,127,720	45,783	129,580	1,157
4 Golf Course Water Recycling	6,765,330	45,102	166,870	1,112	6,141,720	54,837	135,410	1,209

Capital Costs

The estimated capital costs include facilities construction as wells as the necessary engineering and environmental studies, project administration, district formation and financing costs. A 15% contingency allowance is also included. As indicated in **Table 1**, the estimated total project cost for service to 150 parcels is estimated to range from a low of about $5.33 million for Alternative 3A to a high of about $8.37 million for Alternative 2. The estimated costs for Alternative 4 (Golf Course Water Recycling), is approximately mid-way between these two, at $$6.76 million. Estimated capital costs for Alternatives 3B and 3C are virtually the same and are midway between Alternatives 3A and roughly $6.0 million. These total capital costs translate to costs per parcel ranging from about $35,500 for Alternative 3A to $55,800 for Alternative 2. The estimated per parcel cost for Alternative 4 are approximately $45,100, and roughly $40,000 for Alternatives 3B and 3C.

Total estimated costs for service to 75% of study area are proportionally less. However, the costs per parcel are greater for all alternatives except Alternative 2, which is roughly the same for both 100% and 75% participation levels.

The costs estimates presented in this study do not account for any grant assistance. Actual costs to property owners would be reduced by the amount of any grant funding that is obtained to help finance the project.

Annual Operation and Maintenance Costs

The estimated annual O&M costs include costs for administration, labor, equipment, materials, and other expenses required to perform the necessary inspections, treatment plant operation (as applicable), water quality sampling, data analysis, report preparation, pump-outs, and routine maintenance for wastewater facilities. The level and nature of required O&M activities vary according to the wastewater facilities and operating requirements under each alternative.

As indicated in **Table 1**, for service to 150 parcels the total annual O&M costs range from a low of $110,000 for Alternative 3A to a high of $166,670 for Alternative 4, which translate to individual user costs of about $733 to $1,122 per parcel per year. With service to 75% of the properties in the study area the estimated annual O&M costs are all proportionally higher, ranging from a low of $812 (Alternative 3A) to a high of $1,209 (Alternative 4).

APPARENT BEST PROJECT ALTERNATIVE

A comparative analysis was made of the various alternatives for the Woodacre Flats study area considering such factors as regulatory compliance, environmental impacts, reliability and flexibility, resource utilization, land use, and costs. Some of the factors are represented by objective data (e.g., cost), while others required exercise of professional judgment and more subjective information. Based on the comparative analysis two alternatives were ranked roughly the equal, although the strengths and weaknesses vary between the two. The two alternatives identified as the apparent best alternatives are:

- Alternative 3B – Fire Road Community Leachfield, including secondary treatment and shallow pressure distribution leaching trenches.

- Alternative 4 – Golf Course Water Recycling System, including tertiary (Title 22) treatment, winter holding pond and seasonal turf irrigation at San Geronimo Golf Course.

SECTION 3: STUDY AREA CONDITIONS

GEOGRAPHICAL SETTING

The Woodacre Flats Study Area comprises a portion of the unincorporated community of Woodacre, located in the eastern end of the San Geronimo Valley in western Marin County (**Figure 2**). It is roughly defined as the area bordered by and adjacent to San Geronimo Valley Drive on the north, Taylor and Central Avenues on the northeast, Redwood Drive on the southwest, and Carson Road on the southeast. The Study Area includes approximately 150 developed parcels, primarily the low-lying and most densely developed portions of the community. The developed properties are primarily single family residences, with a small number of commercial occupancies. There are also a small number of undeveloped (vacant) parcels within the boundaries of the Study Area. However, the focus of this feasibility study was on the evaluation of wastewater facility improvements for existing developed parcels, and did not consider provision of wastewater service to support new development on undeveloped parcels.

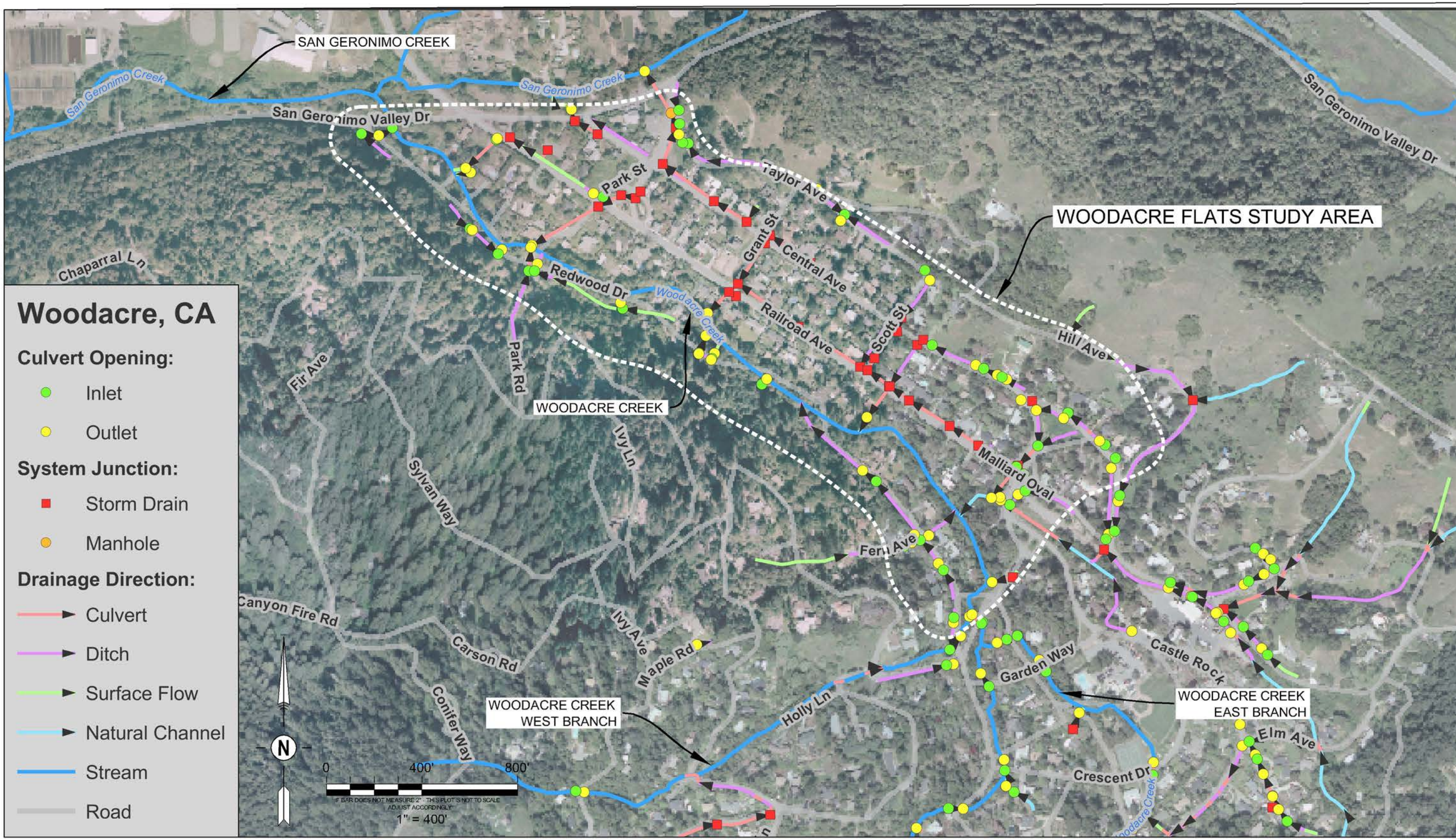
HYDROLOGY AND WATER SUPPLY

Woodacre lies within the watershed of Woodacre Creek, a year-round stream tributary to San Geronimo Creek, which in turn flows into Lagunitas Creek and eventually into Tomales Bay. Woodacre Creek flows through the study area parallel to Redwood Drive, in a southeast-to-northwest direction. Woodacre Creek receives surface runoff and drainage from several small tributary branches and a network of storm drainage channels in the community as shown in **Figure 3.**

The ground elevations in the study area range from about 350 feet above mean sea level (AMSL) in the northwest to about 400 feet AMSL along Taylor Avenue and Redwood Drive. The general slope of the terrain is from the southeast to the northeast at a gradient of approximately 2 to 3 percent. The surrounding upland portions of Woodacre occupy steeper terrain, with elevations up to about 700 feet AMSL.

The hydrology in Woodacre Flats is strongly influenced by the relatively flat gradients, concentrated runoff and drainage from the surrounding steep hills, and alteration of local drainage patterns by roads, the former railroad grade, and development of individual lots. Localized soil saturation and ponding of surface waters is common during the wet season. This has prompted many property owners to install various drainage mitigation measures in yards and around buildings, including curtain drains, sumps, and drainage ditches.

Like most of the California coastal areas, the climate is Mediterranean, with wet winters and dry summers. The annual average rainfall for the area is approximately 42 inches, with 85 percent of the annual total typically occurring during the months of November through April. **Table 2** presents average monthly rainfall amounts for Woodacre, as recorded at the Woodacre Fire Station, which is located a few hundred yards from the southeastern end of the Woodacre Flats study area.



WOODACRE FLATS WASTEWATER FEASIBILITY STUDY

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WOODACRE HYDROLOGY AND DRAINAGE

NOTE:ORIGINAL MAP PRODUCED BY MARIN COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT.

FIGURE 3

LAST SAVED: 12/28/2010 PLOT DATE: 12/28/2010

Table 2: Monthly Rainfall Averages for Woodacre, California

Month	Average Rainfall (inches)
January	5.13
February	8.01
March	9.39
April	7.53
May	5.29
June	2.40
July	1.03
August	0.28
September	0.05
October	0.09
November	0.39
December	2.05
Total	41.6

Water supply for the Woodacre area is provided by Marin Municipal Water District from its San Geronimo water treatment plant. There are no known domestic water supply wells in Woodacre; however, there are known to be a few scattered agricultural wells in surrounding areas.

GEOLOGY AND SOILS

Geology

The regional geology consists of the folded, faulted, and sheared bedrock of the Franciscan Complex, which is an accretionary mélange comprised of greywacke, chert, serpentine, schist, greenstone, and other rock types. The Franciscan Complex was formed 65 to 190 million years ago by the subduction of the Farallon Tectonic Plate and the northwest movement of the Pacific Plate to the North American Plate. Subsequent compression, uplift and faulting occurred during the Miocene and Pliocene epochs of the Tertiary Period (between 5 and 15 million years ago). The current tectonic setting is related to the movement along the northwest-southeast trending faults such as the San Andreas and Hayward Faults.

Locally, the Woodacre area consists of a valley with ridges rising up on both the northeast and southwest sides, and at the southeasterly end. Along the western side, the ridge is formed mainly of sandstone. In contrast, the eastern ridge (Fire Road area) and the uplands in the southern end of the valley consist of Franciscan Melange, including a mixed composition of serpentine, greenstone, chert, shale and sandstone blocks in a clayey/shale matrix. A sizeable sandstone block has been identified along the northern end of the eastern ridge.

Soils

Soils in Woodacre Flats are derived from the accumulation of materials that have washed into the valley from the surrounding upland slopes and ridges. The soils are deep in some areas, but are generally somewhat poorly to very poorly drained, with seasonal groundwater levels less than 3 feet from ground surface. Deeper, sandy alluvial soils occur along the drainageways.

According to the Soil Survey of Marin County, soils in the Woodacre Flats area are primarily Blucher-Cole Complex, 2 to 5 percent slope, which occur in basins and alluvial fans. The distribution of soils in this complex is roughly as follows:

- **40% Blucher Silt Loams**. Blucher soils occur near drainageways and are deep and somewhat poorly drained, with seasonal high water table normally between 3.5 to 5 feet below ground surface. Permeability is typically moderate in near surface soils (to about 2-feet deep), and slow at deeper depths.

- **30% Cole Clay Loam –** Cole soils occur on basin rims and depression areas; they are very deep and somewhat poorly drained, with seasonal high water table normally between 1.5 to 3 feet below ground surface. Permeability is typically slow in Cole soils.

- **30% Clear Lake Soils –** Clear Lake soils occur in depressions and slopes less than 2%pp they are similar to Cole soils, but more clayey and with slow permeability.

- **Cortina Soils** - Cortina soils are deep, gravelly sandy loams that have developed from alluvial deposits along streams.

WATER QUALITY

Monitoring and protection of water quality in Tomales Bay and tributary watersheds, including Lagunitas Creek and its tributary streams, falls under the authority of the San Francisco Bay Regional Water Quality Control Board (RWQCB). The RWQCB is charged with the responsibility of ensuring maintenance of water quality conditions at levels that are protective of the beneficial uses in the Bay and tributary streams, which include shellfish harvesting, water contact recreation, and noncontact water recreation, as well as aquatic habitat uses.

Many years of monitoring results have shown that Tomales Bay and its main tributaries, Lagunitas Creek, Walker Creek and Olema Creek, are impaired by pathogens, as reflected by high fecal coliform bacteria concentrations (San Francisco RWQCB, July, 2005). The presence of pathogens in the Bay and tributary streams poses potential health risks to shellfish consumers, recreational users and other water uses Because of these conditions, these waters have been formally “listed” in accordance with Section 303(d) of the Federal Clean Water Act (CWA) as impaired water bodies. Septic systems in the Tomales Bay watershed are a potential contributor to the water quality impairment.

Water quality sampling of Woodacre Creek and local storm drains in recent years has shown elevated levels of coliform bacteria, nitrate, ammonia and surfactants, in some cases exceeding receiving water quality standards. These influences on water quality may be attributable to the high density of older septic systems combined with the difficult drainage and soil conditions in Woodacre, especially in the Flats. Impacts on water quality locally can be carried downstream to San Geronimo Creek, Lagunitas Creek and eventually to Tomales Bay.

The RWQCB and Marin County EHS are committed to eliminating faulty septic systems and implementing various onsite wastewater management programs and projects to address the water quality concerns in the Tomales Bay watershed. Under the CWA, the State is required to establish Total Maximum Daily Load (TMDLs) for those pollutants causing water quality impairments to ensure that impaired water bodies attain their beneficial uses. In compliance with the requirements of the CWA, in March 2005, the RWQCB issued its report *"Pathogens in Tomales Bay – Total Maximum Daily Load, Proposed Basin Plan and Staff Report"*. The report: (a) documents the basis for the impairment finding: (b) establishes numeric targets for water quality needed to protect beneficial uses; (c) identifies the actual and potential pathogen sources in the watershed; (d) proposes a loading allocation amongst the various contributing pathogen sources to achieve the TMDL; (e) evaluates the linkage between sources and water quality targets; and (f) proposes an implementation plan for achievement of the TMDL goals. The pathogen limits for Tomales Bay and its Tributaries are listed below:

WATERBODY	INDICATOR PARAMETER	TMDL[a,b]	
		Median/Log Mean	90th Percentile
Tomales Bay [c]	Fecal coliform	Median < 14 MPN/100mL	<43 MPN/100mL
Tomales Bay Tributaries [c]	Fecal coliform	Log mean <200 MPN/100 mL	< 400 MPN/100mL [c]

a. Based on a minimum of no less than five samples equally spaced over a 30-day period.
b. Most Probable Number (MPN) is a statistical representation of the coliform test results.
c. All samples should be collected at knee-high depth

The TMDL sets a target of zero discharge of human waste to the waters of Tomales Bay and its tributaries. This is based on the knowledge that human waste can be a significant source of pathogenic organisms, including viruses. Prohibition of human waste discharges into surface waters is consistent with existing water quality plans and policies.

In terms of implementation, the TMDL finds that septic systems that discharge to land in a manner consistent with accepted design standards (for new systems) or according to specific performance standards (for existing systems) will be considered acceptable, providing that they are properly operated and maintained. Compliance with performance standards would also be expected to assure protection of groundwater resources (e.g., drinking water supplies), which can be impacted by improper siting, design, or operation of onsite sewage disposal systems.

SECTION 4:
EXISTING WASTEWATER TREATMENT AND DISPOSAL PRACTICES

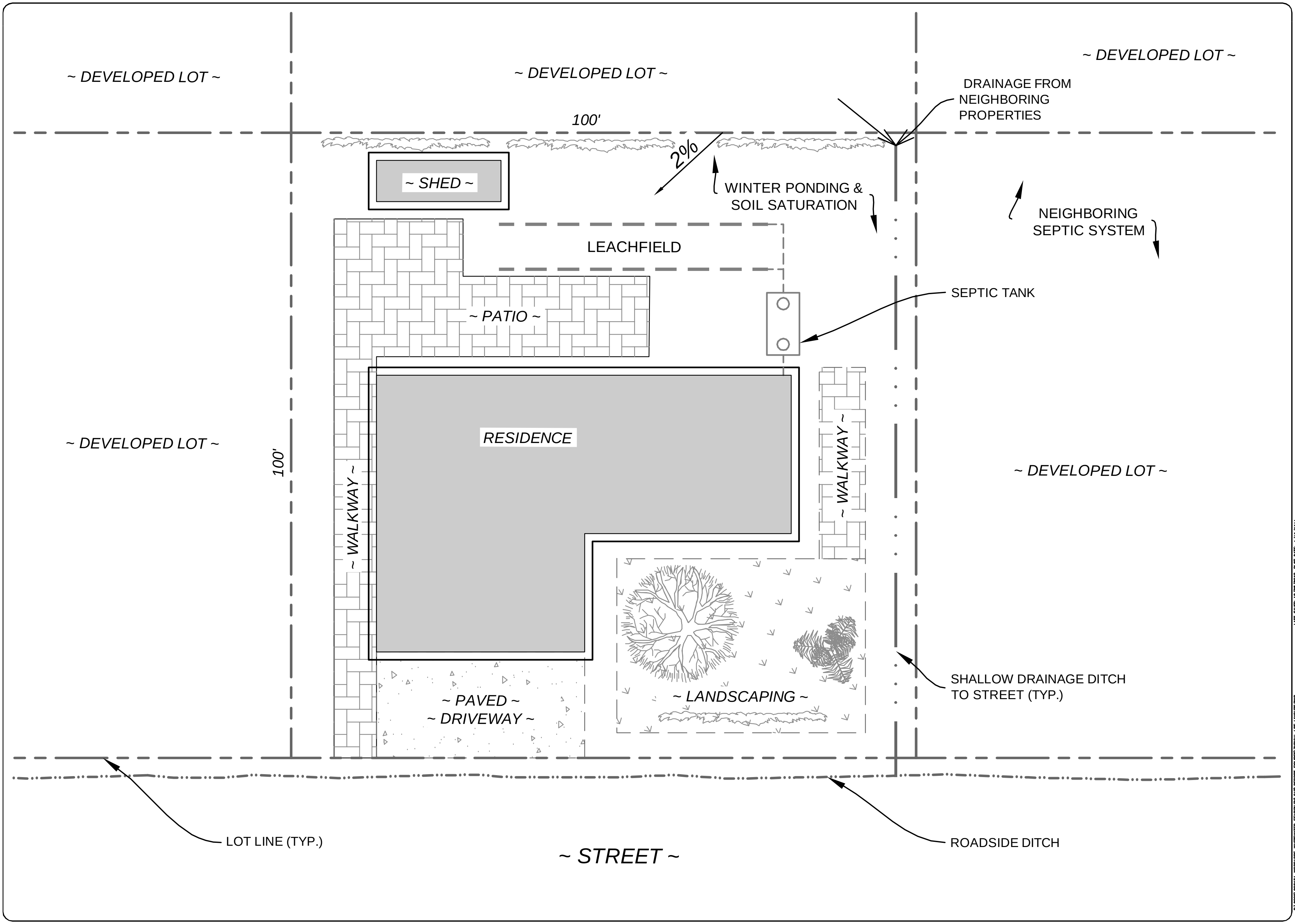
OVERVIEW

There are no public sewers serving the Woodacre area or other communities in the San Geronimo Valley. All property owners rely on individual septic systems for sanitary wastewater treatment and disposal. This typically includes a septic tank for collection and settling of solids, with some type of leaching system for disposal (percolation) of the liquid into the soil. Gravity systems are most common; however, as indicated by the file and field reviews (see below), several properties have more advanced systems that include pumps, pressure distribution leachfields, mounds and/or supplemental treatment systems, such as sand filters aerobic treatment units. Additionally, since most of the properties in the area were developed prior to the adoption of County Codes, there are also some existing septic systems with unknown construction features that likely are of an antiquated or questionable design that differs significantly from modern codes and practices.

The project area includes properties located in the "Flats" as well as a smaller number located at the base of the surrounding upland areas. The properties in the Flats, which account for about 90 percent of the development in the study area, have very serious constraints for onsite sewage disposal. **Figure 4** illustrates the development conditions and associated sewage disposal constraints typical for most of the properties in the Flats. As indicated, the lot sizes are relatively small (generally about 10,000 square feet), with limited area available for septic system placement between buildings, driveways, walkways, landscaping and patio areas. The ground slopes are flat to gently sloping with relatively shallow soils, contributing to poor drainage and seasonal high groundwater conditions. Many property owners have installed drainage ditches, curtain drains and sumps to rid their yards of water ponding during the rainy season. These drainage systems provide a potential avenue for short-circuiting of sewage effluent into the local storm drain system (and subsequently downstream receiving waters) during certain times of the year. The close proximity between neighboring properties further complicates the local drainage situation and often presents additional setback conflicts for sewage disposal systems.

Another area of special concern in the Study Area is the group of homes that border Woodacre Creek. These properties typically have better soil and drainage conditions than the central Flats area. However, in many cases the ability to provide suitable horizontal setback distance between the septic system and the edge of the creek is severely limited.

Figure 5 illustrates a common creekside situation, where small gravity flow systems (often seepage pits/beds) are located between the building and the creek and may provide setback distances of as little as 25 to 50 feet between the disposal area and the edge of the creek bank. Some creekside properties have other available land that could be used effectively for sewage disposal with alternative/pumping systems in a way that would meet standard (100-foot) creek setback requirements; however, some properties lack sufficient and suitable land area to meet all setback requirements.



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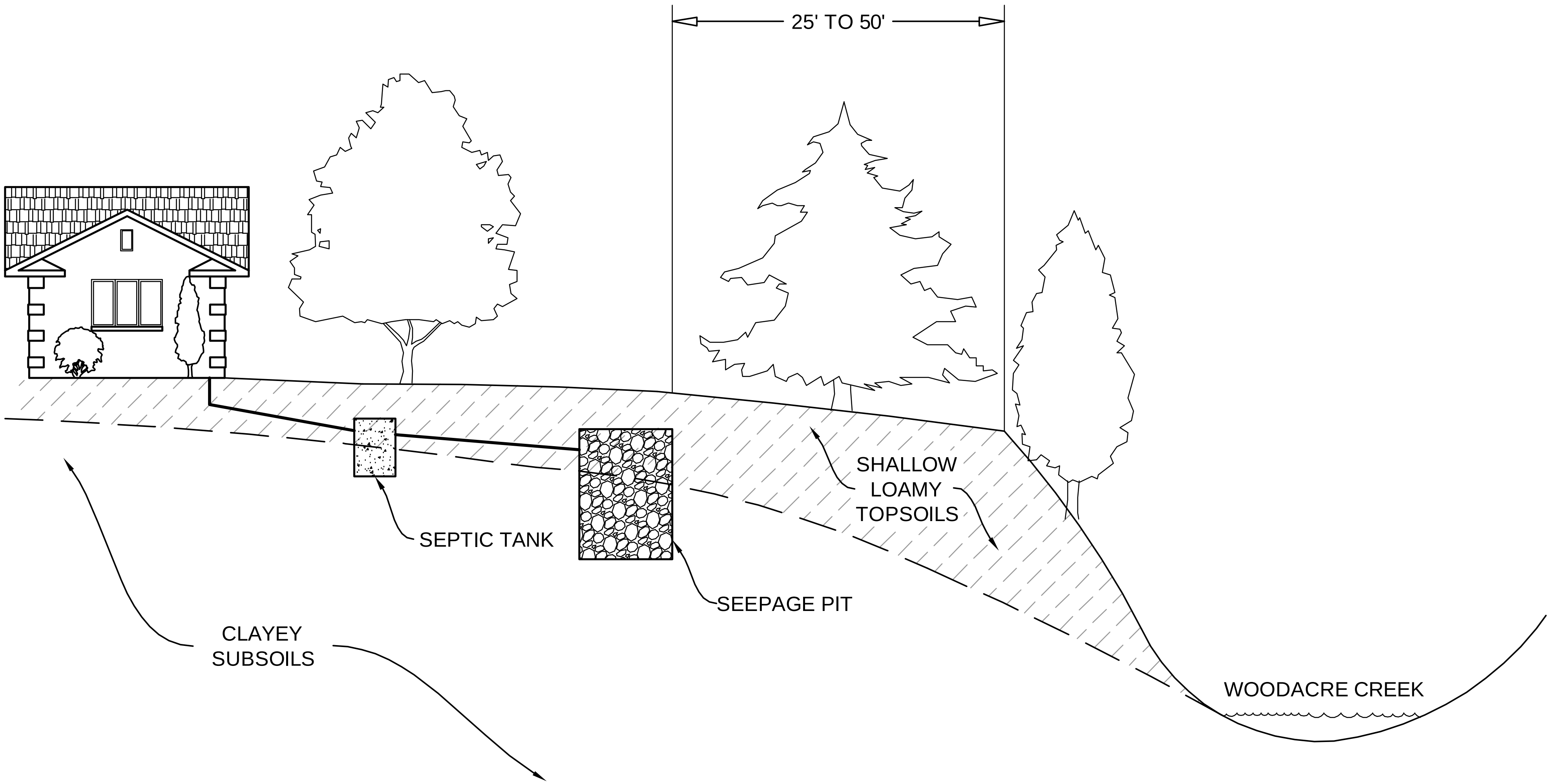
Drawn: ML
Checked: PP
Appr'd: NH

TYPICAL ONSITE CONDITIONS
RAILROAD/CENTRAL AREA

Size: D
Project: 290191
Scale: AS NOTED
FIGURE: 4



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Checked: MW
Appr'd: NH

TYPICAL ONSITE CONDITIONS
CREEKSIDE AREA

Size: D
Project: 290191
Scale: AS NOTED
FIGURE: 5

SEPTIC MATTERS PROGRAM INSPECTIONS

In the years prior to the initiation of this feasibility study, individual septic system inspections were conducted in various parts of Marin County in the period of January 2004-August 2005 (by Kit Rosefield) and in winter of 2007-2008 (by Mike Treinen). This work was funded by the County of Marin through grants received from the State Water Resources Control Board and the California Coastal Commission, and was termed the "Septic Matters Program". The overall goal of the program was to provide community education to homeowners through the completion of free and confidential third-party inspection and testing of septic systems.

The inspections were conducted on a voluntary basis, at the request of individual property owners, and the resulting information particular to any given property was kept confidential (between the inspector and the property owner). A total of 135 inspections were conducted County-wide, with the greatest number (62) being in the Woodacre area. The large number of inspections in Woodacre was as a result of active local encouragement to participate in the program. The inspections in Woodacre included many systems in the Flats area, but also other properties located in the upland areas, outside the limits of the current wastewater feasibility study.

The septic system inspections were conducted to assess the functioning status of individual systems following the general methodology contained in Marin County's "Septic System Performance Evaluation Guidelines". The work included review of permit file information, field inspection and measurements of the septic tank, leachfield system and key site features, and hydraulic load testing of the system. While the location and owners of inspected properties remained anonymous, the overall results of the inspections were compiled and presented to the County by Rosefield and Treinen, and provide a general overview of the functioning status and condition of septic systems in different parts of the County.

Table 3 presents a summary of the key findings as reported by Treinen (2008) for the County as a whole. A copy of the full report is provided in **Appendix A**. In the Woodacre area Rosefield and Treinen encountered most of the problem conditions and issues noted in **Table 3**. In particular, they found many cases of marginal soils, high groundwater conditions, old and undocumented systems, gray water discharges, and a preponderance of small, "overdeveloped" lots, with minimal area provided for adequate onsite wastewater disposal. **Table 4** summarizes the information generated from the voluntary septic system inspections in Woodacre. Overall, the Rosefield/Treinen surveys showed marginal to unacceptable operating conditions for about half to two-thirds of the septic systems inspected in the Woodacre area.

Table 3: Summary of Septic System Inspection Findings, Septic Matters Program (Treinen, 2008)

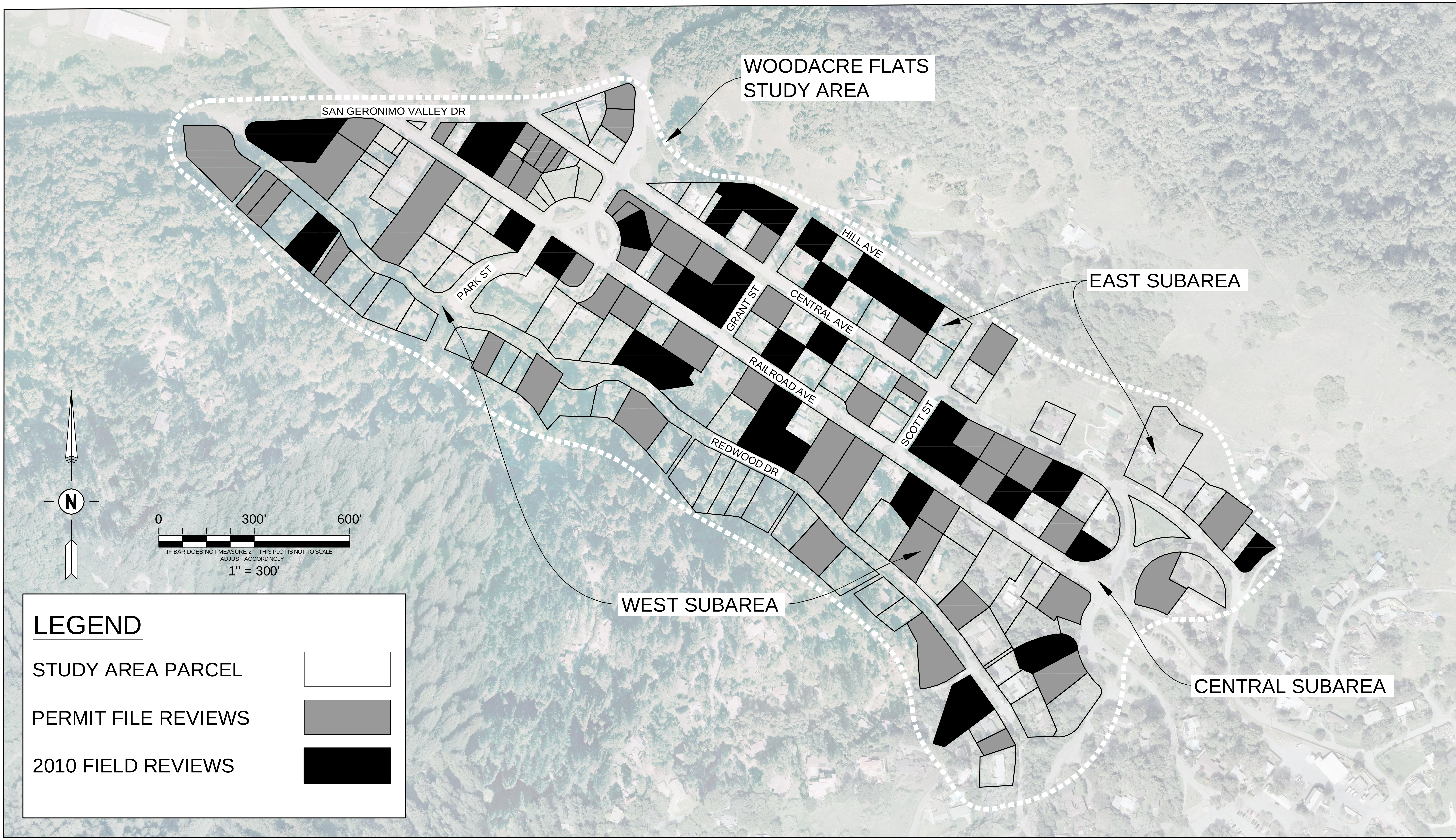
Issue	Findings and Observations
1. System Age	Most systems estimated to be 30-50 years old. Many owners noted repairs had been done, most often without permits.
2. Small Parcels	In general, lot sizes were small, often ranging from 8,000 to 15,000 square feet. Many lots often overdeveloped with homes, garages, driveways, decks, pools and other hardscape, with limited space allowed for the septic system.
3. High Groundwater (GW)	Valley floor and flatter areas (such as Railroad Avenue in Woodacre) tend to have high seasonal GW, observed as high as 4 inches, and commonly 16-18 inches; pose flooding threat for septic tanks and leachfields that may be 3 to 6-feet deep.
4. Small Systems	Many systems smaller or substantially smaller than required under today's more scientifically based standards. Can contribute to faster accumulation of clogging bio-mat, reduced system lifespan and greater potential for hydraulic overload.
5. Marginal or Shallow Soils	Soils in many areas shallow or with marginal percolation, poorly suited for gravity systems, which is most commonly in use.
6. Additional Living Units	Secondary living units observed at 10- 20% of the residences inspected, some existing without permits. This increases wastewater volume and stresses on existing systems.
7. Proximity to Waterways	Many systems closer to waterways than permitted by current code, with increased potential for contaminant transmission.
8. Graywater Discharges	Many homes found to have separate graywater discharges (laundry, showers, sinks) to the ground surface, ditches, or to unpermitted gravel filled sumps. This is done to relieve pressure on marginal or failing septic systems or occasionally by owners pro-actively reducing the load on their systems.
9. Limited or No Fail Safe Area	Most properties have limited or no system replacement area, especially if current set backs from wells, waterways and structures were to be enforced.
10. Restricted Access to Tanks	Development such as decks and pavement stones restrict to some tanks for pumping and diagnosis; may contribute to less frequent or no pumping and diagnostic checks of those tanks.
11. Mosquito Breeding	Mosquito breeding noted in tanks and pump tanks with inadequate or poorly fitting concrete, fiberglass or wooden lids.
12. Unpermitted Repairs	High percentage of repairs (Kit Rosefield estimated 60%) have been made without permits, leading to questions of the adequacy of repair work and the maintenance of reasonable setbacks.
13. Pre-code Tanks	Some sub-standard septic tanks found, including redwood construction and bottomless tanks (e.g., function like cesspools).
14. Types of Repairs	Most common type of repair has been standard gravity leach lines, not necessarily suited to the soil and other site constraints. Some instances of non-standard systems, such as bottomless sand filters, mounds or advanced treatment units with subsurface drip dispersal (usually on steeper slopes). Non-standard systems generally appeared to be functioning properly and more appropriate for the observed site constraints. Non-standard repairs generally not favored by homeowners due to higher costs and large amount of space required; typically installed in connection with real estate transfer, refinancing, or home remodeling project.

Table 4: Inspection Results for Woodacre, Septic Matters Program (2004/05 and 2007/08)

Category	Septic System Evaluation Factors	Results	
		# of Systems	% of Systems Inspected
Overall Status & Site Conditions	Total systems inspected	62	-
	Systems < 100 feet from a watercourse	55	90%
	Systems with "satisfactory" or "good" overall rating	19	31%
	Systems exhibiting one or more problem conditions	43	69%
	Systems exhibiting high groundwater conditions	15	24%
	Systems incorporating alternative treatment/dispersal	8	19%
Septic Tank Status	Acceptable	35	56%
	Unacceptable	15	24%
	Unknown/ not Accessible	12	19%
Disposal System Status	Acceptable	30	48%
	Unacceptable	21	34%
	Unknown/ not Accessible	12	19%
Hydraulic Load Test Results	Good or Excellent	20	32%
	Satisfactory or Marginal	8	13%
	Poor or Failing	28	45%
	Unknown/Not Accessible	6	10%

PERMIT FILE REVIEWS

As part of the current wastewater feasibility study, Questa Engineering with assistance of Marin County EHS staff researched and reviewed septic system and related parcel information on file with Marin County for properties within the Woodacre Flats Study Area. System permits, design drawings, correspondence and other file information were reviewed to determine the date of installation or of last repair, the technology or components of each system, compliance with County codes, and size of the residence or facility served. Out of approximately 150 developed properties in the Study Area permit files were found for 58 parcels. **Figure 6** shows the location of the properties in the Woodacre Flats study area for which septic system records were found and reviewed, along with other properties where field reviews were conducted as part of this feasibility study (see subsequent discussion in this section). There is some overlap in the parcel mapping, as a small number of properties that were field reviewed by Questa also had permit file information that was available and reviewed.



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WOODACRE FLATS WASTEWATER FEASIBILITY STUDY

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SEPTIC SYSTEM PERMIT AND FIELD REVIEWS

FIGURE
6

Key information from this review is presented below:

- **Development.** Total developed properties in Woodacre Flats study area: 150
- **Permit Records**. Total number of systems with County Records: 58 (39%)
- **Age of System.**

Age Grouping (years in service)	Original Installation	Repair System	Total # of Systems	Percent of Total Systems
<10	1	5	6	10%
11-25	6	12	18	31%
26-30	6	5	11	19%
>30	8	15	23	39%
Total	21	37	58	-

- **System Repairs**. About two-thirds of the septic systems (37 out of 58) have been repaired at least once.

- **Prevailing Code.** About 40 percent of the septic systems (new and repair) were constructed under the current (1984) County septic regulations (adopted in 1984); the remaining 60 percent occurred under previous regulations.

- **Types of Systems in Use.** A wide range of septic system technologies and designs have been used in the area, as follows:

System Type		Number of Systems
Gravity Leachfield		31
Seepage Pit/Seepage Bed		14
Alternative Systems	Mound System	7
	Pressure Distribution (PD) Leachfield	1
	Sand Filter/PD Leachfield	2
	Open Bottom Sand Filter	1
Unknown		2

ONSITE FIELD REVIEWS

Following collection of background information, field reviews of 33 properties in the Study Area were conducted by Questa during the period of March 9th to April 8th, 2010. The field reviews were arranged (voluntarily) with willing property owners to make site-specific assessments of constraints and options for onsite system repair and upgrade on a representative number of properties in the study area. **Figure 6** shows the parcels where field reviews were conducted, along with other parcels where permit information was available for review as noted previously. The combined total number of parcels having either septic system permit information and/or field reviews was 86, or roughly 57 percent of the total developed properties in Woodacre Flats.

The field reviews involved mapping and measuring various property features along with hand-auger borings for soil/groundwater observations. From this an assessment was made of the apparent available area for onsite septic system upgrade on each parcel, and to identify and evaluate some of the main construction issues and constraints that would be involved with the implementation of onsite system upgrades. Air photos and Assessor Parcel Maps were used in some cases to supplement field observations regarding property size, boundaries between parcels and setbacks to various landscape features.

Based on the field reviews and other physical characteristics, the Woodacre Flats study area was sub-divided into three geographic subareas, roughly in the shape of southeast-to-northeast corridors. The three subareas are noted in **Figure 6** and described generally as follows:

- **West Subarea**. This includes the properties in the western portion of Woodacre Flats, including those along Redwood Avenue and extending to the west side of Railroad Avenue.

- **Central Subarea.** This includes the central flats area, including properties lying between Railroad Avenue and Central Avenue, plus the Park Street area and the east side of Central Avenue in the northern end.

- **East Subarea.** This includes the gently to steeply sloping areas on the east side of Taylor Avenue and the east side of Central Avenue in the southern end.

The observations and assessments made for individual properties, without disclosure of the address, are included in **Appendix A**. It was a condition of the access agreement with property owners that property-specific information from the field reviews not be presented as a part of this study. The information in **Appendix A** documents the level of review conducted along with the types of observations and assessment made. Field maps of each parcel were also created; these maps will be made available to the respective property owners but not published with as a part of this report. A summary of the information compiled from the field reviews organized according to the three subareas is presented in **Table 5**. It includes various site information relevant to the location and operation of onsite wastewater systems, including ground slope, soil depth, groundwater conditions, drainage and setback issues.

The results from the field reviews along with other background information on existing conditions and practices provided the basis for evaluating the feasibility and requirements for the onsite system upgrade alternative presented in **Section 6, Alternatives Analysis**.

Table 5: Summary of Site Conditions Findings from Questa Field Reviews (2010)

Sub-Area	Properties Reviewed	Site Conditions											Drainage/Setback Issues
		Ground Slope (%)			Effective Soil Depth (ft)			Depth to GW (ft)					
		< 5	5 – 30	>30	1 - 3	> 3	UNK	< 2	2 - 3	3 - 4	> 4	UNK	
1 West	13	9	1	3	5	6	2	1	-	-	6	6	10 of 13 systems can't meet 100' setbacks to Woodacre Creek.
2 Central	12	12	0	0	11	1	-	5	-	-	2	5	Inadequate local drainage ditches affect most properties. Chronic ponded water in winter months. Numerous drains and sumps for drainage control. Very limited undeveloped space
3 East	8	5	2	1	4	4	-	0	3	3	2	1	Inadequate local drainage ditches affect most properties. Numerous drains and sumps for drainage control. Conflicts with between disposal fields and cut banks and between properties.
Totals	33	26	3	4	20	11	2	6	3	3	10	12	

UNK = unknown/not determined

SECTION 5:
SERVICE AREA CHARACTERISTICS AND WASTEWATER FACILITY ALTERNATIVES

SERVICE AREA

The service area for this study of wastewater facility improvements was taken to be the existing developed parcels located within the Study Area as shown in **Figure 2**. This is roughly defined as the portion of Woodacre referred to as the "Flats", which includes primarily low-lying properties along the following streets: Redwood Drive, Railroad Avenue, Central Avenue and Taylor Avenue. This encompasses the area of Woodacre believed to be in most need of wastewater improvements, as well as the portion of the community that has expressed the greatest amount of interest in studying possible sewerage alternatives.

It is important to understand, however, that the service area boundaries are not fixed. The boundaries provide a focus for estimating wastewater facility requirements and costs as required for the conduct of this study. The boundaries selected for a community wastewater project could be narrowed or expanded depending on the level of community interest, the alternative selected, funding sources, environmental issues, or other factors. For example, in the course of conducting this study Questa was contacted by several owners of properties that lie outside the Study Area who expressed interest in being included in a Woodacre community wastewater project. Consideration of such requests to expand the service area boundaries should be taken up as a separate matter following review of the findings from this initial feasibility study. The final decision on service area boundaries would normally occur following environmental review and in conjunction with the formation of an assessment district to develop the local financing for project. This would entail formal public hearings and a majority vote.

According to review of County Assessor information, the Study Area shown in **Figure 2** includes a total of approximately 150 developed parcels plus some undeveloped parcels. As previously noted, the service area covered by this is limited to the existing developed properties, which include both commercial and residential properties, as follows:

- **Commercial Uses.** There are an estimated 16 parcels with developed commercial uses, including the Woodacre Deli, a few apartments and studio-workshops, the Post Office, and several small offices and businesses.

- **Residential Uses.** There are an estimated 134 developed single family residential parcels in the service area, not including commercial properties (from above) that may have a mix of residential and commercial uses. Based on County Assessor records the residential properties in the area have from one to five bedrooms, with an average of approximately 2.5 bedrooms per parcel. No accounting has been made of the number of parcels that may have second dwelling units. According to the 2000 U.S. Census, there are an average of 2.54 persons per household in Woodacre. Applying this statistic to the Woodacre Flats area gives and estimated residential population of 381 people in a service area encompassing 150 parcels.

ESTIMATED WASTEWATER FLOWS

Wastewater flows for the Woodacre Flats service area were developed based on the land uses (i.e., size and nature of development) along with a review of typical reference data and monitoring information from other small community wastewater facilities. The estimated wastewater flows are important in assessing the required capacity for collection, treatment, storage and disposal facilities for the community wastewater alternatives.

Presented in **Table 6** below are projected wastewater flows covering two scenarios: (1) service to all ("100 %") of the existing 150 developed properties; and (b) service to 75% of the developed properties (112 parcels). Wastewater flows for these two participation levels were used subsequently in the project Alternative Analysis in **Section 6**. The two different levels of wastewater service were studied two reasons: (a) there is no current mandate that would require full participation of all properties in the Study Area; and (b) to provide information on how wastewater facilities and associated costs would vary based on the number of parcels served.

Table 6: Estimated Wastewater Flows for Woodacre Flats Service Area

Service Assumption	Total Parcels Served	Disposal/Storage Capacity			Treatment Capacity		
		Unit flow (gpd/parcel)	Average Dry Weather Flow (gpd)	Peak Wet Weather Flow* (gpd)	Unit flow (gpd/parcel)	Peak Daily Dry Weather Flow (gpd)	Peak Wet Weather Flow* (gpd)
(1) 100% of Developed Parcels	150	175	26,250	28,875	210	31,500	34,650
(2) 75% of Developed Parcels	112	175	19,600	21,560	210	23,520	25,875

* Note: Applies to projects using conventional gravity sewers; does not apply where STEP or Pressure Sewers used.

Following is an explanation of the rationale, assumptions and background information that support the wastewater flow estimates in **Table 6**.

- **Disposal/Storage vs. Treatment Capacity Estimates.** Wastewater flow has different importance for the design and operation of different elements of a community wastewater system. Disposal facilities (e.g., leachfield) and storage facilities (e.g., holding pond) are affected by the average flow over a period of time (e.g., a week or two to several months). The wastewater flow is averaged-out by the nature of these facilities through internal storage. Therefore, average flow is most pertinent to the design of these facilities. The only case where this doesn't apply is for subsurface drip lines, which are buried directly in the soil and provide no internal storage capacity for surge flows. The treatment system normally has limited internal storage capacity and should be capable of processing the entire daily flow, including periodic surges (peaks) in flow conditions. In our estimates we increased the unit flow estimate for treatment facilities by 20 percent over that for the disposal/storage capacity estimates to account for daily peaking conditions.

- **Wet Weather Infiltration and Inflow (I/I).** Sewer systems are subject to infiltration of groundwater and inflow of surface water through joints and cracks in pipes and manholes. The amount of I/I depends on the groundwater and drainage conditions, the age and condition of the sewers, and the type of sewer design. Older sewers are most notorious for experiencing high amounts of I/I; in the worst cases the I/I component may equal or exceed the sewage component. However, in newer installations I/I is more typically maintained below 10% of the sewage flow, and may be essentially nil for pressure sewer and effluent systems that don't include manholes. We included a 10% I/I factor as a reasonable allowance for the Woodacre Flats area, which has known high groundwater conditions. This I/I factor applies to conventional gravity sewers; it would not apply to a project where either pressure sewers or STEP effluent sewers are used, since these collection systems exclude the use of manholes and gravity sewer pipes, which are the primary entry point for infiltration and inflow.

- **Residential/Commercial Unit Wastewater Flows.** The Woodacre Flats service area consists mainly of single family residential parcels, with a small amount of commercial uses. The commercial uses in Woodacre tend to be the types that generate wastewater volumes similar to or less than single family residences (e.g., offices, shops, Post Office, small apartments). Accordingly, for this feasibility study a reasonable approximation of wastewater flows can be made by applying a typical unit wastewater flow for residential use uniformly to all parcels in the service area.

  Individual onsite wastewater systems are designed (per Marin County Regulations) on the basis of the number of bedrooms to account, conservatively, for the possibility of any particular system being operated at full occupancy and peak flow conditions for extended periods of time. This is a prudent approach for individual systems, but results in an exaggerated flow estimate when applied to community systems.

  With community systems there is an automatic averaging effect that comes from the consolidation of wastewater from a moderate to large number of residences. Wastewater flow information for other community systems was compiled to assist in selecting appropriate unit flow assumptions for Woodacre Flats. The information is presented in **Table 7**. As can be seen, the wastewater flows for the Lake Canyon and Marshall systems, both effluent (STEP) sewers installed in a community of existing older homes, have very similar, low wastewater generation rates, averaging less than 75 gpd/connection, with peak flows under 125 gpd/connection. These two systems receive very little if any I/I because of the type of sewer system design. The higher flow rates for the French Ranch system are probably influenced by the larger size of homes along with I/I from the gravity sewers and the sand filter treatment system, which is open to direct rainfall infiltration. For Woodacre Flats, an average daily unit flow rate of 175 gpd/connection would be similar to average wastewater generation rates at French Ranch, and would be a reasonable and safe estimate for project analysis. The data for Lake

Canyon and Marshall show that the selection of an effluent (STEP) sewer system would be very advantageous in minimizing wastewater flows, which would be important in connection with community leachfield options.

As an additional point of reference for estimation of expected wastewater flows would be the estimated service area population. As noted previously, the 2000 U.S. Census reported an average household size of 2.54 persons per residence in Woodacre. This can be combined with a daily sewage generation rate of 52.5 gpd per capita, to give an estimated average household wastewater discharge estimate of 133 gpd/residence. This is slightly above the flow data presented in Table 7 for Lake Canyon and Marshall Phase I; but it is still safely within the estimated unit flow of 175 gpd/residence suggested for this study of Woodacre Flats. The per capita sewage generation rate of 52.5 gpd is derived from the standard design flow rate of 105 gpd per bedroom (2 persons per bedroom) used in Marin County for residences incorporating low-flow water conserving plumbing. It is further supported by other literature (e.g., Crites and Tchobanoglous, 1998), which cite 50 gpd per capita as the typical average sewage generation rate in the U.S.

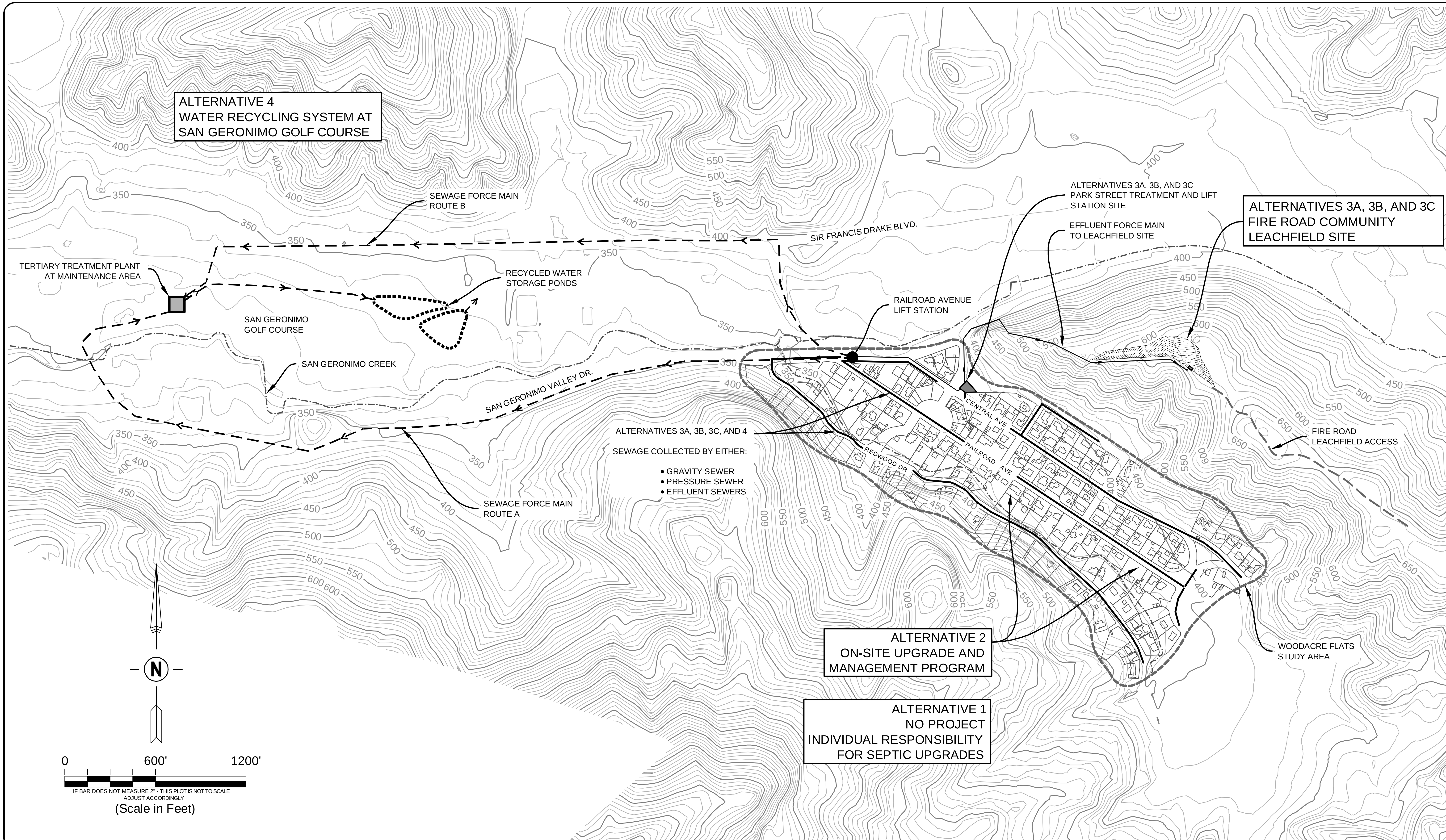
Table 7: Unit Flow Reference Data for Community Wastewater Facilities[1]

Community System	Number of Parcels	Years of Operation	Ave. Daily Flow (gpd/parcel)	Peak Flow (gpd/parcel)	Notes
Lake Canyon CSD (Santa Clara Co.)	51	13	65	120	Old homes; effluent (STEP) collection system to community leachfield
French Ranch (Marin Co.)	28	11	173	356	New subdivision with gravity sewers; peak flows affected by rainfall inflow to sand filter bed
Marshall Phase 1 (Marin Co.)	32	2.5	73	124	Old homes; effluent (STEP) sewers to community leachfield

[1] Source: Self-Monitoring Reports on file with RWQCB

WASTEWATER FACILITY ALTERNATIVES

The general outline of collection, treatment and disposal alternatives to be analyzed was established in consultation with Marin County Environmental Health Services (EHS) at the outset of the project - the basic options being an onsite management program and a local community system. Based on background information for the project area, reconnaissance soils investigations, community input, and additional work by the consultant team, specific wastewater collection, treatment and disposal alternatives for the Woodacre Flats service area were developed for analysis and comparative review. The project alternatives formulated for study are briefly summarized below and illustrated in **Figure 7**.



WOODACRE FLATS
WASTEWATER FEASIBILITY STUDY

WOODACRE, CALIFORNIA

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PROJECT ALTERNATIVES

FIGURE 7

- **Alternative 1 - No Project**. This would involve maintaining the status quo, where individual property owners would be responsible for abatement of septic system failures as directed by Marin County EHS and/or the San Francisco Bay Regional Water Quality Control Board (RWQCB). The No Project alternative is included to provide a frame of reference for evaluation of different types of wastewater improvements.

- **Alternative 2 - Onsite Wastewater Management Program**. This alternative considers the upgrade of onsite systems in conjunction with the formation of a local septic system maintenance and inspection program. The program would be operated under the authority of a maintenance district, County Service Area or similar public entity for the selected service area. Financing of individual septic system improvements would be accomplished with grant assistance to bring all currently developed properties into conformance with minimum acceptable "repair" standards. No facility improvements would be provided for future development.

- **Alternatives 3A, 3B & 3C – Fire Road Community Leachfield**. This alternative would provide for the construction of a central wastewater collection system for the service area, leading to a community leachfield system located on nearby open space lands. The most area identified as a potential community leachfield site is a wooded knoll along the Fire Road ridgeline northeast of Woodacre on property owned by Dickson Ranch. Three community leachfield options were formulated and evaluated: (3A) primary (septic tank) treatment with a shallow pressure distribution leachfield, 100% field, no reserve; (3B) secondary treatment with a shallow pressure distribution leachfield, 100% field, 100% reserve; and (3C) secondary treatment with subsurface drip dispersal leachfield, 200% field.

- **Alternative 4 – Golf Course Water Recycling System**. This alternative would provide for collection, treatment, and recycling of wastewater for turf irrigation at the San Geronimo Golf Course. This would entail the construction of a central wastewater collection system in the service area (similar to Alternatives 3A-3C), a wastewater transmission line (force main) to the San Geronimo Golf Course, a tertiary treatment plant located in golf course maintenance area, holding pond(s) on the golf course (near green #2) for winter storage of recycled water, and seasonal reuse of the recycled water for spray irrigation of the golf course turf grass (front nine area). The wastewater would be treated to meet California State requirements for tertiary recycled water (unrestricted uses), and would be integrated into the existing golf course irrigation system to reduce the amount of raw water currently supplied from MMWD.

SECTION 6: ALTERNATIVES ANALYSIS

INTRODUCTION

This section presents an analysis of each of the identified alternatives for the Woodacre Flats Study Area. The analysis included the completion of field investigation and engineering studies, which were used to determine the facility requirements, engineering feasibility, operation and maintenance needs and estimated costs for the various alternatives.

For each alternative, maps and other reference materials are provided, along with a description of the key facilities, a review of regulatory issues, engineering feasibility, environmental considerations, estimation of construction costs and a discussion of on-going operation and maintenance requirements and costs. Supporting technical information is provided in the appendices. **Section 7** presents a comparative review of the treatment and disposal alternatives and identifies the "apparent best alternative(s)".

In reviewing this analysis it should be recognized that the range of alternatives considered are very diverse, and the alternatives have been developed based on different levels of detail and methods. Overall, the alternatives have been developed to a "planning level" of detail rather than a "design level", which is an appropriate and sufficient basis for comparison of the alternatives and identification of the apparent best course of action for the community.

ALTERNATIVE 1 - NO PROJECT

Description

The No Project alternative, or status quo, is normally presented as a base case condition against which to judge other alternatives; however, no specific engineering evaluation has been made of this alternative. This alternative would provide for the continued use of onsite septic systems, with individual property owners responsible for maintenance and repair of their own systems. Permitting and regulatory responsibility would remain with the Marin County EHS and include oversight from the Regional Water Quality Control Board (RWQCB). Correction of failing septic systems would normally be expected to occur under the following circumstances:

- As a direct result of abatement action taken by EHS for individual properties, in response to complaints;
- As a condition of sale at the time of property transfers;
- In connection with permits for building modifications; or
- By individual property owners on their own initiative.

Septic system repair work expected under this alternative might include, for example, replacement of existing substandard or failing septic systems with a new septic tank and disposal system. In most cases, an alternative system, such as a mound or advanced ("supplemental") treatment unit with drip dispersal or pressure distribution leachfield, would likely be required because of particularly poor site conditions for standard septic tank/leachfield systems. These conditions include the shallow soil depths, seasonal high groundwater, setback constraints, and limited available land area on mostly small parcels. Retrofitting houses with ultra-low flush toilets and other water conserving plumbing devices would also be a necessity for many houses to reduce the volume of wastewater to be disposed. New residential construction, building additions and second units would not be permissible except where site conditions can support the installation of an onsite system that conforms to current code requirements and/or the County's Remodel & Additions Policy.

Assessment

Over some period of time, the above-described efforts may lead to improved water quality and public health conditions in the community. But it is unreasonable to expect that the existing threat of water quality impact to Woodacre Creek and downstream receiving waters would be satisfactorily corrected. Under the No Project alternative, the possibility exists that the County EHS and/or RWQCB would find it necessary at some point to undertake a systematic lot-by-lot inspection and abatement effort to mandate an upgrading of all septic systems to acceptable, modern standards. This could occur as a result of the implementation of the Tomales Bay Pathogens TMDL or requirements that may be mandated by statewide regulations adopted under AB 885.

The TMDL requires that there be no discharge of human pathogens to Tomales Bay or its tributaries from septic systems. The TMDL further specifies that compliance with this requirement can be achieved by either: (a) documenting or bringing the septic system into conformance with RWQCB and County regulations for new construction; or (b) monitoring the septic system to verify compliance with the above "no pathogen discharge" performance standard. For existing septic systems in the watershed area found (or suspected) to be failing, the TMDL would require substantial upgrading (per Marin County Class 2 Repair Criteria), and ongoing monitoring of the new/replacement system under a County operating permit. However, the timing for implementing such corrective action is presently not specified.

Additionally, state regulations for onsite wastewater treatment systems adopted pursuant to AB 885 will include specific requirements for OWTS located adjacent to 303(d) listed water bodies. The AB 885 regulations are still under development, so there is no clear indication of the standards that may apply to the Woodacre Flats area. Previous versions of draft regulations (November 2008) have included requirements calling for substantial upgrading of all existing onsite systems within 600 feet of 303(d) listed waters for pathogens or nutrients (such as Tomales Bay and its tributaries). This included that all systems, whether or not they are found to be failing, would be required to install a supplemental treatment system, which would require water quality testing a minimum of four times per year for the life of the system. More recent communication with the State Water Resources Control Board staff (Darin Polhemus, Chief of Water Quality Division, May 2010), indicate that the previous draft regulations have been revised significantly, with the intent of providing more latitude for local jurisdictions and Regional Water Boards to establish repair and upgrade requirements for existing septic systems. However, to date revised draft regulations have not been made available for public review.

ALTERNATIVE 2 - ONSITE WASTEWATER UPGRADE AND MANAGEMENT PROGRAM

Description

This alternative would provide for inspection and as-needed upgrading of all existing septic systems in the study area, and formation of a septic system management authority to perform ongoing inspection, monitoring, and maintenance of these systems. Septic systems would need to be upgraded to a minimum set of standards, or determined to be in compliance with a minimum performance standard that would assure proper functioning and elimination of public health and water quality problems. The current standards of the Marin County EHS and the RWQCB would apply, with the possibility of adopting certain local modifications with concurrence by both of these agencies. In general, all applicable siting criteria (i.e., soil depth, percolation, groundwater, slope requirements, etc.) would be considered to the greatest extent possible in evaluating and designing septic system upgrades.

On-lot septic system improvements under this alternative would be similar to those for the No Project alternative; i.e., replacement of substandard systems with new septic tanks, supplemental treatment units (e.g., sand filter, AdvanTex filter) and new disposal fields, most likely using pressure distribution or drip dispersal. Other alternative technologies might also be considered on a case-by-case basis. Retrofitting houses with ultra-low flush toilets and other water conserving plumbing devices would also be a necessity for many houses to reduce the volume of wastewater to be disposed. The specific siting and design criteria for each alternative technology would have to be in accordance with currently adopted standards of the County and RWQCB, or based on criteria developed and agreed upon by both agencies specifically for this Project. In the course of developing this alternative, appropriate criteria have been determined in consultation with these agencies and are presented and used in the evaluation that follows.

Following septic system upgrading, a continuing inspection and monitoring program would be carried out by a public management authority. This would entail regular inspection of each septic system, water quality sampling of treatment systems as well as Woodacre Creek, possibly other local drainages, and groundwater monitoring wells, with periodic reporting to the County and RWQCB on the inspection results and overall compliance with system performance, water quality and public health standards.

Regulatory Requirements and Policies

Criteria governing the siting and design of onsite sewage disposal facilities in the project area are contained in: (a) Marin County Sewage Disposal Regulations; and (b) the San Francisco Bay Regional Water Quality Control Board's "*Minimum Guidelines for the Control of Individual*

Wastewater Treatment and Disposal Systems" ("Minimum Guidelines"). The requirements specified in these documents are oriented primarily toward individual septic tank - leachfield systems, but they also include provisions that relate specifically to alternative technologies. Some of the key regulatory provisions contained in Marin County regulations for onsite wastewater systems are reviewed here.

Soil Depth

A minimum of 3 feet of soil depth is required below the leaching trenches (or bed). The soil within and below the leaching trenches must be permeable and of a suitable texture and structure for absorption of sewage effluent. Coarse sand and gravels are unacceptable due to the lack of fine soil particles for filtration and treatment; heavy clay soils, on the other hand, are generally unsuitable due to inadequate permeability.

Percolation Rates

The percolation rate for conventional leachfields and alternative disposal systems is required to be within the range of 1 to 120 minutes per inch (MPI). The percolation rate is used to establish an appropriate wastewater loading rate, which is then used for sizing the disposal field.

Depth to Groundwater

The required depth to groundwater, below the bottom of the leachfield trench varies according to the percolation rate and soil characteristics and system type. For percolation rates of 5 to 60 MPI or where the soils have more than 15 percent silt plus clay fraction ("fines"), the required depth to groundwater is 3 feet (below trench bottom). A greater depth to groundwater is required for rapidly permeable soils where the soil texture lacks sufficient "fines" for treatment. For soils with a percolation rate between 1 and 4 MPI, the required depth to groundwater is 10 feet where there are 10 to 15% fines, and 20 feet where there are less than 10% fines. These depth requirements apply to disposal of septic tank effluent through conventional leaching trenches, and may be reduced (to a minimum of two feet) if additional treatment or alternative disposal system design (e.g., mounds) are provided.

Setbacks from Wells and Watercourses

Required minimum setback distances between wastewater disposal fields and various water features are as follows:

* Water Wells	100'
* Springs	100'
* Natural Lake or Water Supply Reservoir	200' (from high-water line)
* Perennial Watercourses	100' (from edge of 10-year floodplain)
* Seasonal Streams and Wetlands	75' (from top of bank)
* Intermittent Streams	50' (from top of bank

Marin County Regulations also specify minimum setback distances for other site features such as property lines, buildings, paved areas, cuts and embankments, and water lines. Variations in setback requirements are permitted in conjunction with certain alternative systems (e.g., sand filters), for system repairs, and under formal variance provisions.

Disposal System Design

The standard disposal field design in Marin County is a trench system, 18-inches wide and ranging in depth from 2 to 8 feet. The system is sized according to the trench sidewall area and the wastewater loading rate determined from the percolation test results (see above). The design wastewater flow for a residential system is based on the number of bedrooms in the house, and a standard flow criterion of 150 gpd/bedroom, which may be reduced to 105 gpd/bedroom with the incorporation of low-flow plumbing fixtures.

Dual System Capacity

Individual wastewater disposal systems are required by Marin County and RWQCB policies to have dual fields; i.e., a primary and back-up disposal field, each with 100% capacity, that operate on an alternating basis. The purpose is to extend the life of the disposal field. Normally, in such a system the flow is alternated between leachfields every six months. In many repair situations, dual capacity (and sometimes 100% capacity) cannot be provided; in such instances the disposal system is often designed to make maximum use of available suitable area.

Operations and Monitoring

Alternative wastewater systems require monitoring of system operations, and submission of periodic reports to the County and/or RWQCB. The monitoring is intended to keep track of such things as wastewater flow rates and volumes, treatment effectiveness, disposal field performance and conditions, and downstream/downgradient water quality measurements at monitoring wells or surface drainage points. Quarterly monitoring and annual reporting requirements are typical for the first few years of system operation, declining to semi-annual or annual monitoring in subsequent years depending upon successful system performance.

Repair System Requirements

As previously noted, for repair of existing septic systems, Marin County EHS attempts to achieve compliance with current regulations to the maximum extent practicable. However, full compliance with all code requirements is generally not possible. Heavy emphasis is given to case-by-case evaluation to achieve the best repair possible, considering the site limitations and environmental resources and public health issues at risk. **Table 8** lists the repair criteria and design assumptions that have been developed for application in an onsite wastewater management program for Woodacre Flats (per this alternative). These were developed in consultation with EHS staff, and have also been reviewed with the RWQCB staff in a project meeting held on April 13, 2010 (*personal communications with Rebecca Ng, Armando Alegria, Robert Turner, and Blair Allen).*

Table 8: Repair Criteria
Woodacre Flats Onsite Wastewater Management Program

ITEM	CRITERIA / DESIGN ASSUMPTION
Wastewater Design Flow	▪ Property owners responsible for installing ultra-low flush toilets and low flow fixtures; ▪ Assume design flow of 105 gpd/bedroom; ▪ Design flow of <105 gpd/bedroom if necessary due to dispersal area limitations and with additional monitoring requirements (per below).
Septic Tanks	▪ Existing concrete/fiberglass tanks of 1,200 gal or greater may be retained if found to be structurally sound, watertight and are upgraded with code compliant access risers. ▪ Effluent filters required for all new and upgraded tanks ▪ Setbacks to water and landscape features to be maintained as close as possible to code requirements; ▪ Setbacks to wells and springs - 50-ft minimum
Supplemental Treatment Units	▪ NSF Certification or equivalent technology verification required. ▪ Performance standard: Per standard EHS protocol*; for special/extreme creek encroachment situations, TMDL receiving water standard for fecal coliform at end of supplemental treatment process (i.e., dosing tank) or at groundwater monitoring wells adjacent to disposal field.
Dispersal System	▪ All reasonable dispersal technologies may be considered, including trenches, beds, mounds, drip dispersal; ▪ Design capacity – 100% of daily sewage; provide reserve area as feasible; ▪ Design loading rate: per soil characteristics and percolation rate; treatment credit for supplemental treatment OK per established sand filter design criteria; ▪ Setbacks to water and landscape features to be maintained as close as possible to code requirements; ▪ Setbacks to wells and springs - 100-ft minimum
Site Modifications	▪ Utilize curtain drains and surface drainage alteration wherever needed and feasible without impacts to/from other onsite systems or to surface waters; ▪ Soil excavation and replacement with sand fill – OK
Performance Monitoring	▪ Wastewater flow: Monitor from pump operations and/or water meter; require flow meter (or comparable device) and data logging for systems without 100% disposal capacity; ▪ Monitoring: water quality sampling required for coliform for special case systems at pump basin (following supplemental treatment), once per year; ▪ Visual inspection and maintenance once per year minimum; ▪ Remote alarm monitoring for identified high risk systems, e.g., creek encroachment with less than 100% disposal capacity.
Other Alternatives	▪ Holding tanks: May be required case-by-case to overcome extreme site limitations, such as soil/groundwater/drainage conditions or water course setbacks; ▪ Composting toilets: Not anticipated to be feasible or acceptable in high density residential area such as Woodacre Flats. ▪ Greywater Systems: Case-by-case evaluation based on State Greywater Standards

*Includes operating permit with standard and site specific inspection, testing, and reporting requirements

Feasibility Assessment

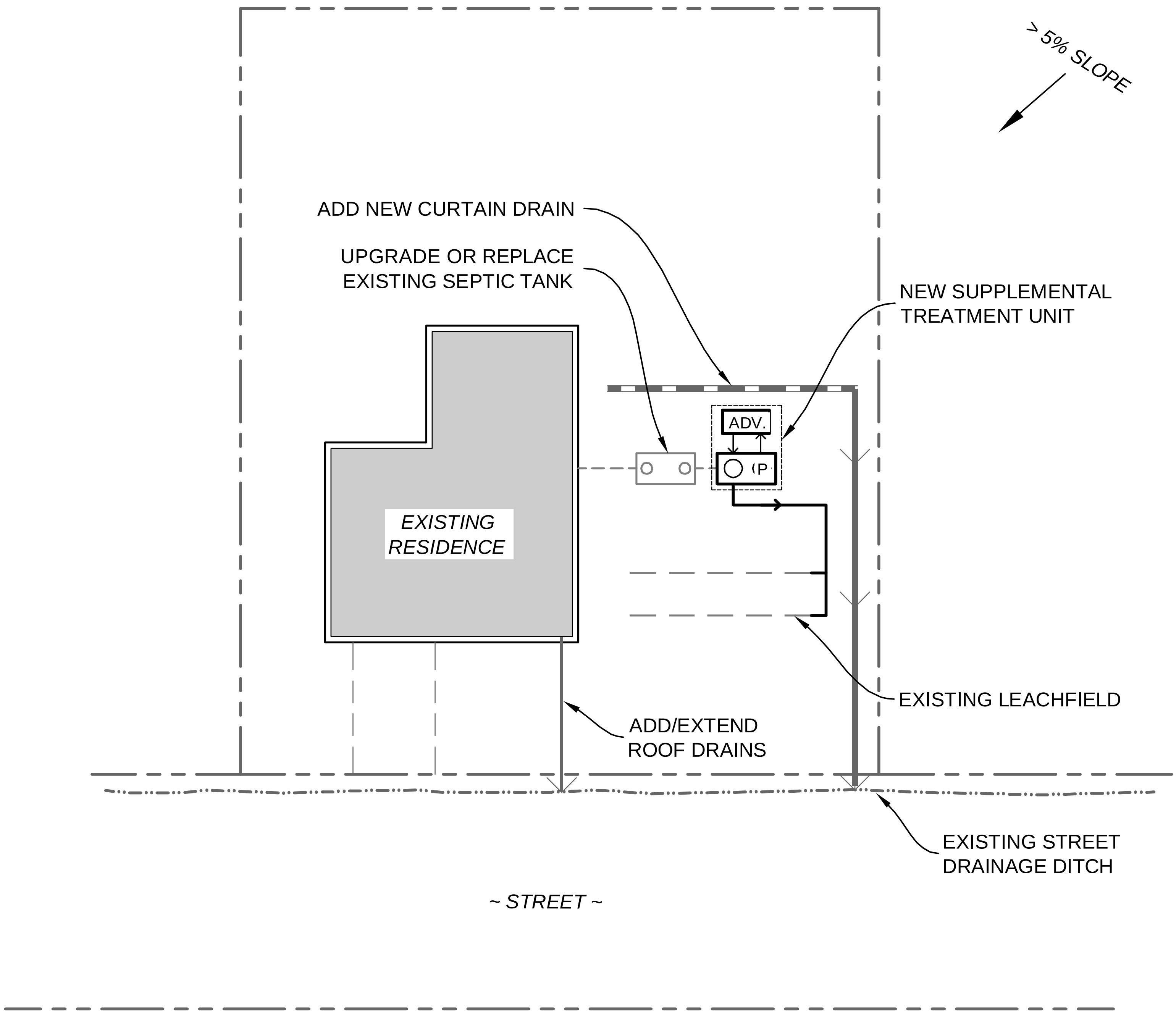
An assessment of onsite wastewater disposal feasibility for lots within the Woodacre Flats Study Area was completed utilizing the repair criteria listed in **Table 8**. Background file information, to the extent available, was utilized along was a field reconnaissance review of a representative cross-section of properties in the Study Area for this assessment. **Section 4** provides a description and summary of findings from the background file reviews (58 parcels with records) and the onsite field reviews of 33 developed parcels in the Study Area. **Figure 6** (**Section 4**) shows the location of the properties reviewed, along with notations designating the West, Central and East Subareas of the Study Area.

A key objective of the onsite field reviews was to assess the apparent available area for onsite septic system upgrade on each parcel, and to identify and evaluate some of the main construction issues and constraints that would be involved with the implementation of onsite system upgrades. As part of each site inspection, Questa's field review team made an assessment of the potential options for implementing an onsite system upgrade or repair taking into account the slope, soil, groundwater, drainage and area/setback factors. The upgrade/repair options considered were in accordance the basic repair criteria outlined in **Table 8** that would be applied as part of a community-wide onsite wastewater improvement and management program. A specific design was not prepared for each property; instead, using best professional judgment each property was placed into one of three upgrade/repair categories based on the level of difficulty and associated work required, as follows:

- **Low Level –** This was assigned to properties having an existing Class 1 or Class 2 code system, where little or no repair or upgrade work would be anticipated. This included properties with mound systems, sand filters and pressure distribution leachfields, mostly permitted and installed within the last 10 to 15 years. Upgrade work for these situations might include repair or replacement of various mechanical and electrical components and possibly drainage mitigation work. It would not include major changes to the existing system.

- **Moderate Level –** This was assigned to properties having sufficient area and reasonably good soil and groundwater conditions that could accommodate relatively straight forward upgrades to either the treatment or disposal system, such as: (a) addition of a supplemental treatment unit along with drainage mitigation measures; or (b) expansion of disposal capacity with shallow pressure distribution trenches along with drainage mitigation measures. **Figures 8** and **9** provide example (generic) site plans illustrating these types of septic system upgrades.

- **High Level -** This was assigned to properties having severe space limitations along with shallow soil/high groundwater conditions and/or drainage setback constraints requiring considerable work to implement a satisfactory onsite upgrade/repair. The type of upgrade/repair likely to be required for most of these situations would include: (a) supplemental/advanced treatment unit, often with UV disinfection; (b) drip dispersal, often with imported soil cover fill or raised beds; and (c) surface and subsurface drainage mitigation measures. Variances to standard setback requirements would be



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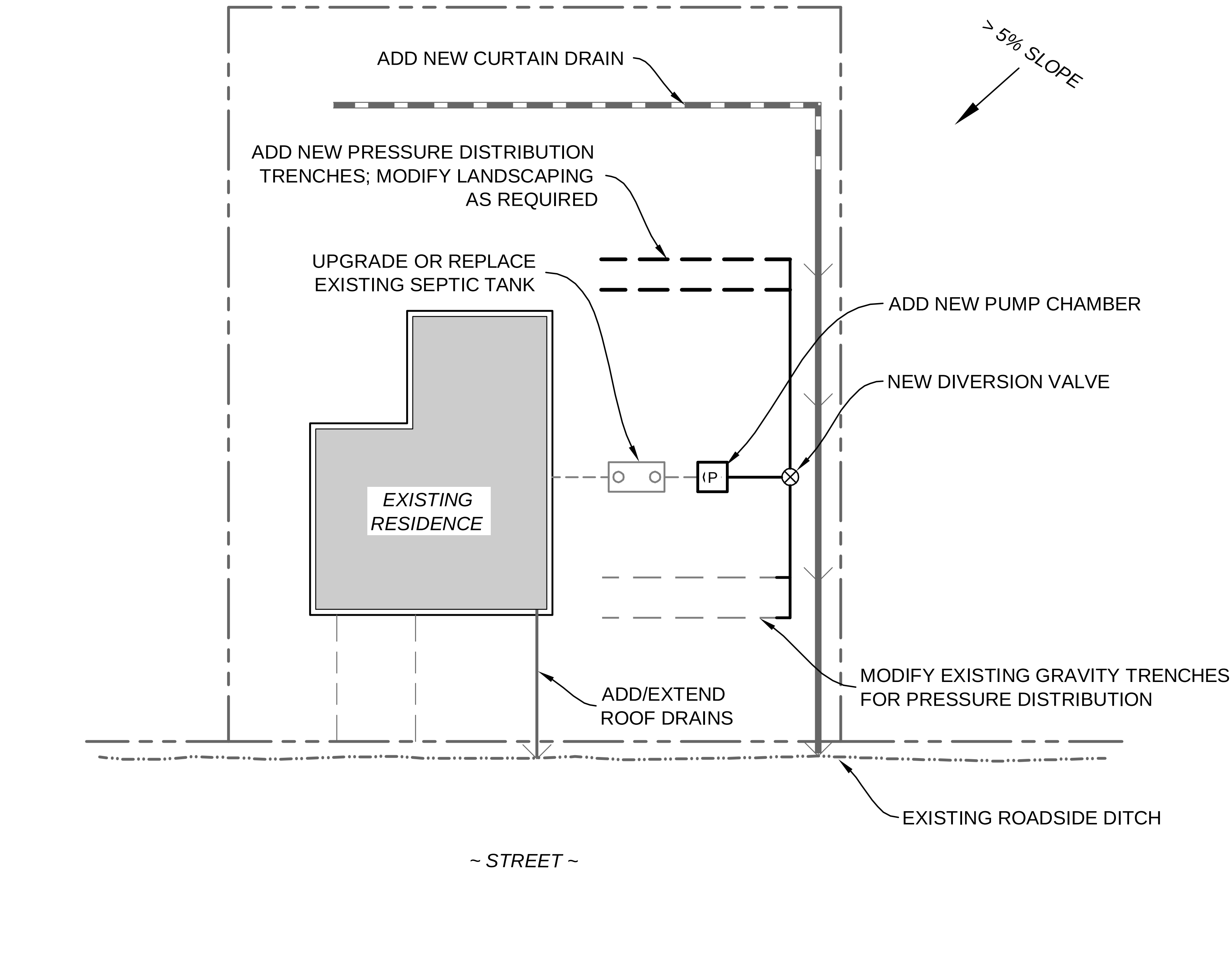
ON-SITE UPGRADE EXAMPLE
TREATMENT AND DRAINAGE

Size: D
Project: 290191
Scale: AS NOTED
FIGURE: 8



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ON-SITE UPGRADE EXAMPLE
DISPOSAL FIELD AND DRAINAGE

Size: D
Project: 290191
Scale: AS NOTED
FIGURE: 9

required for most properties in this category. **Figure 10** illustrates what a typical onsite system upgrade in this category would consist of. Technical information regarding small supplemental treatment units (AdvanTex) and subsurface drip dispersal (Geoflow) are included in **Appendix B**. These are two alternative onsite wastewater technologies that would have applicability for many situations in Woodacre Flats.

The results of this assessment by subarea and overall totals are presented in **Table 9.** Based on 33 properties reviewed, the results indicate that a substantial portion (73%) of the properties in the Woodacre Flats area would require a High level of septic system upgrade/repair work to come into compliance with operating requirements under an onsite wastewater management program approach. A small number of properties (12%) could probably come into compliance with repair standards with less elaborate methods (Moderate level), and about 15% of the properties have existing onsite systems in close conformance with expected standards, such that little if any additional work would be required for compliance. The bottom of in **Table 9** extrapolates the findings of the field reviews to the developed properties in the Study Area, including estimates for both 100% participation of the 150 developed properties, and 75% participation (112 parcels). This gives estimates of the approximate numbers of onsite systems falling into each upgrade/repair level for both participation scenarios.

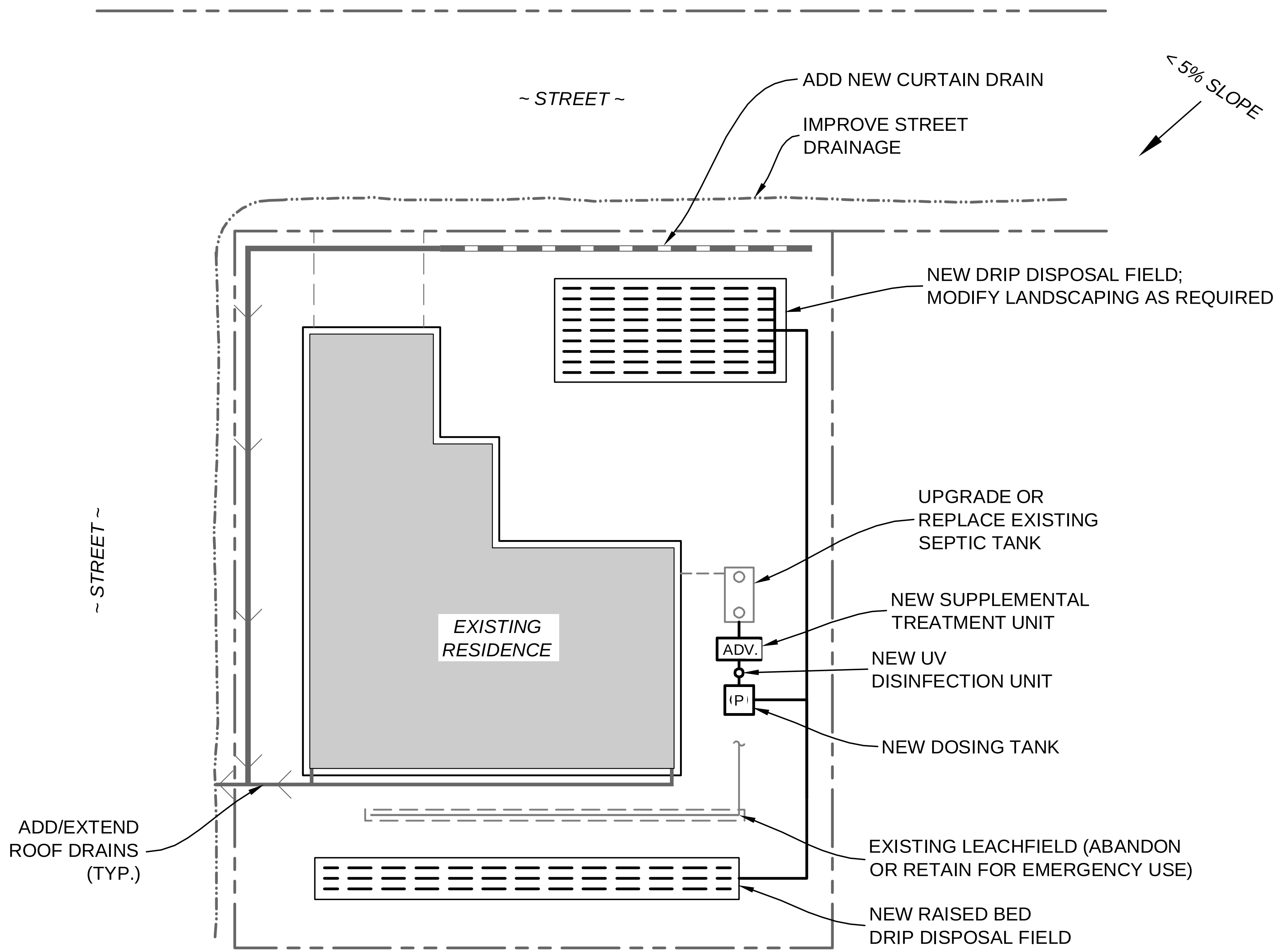
Table 9: Onsite System Upgrade Assessment Needs Summary

Area	Total Properties	Estimated Level of Upgrade (# of properties)		
		Low	Moderate	High
West Subarea	13	3	2	8
Central Subarea	12	2	0	10
East Subarea	8	0	2	6
Total	33	5	4	24
Percent of Total	-	15%	12%	73%
Application of percentage estimates to Study Area:				
100% Participation	150	22	18	110
75% Participation	112	17	13	82

Operation and Maintenance Needs

Following septic system upgrading, a continuing inspection and monitoring program would be carried out by a public maintenance authority; this is assumed to be a requirement of both the County and the RWQCB for implementation of the Tomales Bay Pathogens TMDL. This would be expected to entail the following routine items:

- Inspection of each system, normally once per year;
- Water quality sampling of the effluent from a representative number of treatment units; assume 20 percent of systems sampled each year and all systems sampled at least once every five years;



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ON-SITE UPGRADE EXAMPLE
TREATMENT, DISPOSAL FIELD, & DRAINAGE

Size: D
Project: 290191
Scale: AS NOTED
FIGURE: 10

- Groundwater and surface water quality monitoring;
- Reporting water quality failures or malfunction of systems;
- Annual reporting to the County and RWQCB on the inspection results and overall compliance with water quality and system performance standards; and
- Periodic cleaning and pumping of septic tanks/treatment units, usually every 3 to 5 years;

There would be electrical costs associated with the operation of the advanced treatment systems, any UV disinfection units, and the pump systems used for dosing the pressure distribution and drip dispersal fields. Each property owner would be responsible for providing and maintaining electrical service. From time-to-time various system components (such as valves, UV light bulbs, pumps and float controls) would require repair or replacement. The need for this work would be determined by the maintenance authority; depending upon the complexity, the actual repair/replacement work could be done by the maintenance authority, a contractor or, possibly, the property owner.

To facilitate system maintenance and oversight, it is assumed that a telemetry control system would be included in the system design, so that alarm conditions at individual systems can be relayed and monitored at a remote location by the responsible maintenance authority or contractor.

Estimated Costs

Capital Costs

Table 10 summarizes the estimated range in cost that would be anticipated for an individual system upgrade within Low, Moderate and High upgrade categories, as discussed above. Supporting cost estimation details and assumptions are provided in **Appendix C.** The costs were developed based on Questa's experience with these types onsite system projects Marin County, and included consultation with local contractors, manufacturers, and equipment suppliers. In addition to new construction items, the upgrade costs also include allowance for abandonment of the existing system (as required), electrical work, site restoration, permitting, and testing. The costs do not include an allowance for retrofitting of buildings with low-flow plumbing fixtures or appliances, which would be a homeowner responsibility and likely has already been done in many instances. Cost allowances for contingencies, engineering, environmental, and related project implementation activities are accounted for as lump sum items for this project alternative as a whole, rather than for individual systems (see below).

Table 10:
Estimated Individual Onsite System Upgrade Costs

Item	Low Estimate ($)	High Estimate ($)	Average ($)
Low Level Upgrade	1,500	4,500	3,000
Moderate Level Upgrade	27,500	30,000	28,750
High Level Upgrade	36,000	51,000	43,500

Using the estimated number of upgrades by level of work provided in **Table 9** and the estimated average per system upgrade costs in **Table 10,** overall cost estimates for this alternative were developed. The overall project costs are summarized in **Tables 11** and **12**, respectively, for 100% and 75% participation scenarios. As indicated, in addition to individual system construction, the total project cost estimate includes other allowances as follows: (a) 20% contingency; (b) 15% for engineering and environmental studies; (c) 10% for construction management; and (d) 5% for project administration, district formation and financing. As indicated, the total estimated capital costs for Alternative 2 would be on the order of about $8.37 million for service to 150 parcels in Woodacre Flats, and $6.23 million for service to 112 parcels. The corresponding costs per parcel are estimated to be $55,832 and $55,600, respectively.

Table 11: Estimated Costs for
Onsite Upgrade and Management Program
100% Participation (150 parcels)

Upgrade Work Category	Number of Systems	Average Cost per System	Total Cost ($)
Low Level	22	3,000	$66,000
Moderate Level	18	28,750	$517,500
High Level	110	43,500	$4,785,000
		Subtotal	$5,368,500
		Contingency @ 20%	$1,073,700
		Subtotal	$6,442,200
		Engineering and Environmental Studies @ 15%	$966,330
		Construction Management @ 10%	$644,220
		Project Administration, District Formation and Financing @ 5%	$322,110
		TOTAL	$8,374,860
		Average Cost Per Connection (150 parcels)	$55,832

Table 12: Estimated Costs for
Onsite Upgrade and Management Program
75% Participation (112 parcels)

Upgrade Work Category	Number of Systems	Average Cost per System	Total Cost ($)
Low Level	17	3,000	$51,000
Moderate Level	13	28,750	$373,750
High Level	82	43,500	$3,567,000
		Subtotal	$3,991,750
		Contingency @ 20%	$798,350
		Subtotal	$4,790,100
		Engineering and Environmental Studies @ 15%	$718,515
		Construction Management @ 10%	$479,010
		Project Administration, District Formation and Financing @ 5%	$239,505
		TOTAL	$6,227,130
		Average Cost Per Connection (112 parcels)	$55,600

Operation and Maintenance Costs

Annual operation and maintenance costs for the onsite management alternative are summarized in **Table 13**, including estimates for both 100% and 75% service area participation levels. The estimates are based on best professional judgment and experience with onsite system monitoring activities in Marin County and with other onsite wastewater management programs. Supporting details regarding cost assumptions are itemized in **Appendix C**. As indicated, O&M costs for this alternative include district and program administration costs, labor and expenses to perform the necessary system inspections and reporting, an allowance for equipment and material costs associated with system maintenance and replacement, laboratory costs for water quality sampling and analysis, electrical costs for individual treatment/disposal system equipment (directly absorbed by property owners), and routine septic tank pump-outs. An allowance of 10% is included as a contingency. As indicated, the total annual O&M cost for Alternative 2 is estimated to range from $141,295 for a 150-parcel service area, to $107,206 for 112 parcels. The corresponding annual cost per parcel would be $942 to and $975, respectively, for 150 and 112 parcels.

Table 13:
Estimated Annual Operation and Maintenance Costs for
Onsite Upgrade and Management Alternative

Items	Assumptions	Estimated Annual Cost ($)	
		100% Participation (150 parcels)	75% Participation (112 parcels)
District/Program Administration	Insurance, legal, financial, permits	$ 27,500	$21,700
On-lot System Inspection, Monitoring & Reporting	Annual inspection of all systems, remote monitoring, data compilation, annual reporting, as-needed engineering consultation	$40,950	$31,200
Maintenance	Equipment, materials, maintenance & replacement	$30,000	$22,000
Laboratory & Expenses	Sampling 20% of individual treatment systems annually, surface and groundwater sampling, travel expenses and supplies	$10,500	$8,700
Electrical	Property owner expense for treatment & dispersal pumps and other electro-mechanical items.	$4,500	$3,360
Septic Tank Pumping	25% of tanks pumped annually	$14,000	$10,500
	Subtotal	$128,450	$97,460
	Contingencies (@ 10%)	$12,845	$9,746
	TOTAL	$141,295	$107,206
	ANNUAL COST PER PARCEL	$942	$975

Summary

The onsite upgrade and management alternative would substantially reduce present water quality and public health problems, bring more (as opposed to the No Project option) of the existing onsite systems into conformance with accepted practices, and would do so in a timely manner. The primary shortcoming of this alternative is the heavy reliance on advanced treatment systems and the substantial variances to normal siting and design standards – especially in regard to soil conditions and setbacks from watercourses.

The septic system upgrade efforts, along with establishment of an onsite management program, would largely eliminate the public health hazards and water quality threat from septic systems in the local community, and contribute to improvement in conditions in downstream receiving waters. Existing seepage pits and other disposal systems that drain directly into groundwater or periodically experience surface failures would be eliminated in favor of advanced treatment units, disinfection in some cases, and upgraded dispersal systems, including raised drip disposal beds and other similar alternative technologies. The institution of an onsite wastewater management program would provide the means for monitoring the performance of all upgraded systems, as well as the local environment, for possible wastewater impacts. Potential negative aspects of this plan would be the land disturbance required on individual properties to upgrade on-lot disposal systems, and probable conflicts with other existing or potential uses of the limited yard areas. The septic system upgrades may interfere with parking in some cases, and require changes to landscaping.

This alternative represents a substantial improvement in reliability over existing conditions, through the proposed implementation of an onsite inspection and maintenance program. Alternative 2 would also introduce some additional flexibility for septic system management, by providing for the use of holding tanks (if needed in special cases), and perhaps other design alternatives that would not be approved for operation by individuals outside of a septic system management program, e.g., under the No Project Alternative.

Alternative 2 would not bring about any significant land use/development changes in Woodacre Flats; however, an onsite wastewater management program would make it possible for house remodeling and some amount of additions to existing structures. There would be no assurance that undeveloped properties could be developed, or that house additions/remodeling could be undertaken without restrictions and conformance with Marin County EHS Remodel Policy.

ALTERNATIVES 3A, 3B & 3C – FIRE ROAD COMMUNITY LEACHFIELD

Description

This alternative, which includes three different variations, provides for the construction of a central wastewater collection system for the Woodacre Flats Study Area, leading to a community leachfield system located on nearby forested lands (**Figure 11**). The area identified as a potential community leachfield site is a wooded knoll along the Fire Road ridgeline northeast of Woodacre on property owned by Dickson Ranch. The property owners granted access to Questa Engineering staff for field studies to evaluate various locations on the Dickson Ranch for potential use as a community wastewater treatment and disposal site for Woodacre Flats. The three different community leachfield options formulated and evaluated under this alternative are:

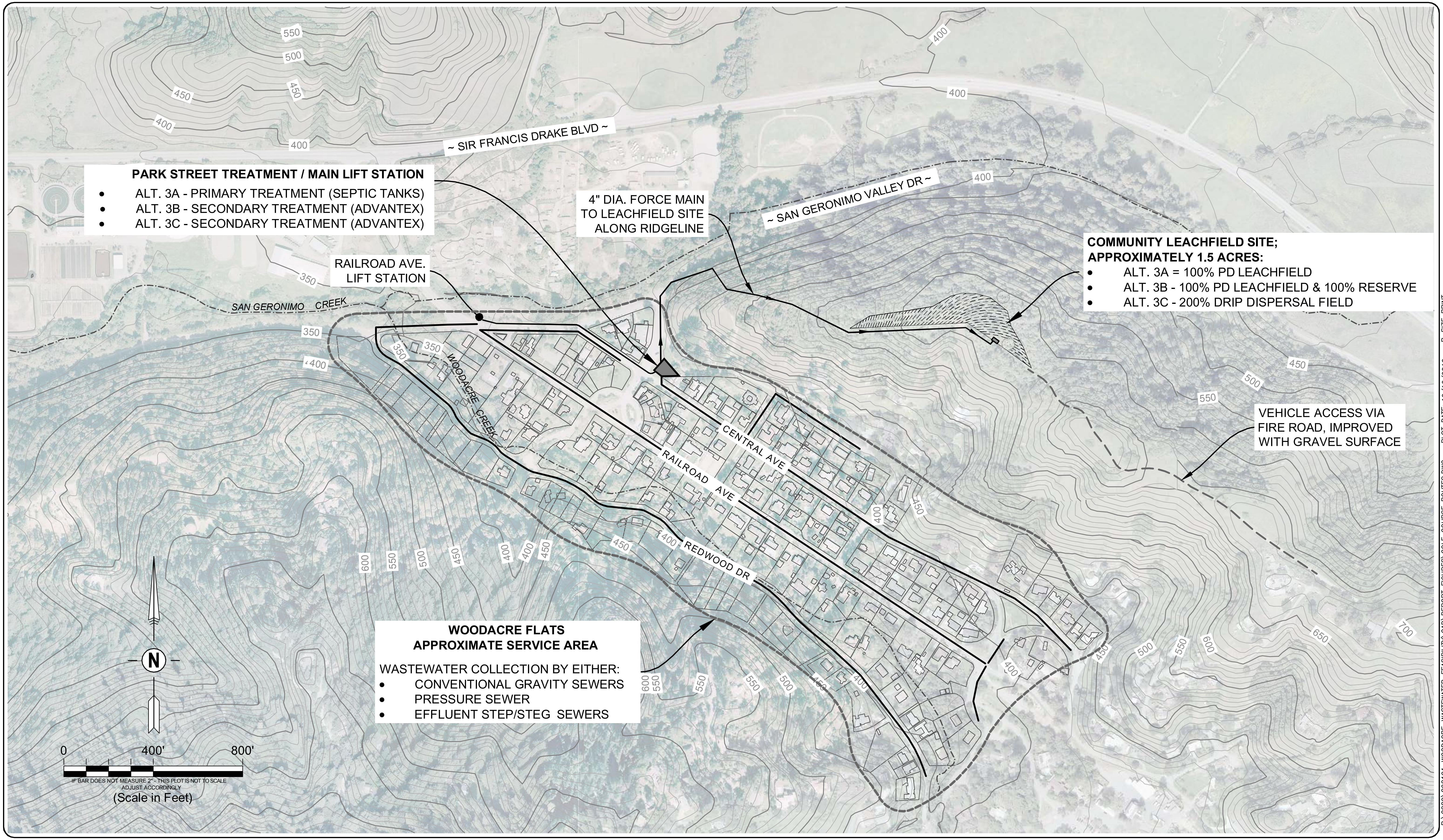
- **Alternative 3A** - Primary/septic tank treatment with a shallow pressure distribution leachfield, sized to provide 100% disposal capacity and no reserve area.

- **Alternative 3B** - Secondary treatment (AdvanTex filter) with a shallow pressure distribution leachfield, sized to provide 100% disposal capacity plus 100% reserve area.

- **Alternative 3C** - Secondary treatment (AdvanTex) with a subsurface drip dispersal leachfield, sized to provide 200% disposal.

Collection System

Several possible wastewater collection system options were evaluated, including conventional gravity sewers, pressure sewers, and effluent sewers in which septic tanks are retained on



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WOODACRE FLATS
WASTEWATER FEASIBILITY STUDY

WOODACRE, CALIFORNIA

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FIRE ROAD COMMUNITY LEACHFIELD
WASTEWATER ALTERNATIVES 3A, 3B & 3C

FIGURE
11

individual properties for solids collection. All collection system options provide for bringing the wastewater to a central location at the intersection of Park Street and Central Avenue. The eastern portions of the Study Area (along Taylor and Central Avenues) could flow by gravity to the Park Street location. Sewage flow from properties along Railroad Avenue would be collected in a neighborhood lift station at the intersection of Railroad Avenue and San Geronimo Valley Drive, and from there pumped to Park Street. A pressure or STEP sewer line would be provided for properties along Redwood Drive, requiring individual pump units at each residence.

At Park Street a main lift station would be installed to pump the wastewater via a force main to the community leachfield site at the Fire Road ridge location, which is at an elevation approximately 230 feet above Park Street. If a secondary treatment system is included (per Alternatives 3B and 3C), the treatment plant would also be installed at this Park Street location.

A full description and review of collection system alternatives, including equipment and pipeline routing details, operational requirements and cost comparisons are provided in Appendix D. Since a central collection system is also an element of Alternative 4, the analysis in Appendix D includes information applicable to Alternative 4 as well as Alternatives 3A-3C.

As detailed in Appendix D, conventional gravity sewers, pressure sewers (using grinder pumps) or effluent sewers using a combination of pump (STEP) and gravity (STEG) connections are all feasible and compare closely in terms of costs, layout and other operational factors. However, the collection analysis determined that effluent STEP/STEG sewers would be favored for community leachfield alternatives on the basis of cost and the ability to limit entry of extraneous water into the sewer system from groundwater and rainwater infiltration and inflow (I/I). Conventional gravity sewers expose the collection system to higher amounts of I/I through pipe connections and manholes. The high groundwater conditions in Woodacre Flats would make a conventional gravity sewer vulnerable to I/I, which could be damaging for a community leachfield system, putting greater stress the limited soil absorption capacity. Effluent sewers use small diameter pipe, with glued, fuse or threaded fittings, and have cleanouts but no manholes. Also, for the Fire Road site, the increased energy requirements and costs of pumping unnecessary I/I up to the ridgeline leachfield area could be significant.

Treatment Facilities

Different levels and types of treatment were considered and used to define different options under Alternative 3. The level of treatment required for different community leachfield options is dictated partly by the type of disposal system and in turn by the site constraints and overall performance requirements for the particular site. For example, primary (septic tank) treatment can be used in conjunction with a conventional leachfield design, including shallow pressure distribution trenches. However, an advanced (secondary) level of treatment may be warranted or required, for instance, for areas having shallow soils and groundwater depths, for very rocky soil conditions, where setbacks are limited, and to allow increased wastewater loading rates to the soils. Secondary treatment, including nitrogen reduction and/or disinfection, may also be needed to overcome other environmental site sensitivities, such as nitrate additions to groundwater or other potential impacts to water supply source areas. Also, secondary treatment is necessary in conjunction with the use of subsurface drip dispersal methods.

For the Fire Road community leachfield alternative, various treatment technologies were considered and reviewed for their applicability, as discussed below.

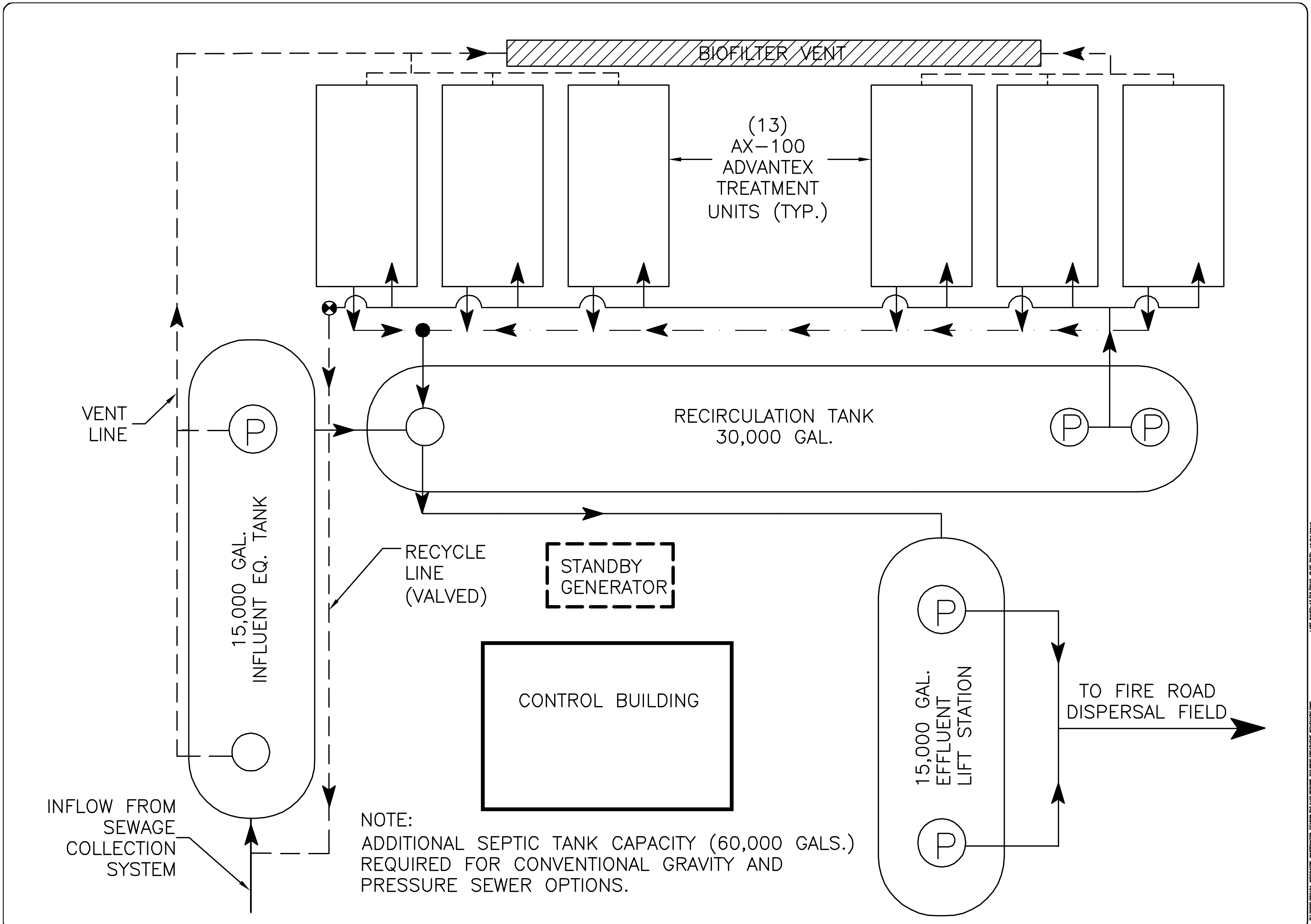
Primary Treatment. It was determined that primary treatment only (i.e., septic tanks), would be acceptable for the soil conditions at the Fire Road site, and would represent the simplest community leachfield approach. Therefore, septic tank treatment was identified as the treatment process for Alternative 3A. Based on the recommended use of an Effluent STEP/STEG collection system (per above), basic septic tank treatment under this alternative would occur at the individual tanks on each property, and there would be no need for community septic tanks. This is the design approach that was adopted for the Marshall Phase 1 Community Wastewater System. A variation of this alternative might include the use of one or more community septic tanks (e.g., located at the Park Street area), which might be found cost effective as a result of value engineering analysis during project design. However, at this stage of analysis it is reasonable to plan for individual septic tanks at each parcel. Under this approach, the septic tank effluent would be collected at the Park Street site where a main lift station would be located, from which the wastewater would be pumped into a force main (buried) leading to the Fire Road Leachfield site.

Secondary Treatment. Alternatives 3B and 3C would both include a secondary treatment system to improve the quality of wastewater effluent prior to dispersal in the leachfield (3B) or dripfield (3C). In Alternative 3B, secondary treatment would allow the same quantity of wastewater to be dispersed in a smaller amount of leachfield (50% less than for primary treatment) as a result of the reduced solids and organic loading to the soils. In Alternative 3C, secondary treatment would be included to bring the effluent quality to a level suitable for use with subsurface drip dispersal tubing. The identified location for the secondary treatment system, for both 3B and 3C, would be at the Park Street area. Following treatment, the wastewater effluent would collect in a main lift station and from there would be pumped in a force main to the Fire Road Leachfield site (same as Alternative 3A).

The secondary treatment requirements for Alternatives 3B and 3C would be the same, and there are a multitude of treatment technologies that could be used. Options include a recirculating sand filter, proprietary packed bed filter such as AdvanTex, and various proprietary aerobic treatment systems. Based on the small amount of required land area, either an AdvanTex system or an aerobic treatment unit would be preferred over a recirculating sand filter. In our experience the AdvanTex system would likely be a competitive option and, therefore, we have used it for our analysis. It is recognized in Marin County Regulations as an accepted secondary treatment system; technical information on the AX-100 system, suited for community-scale applications, is provided in **Appendix B**.

A schematic layout of an AdvanTex system to meet the project needs is provided in **Figure 12.** As indicated, the system would include the following components:

- **Flow Equalization.** Effluent from the collection system would first enter a flow-equalization (EQ) tank, which would serve to regulate flow of wastewater into the AdvanTex treatment tank. It can be sized to provide additional septic tank treatment



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SECONDARY TREATMENT SCHEMATIC
(ALTERNATIVE 3B AND 3C)

Size: D
Project: 290191
Scale: AS NOTED
Sheet: 12

capacity, emergency storage capacity, and would also be available to be used as a denitrification recycle loop, if needed. At a minimum, the operating level in the EQ tank would be set to absorb and even-out surges in flow. The EQ tank will be vented to a subsurface biofilter, carbon filter vent or equivalent system to mitigate odors.

- **AdvanTex Unit**. The AdvanTex treatment system provides secondary treatment for removal of biochemical oxygen demand (BOD), solids, and nitrogen. It is a multi-pass, packed bed aerobic wastewater treatment technology specifically designed and engineered for long-term processing of domestic strength wastewater. When effluent enters the recirculation tank, it blends with the contents of the tank and is transported to a distribution manifold in the AdvanTex filter pods by a pump included with the system. Effluent then percolates down through the textile media, where it is treated by naturally occurring microorganisms that populate the filter. After passing through the filter, the treated effluent flows out of the filter pod through the filtrate return line that returns the effluent to the recirculating valve. The function of this valve is to automatically split or divert the flow between the recirculation tank and the final discharge and controls the liquid level within the tank. With the configuration in **Figure 12**, a series of thirteen AdvanTex pods (Model AX-100) would be required to for the projected wastewater of 31,500 gpd (based on 2,500 gpd capacity per pod).

- **Sludge Disposal.** Wastewater sludge (septage) would be collected and stored in septic tanks within the collection system and in the EQ and recirculation tanks at the treatment plant. Accumulated septage would be pumped periodically, as needed, from the various tanks and hauled for disposal at approved septage receiving facilities in Marin County.

- **Telemetry.** The treatment plant and lift stations would be equipped with a telemetry control system that allow remote monitoring and control of various mechanical and electrical equipment and tank water levels. The control system would be monitored and maintained by a qualified maintenance contractor. Although the system will typically require weekly attendance by an operator, the telemetry system will provide for continuous (24-hour) monitoring and emergency response from a remote location. The control system will provide for logging of data on system operations (e.g., flow and pump operations), and will have auto-dialer features to page the operator(s) in the event of alarm conditions.

- **Emergency Generator.** A standby emergency generator would be provided at the treatment plant site to operate the treatment plant and the main lift station in the event of a power outage.

- **Control Building.** A small control building, 250 ft^2 or less, would be provided at the treatment plant site for the location of electrical control equipment, supplies, spare parts, and other materials.

It is estimated that the treatment plant layout as shown in **Figure 12** and described above would require an area of approximately 10,000 ft^2, which can be accommodated in the County right-of-way area at the intersection of Park Street and Central Avenue.

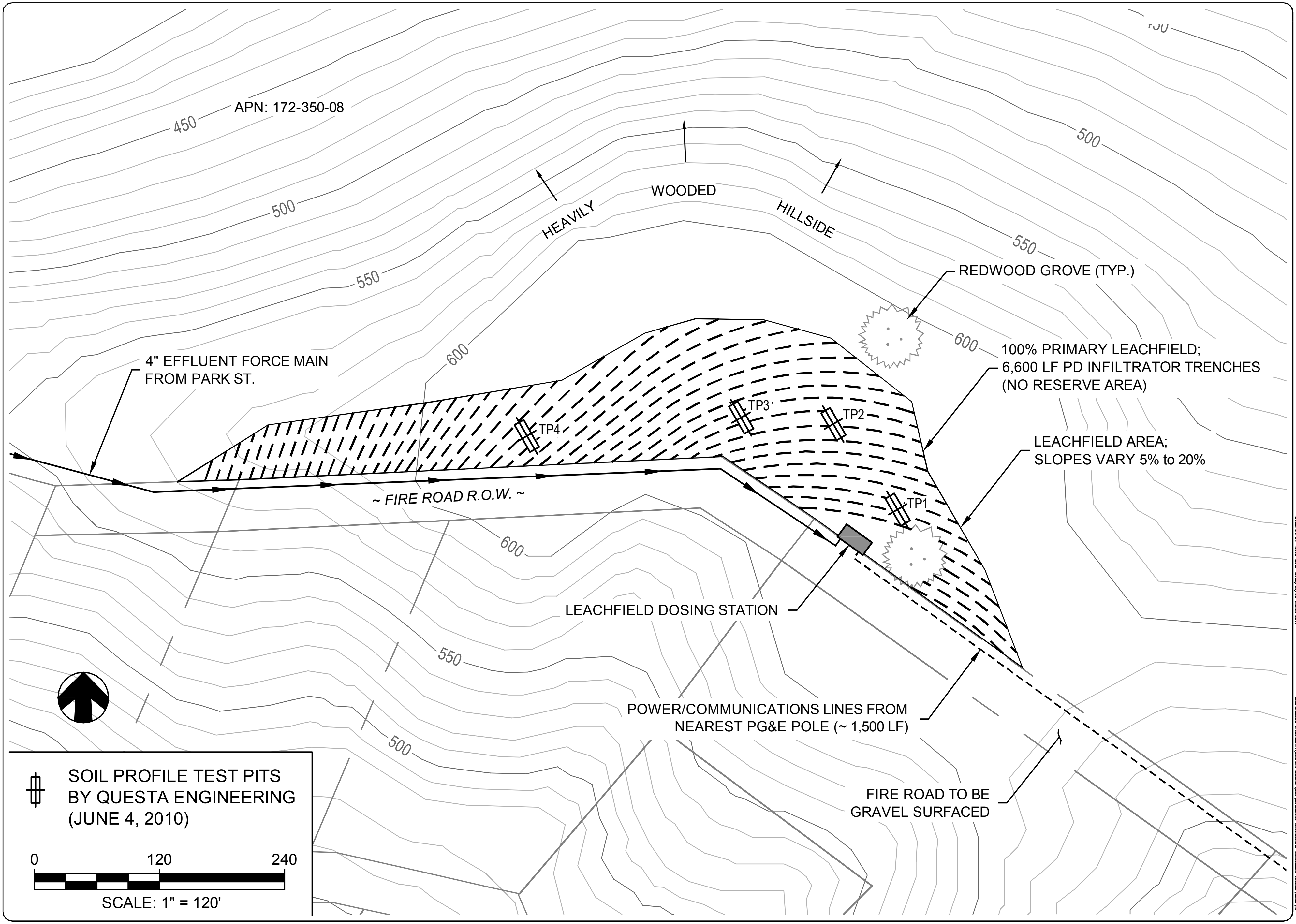
Disposal Facilities

Fire Road Site Conditions. Field reconnaissance investigations were conducted on several large properties in the Woodacre area to identify sites that might be suitable and of sufficient size to accommodate a community wastewater disposal system. A few potential sites were located on the Dickson Ranch property and on lands owned by the Tamalpais Union High School District, east of Woodacre. Based on the amount of area, soil conditions, and land owner interests and concerns, the most promising site identified was an approximately 1.5-acre wooded knoll on Dickson Ranch property located along the Fire Road ridgeline. This is referred to as the Fire Road Site and, from preliminary analysis, was estimated to have sufficient capacity to accommodate a community leachfield system of the size required to serve the Woodacre Flats area. The Fire Road Site is included as the community leachfield area for Alternatives 3A, 3B and 3C.

The Fire Road Site was initially identified as a potential area of interest from review of air photos, and topographic and geologic maps. It lies on a portion of the ridgeline composed of sandstone. The area considered suitable for a community leachfield a 1.5-acre knoll, extending approximately 1,000-feet along the ridgeline in a southeast-northwest direction, sloping predominantly to the north and northeast at grades varying from about 5 to 20 percent. A small portion of the site (estimated 5 to 10 percent) drains in a southwesterly direction toward Woodacre. Immediately north of the knoll, the slopes steepen considerably to greater than 30%, which continue downhill to San Geronimo Valley Drive. The knoll is wooded, mostly with bay trees, a few oaks and Douglas fir, and two distinct clusters of redwoods. There is a limited amount of understory vegetation. The steeper hillslopes to the north and northeast are densely wooded, with predominantly with redwoods and Douglas fir. There is no development on the site or on any lands between the site and San Geronimo Valley Drive.

As a result of its topographically high position, there are no watercourses on or within 200 to 300 feet of the Fire Road site. Runoff from the site is dispersed by sheet flow, and is slowed by the gentle slopes, vegetative cover, and sandy soil conditions. Farther down the hillslope to the north and northeast, swales form which eventually become seasonal drainages at the base of the hillslope near San Geronimo Valley Drive. There are no known wells on the site or in the immediate vicinity. The nearest well an agricultural supply well located approximately 600 feet to the southeast.

Following initial hand-auger soils inspection, four exploratory test pits were excavated in the Fire Road site by Questa on June 4, 2010, to evaluate soil suitability for wastewater disposal. Test pit locations are shown in **Figures 13-15**. All test pits showed similar soil conditions, consisting of loam and sandy loam topsoils underlain by highly weathered sandstone to the depth explored. No groundwater or evidence of seasonal saturation was observed in any of the profiles. **Table 14** summarizes the soil profiles logs.



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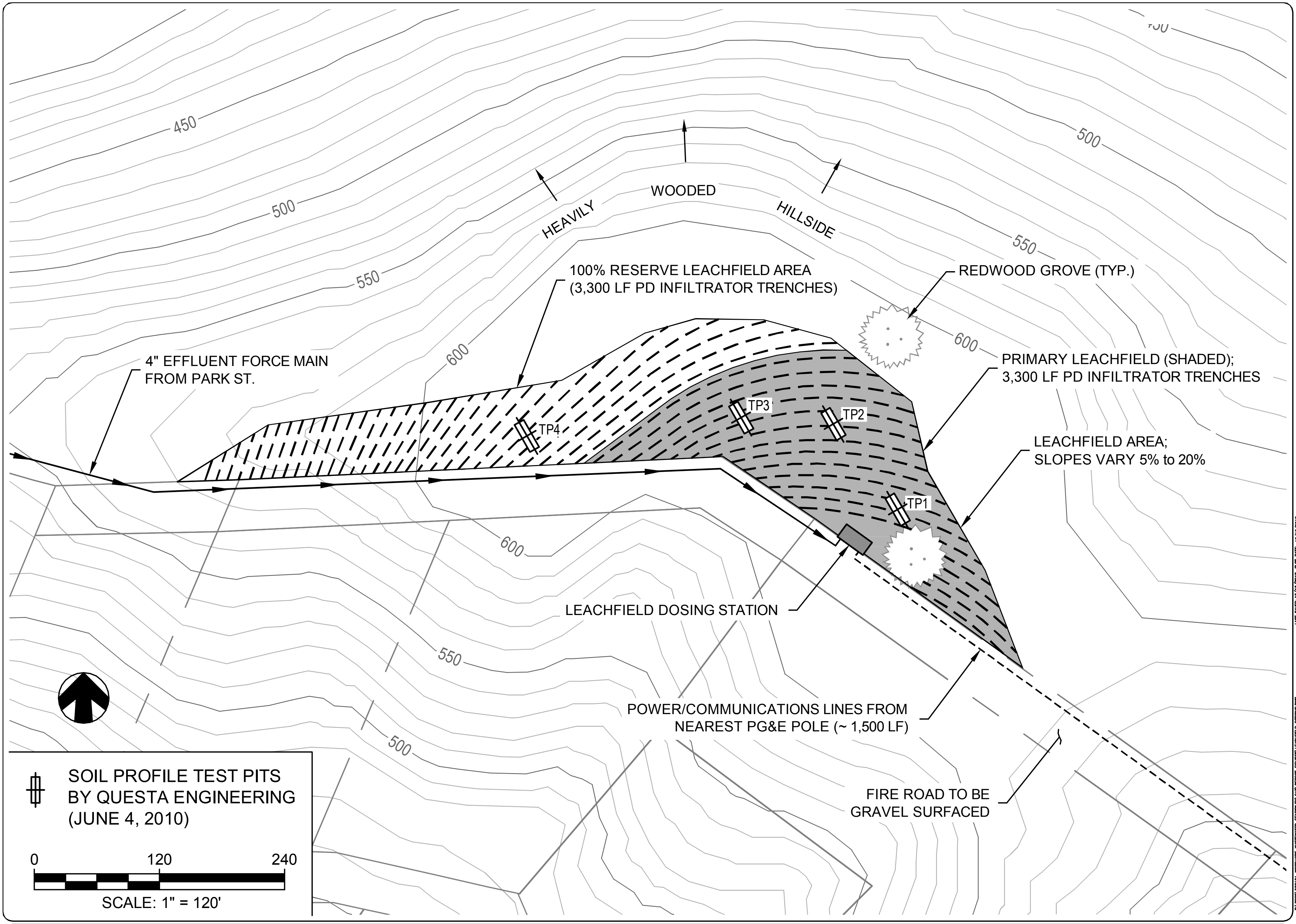
ALTERNATIVE 3A - FIRE RD LEACHFIELD
PRIMARY TREATMENT - PD LEACHFIELD

Size: D
Project: 290191
Scale: AS NOTED
FIGURE: 13



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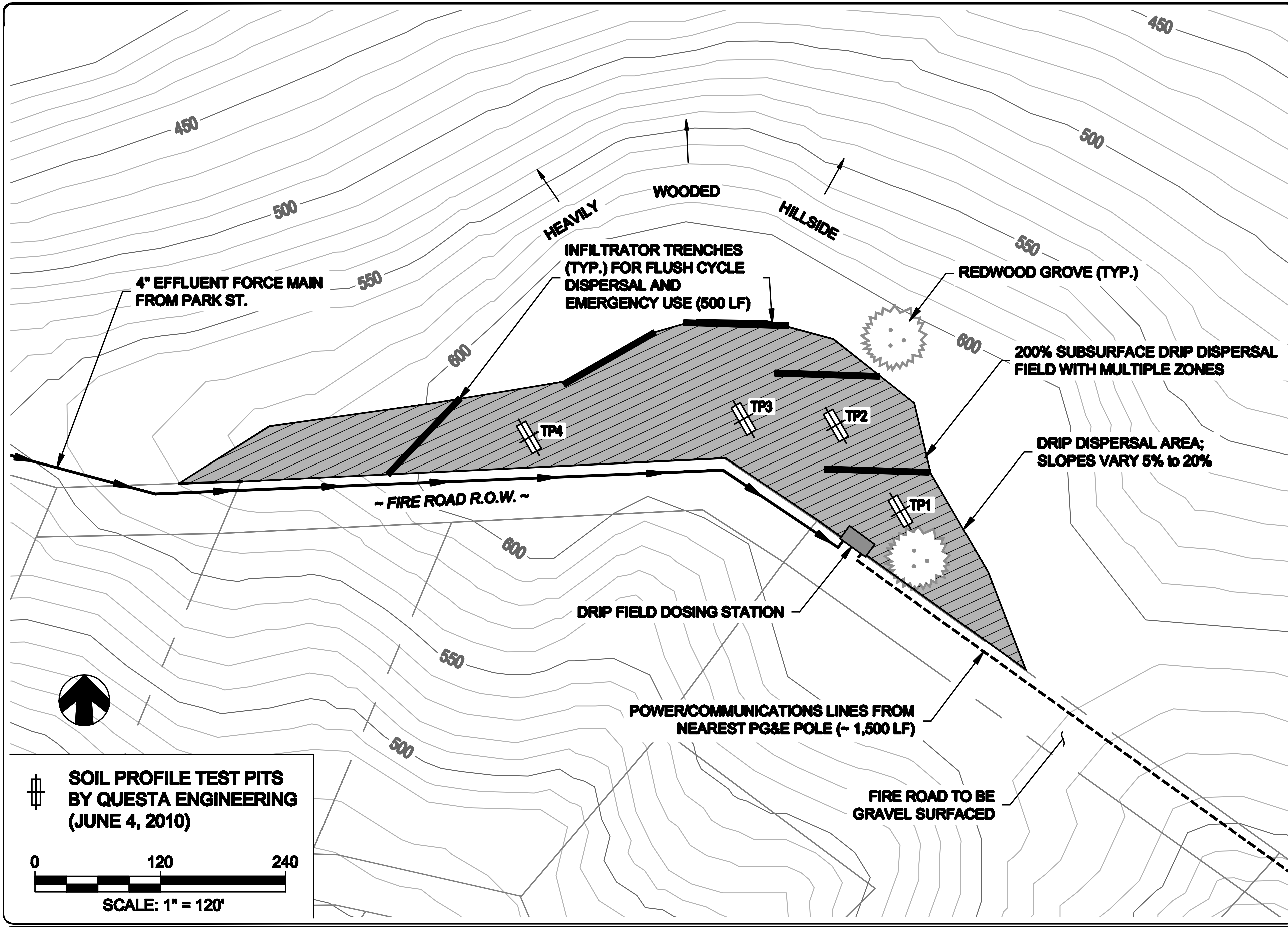
ALTERNATIVE 3B - FIRE RD LEACHFIELD
SECONDARY TREATMENT - PD LEACHFIELD

Size: D
Project: 290191
Scale: AS NOTED
FIGURE: 14



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ALTERNATIVE 3C - FIRE RD LEACHFIELD
SECONDARY TREATMENT - DRIP DISPERSAL

Size: D
Project: 290191
Scale: AS NOTED
FIGURE: 15

Table 14: Soil Profile Summary, Fire Road Site

Test Pit #	Depth (inches from surface)	Soil Description
T-1	0 - 21	Loam
	21 - 66	Very weathered sandstone
	66 - 90	Very weathered sandstone, increasing density
T-2	0 – 24	Fine sandy loam
	24 – 66	Highly weathered sandstone; textures to sandy clay loam
	66 - 78	Weathered sandstone, very soft and friable
T-3	0 - 16	Loam to sandy loam
	16 – 72	Weathered sandstone, variable from sandy loam to sandy clay
T-4	0 – 28	Sandy loam
	28 - 60	Very weathered sandstone; textures to sandy loam

No percolation testing conducted; however, based on the observed sandy soil conditions and experience with other similar soils in the Woodacre area, we estimated soil percolation rates would likely be in the range of 5 to 15 minutes per inch (MPI), with faster rates in the upper 2 to 3 feet and becoming slower with depth. These percolation rates would be suitable for disposal of either primary/septic tank effluent or secondary treated wastewater effluent, making the site feasible for a variety leachfield designs, including standard and pressure distribution trenches (2 to 5-feet deep), mound systems, or subsurface drip dispersal. Formal percolation testing in accordance with standard Marin County procedures should be conducted prior to final project selection and design to verify percolation rates and leachfield sizing for the service area and wastewater flows to be accommodated. Ideally, this should be completed during environmental review.

Community Leachfield Options. Based on the favorable soil and site conditions along with the amount of available land area, several different design options and configurations were considered for the Fire Road site. This resulted in the development of three different community leachfield alternatives, 3A, 3B and 3C, which are illustrated in **Figures 13**, **14** and **15**, respectively. **Table 15** presents an itemized listing of the elements and design factors for each of the three leachfield alternatives, which are discussed below.

- **Alternative 3A.** The first Fire Road option is a shallow pressure distribution leachfield system for disposal of septic tank effluent. The trenches would be constructed with the use of Infiltrator Chambers to eliminate the need for hauling large quantities of drain rock to the Fire Road site. The trenches would be 30-inches deep and 36-inches wide, with an effective wastewater application area of 5 ft^2 per lineal foot. This is based on the combination of 3-ft wide bottom area plus 12 inches sidewall area (two sides), following sizing criteria contained in the RWQCB Minimum Guidelines. Minimum trench spacing would be 6 feet (on centers); however a spacing of 10 feet has been assumed to provide a reasonable margin of safety for avoidance of trees and other local incongruities in the topography. Using an average percolation rate of 10 minutes per inch (MPI) would give a wastewater loading rate of 0.8 gpd/ft^2, or 4.0 gpd/lineal foot of trench. Although the use of Infiltrator Chambers is recommended, if rock-filled trenches are preferred from a regulatory standpoint or for other reasons, the trench dimensions and overall sizing would be the same as presented above. No extra capacity credit is assumed for the use of Infiltrator Chambers in this analysis. The costs for rock-filled trenches and rock-hauling impacts would be greater than for the recommended Infiltrator Chamber design.

For a design wastewater flow of 26,250 gpd (150 parcels at 175 gpd/parcel), the required leachfield length would be 6,563 lineal feet for a 100% system (round to 6,600 lf). The available disposal area at the Fire Road site is estimated to be approximately 65,000 to 66,000 square feet, which would accommodate approximately 6,500 to 6,600 lineal feet of trench at 10-foot o.c. trench spacing. Therefore, under this alternative all available area at the Fire Road site would be utilized to provide capacity for 100 percent of the daily design flow, with no additional reserve area.

An alternative leachfield design approach following Marin County regulations for individual systems would include the use narrower, deeper trenches, e.g., 18-inches wide by 46-inches deep to provide the same amount of effective wastewater application area. In this design the application area is assumed to be two sidewalls, 30-inches depth below distribution pipe, with a 2-inch distribution pipe and 2 inches of gravel cover, plus 12 inches of soil backfill. It would occupy the same overall area and provide the same leaching capacity. As noted above, standard rock-filled trench design would have higher costs and greater rock-hauling impacts than the recommended Infiltrator Chamber design.

For the smaller 75% service area participation (112 parcels), the Fire Road site would be able accommodate a 100% leachfield and provide room for 50% reserve area. Alternatively, a 150% capacity system could be installed and zoned into three sections, with two zones active and one zone inactive at all times.

- **Alternative 3B.** This alternative would include a secondary treatment system that would have the effect of reducing the required leachfield area by one-half compared with Alternative 3A. Using the same pressure distribution system design as for Alternative 3A (including Infiltrator Chambers), the wastewater loading rate would increase two-fold from 0.8 to 1.6 gpd/ft^2. This would increase the loading rate to 8 gpd/ft^2, and reduce the overall trench requirement to approximately 3,280 lineal feet (round to 3,300 lf). Using the same trench spacing of 10 feet o.c., the leachfield would occupy approximately half of the available disposal area, leaving enough unused area to serve as a 100% replacement area.

  For the smaller 75% service area participation (112 parcels), under Alternative 3B the Fire Road site would be able accommodate a 100% leachfield and provide room for more than 150% reserve area.

The assumption of a higher wastewater loading rate for dispersal of secondary treated water is derived from Marin County regulations (in effect since 1996) and is supported in technical literature (e.g., U.S. EPA Onsite Wastewater Treatment Systems Manual, 2002). Marin County regulations authorize increased leachfield loading rates (as compared with standard septic tank effluent) for systems that include advanced treatment using either an intermittent sand filter, recirculating sand filter, or packed bed filter such as AdvanTex. For soils with percolation rates up to 90 minutes per inch, the application rate may be increased up to two times the standard rate for septic tank effluent. The scientific rationale is that wastewater with low organic strength (low BOD) reduces the amount of organic material delivered to the soil absorption field, and promotes the maintenance of aerobic soil conditions and microbial populations that are more efficient (as compared with anaerobic bacteria) in assimilating the organic materials in the effluent. The net result is reduced soil clogging and better water transmission through the soil.

- **Alternative 3C.** Using the same secondary treatment system as 3B, Alternative 3C would include a subsurface drip dispersal system in lieu of the shallow pressure distribution leachfield system included in the other two Fire Road alternatives.

  The drip dispersal system uses a specially manufactured dripline, such as Geoflow Wasteflow™, developed for wastewater applications. Technical literature describing subsurface drip dispersal equipment and design/installation procedures is provided in **Appendix B.** In brief, the dripline consists of 1-inch diameter polyethylene tubing with pressure-compensating emitters spaced 12 to 24 inches apart. The driplines are typically installed at a depth of 6 to 12 inches in below ground surface, and up to 18 inches in wooded areas. Spacing between driplines depends is typically 24 inches, although it can be varied around vegetation. The drip dispersal system would be organized into a series of zones (of roughly equal disposal capacity) to be dosed from the central wastewater effluent dosing station at the disposal site.

  The sizing and design of the drip field would follow criteria contained in Marin County sewage disposal regulations and manufacturer recommendations. The sandy/loamy soil conditions at the site would warrant a wastewater application rate in the range of 0.6 to 1.0 gpd/ft^2, based on the surface area of the disposal field. Using an average value of 0.8 gpd/ft^2, the required disposal area for a design flow of 26,250 gpd would be about 32,800 square feet. Including an additional 100% reserve field, the required area would be double, or about 65,600 square feet. The estimated 65,000 to 66,000 square feet at the Fire Road site would accommodate both a 100% primary and 100% reserve drip field. Installation of both primary and reserve drip fields is advisable to accommodate peak flows and for overall reliability. Therefore, Alternative 3C would include installation of a 200% system (primary plus reserve).

Table 15: Community Leachfield Design Assumptions
(Design Flow: 26,250 gpd)

Alternative	Treatment	Leachfield Details
3A	Primary (Septic Tanks)	▪ Pressure distribution leachfield, w/Infiltrator Chambers ▪ Trench depth - 30 inches ▪ Trench width - 36 inches ▪ Effective Application Area – Sidewalls + Bottom; 5 ft^2/lf ▪ Trench spacing – 10 feet o.c ▪ Wastewater application rate - 0.8 gpd/ft^2 (estimated) ▪ Total trench length – 6,600 L.F. ▪ Total leachfield area - 1.5 acres (primary only) ▪ Setbacks - No streams within 200+ feet; no wells within 500 feet
3B	Secondary	▪ Pressure distribution leachfield, w/Infiltrator Chambers ▪ Trench depth - 30 inches ▪ Trench width - 36 inches ▪ Wastewater application rate – 1.6 gpd/ft^2 (2 x standard rate per 3A) ▪ Total trench length – 3,300 L.F. ▪ Trench spacing - 10 feet, o.c. ▪ Total leachfield area - 1.5 acres (primary + 100% reserve) ▪ Setbacks – No streams within 200+ feet; no wells within 500 feet
3C	Secondary	▪ Drip dispersal ▪ Dripline at 6 to 12 inches deep ▪ Wastewater application rate - 0.8 gpd/ft^2 (estimated) ▪ Total drip field area - 1.5 acres (200%) Setbacks – No streams within 200+ feet; no wells within 500 feet

Other Facilities. Other elements of the disposal facilities that would be common to Alternatives 3A, 3B and 3C include the following:

- **Effluent Force Main from Park Street.** A 4-inch diameter force main, approximately 2,200 feet long, would be installed to convey wastewater effluent from the main lift station at Park Street to the Fire Road site. The recommended route as shown in **Figure 12** would be via Park Street, then San Geronimo Valley Drive, and then overland through Dickson Ranch property along the ridgeline to the Fire Road leachfield site.

- **Effluent Dosing Station.** An effluent dosing station would be installed near the southerly end of the Fire Road site (high point). It would consist of a large tank (e.g., 15,000 gallon fiberglass) and multiple pumps and control system. The control panel would be housed in a small building or enclosure (e.g., <100 ft^2). For emergency purposes (power or pump outages), a gravity dosing tank to a series of overflow leachlines would be installed and the control system would be designed to be operated with a portable generator.

- **Electrical Power.** Electrical power from PG&E would be brought to the Fire Road site from the nearest location, estimated to be about 1,500 feet away on Fire Road.

- **Fencing.** The 1.5-acre leachfield site, including the dosing station, would be fenced with typical farm fencing (barbed wire) to keep animals out of the site.

- **Fire Road Access Improvements.** Improvements (grading and gravel surface) would be made to Fire Road to provide all weather vehicle access to the leachfield site.

- **Land Acquisition.** The land for the leachfield and the effluent force main to the site would have to be purchased or an easement acquired from the Dickson Ranch. The property owners willingly granted access for the investigation of the Fire Road leachfield site as well as preliminary exploration of other areas of the Dickson Ranch. They indicated interest in cooperating with the community and also expressed interest in possibly being incorporated into the service area for a community wastewater system.

Regulatory Requirements

Regulatory requirements applicable to subsurface leachfields for a community system would be basically the same as those described in the discussion under Alternative 2 relative to individual septic systems. Based on the discussions with RWQCB and Marin County EHS staff (*personal communications, April 13, 2010, with Rebecca Ng, Armando Alegria, Robert Turner and Blair Allen)*, additional requirements that would be anticipated to apply to a Woodacre Flats community leachfield system include the following:

- **Permitting.** A community system of the scale being considered for Woodacre Flats would be regulated by the RWQCB through the issuance of Waste Discharge Requirements (permit) for the community facilities.

- **Treatment Level**. The level of treatment prior to disposal may include either primary treatment (septic tanks) or secondary treatment; the level of treatment included in the system would dictate the sizing and design options for the leachfield. Based on present soils information, a community leachfield at the Fire Road site would not require effluent disinfection; however, it could be incorporated in response to further soils information or the outcome of other environmental studies. The need for nitrogen removal would be determined through environmental studies of the community leachfield site, focusing on potential impacts on water supplies located downslope/downgradient of the leachfield site.

- **Monitoring.** Secondary treatment systems would likely require monitoring influent and effluent for multiple parameters, including BOD, total suspended solids, and probably nitrogen. Monitoring of a primary treatment system (septic tank), would likely be limited to effluent sampling for these same parameters. The monitoring frequency would likely be monthly at system startup, possibly reducing to quarterly in the future, depending upon successful performance. Receiving water sampling (quarterly) at groundwater monitoring wells installed upgradient and downgradient should also be assumed. There are no surface waters near the Fire Road leachfield site that would require monitoring.

Operation and Maintenance Requirements

Under Alternatives 3A, 3B and 3C, the community collection, treatment and disposal facilities would be owned and operated by the wastewater district formed as part of the project. The actual operations and maintenance work would be performed or overseen by a qualified wastewater treatment plant operator. Local maintenance contractors may be hired to perform routine inspection, maintenance, and monitoring activities. Operation and maintenance activities can be expected to include the following:

- **Facility Inspections, Maintenance and Operations.** This includes routine inspections and maintenance of the individual STEP and STEG units, collection system pipelines and valves, lift stations, community treatment system (as applicable), leachfield/dripfield dosing pumps and pipelines, and leachfield/dripfield piping, trenches and valves, and all electrical/mechanical control equipment. Other maintenance work includes the pump-out and hauling of sewage solids from septic tanks and other treatment units, general upkeep of the treatment plant grounds, and periodic servicing or replacement of equipment. The inspection, maintenance and operations of the facilities would be conducted on an as needed basis; it would be facilitated by remote telemetry equipment for notification of alarm conditions. Some level of onsite inspection and/or maintenance work is likely to occur on a weekly basis.

- **Performance Monitoring.** The waste discharge permit for the community wastewater facilities will require routine monitoring of the wastewater treatment and disposal facilities to verify compliance with performance standards and proper operation. A formal monitoring and reporting program will be established by the RWQCB as a permit condition. This is anticipated to include monitoring of wastewater flow, influent and effluent quality, and disposal field conditions. Daily flow monitoring and monthly/quarterly sampling frequency are anticipated. Wastewater flow monitoring can be done automatically with a recording flow meter.

- **Receiving Water Quality Sampling.** The waste discharge requirements and operating permit may also include requirements for sampling and analysis of groundwater near and downgradient of the leachfield sites. The expected parameters of interest would be nitrate and coliform bacteria. Monthly sampling frequency should be anticipated. There are no surface waters near the Fire Road leachfield site that would require monitoring.

- **Reporting.** The monitoring results would be summarized and submitted in monitoring reports (e.g., quarterly) to the RWQCB. Additionally, an annual report would be prepared that presents the monitoring results, compares the results with the discharge requirements and performance objectives for the system, and discusses any problems, corrective actions, or other pertinent observations regarding to the operation of the system.

Estimated Costs

Capital Costs

The estimated capital costs for the various options under Alternative 3 are summarized in **Tables 16** and **17** for service area participation levels of 100% (150 parcels) and 75% (112 parcels), respectively. Itemized cost estimates including quantities and unit cost assumptions are provided in **Appendix E** for each alternative. The cost assumptions were developed through discussions with manufacturers, equipment suppliers, and local contractors, and through review of recent contractor bids for similar work in Marin County, where applicable. The bottom line both tables converts the total project costs to average cost per connection, based on either 150 or 112 parcels, as applicable. Detailed itemization of costs is provided in **Appendix E**, including quantities and unit cost assumptions. These assumptions were developed through discussions with manufacturers, equipment suppliers, and local contractors, and through review of recent contractor bids for similar work in Marin County, where applicable.

Table 16: Capital Cost Summary
Alternatives 3A, 3B & 3C - Fire Road Community Leachfield Alternatives
(100% participation – 150 parcels)

Cost Item	Estimated Capital Costs ($)		
	Alternative 3A	Alternative 3B	Alternative 3C
Collection System (Effluent STEP/STEG)	$2,370,750	$2,370,750	$2,370,750
Treatment System	$130,000	$682,500	$682,500
Disposal System	$696,000	$551,500	$624,000
Land/Easement Costs	$100,000	$100,000	$100,000
Mobilization/Demobilization	$100,000	$100,000	$100,000
Permit Fees & Encroachment Fees	$20,000	$20,000	$20,000
Subtotal	$3,416,750	$3,824,750	$3,897,250
Contingency @ 20%	$683,350	$764,950	$779,450
Subtotal	$4,100,100	$4,589,700	$4,676,700
Engr & Environ Studies @ 15%	$615,015	$688,455	$701,505
Construction Management @ 10%	$410,010	$458,970	$467,670
Admin, Dist Formation, Financing @ 5%	$205,005	$229,485	$233,835
Total Estimated Cost	$5,330,130	$5,966,610	$6,079,710
Estimated Cost Per Connection	$35,534	$39,777	$40,531

Table 17: Capital Cost Summary
Alternatives 3A, 3B & 3C - Fire Road Community Leachfield Alternatives
(75% participation – 112 parcels)

Cost Item	Estimated Capital Costs ($)		
	Alternative 3A	Alternative 3B	Alternative 3C
Collection System (Effluent STEP/STEG)	$1,953,500	$1,953,500	$1,953,500
Treatment System	$130,000	$576,000	$576,000
Disposal System	$621,500	$509,000	$537,500
Land/Easement Costs	$100,000	$100,000	$100,000
Mobilization/Demobilization	$100,000	$100,000	$100,000
Permit Fees & Encroachment Fees	$20,000	$20,000	$20,000
Subtotal	$2,925,000	$3,258,500	$3,287,000
Contingency @ 20%	$585,000	$651,700	$657,400
Subtotal	$3,510,000	$3,910,200	$3,944,400
Engr.& Environ Studies @ 15%	$526,500	$586,530	$591,660
Construction Management @ 10%	$351,000	$391,020	$394,440
Admin, Dist Formation, Financing @ 5%	$175,500	$195,510	$197,220
Total Estimated Cost	$4,563,000	$5,083,260	$5,127,720
Estimated Cost Per Connection	$40,741	$45,386	$45,783

As indicated, the estimated capital costs are least for Alternative 3A, which provides only a 100% capacity system. The costs for Alternatives 3B and 3C are very close (within 1 to 2% of each other), and are about 11 to 12% higher than Alternative 3A. The cost per connection is estimated to be approximately $5,000 greater for a project serving 112 parcels (75%) as compared with a project serving 100% of the area (150 parcels).

Operation and Maintenance Costs

The estimated annual operation and maintenance costs for the three community leachfield options under this alternative are presented in **Tables 18** and **19**, respectively, for service participation levels of 100% and 75%. Supporting itemized calculations and assumptions are provided in **Appendix E**. The O&M costs were estimated based on labor, equipment, materials and other expenses required to perform the necessary inspections, water quality sampling, data analysis, report preparation, pump-outs, and routine maintenance and equipment replacement for the community treatment and disposal facilities, as well as for the collection system and all individual STEP/STEG units served by the system. Also included are estimates of annual energy costs (electrical) for operation of the community treatment system and pumps. The electrical costs for individual STEP units at each property (estimated to be a few dollars per month) are not included. A 10% contingency allowance is also included. The cost estimates were developed based on the expected operation and monitoring needs defined above, and using data and experience from monitoring and maintenance of other similar systems in Marin County and other Northern California communities, including the Marshall Phase Community Wastewater system.

As indicated, the estimated total O&M costs are lowest for Alternative 3A and progressively greater for Alternatives 3B and 3C, respectively. The increased costs for 3B and 3C are attributable to the additional O&M requirements and expenses associated with the secondary treatment facility included as a part of these two alternatives. An increased level of work for inspection and maintenance of the drip dispersal field, as compared with a pressure distribution leachfield, accounts for the higher O&M costs estimated for Alternative 3C compared with Alternative 3B.

The estimated annual costs per connection range from a low of $733for Alternative 3A with150 parcels, to a high of $1,122 for Alternative 3C with 112 parcels. The projected individual user costs for the larger service area (150 parcels) are about 10 to 15% less than the costs for the smaller service area (112 parcels). As a point of comparison, the annual O&M costs for the Marshall Phase 1 system, serving 35 parcels, are approximately $1,200 per parcel.

Table 18: Estimated Annual Operation and Maintenance Costs
for Community Leachfield Alternatives 3A, 3B & 3C
(100% Participation - 150 parcels)

Items	Assumptions	Estimated Annual O&M Cost ($)		
		Alt. 3A	Alt. 3B	Alt. 3C
District/Program Admin	Insurance, legal, financial, permits	$13,500	$ 16,500	$16,500
Inspection, Monitoring & Reporting	On-lot STEP/STEG systems, lift stations, treatment/disposal system; remote telemetry; monthly/annual reports; as-needed engineering	$42,000	$49,200	$63,600
Maintenance	Equipment, materials, maintenance & replacement; site maintenance; sewer cleaning	$21,800	$25,400	$25,400
Laboratory & Expenses	Monthly treatment system and monitoring well sampling and analysis, travel expenses & supplies	$5,100	$7,800	$9,000
Electrical	Treatment plant, lift stations & leachfield dosing	$3,600	$7,800	$7,800
Septic Tank Pumping	25% of tanks pumped annually	$14,000	$14,000	$14,000
	Subtotal	$100,000	$120,700	$136,300
	Contingencies (@ 10%)	$10,000	$12,070	$13,630
	TOTAL	$110,000	$132,770	$149,300
	ANNUAL COST PER PARCEL	$733	$885	$1,000

Table 19: Estimated Annual Operation and Maintenance Costs
for Community Leachfield Alternatives 3A, 3B & 3C
(75% Participation - 112 parcels)

Items	Assumptions	Estimated Annual O&M Cost ($)		
		Alt. 3A	Alt. 3B	Alt. 3C
District/Program Admin	Insurance, legal, financial, permits	$10,500	$ 13,500	$13,500
Inspection, Monitoring & Reporting	On-lot STEP/STEG systems, lift stations, treatment/disposal system; remote telemetry; monthly/annual reports; as-needed engineering	$36,000	$43,200	$57,600
Maintenance	Equipment, materials, maintenance & replacement; site maintenance; sewer cleaning	$18,200	$21,800	$21,800
Laboratory & Expenses	Monthly treatment system and monitoring well sampling and analysis, travel expenses & supplies	$4,500	$7,200	$8,400
Electrical	Treatment plant, lift stations & leachfield dosing	$3,000	$6,000	$6,000
Septic Tank Pumping	25% of tanks pumped annually	$10,500	$10,500	$10,500
	Subtotal	$82,700	$102,200	$117,800
	Contingencies (@ 10%)	$8,270	$10,220	11,780
	TOTAL	$90,970	112,420	129,580
	ANNUAL COST PER PARCEL	$812	1,004	1,157

Summary

This group of alternatives provides three different approaches for developing a community leachfield system within a 1.5-acre wooded knoll on the Fire Road ridgeline above (northeast) of Woodacre Flats. The leachfield site is on Dickson Ranch property. All three options would include a central wastewater collection system terminating in the area of Park Street and Central Avenue. From this point the wastewater effluent would be pumped up the hill to the Fire Road site via force main route along Park Street and San Geronimo Valley Drive, and then overland following the ridgeline. The three options differ as follows:

- Alternative 3A is the simplest approach, including only septic tank (primary) treatment with the disposal system consisting of a shallow pressure distribution leachfield. Using the entire available disposal area, it is estimated that this alternative would be able to provide capacity for a 100% system for service area of 150 parcels; but there would be no reserve area provided. This alternative would have the lowest capital cost and annual O&M cost among the three Fire Road leachfield alternatives.

- Alternative 3B would use include the same type of leachfield design as Alternative 3A, but it would be modified by including a secondary treatment system (such as AdvanTex) to be located in the Park Street area. The inclusion of secondary treatment would allow a 50% reduction in the leachfield size, making the 1.5-acre Fire Road site capable of accommodating both a 100% capacity leachfield, plus a 100% reserve area. The capital costs for this alternative would be about 11 to 12% higher than Alternative 3A, and O&M costs are estimated to be about 15 to 20% higher.

- Alternative 3C would be similar to Alternative 3B in the use of a secondary treatment system in the Park Street area. But wastewater disposal at the Fire Road site would be provided by a subsurface drip system rather than shallow pressure distribution trenches. This alternative would also be able to provide a 100% primary dispersal field plus a 100% reserve field; in this case both the primary and reserve would be installed. The capital costs for this alternative are with 1 to 2% of the estimated costs for Alternative 3B. However, the estimated annual O&M costs are higher than 3b by about 12 to 15% due to additional costs associated inspection and maintenance of the drip dispersal components.

ALTERNATIVE 4 – GOLF COURSE WATER RECYCLING SYSTEM

Description

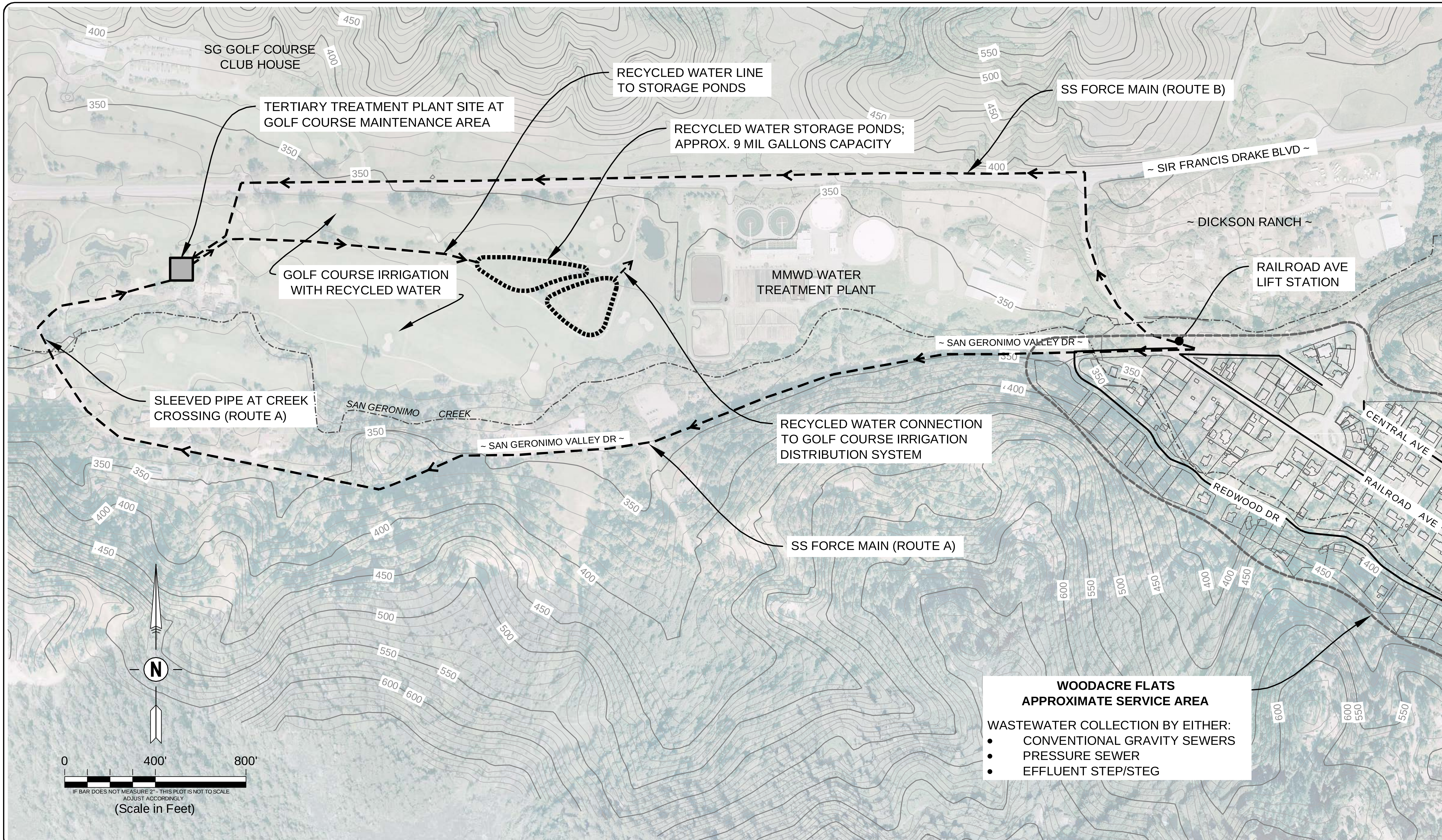
This alternative includes collection, treatment, and recycling of wastewater for turf irrigation at the San Geronimo Golf Course. This would entail the construction of a central wastewater collection system in the service area (similar to the Fire Road alternatives), a wastewater transmission line (force main) to the San Geronimo Golf Course, a tertiary treatment plant located in the golf course maintenance area, holding pond(s) on the golf course (near green #2) for winter storage of recycled water, and seasonal reuse of the recycled water for spray irrigation of the golf course turf grass. **Figure 16** is a map showing the location of key features of this alternative. **Figure 17** provides a schematic diagram of the water recycling system. The wastewater would be treated to meet California State requirements for tertiary recycled water (unrestricted uses), and would be incorporated into the existing golf course irrigation system, reducing the amount of raw water supplied to the golf course from MMWD. The overall concept and main elements of this alternative have been developed in consultation with the golf course owners and maintenance personnel, who have indicated strong interest in considering this plan.

Key elements of this alternative are summarized below.

Collection System

Based on the collection system analysis presented in **Appendix D**, the recommended sewage collection method for this alternative is a conventional gravity system, with a main lift station located at the northeast corner of Railroad Avenue and San Geronimo Valley Drive. The sewage would be conveyed to the treatment plant location at the golf course maintenance area in a 4-inch diameter force main. There are two possible routes for the force main, as follows:

- **Force Main Route A.** This route would follow San Geronimo Valley Drive. The force main would be installed within the road right-of-road, either beneath or immediately adjacent to the paved roadway. The force main would enter the golf course property at



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WOODACRE FLATS WASTEWATER FEASIBILITY STUDY

WOODACRE, CALIFORNIA

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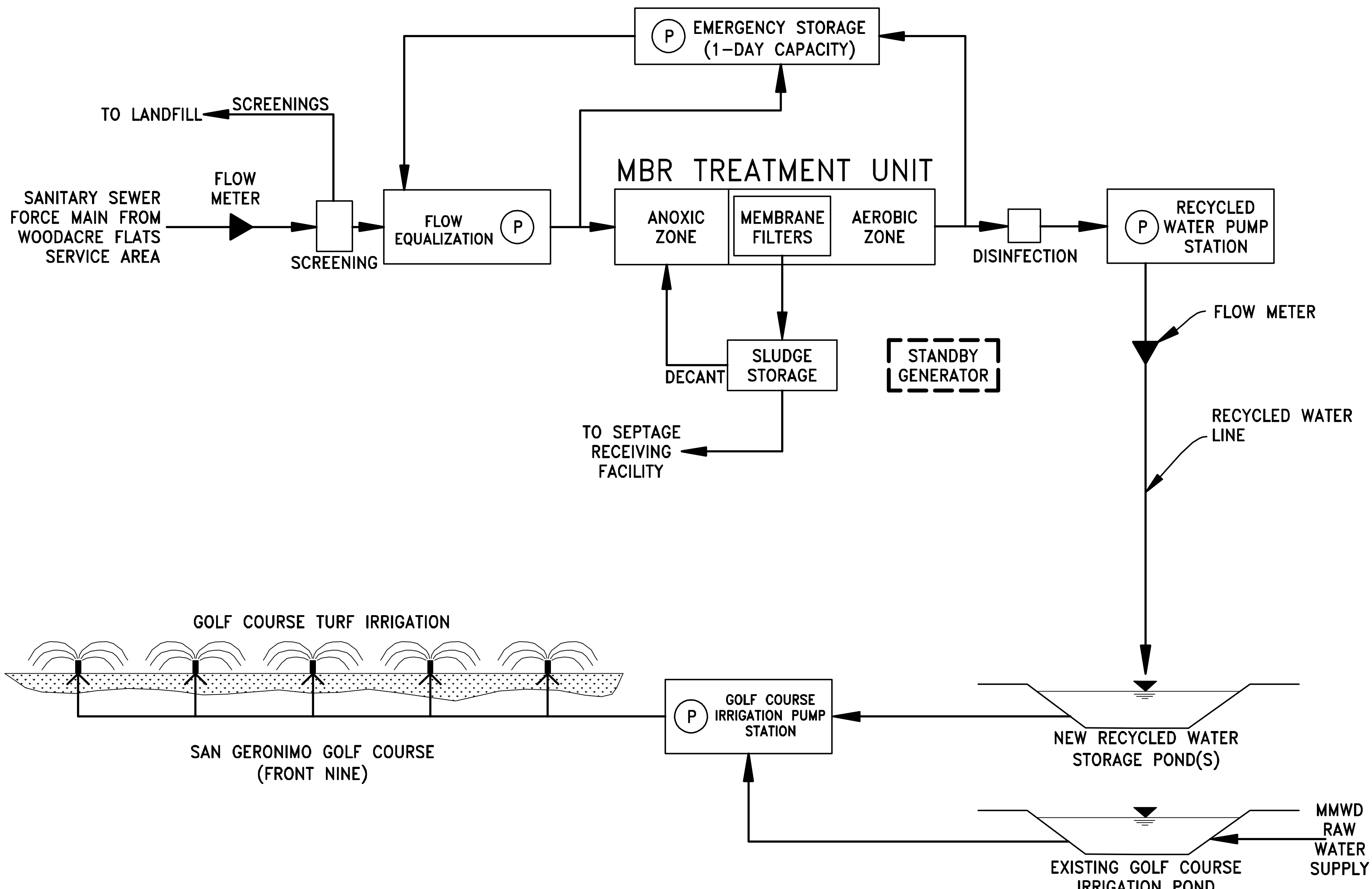
Design: PP/NH
Drawn: ML
Checked: PP/NH
Appr'd: NH

ALTERNATIVE 4
WATER RECYCLING AT SAN GERONIMO GOLF COURSE

FIGURE 16



MBR = MEMBRANE BIOREACTOR

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Design: NH/MW
Drawn: DI
Checked: NH
Appr'd: NH

WATER RECYCLING SYSTEM SCHEMATIC

Size: D
Project: 290191
Scale: NO SCALE
FIGURE: 17

the existing maintenance access road approximately 300 feet north of Meadow Way, and then follow the access road to the treatment plant site on north side of the maintenance area. The force main would cross San Geronimo Creek on the existing road bridge where a ductile iron pipe sleeve would be provided for physical protection of the pipe and prevention/capture of any leakage. The total force main length for Route A is approximately 5,860 feet.

- **Force Main Route B:** This route would run north from the main lift station within the road rights-of way of Railroad Avenue, and then westerly along Sir Francis Drake Blvd to the location of the San Geronimo Golf Course cart path undercrossing. At this point the pipeline would be routed across the golf course near green #8 to the treatment plant site on the north side of the maintenance area. The pipeline would be buried over its entire length, including where Railroad Avenue crosses San Geronimo Creek; here the pipeline would be installed beneath the road bed, above the concrete box culvert which contains the creek flow at this location. The total force main length for Route A is approximately 5,350 feet.

Preliminary analysis indicates force main Route B would be preferred over Route A on the basis of cost (shorter distance) and reduced potential for impacts to San Geronimo Creek. Route B would put the pipeline a much greater distance from San Geronimo Creek along most of its length and would include a less vulnerable means for crossing of the creek – i.e., buried within the road bed of Railroad Avenue rather than sleeved and secured to the road bridge. For either pipeline route, the installation could be done using trenchless technology (horizontal directional drilling) to minimize traffic disruption and physical disturbance to road pavement.

Treatment Facilities

The treatment facilities under this alternative would need to produce disinfected tertiary water meeting the requirements of California Code of Regulations, Title 22 Water Recycling Criteria. Recycled water meeting these standards is acceptable for unrestricted landscape irrigation, including golf course irrigation, as well as other water recycling uses. Further explanation and discussion of Title 22 water recycling criteria are provided later in this section.

- **Treatment Plant Site.** As shown in **Figure 16**, the identified location for the wastewater treatment/recycling plant is on the north side of the golf course maintenance area. It should be noted, however, that this is a suggested location and the exact positioning of the treatment facilities is not fixed. At a minimum the plant would be situated to: (a) maintain at least a 100-foot horizontal setback from any watercourses and golf course ponds; (b) avoid interference with or impact from golf course play; and (c) be coordinated with golf course maintenance facilities and activities. While no commitment has been made, golf course owners and maintenance personnel have indicated a willingness to consider the placement of a wastewater treatment/recycling plant on golf course property in this location. The treatment plant would occupy an area of approximately 10,000 square feet, including allowance for vehicle access and parking. It is assumed that the treatment plant would be fenced and screened with vegetation. In addition to treatment tanks, pumps, piping and various mechanical and electrical equipment, there would be a small control building (approximately 500 ft^2), to house equipment and supplies, as well as a small office. This alternative does not assume full enclosure of the treatment plant inside a building; however, this could be incorporated at additional cost.

- **MBR Treatment System.** Various types of treatment technologies, designs and manufacturers are available that could meet Title 22 water recycling requirements for a project to serve Woodacre Flats. This feasibility study has identified one particular system, membrane bioreactor (MBR), which is well suited because of the small area requirement, relatively low demands for operator control of the system (based on ease of automation), commercial availability, and acceptance by the California Department of Public Health. It is not the only type of treatment system that could be used, but it would be a top consideration and provides a reasonable basis for estimation of costs. Background information and technical details on the MBR treatment process (including advantages and disadvantages) are covered in an EPA Fact Sheet, which is provided in **Appendix F**.

  The facilities required for an MBR system to meet Title 22 water recycling criteria are diagrammed schematically in **Figure 17**. The MBR has small space requirements because it is designed to utilize a single complete mix reactor in which all the steps of the conventional activated sludge process occur with a membrane filter system submerged in the reactor.

  Screening influent sewage occurs at the treatment plant headworks, followed by collection and metering of flow through a flow-equalization (EQ) tank, which evens out the flow of sewage through the treatment process.

  From the EQ tank the raw sewage is pumped into the MBR treatment unit, consisting of tank(s) which include an anoxic and aerated zone, pumps, electrically-actuated valves, blowers, level controls, a programmable logic controller (PLC) and ultra-filtration membrane filter. The sewage is mixed with recirculated mixed liquor in the anoxic cell and then flows to the aeration cell. In the aeration cell, the wastewater is aerated through a grid of fine bubble diffusers connected to positive displacement blowers. The ultra-filtration membranes are immersed directly in the aerated mixed liquor and are connected to the suction side of a centrifugal pump (or pumps). The clean permeate is drawn through the membranes and discharged to the disinfection system, which may be by chlorination or UV light.

  Sludge is withdrawn periodically from the anoxic tank, collected in a storage tank and periodically hauled for disposal/discharge at an acceptable septage receiving facility. Estimated sludge production rate for this project would be on the order of about 50 gallons per day, with sludge hauling occurring every one to two months. It is assumed that odor control facilities will be included in the design, which are needed primarily in connection with the headworks, EQ tank, anoxic tank and sludge storage tank(s).

Additional facilities specifically to satisfy Title 22 recycled water standards include: (a) standby emergency generator to operate the treatment plant during power outages; and (b) emergency storage sufficient to store at least one-day of incoming sewage flow from the service area. It is assumed that this would be provided by one or more large-capacity holding tanks (buried). Additionally, the treatment system would be equipped with automatic turbidity monitoring and control equipment that would temporarily interrupt and redirect the flow of treated water to the emergency storage tank in the event that turbidity limits are exceeded.

Following the treatment process, a pump station would be provided to collect and route the recycled water to storage pond(s) located on the golf course.

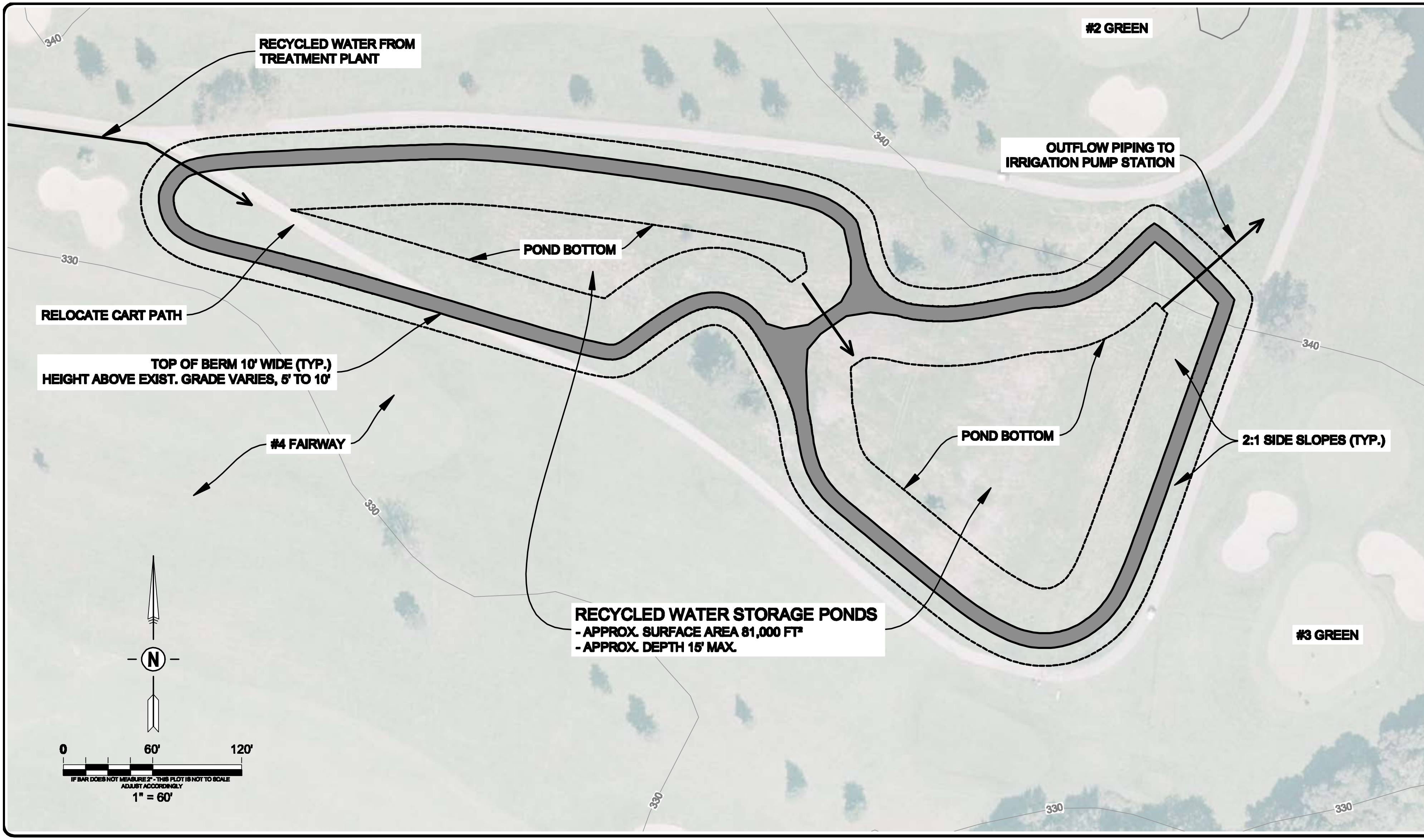
Recycled Water Storage

As indicated in **Figures 16** and **17**, new ponds would be constructed on the golf course for storage of recycled water during the wet season. The identified location for the ponds is an existing 2.5-acre triangular buffer area between the #2 green and #4 fairway, suggested by the golf course owners. The existing golf course irrigation pump station for the front nine of the golf course is located behind the #2 green, about 300 feet from this pond location. **Figure 18** shows a tentative pond layout that would meet estimated storage requirements; however, other configurations are possible. Two ponds are proposed to avoid existing trees and to best accommodate the gentle (3% to 4%) ground slope in the area.

The ponds would be constructed through a balanced combination of excavation below existing grade (e.g., 6 to 10-feet deep) and engineered fill embankments above grade. Balancing of excavation and fill would minimize or eliminate the need for off-hauling or importing of soil. For the configuration shown in **Figure 18**, the overall depth of the ponds is estimated to be on the order of 17 to 18 feet, and at capacity the total surface area of the ponds would be approximately 2 acres.

Soil profile observations by Questa in the proposed pond area revealed a thin topsoil layer (12 to 18 inches) underlain by stiff clayey subsoils. These soil conditions are favorable for pond construction; and it is likely that the native clay subsoils would be suitable material to be used in forming the required impermeable pond liner. If not, an artificial (plastic) liner would used. Drainage which presently flows overland in the pond area would have to be collected and re-routed. Some portions of the existing golf cart paths that border the pond area would also have to be re-routed, as would a main irrigation pipeline that crosses through the pond area.

The ponds would be used to store treated water (plus rainfall) during the wet weather months (November-March), and would be drained down (via irrigation) during the dry season. Using the assumed pond configurations in **Figure 18**, water balance calculations (monthly time steps) were made to estimate the storage capacity, and corresponding water depth, needed to accommodate projected recycled water volumes plus direct rainfall. Calculations were made for two different wastewater flow assumptions of 29,000 gpd and 22,000 gpd, which represent, respectively, the projected average daily wet weather flow for 150 (100%) and 112 (75%) service connections, including 10% allowance for wet weather I/I. Calculations were made for both 10-yr (61.3



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WOODACRE FLATS
WASTEWATER FEASIBILITY STUDY

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Design:	NH/MW
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Checked:	NH
App'd:	NH

RECYCLED WATER STORAGE
POND LAYOUT - CONCEPTUAL

FIGURE
18

in/yr) and average (41.6 in/yr) rainfall amounts. The RWQCB requires pond capacity be designed to accommodate 10-yr rainfall amounts. Calculations for average rainfall conditions are included to provide an estimate of the typical volume of water that would be available for golf course irrigation. Rainfall amounts were estimated using data from Woodacre Fire Station combined with long-term records from Kentfield and San Rafael. Water balance spreadsheet calculations are provided in **Appendix G**, and the results are summarized in **Table 20** below.

Table 20: Water Balance Summary for Recycled Water Storage Ponds

Service Connections (# of parcels)	Ave Wet Weather Wastewater Flow (gpd)	Rainfall Scenario	Max Pond Water Depth (ft)	Max Storage Volume (mill. gals)	Recycled Water Produced for Irrigation*		
					Ave Flow (gpd)	Total Volume	
						mill. gals	ac-ft
150	29,000	Average	14.00	5.7	50,000	10.7	33
150	29,000	10-yr	15.49	6.6	54,800	11.7	36
112	22,000	Average	12.10	4.6	38,000	8.1	25
112	22,000	10-yr	13.69	5.5	42,800	9.2	28

** For irrigation period of April-October*

The ponds would be designed to provide a minimum freeboard depth of 2.0 feet above maximum projected water level, indicating overall pond depths on the order of 16 to 17.5 feet, depending on the number of parcels served by the system. These are not the only feasible pond dimensions; different assumed pond configurations would yield somewhat different depths and overall volumes.

Irrigation Disposal Facilities

During the dry season (typically April-October), the water from the storage ponds would be integrated into the main irrigation water supply for the golf course, which presently comes from MMWD. The recycled water would be routed to the existing irrigation pump station for the golf course front nine located behind the #2 green. The irrigation pumps currently draw water from the existing golf course pond in front of the #3 tee, which is feed by a raw water pipeline from MMWD. Piping and pump station modifications would be required to incorporate water from the recycled water ponds.

According to maintenance personnel, irrigation water demand on the golf course during the dry season can exceed 300,000 gallons per day, about half of which is used on the front nine. As indicated by the water balance summary in **Table 20**, the net amount of recycled water produced for golf course irrigation would be on the order of about 10.7 to 11.7 million gallons (33 to 36 acre-feet) per year for a wastewater project serving 150 parcels, and about 8 to 9 million gallons (25 to 28 acre-feet) per year for a project serving 112 parcels. These recycled water volumes would provide an average irrigation contribution in the range of 38,000 to about 55,000 gpd if spread evenly over the normal April-October dry season irrigation period. This would amount to roughly 15% of the total golf course irrigation demand, and could be as much as 30% of the irrigation water demand on the front nine. The actual amount of water in any given year would depend on actual wastewater flows, plus rain water collected in the ponds, minus the water lost to evaporation from the pond surfaces. The recycled water contribution to the golf course irrigation supply would be significant, but still well within the capacity of the golf course to put the water to beneficial use.

In addition to changes to the irrigation pump station, the golf course would have to comply with recycled water use area requirements, which are reviewed below. These cover items such as signage and markings, protection of drinking water fountains and outdoor eating areas, setbacks from wells, prevention of runoff and spray drift, and protection against cross-connection with domestic water lines.

Regulatory Requirements

Title 22 - Water Recycling Criteria

Wastewater treatment facilities proposing to utilize the treated water for recycling are governed by requirements contained in California Code of Regulations, Title 22-Water Recycling Criteria. The California Department of Public Health (CDPH) is responsible for administering Title 22, which requires review of all wastewater recycling projects for conformance with the adopted regulations and criteria. The CDPH acts in an advisory capacity to the RWQCB, who normally incorporate Title 22 requirements into waste discharge permits, along with CDPH findings and recommendations. Key provisions of Title 22 Water Recycling Criteria are summarized here.

- **Treatment.** Recycling water for golf course irrigation requires that it be “disinfected tertiary recycled water”. Among other things, this requires that, following secondary (biological) treatment, the oxidized wastewater must be filtered and disinfected by an approved process and meet the following requirements:

  (a) Total Coliform. “The median concentration of total coliform bacteria measured in the disinfected effluent does not exceed a most probable number (MPN) of 2.2 per 100 mL utilizing the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform bacteria does not exceed a MPN of 23 per 100 mL in more than one sample in any 30 day period. No sample shall exceed a MPN of 240 total coliform bacteria per 100 mL.”

  (b) Turbidity. “... the filter effluent turbidity does not exceed 2 NTU, the turbidity of the influent to the filters is continuously measured, the influent turbidity does not exceed 5 NTU, and that there is the capability to automatically activate chemical addition or divert the wastewater should the filter influent turbidity exceed 5 NTU at any time.”

  Title 22 includes daily coliform analysis and continuous turbidity monitoring to verify compliance with the above effluent quality requirements. The sampling requirements are established to assure protection of the public health because there is significant risk of human exposure to the recycled water.

- **Reliability and Storage.** Title 22 includes provisions for emergency storage of sewage influent (minimum one day of design flow) and redundancy in various treatment processes to ensure continuous and reliable operation. Additionally, Title 22 requires provisions for long-term storage (minimum of 20 days) or an alternate method of disposal for periods when recycling is not possible, e.g., due to the lack of irrigation demand during rainy periods or when/if the treated effluent fails to meet bacteriological limits.

- **Use Area Requirements.** Title 22 contains the following requirements pertaining to the areas where tertiary recycled water can be applied:

  (a) No application of tertiary recycled water shall occur within 50 feet of a domestic well, unless supported by a geological investigation;

  (b) No impoundment of tertiary recycled water shall occur within 100 feet of any domestic water well;

  (c) No runoff of irrigation water from the recycled use area shall occur unless determined not to pose a public health threat and authorized by the regulatory agency;

  (d) No spray, mist or runoff shall enter dwellings, designated outdoor eating areas, or food handling facilities;

  (e) Drinking water fountains shall be protected against contact with recycled water spray, mist or runoff;

  (f) Standard warning signs shall be posted where recycled water is used that are accessible to the public;

  (g) No physical connection shall be allowed between recycled water systems and potable water systems;

  (h) No hose bibs shall be allowed in the recycled water system in areas accessible to the public; quick couplers shall be used instead.

  (i) No recycled water agency shall deliver recycled water for any internal use to any individually-owned residential units including free-standing structures, multiplexes, or condominiums.

Any project proposing water recycling is required to submit for review and approval to the California Department of Public Health (CDPH), an Engineering Report in compliance with the provisions of Title 22, Section 60323 of the California Code of Regulations. This report is required to follow the document titled "Guidelines for the Preparation of an Engineering Report for the Production, Distribution, and Use of Recycled Water", issued by CDPH. This report is normally completed prior to, or in conjunction with, the filing of a Report of Waste Discharge with the Regional Water Quality Control Board.

Operation and Maintenance Requirements

The wastewater facilities described under this alternative would require maintenance by a California certified wastewater treatment plant operator (minimum Grade III). This would cover operation, maintenance, and monitoring responsibilities for the collection system and the treatment plant. It is envisioned that the golf course personnel would be responsible for maintenance and operation of the storage ponds, irrigation pump and distribution system and the recycled water uses areas (i.e., the golf course turf areas).

System maintenance will include regular inspection of all equipment and processes. A telemetry system would be incorporated to facilitate remote, continuous monitoring of the critical elements of the pump stations and the treatment system. Ongoing inspection and maintenance of the facility is anticipated to include on-site physical work several days a week.

Effluent water quality sampling and analysis will be an important aspect of the ongoing operation and maintenance of the MBR system and will be required for permit compliance under terms of the Monitoring and Reporting Program established by the RWQCB. This will include daily sampling and analysis for coliform bacteria per Title 22 water recycling requirements. Contract arrangements with MMWD for coliform testing at their San Geronimo Water Treatment Plant would be an efficient way to meet this critical operating requirement.

The holding ponds will be a relatively passive system requiring periodic inspection and upkeep - but little in the way of day-to-day operational requirements. The pond water levels will require management to assure suitable capacity for wet weather storage needs; pond maintenance also requires implementation of mosquito control measures, normally consisting of application of microbial larvicides that are registered and approved for use by the US EPA. It is anticipated that pond operation and maintenance will be handled by the golf course maintenance personnel, as will the irrigation pump station and spray operations.

Since the treated water will be incorporated into the existing golf course irrigation system for dry season application to existing managed turf areas, it is not anticipated that any receiving water sampling requirements (e.g., groundwater monitoring wells or stream sampling) would be imposed.

All flow monitoring, influent and effluent water quality data, storage pond levels and conditions, sludge hauling volumes, and wastewater treatment and water recycled water system inspection reports would be prepared and submitted to the San Francisco Bay RWQCB according to a schedule prescribed by the RWQCB in the Monitoring and Reporting Program. It is anticipated to include monthly and annual reporting frequency.

Estimated Costs

Capital Costs

The estimated capital costs for Alternative 4 are presented in **Table 21**, showing the costs for the two alternate force main routes, A and B, and for both 100% and 75% service connection scenarios. The bottom line in the table converts the total project costs to the average cost per connection, based on either 150 or 112 parcels, as applicable. Detailed itemization of costs is provided in **Appendix H**, including quantities and unit cost assumptions. These assumptions were developed through discussions with manufacturers, equipment suppliers, and local contractors, and through review of recent contractor bids for similar work in Marin County, where applicable.

Table 21: Capital Cost Summary
Alternative 4 – Golf Course Water Recycling System

Cost Item	100% Service (150 parcels)		75% Service (112 parcels)	
	Route A Cost ($)	Route B Cost ($)	Route A Cost ($)	Route B Cost ($)
Collection System (Gravity Sewer)	2,541,800	2,488,750	2,282,050	2,229,000
Tertiary Treatment Plant	1,050,000	1,050,000	1,025,000	$1,025,000
Recycled Water Storage & Transmission	678,000	678,000	563,000	$563,000
Land/Easement Costs	0	0	0	$0
Mobilization/Demobilization	100,000	100,000	100,000	100,000
Permit Fees & Encroachment Fees	20,000	20,000	20,000	20,000
Subtotal	4,389,800	4,336,750	3,990,050	3,937,000
Contingency @ 20%	877,960	867,350	798,010	787,400
Subtotal	5,267,760	5,204,100	4,788,060	4,724,400
Engr & Environ Studies @ 15%	790,164	780,615	718,209	708,660
Construction Management @ 10%	526,776	520,410	478,806	472,440
Admin, Dist Formation, Financing @ 5%	263,388	260,205	239,403	236,220
Total Estimated Cost	$6,848,088	$6,765,330	$6,224,478	$6,141,720
Estimated Cost Per Connection	$45,654	$45,102	$55,576	$54,837

The total project costs are based on treatment facilities and storage ponds to accommodate an average daily flow of approximately 29,000 gpd as projected for service to 150 parcels, and 22,000 gpd for service to 112 parcels, including an allowance of 10% I/I flow contribution associated with the recommended conventional gravity sewer system. Included are all expected costs for the abandonment of existing septic systems, new gravity sewer system, lift station and transmission line to the golf course, MBR treatment system, recycled water storage ponds on the golf course, and connections to the golf course irrigation pumping system. Also included is a contingency 20% allowance, as well as estimated costs for engineering design, environmental studies, construction management, project administration, district formation and financing. It should be noted that the golf course owners have indicated that the land needed for the treatment plant and storage ponds would be made available at no cost, and also that they would assume responsibility for any facility improvements or modifications to the golf irrigation system needed for compliance with Title 22 requirements for recycled water.

As indicated in **Table 21**, the estimated total costs for Alternative 4, Route B, would be on the order of about $6.77 million for service to 150 parcels in Woodacre Flats, and $6.14 million for service to 112 parcels. The corresponding costs per connection are estimated to be $45,102 and $54,837, respectively. The costs for force main Route B are estimated to be about $83,000 higher in total costs, with individual costs higher by about $550 to $750 per connection, depending on the number of connections.

Operation and Maintenance Costs

The estimated annual operation and maintenance costs for Alternative 4, for both 100% and 75% service connection scenarios, are provided in **Appendix H,** including supporting itemized calculations and assumptions. The O&M costs were estimated based on labor, equipment, materials and other expenses required to perform the necessary inspections, water quality sampling, data analysis, report preparation, sludge disposal, and routine maintenance for the collection system and MBR treatment/recycling plant. Not included are any costs associated with the storage and use of the recycled water by the golf course for turf irrigation. Also included are estimates of annual energy costs (electrical) for operation of the main lift station and the treatment system. Additionally, O&M costs include an allowance for equipment repair/replacement, which will be required over the life of the system. An allowance of 10% is included as a contingency. The cost estimates were developed based on the expected operation and monitoring needs defined above, and using data and experience from monitoring and maintenance of other similar systems in Marin County and other Northern California communities. The total annual O&M costs and corresponding cost per connection are listed in the summary table below

Table 22: Estimated Annual O&M Costs
Alternative 4 – Golf Course Water Recycling System

Wastewater Service Assumption	# of Parcels Served	Estimated Total Annual O&M Costs ($)	Estimated Annual O&M Cost per Parcel ($)
100% Connections	150	166,870	1,112
75% Connections	112	135,410	1,209

Summary

Alternative 4 presents a viable option for treating and recycling wastewater from Woodacre Flats at the San Geronimo Golf Course. This could be accomplished with a conventional gravity sewer system in the community, a 4-inch diameter transmission line via Sir Francis Drake Blvd., a compact water recycling treatment plant located at the golf course maintenance area, approximately 2-acre recycled water storage pond(s) on the golf course, and integration of the recycled water into the existing irrigation system for the front nine of the golf course. At full capacity, a wastewater system serving 150 parcels in Woodacre Flats could produce up to approximately 10 to 11 million gallons of recycled water per year for irrigation use that would directly reduce the use of MMWD raw by an equivalent amount. The golf course owners and maintenance personnel have been consulted in the development of this alternative and have expressed interest in cooperating and partnering with the community to implement a water recycling project.

SECTION 7: COMPARATIVE ANALYSIS OF PROJECT ALTERNATIVES

This section reviews the advantages and disadvantages of the various project alternatives with respect to regulatory compliance, environmental impacts, reliability, flexibility, resource utilization, land use and costs. A comparative summary and ranking is provided at the end of the section, along with identification of the “apparent best” alternative or alternatives.

REGULATORY COMPLIANCE

A primary goal of a wastewater facilities project in Woodacre Flats would be to correct existing water quality, public health and nuisance problems, and bring wastewater disposal activities into compliance with accepted sanitary practices and environmental quality standards.

Alternative 1 (No Project) fails to achieve these objectives although, over a number of years, improvements in local water quality, public health, and sanitation conditions may occur. It is estimated that nearly 70% of the properties in the Woodacre Flats area are in serious conflict with current septic system standards and would have significant difficulty complying with County repair standards.

Alternative 2 would substantially reduce present water quality and public health problems, and bring more (as compared with the No Project option) of the existing onsite systems into conformance with accepted practices. Where this alternative falls short of meeting environmental health/water quality requirements would be in the heavy reliance on advanced treatment systems for many of the properties in the service area, along with the need for continued monitoring and surveillance to document suitable system performance and compliance with water quality objectives.. The need for advanced treatment systems results from the shallow soil and groundwater conditions combined with the land area/setback constraints due to the small lot sizes and high intensity of development.

Alternatives 3A would be expected to satisfy Marin County septic system repair requirements, but may have difficulty complying with RWCQB requirements, since it would only provide for a single 100% capacity disposal system, with no designated reserve area.

Alternatives 3B, 3C and **4** would all be expected to satisfy Marin County septic system repair requirements as well as waste discharge requirements established by the RWQCB. Each of these alternatives would meet standards for new construction, in terms of treatment technology, disposal area conditions and design requirements. **Alternative 4** would comply with California Water Recycling Criteria for unrestricted recycling uses, a higher environmental standard.

ENVIRONMENTAL IMPACTS

A complete environmental impact report would be prepared separately as part of the overall facilities planning work if a project moves forward for the Woodacre Flats area. Provided here is a brief overview of the environmental issues posed by the different alternatives. This review is intended to assist in identification of the preferred alternative; it is not a substitute for the environmental documentation requirements of the California Environmental Quality Act.

Alternative 1 will include an unknown number of new and upgraded OWTS using conventional septic tanks and disposal systems similar to existing practices. There will be increased use of pump systems, fill soil and drainage work, amounting to increases in the amount of land disturbance compared with current and historical practices. The general trend would be toward installing shallow disposal fields matched more closely with the shallow permeable soil conditions. The negative impacts of the No Project alternative would be the lack of any comprehensive plan or schedule to bring about the upgrading of onsite systems, and the continued potential for existing impacts on public health and water quality to occur. Another negative aspect of this alternative would be the possible need to revert to holding tanks and regular sewage hauling for some properties that have no acceptable on-lot options.

Alternative 2 will largely eliminate the public health hazards from failing or poorly functioning septic systems through elimination of problematic systems, addition of individual advanced treatment units, and development of upgraded and improved means for onsite dispersal of the treated water. The institution of an onsite wastewater management program will provide the means for monitoring each system to oversee the protection of the local environment against wastewater impacts. The potential negative aspects of this plan would be the land disturbance required on individual properties to upgrade onsite systems. The importing of soil fill, removal of landscaping to make room for advanced treatment units, and raised bed dispersal systems will likely be objectionable in many instances. Conflicts with other uses of limited available land area would be a potentially significant issue. Also, similar to Alternative 1, there may be instances requiring holding tanks and regular sewage hauling as part of a solution for some properties.

Alternatives 3A – 3C will have pose similar environmental impacts related to the construction of a sewer system, lift stations, treatment facilities and disposal field at the Fire Road site. The collection system, utilizing small diameter piping, will generate impacts during the construction phase. Also, the recommended sewer option includes the use of STEP and STEG systems, which creates the continuing need for septic tank and pump maintenance on individual properties, along with routing septic tank cleaning. Pump failures and/or pipeline leaks or breaks would pose the potential for discharge of partially treated sewage to the environment if not properly mitigated through design and operational procedures.

More significant impacts for the Fire Road leachfield alternatives may be posed by the conversion of the Park Street area to site for a main lift station (**Alternative 3A**) or a secondary treatment plant (**Alternatives 3B** and **3C**). The main lift station and/or treatment plant will mainly consist of below ground or low-profile tanks and submersible pumps, plus a small control building. It would be fenced and could be screened with vegetation to mitigate visual impacts. Noise levels would be low, but there would be regular activity at the site and routine maintenance running of a standby generator. Sewage odors would be generated, but can be mitigated with appropriate odor control facilities.

The Fire Road leachfield site and the pipeline route to the site would involve a substantial amount of excavation, requiring mitigation for erosion control. The leachfield site and force main route were identified to avoid geologically unstable areas; however there are steep slopes and potentially unstable lands in the vicinity, which will require evaluation to confirm avoidance of impacts. The land areas disturbed by the leachfield and pipeline impacts would be expected to revegetate easily to native conditions. The addition of primary treated effluent (Alternative 3A) or secondary treated effluent (Alternative 3B and 3C) are compatible with the soil conditions in the identified leachfield site. However, additional soils and groundwater investigation and the potential for impacting water quality or hydrology in locations downgradient/downhill from the leachfield site would need to be considered as part of formal environmental review and system design.

Alternative 4 will include some elements and associated environmental impacts of Alternatives 3A-3C regarding the installation, operation and maintenance of wastewater collection facilities in Woodacre. The main difference is that a conventional gravity sewer, rather than effluent STEP/STEG, would be used such that there the on-lot septic tanks and any associated impacts would be eliminated. Additionally, there would be no planned facilities at the Park Street site; instead a main lift station would be located at the intersection of Railroad Avenue and San Geronimo Valley Drive.

The recommended pipeline route from Woodacre to the golf course is via Railroad Avenue and Sir Francis Drake Blvd. It is likely that it would be installed for most of its length using trenchless methods (i.e., horizontal directional drilling), such that impacts to road surfaces and traffic would be greatly minimized. The recommend pipeline route would cross San Geronimo Creek as a buried pipe the road, mitigating potential concerns about sewage leakage into to the creek.

The main impacts from Alternative 4 would be confined to the golf course area, including: (a) those associated with the treatment plant (visual, odors, noise, spills) located in the golf course maintenance complex; (b) the construction and maintenance of a 2-acre holding pond in a currently unused part of the golf course; and (c) the integration of recycled water into the golf course irrigation system. The treatment plant would be of a compact design and provided with odor control facilities and screening to minimize its local impacts. The treatment system would be required to comply with Title 22 standards for water recycling, which are very stringent in the direction of public health and water quality protection. The holding ponds on the golf course would be designed to capture and hold rainfall as well as tertiary treated water. The ponds would have to be managed to control mosquitoes, prevent overflows, and be maintained in a safe condition and off-limits to golfers. Final dispersal of the recycled water in the irrigation system would be limited to the dry season, at appropriate application rates and to areas where there is no threat of runoff to local drainages or San Geronimo Creek. Violation of these standard conditions of the RWQCB could result in recycled water runoff into San Geronimo Creek.

RELIABILITY

Reliability considerations relate to the ability to consistently meet wastewater treatment and disposal objectives and have adequate provisions for emergencies, malfunctions, extreme climatic conditions, or fluctuations in flow.

Alternative 1 rates poorly in terms of reliability. Options to correct existing septic system problems will be limited and costly. Some property owners will have extreme difficulty finding solutions that can assure long-term performance reliability because of shallow soil/groundwater conditions and space limitations. Without a concerted effort to systematically assess and upgrade existing systems, many systems will remain as is and a source of continuing public health and water quality concerns.

Alternative 2 represents a substantial improvement in reliability through the proposed implementation of an onsite inspection and maintenance program. However, the need to rely on many individual advanced treatment units, although feasible, will intensify the oversight and maintenance requirements, and affect the overall reliability of this alternative.

Alternatives 3A, 3B and 3C (Fire Road Community Leachfield) all offer a high degree of reliability over present sewage disposal practices. In all cases the facilities would be capable of meeting repair standards for wastewater treatment and disposal, including built-in emergency and redundancy provisions for potential equipment failures, power outages, etc. However, **Alternative 3A** would be inferior to **3B** and **3C** since it would not provide any reserve disposal area as normally required for new construction. Also, the fact that **Alternatives 3B** and **3C** include secondary wastewater treatment prior to disposal reduces the amount of dependence on the soil environment for absorption and treatment of wastewater, and increases the reliability of these alternatives over **Alternative 3A**, which provides for discharge of septic tank effluent. The electrical and mechanical elements of the secondary treatment system would be subject to periodic malfunction. However, these aspects of the treatment system can be routinely monitored, maintained, repaired and replaced as necessary. On the other hand, damage to and/or decline in the performance of the soil absorption system is not easily remedied; which is a greater concern for septic tank effluent than for secondarily treated effluent.

Alternative 4 would provide the highest level of reliability as it would have to be designed and operated to comply with State standards (Title 22) for tertiary recycled water. The applicable standards for water recycling have built-in redundancy and fail-safe requirements to assure against human health impacts from exposure to recycled water. These requirements include such things as automatic monitoring and control systems, duplicate unit processes, and emergency storage/holding capacity. The method of final dispersal of the treated water (winter storage/summer irrigation) is inherently more reliable than depending on year-round soil absorption, as per the other alternatives.

FLEXIBILITY

Flexibility of each alternative relates to the ability to accommodate future connections or building remodels from other Woodacre Flats properties, to be expanded, and to provide reclamation/reuse opportunities.

Alternatives 1 and **2** rate very low in terms of flexibility. As stated before, **Alternative 1** offers limited or poor solutions for existing developed properties, let alone assisting in the potential solution of other problems. By establishing a formal management program **Alternative 2** would introduce some additional flexibility for septic system upgrades not only for the properties addressed in Woodacre Flats, but for other properties in the adjoining areas of Woodacre as well.

Alternatives 3A, 3B and **3C** would all provide significant flexibility to facilitate current and future upgrade of septic system practices in the Woodacre Flats area. The alternatives rank fairly close to one another on this issue. However, on balance, the greatest flexibility would be offered by **Alternatives 3B** and **3C** because of the inclusion of secondary treatment facilities. This will preserve more of the land disposal capacity of the site for future connections, as compared with **Alternative 3A**, which includes primary treatment only, and does provide any reserve capacity in the Fire Road site. Also, the secondary treated water could potentially be used for seasonal irrigation.

Alternative 4 offers direct reuse opportunities and potentially could also offer future expansion possibilities to serve other neighboring areas of Woodacre or possibly other parts of the San Geronimo Valley. The recycled water produced by the Woodacre Flats service area would supply only a small portion of the golf course irrigation demand. Capacity of the system could potentially be expanded in the future to aid in addressing other septic system problem areas and, in turn, making more recycled water available to replace the existing uses of MMWD water for golf course irrigation. Such expansion would be subject to further engineering and environmental study and, at a minimum, would entail larger treatment facilities and increased storage capacity for treated water during the wet season.

RESOURCE UTILIZATION

Alternative 1 would create new energy requirements and resource demands only to the extent that individual actions are taken to upgrade existing septic systems with more modern treatment devices.

Alternative 2 would increase energy requirements in comparison with the No Project Alternative, since it assumes that a substantial number of properties would be served by an advanced treatment/dispersal system utilizing pumps and possibly UV disinfection and aeration units. There would also be increased usage of fossil fuels for **Alternative 2** as a result of the construction work for onsite system improvements, regular inspection and monitoring activities, and a somewhat higher rate of septic tank pump-outs that would likely occur with a management program in place.

Alternatives 3A, 3B, 3C and **4** would all have increased energy requirements, in comparison with **Alternatives 1** and **2**, because of the need to pump the wastewater to offsite treatment/disposal locations and, for **3B**, **3C** and **4**, the operation of pumps, aerators and other equipment needed for secondary and tertiary treatment facilities. Preliminary estimate of pumping and treatment equipment indicates that Alternative 4 would have the greatest energy requirements, followed by **Alternatives 3B** and **3C**, which would about the same, with **3A** (no treatment system) having the lowest requirements. There would also be increased usage of fossil fuels for all of the community system alternatives as compared with **Alternatives 1** or **2** as a result of the more extensive construction work for the community system improvements, and ongoing inspection and monitoring activities.

Another resource utilization factor is the reuse of treated wastewater. This is a positive environmental benefit of Alternatives 4, which would produce recycled wastewater (up to as much as 10 to 11 million gallons per year) to be used to supplant some of the existing raw municipal water used for irrigation of the San Geronimo Golf Course.

LAND USE

This factor considers the impact of wastewater facilities on individual properties, public areas and other lands**.** **Alternative 2** would pose the biggest impact on individual properties in the service area through the need to modify and expand onsite wastewater systems on each property, affecting existing landscaping and other property improvements and activities. **Alternative 1** would have a similar effect, but not to the same degree. Neither of these alternatives would impact land uses elsewhere in Woodacre or surrounding areas. **Alternatives 3A-3C** and **4** would all involve the installation of sanitary sewers in the local streets, plus one or more lift stations in the community. The recommended sewer system approach (effluent STEP/STEG) for the Fire Road leachfield alternatives (3A-3C) would require the continued use and maintenance of individual septic tanks on each property. The recommended use of conventional gravity sewers for Alternative 4 would eliminate this impact.

With respect to offsite land uses, **Alternatives 3A-3C** would all require community facilities in the Park Street area. For **Alternative 3A** it would be limited to a main lift station, with mainly buried tanks. The impacts would be greater for **Alternatives 3B** and **3C** through the use of the Park Street area for a secondary treatment plant and main lift station. All three of these alternatives would also include the conversion of the approximately 1.5 acres of wooded knoll at Fire Road to community leachfield uses.

The land use impacts of **Alternative 4** within the community would be limited to the installation of gravity sewers and manholes in the streets and associated maintenance, plus the a single main lift station near the intersection of Railroad Avenue and San Geronimo Valley Drive. From this point to the Golf Course the sewage pipeline would be buried in the road rights of way. At the golf course the treatment plant would occupy an approximately 10,000 square foot area in the existing golf course maintenance area. Additionally this alternative would require the construction of approximately 2 acres of new holding pond within the golf course. The ponds would be visible from Sir Francis Drake Blvd., but the impacts would be primarily to the golf course owners and those using the course. No land use impacts would be associated with the dispersal of the recycled water, since it would be integrated into the existing golf course irrigation system.

COSTS

The estimated capital cost and operation and maintenance (O&M) cost for the various wastewater project alternatives are summarized in **Table 23** for assumed service to 100% of the 150 developed parcels. Supporting cost information is itemized for each alternative in preceding individual sections and in the appendices. No estimated is given for the No Project Alternative. However, judging by other experience in Marin County, it is recognized that for individual property owners, the future cost of compliance with environmental requirements is likely to be substantial.

Table 23 also converts the estimated O&M costs for each alternative to a present worth value, using an assumed 30-year service life, an assumed inflation rate of 2% per year, and an assumed interest rate of 5%. The total of the capital cost and present worth O&M cost are combined at the bottom of the table for project comparison. The cost ranking (lowest cost = highest ranking) is indicated in the bottom row. The cost comparison shows **Alternative 3A** to have the lowest projected capital, O&M, and present worth costs. Onsite upgrade/management project Alternative 2 is indicated to have the highest capital cost and present worth cost. Alternative 4 is estimated to have the highest O&M cost and the second highest present worth cost.

Table 23:
Cost Comparison of Alternatives
(100% participation; 150 parcels)

COST FACTOR	1 No Project	2 Onsite Upgrades & Mgt. Program	3A Fire Road Community Leachfield Primary Treatment PD Disposal	3B Fire Road Community Leachfield Secondary Treatment PD Disposal	3C Fire Road Community Leachfield Secondary Treatment Drip Disposal	4 Golf Course Water Recycling Tertiary Treatment Storage Pond Spray Irrigation
Estimated Capital Cost	N/A	$ 8,374,860	$ 5,330,130	$ 5,996,610	$ 6,079,710	$ 6,765,330
Annual O&M Cost	N/A	$ 141,295	$ 110,000	$ 132,770	$ 149,930	$166,870
Present Worth O&M Cost	N/A	$2,769,380	$ 2,156,000	$ 2,602,290	$ 2,938,630	$3,270,650
Total Present Worth	N/A	$11,144,240	$7,486,1130	$8,598,900	$9,018,340	$10,035,980
Cost Rank*	N/A	1	5	4	3	2

Lowest cost = Highest Ranking

COMPARATIVE SUMMARY

An overall comparison is drawn here between the project alternatives, taking into consideration the various factors presented in the section. Numerical ratings were assigned to each alternative for each factor according to the following guidelines. Where projects were judged to be essentially equal for a given factor they were given the same score. Results are displayed in **Table 24**. The scoring was based on a combination of objective information (e.g., costs) and subjective best professional judgment. The results are not an absolute determination of the best project alternative.

Regulatory Compliance

Project alternatives were evaluated with respect to their ability to meet public health and water quality standards, along with the level of standard applicable to the project. Projects were ranked in order of increasing environmental quality standards, and points were assigned according to rank, from 1 (minimum) to 6 maximum. The No Project alternative, which would have the greatest degree of non-compliance, was assigned the lowest ranking and point score. Increasingly higher environmental standards would be met by Alternatives 2 through 4, and they were ranked and scored accordingly.

Environmental Impacts

Projects were subjectively ranked in order of decreasing impacts on the natural environment, and assigned points according to rank. The least impact project was assigned the highest score (6).

Reliability and Flexibility

Projects were subjectively ranked in order of increasing flexibility and reliability and assigned points according to rank. The most reliable/flexible project was assigned the highest score (6).

Resource Utilization

Project alternatives were ranked in order of decreasing demands on natural resources, principally energy requirements, and assigned points according to rank. Wastewater reuse was also considered as a positive resource utilization factor; to account for this, an additional point was added to the score for **Alternative 4.** Higher points correspond to projects with lower net resource demands.

Land Use

Project alternatives were subjectively ranked in order of decreasing impacts on land uses, based on the amount of land that would be converted or dedicated solely to wastewater treatment and/or disposal uses.

Costs

Lastly, project alternatives were ranked by costs, using the present worth values and ranking given in **Table 23**. Because of the importance of costs to project implementation and long-term operation, a greater significance was given to this factor. This was done by weighting the scoring double that of other factors, with a high point total of 12 as compared with 6 for the other evaluation categories. Point scores were assigned from low to high in 2-point increments. The lowest point total was given to the No Project alternative. This is due to the fact that, although no information has been developed on the total cost of this alternative, there is a strong likelihood that the future cost of individual compliance for any given property owner could easily exceed the estimated per parcel costs for the any of the other community-based project alternatives.

Apparent Best Alternative

This comparative analysis shows **Alternative 3B** and **Alternative 4** to have the highest ranking among the alternatives evaluated and are identified as the "apparent best" alternatives for the compared to one another, with costs considerations favoring **Alternative 3B** and environmental, water quality and reliability factors tending to favor **Alternative 4**.

As noted before, this evaluation includes some degree of subjective professional judgment on the part of the consultant team. Community members or others may place different weight on the various evaluation factors which could alter the outcome. Also, the availability of funding could affect projects differently, which could in turn affect the actual cost to property owners and the cost comparison between project alternatives. For example, grant funds available specifically for water conservation/reuse may be projects could reduce the effective cost to property owners and elevate the status of Alternative 4 with respect to costs. Also, the results of formal environmental studies could provide additional information affecting the comparative ranking among the alternatives.

Table 24: Numerical Rating of Alternatives*

COST FACTOR	1 No Project	2 Onsite Upgrades & Mgt. Program	3A Fire Road Community Leachfield Primary Treatment PD Disposal	3B Fire Road Community Leachfield Secondary Treatment PD Disposal	3C Fire Road Community Leachfield Secondary Treatment Drip Disposal	4 Golf Course Water Recycling Tertiary Treatment Storage Pond Spray Irrigation
Regulatory Compliance	1	2	3	5	5	6
Environmental Impacts	1	2	3	5	5	6
Reliability & Flexibility	1	2	3	5	5	6
Resource Utilization	6	5	4	3	3	1 + 1
Land Use	2	1	5	4	4	6
Present Worth Cost	2	4	12	10	8	6
TOTAL	13	16	30	32	30	32
RANKING	6	5	3	1	3	1

**Maximum point score = 6 for all factors except for Present Worth Cost, where it is 12 points*

SECTION 8: MANAGEMENT REQUIREMENTS AND ALTERNATIVES

This section addresses management issues. Specifically, it provides background information regarding management requirements and alternatives for a community wastewater system as well as for an onsite wastewater management approach for the Woodacre Flats study area. A specific recommendation is not presented, since it was beyond the scope of this feasibility study to evaluate and identify a preferred management approach. This is an important next step in the process of developing a wastewater improvement program for the community.

COMMUNITY WASTEWATER FACILITIES MANAGEMENT REQUIREMENTS

As described in the preceding sections of this report, a community wastewater project in Woodacre Flats is anticipated to involve construction of physical wastewater facility improvements for up to 150 existing homes and businesses located in the Study Area. Several different wastewater improvement alternatives have been identified, evaluated and compared. If the community decides to move forward, project selection would be made upon completion of an environmental impact analysis and report and in connection with acquisition of necessary governmental and local sources of funding to finance the project. At this time the two best alternatives identified for the community appear to be: (a) a community leachfield system located at the Fire Road site, including a secondary treatment system and shallow pressure distribution trenches (Alt. 3A); and (b) a water recycling system at the San Geronimo Golf Course, including tertiary treatment, winter storage pond, and seasonal golf course turf irrigation (Alt. 4).

Management requirements for implementation and ongoing operation of a community wastewater project for either of these two alternatives include the following:

- **Public Entity for Facility Ownership and Operation**. A public entity will be required to assume responsibility for ownership and ongoing operation of any community facilities that are constructed. A public entity is also required to oversee the construction of the wastewater facility improvements, including the acquisition and management of funding for construction as well as for ongoing operation and maintenance. The public entity formed for ongoing operation and maintenance must be in place prior to initiation of project construction.

- **Assessment District for Construction Financing.** Grant fund from State, Federal or other sources may available for the implementation of a community wastewater project for Woodacre Flats. Such funds could be used to pay for administration, planning and design-related services, and construction costs; however, it is likely that any grant funds would only be able to cover a portion of the total costs. For example, in the Marshall Phase 1 Community Wastewater Project, grant funds covered roughly half of the overall project costs; the remaining costs ("local share") were financed through the formation of a local assessment district. This is one of the most common methods used to finance sewer systems and other public works projects. The assessments, secured against the properties in the project service area, are used to support low-interest loans and/or the sale of bonds to pay for the balance of the construction costs not covered by grants.

- **Ongoing Operation and Maintenance/Management Fees.** Once constructed, the project facilities will require ongoing operation and maintenance, the costs for which will be paid through the collection of fees or user charges from all properties served by the project. These fees are normally collected as part of the annual tax bill; however, they may be collected through direct billing, which is more cumbersome and not as common. The annual operation and maintenance costs will vary depending upon the specific facilities included in the selected project as well as the number of service connections. A review of anticipated operation and maintenance requirements and costs for the various project alternatives is covered in **Section 6**.

WOODACRE FLATS ONSITE WASTEWATER MANAGEMENT PROGRAM

Although not identified as the preferred project, Alternative #2 presents the option of upgrading individual onsite septic systems along with ongoing management and oversight. Implementation of this alternative would require the establishment of an onsite wastewater management program (also "management district" or "management zone") that covers all developed properties within the defined Woodacre Flats service area. The aim would be to develop and implement a local program to help finance and oversee the implementation of onsite wastewater system improvements, and for ongoing oversight of all systems in the service area. In the future, such a district might also be in a position to undertake planning, implementing and managing subsequent phases of septic system improvements in other parts of Woodacre.

The functions of an onsite wastewater management district can range widely, depending on the goals, the facilities to be maintained, local resources and capacity to undertake management and maintenance responsibilities. Some of the key functions of a management program for the Woodacre Flats area are expected to include:

- Inspect and monitor individual onsite system upgrades;
- Conduct ongoing water quality monitoring of groundwater and/or surface waters in selected areas;
- Plan and develop additional wastewater improvement project phases;
- Seek grant funds or other financing for other phases of improvements, and for direct assistance to homeowners;
- Provide reports to County, RWQCB and others on the status of wastewater-water quality conditions in the Woodacre Flats area; and
- Represent the Woodacre Flats property owners in regulatory matters concerning wastewater system requirements for the area.

The institutional and financial requirements for implementing an onsite wastewater management program would include the same basic items previously described for a community wastewater facility, with some variation as described below.

- **Public Entity.** Formation of a public entity (i.e., management district) would be required to obtain and utilize public grants or loan assistance for implementing onsite wastewater improvements and to carry out the ongoing septic system oversight and management functions. In the future, a public entity could also potentially implement other wastewater improvement projects in the Woodacre area.

- **Assessment District and Loans.** An assessment district could potentially be formed to help finance the onsite wastewater improvements. However, since assessment districts are normally used for financing facilities that serve the common good, rather than individual property improvements, there is little experience in this area and finding suitable lending sources may be difficult. Alternatively, a loan program could potentially be set up by the public management district to make low-interest State funds available to private property owners to help finance individual onsite improvements.

- **Ongoing Operation and Maintenance/Management Fees.** Costs to maintain and oversee the onsite wastewater improvements would be paid for by user fees from the homeowners in the Woodacre Flats service area. Similar to the requirements for a community wastewater facilities project, such fees would go toward the payment of district administration and overhead costs, technical services/equipment for inspections, monitoring of individual systems, water quality sampling costs, and reporting. The fees could be included on the tax bill or collected through direct billings. The fee structure could be customized to reflect different levels of management oversight. For example, a fee structure could be established to charge a uniform base rate to all properties, with additional fees assigned according to the type of technology (standard or advanced system), monitoring frequency, etc.

INSTITUTIONAL ALTERNATIVES

Introduction

The implementation of a community wastewater project in Woodacre will require the formation of or annexation to a public district that has suitable powers and authority for operation and management of public sewers. This is required as a matter of public policy and also to enable the community to obtain and utilize various forms of public financial assistance available from the State and Federal government.

Provided here is a brief overview of the potential options available along with some of the key considerations that may influence the local decision on an appropriate institutional arrangement for the community. In general, all options presented here are technically viable; the ultimate decision by the community will likely focus on issues of local autonomy, economics and possibly political or personal preferences.

Existing Institutions

The present wastewater feasibility study is being conducted by the County of Marin, which has general authority for wastewater management throughout the unincorporated area of the County. Acting in this general capacity, the County has the authority to continue through the design and construction phase of the project, if this is desired. This is the approach that was followed for the Marshall Phase 1 Community Wastewater System. However, ultimately a district will be needed for the operation and maintenance of the facilities that are constructed or for the governance of an onsite wastewater management program, if that option is selected.

Presently, there are two local districts with sewerage powers that encompass or are in reasonable proximity to the Woodacre Flats area: (1) Marin Municipal Water District (MMWD) and (2) Ross Valley Sanitary District (RVSD). MMWD provides water service to the area, and has the authority to expand its scope of activities to include wastewater services. However, this would be a significant departure from existing MMWD operations and no inquiry has yet been made into the potential interest of MMWD in taking on sewer service responsibilities. The RVSD operates an extensive sewer collection system with sewer service boundaries that extend to Fairfax. RVSD has the capabilities to provide wastewater service for a project in Woodacre; however, its boundaries would have to be extended into the San Geronimo Valley through annexation. Thus far no inquiry has been made into the potential interest of RVSD in expanding their service area and activities to encompass a community wastewater project in Woodacre.

Independent Local Districts

Independent local districts are those formed to carry out a specific local public function, where the administration and decision-making is entrusted to a locally elected Board of Directors. This board assumes the responsibility for all policy, staffing and fiscal matters for the properties within the district. The boundaries of the district are established to encompass the areas benefiting from the district facilities or activities. Common types of independent local districts pertinent to the provision of sewerage services include:

- **Community Services District (CSD)**. These districts have the authority to provide a broad range of public services, including police and fire protection, recreation and lighting, as well as water and sewer service. The formation of a CSD is initiated by local initiative; i.e., petition to the Board of Supervisors. An election is required for district formation and for election of the Board of Directors. The election can be waived if the petition includes at least 80 percent of the registered voters in the proposed district. There are no existing CSDs in the San Geronimo Valley. However, there are other CSDs in West Marin, e.g., Tomales Village CSD, which operates the community's wastewater collection, treatment and disposal facilities.

- **County Water Districts**. These local districts, authorized under the California Water Code, are formed in a similar manner to CSDs. But their powers are limited to provision of water and sewer service within their boundaries. Stinson Beach County Water District (SBCWD) is an example of this type of district. The SBCWD, with a locally elected board of directors, provides water service and also manages the onsite wastewater management program for the entire Stinson Beach community. Marin Municipal Water District is another example of a County Water District, which supplies water to the majority of the population in Marin County, including incorporated and unincorporated areas.

- **Sanitary Districts**. These districts are authorized under the Health and Safety Code specifically for the provision of sewage collection, treatment and disposal services. They can also provide water service. They are formed in a manner similar to CSDs and County Water Districts. The governing board of a Sanitary District is locally elected. Presently, there are no Sanitary Districts or County Sanitation Districts in West Marin. However, there are several sanitary districts throughout other parts of the County, such as the Ross Valley Sanitary District, Novato Sanitary District, and Las Gallinas Sanitary District.

- **Public Utility Districts.** These districts are authorized under the State Public Utilities Code and can provide a wide range of utility services, including sewer and water service. Public Utility Districts (PUD) can only be formed in unincorporated areas. They are governed by a locally elected board consisting of either three or five members. Inverness PUD and Bolinas Community PUD are local examples of PUDs in Marin County. Both of these districts provide water service within their districts; Bolinas Community PUD also owns and operates community sewerage facilities serving the downtown area of Bolinas.

Some of the common advantages of independent local districts include: (1) local autonomy in the decision-making process; and (2) local accountability and control over costs. The disadvantages of independent local districts may include: (1) limited financial resources and leverage; (2) limited economies of scale; and (3) limited resources and ability to meet public service demands. However, as in the case of MMWD and RVSD, independent water and wastewater districts can be large enough to encompass multiple jurisdictions and overcome economy of scale limitations.

County-Dependent Districts

This category encompasses those districts formed and administered as sub-sets of County government. The County Board of Supervisors serves as the governing body or decision-maker for these districts. The Board of Supervisors acts as the Board of Directors for various dependent districts. As such, they assume responsibility for all policy, staffing, debt and rate structures within the boundaries of the district.

Marin County utilizes dependent districts to provide such things as sewer maintenance, landscape maintenance, lighting, recreation, fire protection, drainage and paramedic services. Marin County Counsel provides legal service. The Board of Supervisors typically works with a Citizen's Advisory Committee within each of the dependent districts to provide an opportunity for local input to the decision-making process.

Examples of County-dependent districts in Marin County include the following:

- **County Service Areas (CSA)**. County service areas are much the same as CSDs in their range of authority. The key distinction is the governing body, which is the Board of Supervisors for all CSAs. They can be formed by either local petition or by a resolution of the Board of Supervisors. Presently, there are 16 CSAs in Marin County providing a variety of public services, ranging from park and open space management to drainage maintenance. There are currently no existing CSAs in Marin County that provide sewer services. However, in neighboring Sonoma County, a county-wide CSA, with multiple zones of benefit, is used to provide wastewater treatment and disposal services for several unincorporated communities.

- **Sanitation Districts**. These districts are authorized under the Health and Safety Code specifically for the provision of sewage collection, treatment and disposal services. They can also provide water service. It can include unincorporated and incorporated areas; its governing board is made of County Board of Supervisors and/or City Council members, depending upon the makeup of the district. A sanitation district may be formed upon local petition and Board approval. San Rafael Sanitation District is currently the only County Sanitation District in Marin County; it was formed to manage the sewer collection system for the San Quentin area.

- **Onsite Wastewater Management Districts.** The concept of public management of onsite wastewater disposal was developed in California in the mid-1970s to expand wastewater options in rural and suburban communities, specifically by providing a means for more effective planning, operation and maintenance of onsite systems. The enabling legislation, Senate Bill 430, became law in January 1978 and was added to the California Health and Safety Code, commencing with Section 6950. This legislation enables public agencies that have powers to manage sewerage systems to form, under certain specified conditions, Onsite Wastewater Disposal Zones (Zones) in order to provide for the collection, treatment, reclamation or disposal of wastewater without the use of community-wide sanitary sewers or sewage systems. Such Zones may also manage community leachfield systems. Public agencies empowered to form such Zones include qualified special districts such as county service areas, community services districts, utility districts, sanitation districts, water districts, etc., as well as cities. The Zone formed under the Health and Safety Code is the area defined for operation and maintenance of onsite wastewater systems by the public agency. In 2207 the County of Marin formed the Marshall Onsite Wastewater Disposal Zone to serve as the governing entity for the Marshall Phase 1 Community Wastewater System.

The main advantages of County-dependent districts include: (1) availability of county resources and associated economies of scale; (2) financial strength and leverage for bonding and contracting. The key disadvantages of County-administered districts include: (1) reduced local control of the decision-making process; and (2) reduced ability to influence fiscal matters, e.g., through voluntary/community service or other cost reduction measures (e.g., County overhead, travel time and costs).

LAFCO

The Local Agency Formation Commission (LAFCO) was created by the Legislature in 1963 to discourage urban sprawl and encourage the orderly formation and development of local government agencies. There is a LAFCO in each county in California except the City and County of San Francisco. LAFCO is a seven-member Commission comprised of two city council members (chosen by the Council of Mayors), two county supervisor members (chosen by the Board of Supervisors), two special district members (chosen by Independent Special District election), and one public member (chosen by the members of the Commission).

LAFCO has four major functions under State law:

1) To review and approve or disapprove proposals for changes in the boundaries or organization of cities and special districts in the county (including annexations to or detachments from cities and districts, incorporations of cities, formations of districts, and the dissolution, consolidation or merger of special districts), applications for activation of special district latent powers, and applications to provide service outside of a city or district boundary;
2) To establish and periodically update the sphere of influence or planned service area boundary for each city and special district;
3) To initiate and assist in studies of existing local government agencies with the goal of improving the efficiency and reducing the costs of providing urban services; and
4) To provide assistance to other governmental agencies and the public concerning changes in local government organization and boundaries.

With regard to the formation of County Service Areas, the Marin LAFCO implements the following policy:

> *"County Service Area (CSA) Policy*
>
> *A County Service Area may be formed when unincorporated areas that are located outside municipal sphere-of-influence boundaries desire extended urban-type services including police and fire protection from the County of Marin.*
>
> *Unincorporated lands located within a municipal sphere-of-influence boundary should not be eligible to receive extended urban-type services from the county in the form of a County Service Area except when (a) evaluation on a case-by-case basis justifies creation and (b) the affected city, by letter, expresses approval of such action. (Originally Adopted: July 13, 1977; Revised: January 13, 1983)"*

Woodacre does not fall within the sphere-of-influence boundary of any municipality. LAFCO policy concerning the formation of County Service Areas would appear to permit the establishment of a CSA for the provision of wastewater collection and treatment services for the Woodacre Flats area.

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Appendix A

Onsite System Survey Information

- 2004-2005 Septic Matters Program
- 2010 Questa Field Reviews

2004-2005 Septic Matters Program

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The Septic Matters Program

A Survey of Septic System Conditions in the Tomales Bay Watershed

Background
Contaminants relating at least in part to septic systems were found in Tomales Bay and in tributaries that flow into the Bay. Salmon spawning is known to occur in some of the tributaries. Marin County Environmental Health Services applied for grants to survey the condition of septic systems in close proximity to the Bay and to waterways in the Tomales Bay watershed. Grants were provided through the State Water Resources control Board and the Coastal Conservancy and inspections were made in the communities of Forest Knolls (19), Inverness (18), Lagunitas (13), Marshall (2), Nicasio 2), San Geronimo (8), Petaluma (2), Point Reyes Station (9), and Woodacre (62 – note an active community group encouraged participation).

As owner permission to review and test individual septic systems would have been unlikely, the Septic Matters Program was devised by Marin County Environmental Health (EH) to provide community education to homeowners while offering a free and confidential third party inspection and testing of the systems. It was felt that education regarding the function of septic systems and the impacts of failing or marginal systems would be a valuable foundation to the program. Additional site specific education was provided to individual homeowners who voluntarily requested septic system inspections. Inspection data labeled by community was provided to Marin County minus the specific address of the residence. A total of 135 inspections were done between 1/26/04 and 3/22/08. (Eleven additional inspections were made in Bolinas and Novato which are outside of the Tomales Bay watershed.)

From 1/26/04 to 1/31/06, 98 inspections (87 in the watershed) were made by Kit Rosefield, a septic system inspector with certifications through both the National Sanitation Foundation (NSF) and the National Association of Wastewater Transporters (NAWT). Kit held 18 Septic Social educational workshops in four different communities. When Mr. Rosefield moved his business to Tuolumne County, EH asked me to perform additional inspections. I was able to complete 48 septic system reviews from 12/3/07 to 3/22/08. My experience consists of nearly 30 years in onsite wastewater practice with both San Diego and Sonoma Counties, with the last seven years in private practice. I left Sonoma County in 2001 as Supervisor of the Well and Septic Division and am also a NAWT certified inspector. Kit Rosefield and I are both instructors for NAWT through the California Onsite Wastewater Association.

During the inspections, a number of problems were discovered, including failing systems, leaking tanks, failed pumps, and inoperational equipment. A combination of education, suggestion and assistance for repairs led to a number of corrections which has, at least in some way, contributed to beneficial effects on the quality of the ground and surface waters of the watershed.

Goals

The program was set up to offer community and individual homeowner septic system education and to provide a sampling of the condition and function of septic systems in close proximity to the Bay and to water ways of the Tomales Bay watershed. In addition, suggestions and assistance for system repair and improvement were to be provided.

Process

Through community educational meetings, newspaper ads, interested community groups, real estate office flyers and word of mouth, appointments were made at the request of homeowners to inspect their septic systems. Prior to meeting with homeowners, we pulled copies of septic system permits and plot plans from EH and provided those, where available, for the owner. I estimate that some level of septic system records were available for about 2/3 of the homes. Some people did not know what their system was comprised of or where some components were located. At that time, we offered educational materials and County lists of pumping firms, contractors and designers. We discussed needed repairs and offered suggestions as to how to what professional groups were most suited to do them. Common suggestions were for the replacement of tanks or systems, installation of fiberglass surface risers and effluent filters, tank pumping, and hook-up of surface graywater lines back into the septic tank.

Inspections were made, where possible, of the tanks, pump tanks, and any components of the system accessible from the surface such as valves and monitoring wells. A hydraulic load test meeting Marin County standard Memorandum #1 was performed where possible. Written reports were generated, usually on site, and handed to the homeowner. No copies were kept, giving increased credence to the confidential nature of the inspection. General information by community, minus specific addresses, was kept on spreadsheets (attached) for Marin EH.

As inspections came from voluntary homeowner requests, a truly random sampling program was not available. I believe, however, that given the similar site characteristics, system ages, and lot sizes for a majority of the homes, the findings offer a reasonably valid snapshot of overall conditions in some of these communities.

Onsite Wastewater Issues Observed in the Survey

1. *System Age* – The majority of the houses were from the turn of the century through the 1970's. Newer homes with more modern systems were in the minority. In relation to the average system lifespan generally estimated at thirty years, most of the systems viewed were 30-50 years old. Many of the system owners noted repairs had been done, most often without permits.
2. *Small Parcels* – As is often seen in older subdivisions, many of the lot sizes are small, often ranging from 8-15,000 square feet. The lots were often overdeveloped with homes, garages, driveways, decks, pools and other hardscape in relation to the space given to the septic system. There was often little or no fail safe or system replacement area remaining.
3. *High Groundwater (GW)* – Valley floor and flatter areas (such as Railroad Avenue in Woodacre tend to have high seasonal GW. I observed GW as high as 4 inches and many sites at 16-18 inches from the surface. These elevations typically flood both gravity septic tanks and dispersal fields that may be 3-6 feet deep. It is documented that such saturated soils provide for transmission of pathogenic organisms up to 1,000 feet. Anecdotal reports of heavy rain sheet flow were also mentioned by some homeowners.

4. *Small Systems* – Many of the systems are smaller or substantially smaller than would be required under today's more scientifically based standards. These conditions will likely result in faster accumulation of clogging bio-mat and a reduced system lifespan. In addition, smaller systems are more subject to hydraulic overload.
5. *Marginal or Shallow Soils* – In discussions with EH staff and anecdotal talks with homeowners, many of the area's soils are shallow or marginal, with standards gravity systems (the most common type found) poorly suited for adequate dispersal under these conditions.
6. *Additional Living Units* – Secondary living units were seen at 10-20% of the residences inspected, some existing without permits. This increases wastewater volume and stresses on existing systems.
7. *Proximity to Waterways* – Many systems are closer to waterways than current standards would allow, creating increased potential for contaminant transmission.
8. *Graywater Discharges* – A number of homes discharge graywater (laundry, showers, sinks) to the ground surface, ditches, or to unpermitted gravel filled sumps. As graywater carries pathogens, this increases the possibility of contaminants being carried offsite. This is done to relieve pressure on marginal or failing septic systems or occasionally by owners pro-actively reducing the load on their systems.
9. *Limited or No Fail Safe* – Most properties had limited or no system replacement area, especially if current set backs from wells, waterways and structures were enforced.
10. *Reduced Access to Tanks* – Development such as decks and pavement stones have limited reasonably easy access to some tanks for pumping and diagnosis, resulting, in my opinion, in less frequent or no pumping and diagnostic checks of those tanks.
11. *Mosquito Breeding* – This was noted in several tanks or pump tanks with inadequate or poorly fitting concrete, fiberglass or wooden lids.
12. *Unpermitted Repairs* – A high percentage of repairs (Kit Rosefield estimated 60%) have been made without permits, leading to questions of adequate repairs and reasonable setbacks. Anecdotally, homeowners were afraid that if they sought permits, the County might reject them or require an unaffordable system. Also, there were concerns that the County may view other unpermitted work or second dwelling units and cause further problems. For some, it was an issue of philosophically not desiring any contact with governmental representatives. Some noted when there are problems with those repairs; however, the installer is often not interested in returning calls or correcting their work.
13. *Pre-code Tanks* – A modest percentage of tanks are redwood or, more rarely, bottomless, and are more likely to act like cesspools with reduced treatment and retention.
14. *Appropriate Repairs* – Most repairs have been "more of the same" gravity leach lines. With high GW and small spaces, the most appropriate repairs would be Bottomless Sand Filters, Mounds, or Advanced Treatment with Drip systems (on steeper slopes). These nonstandard type systems generally appeared to be functioning properly during the inspections. With price tags estimated at $40-60,000, they are not well accepted by homeowners. In addition, Bottomless Sand Filters and Mounds may take up much or all of the available recreational space on a small property, an issue also not well accepted. Many such nonstandard systems we observed were required as the result of a property transfer negotiation or as a County requirement for a new house, additional bedrooms or a major remodel.

Although not a registered geologist, my work of nearly 30 years in this field with geologists and hydro geologists alerts me to note the obvious geological setting of these valleys. Essentially all surface and subsurface wastewater discharges in the valley settings experienced in this study eventually drain to the tributaries which in turn feed Tomales Bay.

Findings – Septic Tank and Dispersal Systems (135)

	Septic Tank		Dispersal Systems	
	#	%	#	%
Acceptable	82	61	80	59
Unacceptable	39	29	42	31
Unknown/NA	14	10	13	10

Please see the Appendices section for definitions of Acceptable, Unacceptable and Unknown. A point here is that there were 14 tanks that could not be examined.

Findings – Hydraulic Load Testing (135)

	#	%	As a % of those actually tested
Excellent	17	12.5	20
Good	40	30	48
Satisfactory	4	3	5
Satisfactory / Marginal	4	3	5
Marginal	3	2	4
Poor	4	3	5
Failed	11	8	13
Unknown / N/A	52	38.5	--

Please see the Marin County EH Memorandum #1 for definitions and testing procedure. A point here is the high number of tests which could not be performed to flooded leaking tanks, failed pumps, access or other problems. Of 135 systems, only 83 could be tested. Many of those not tested would have been considered Failed if we had chosen to test an already unacceptable dispersal system or flooded tank.

Assumptions

The basic site conditions are unlikely to change: small parcels, high GW, often marginal soils, close proximity to waterways, limited replacement area, and seasonally saturated soil transmission of contaminants.

With the status quo, conditions that are unlikely to change or that may worsen with time are aging (deteriorating) systems, small systems, graywater or other discharges, unpermitted system repairs and remodeling, mosquito breeding, reduced access to tanks, and creek contamination.

Approximately half the inspections were done during the dry months (May through September). It is surmised that if all the inspections were done during wet weather periods, the rate of systems classified as failures would have been higher due to elevated winter GW and saturated soils.

Conclusions

A problem exists with many older systems in the Tomales Bay Watershed. Although some of the communities we visited had too few inspections requested to form a valid conclusion, there seems to be a pattern with the older systems and smaller parcels. Systems will continue to age, resulting in an increasing risk for surface and subsurface contamination of waterways. There appear to be two main categories of solution whose engineering realities, environmental issues, cost and benefit remain to be studied in more detail. The first is the construction of onsite improvements, with the main impediments as discussed being cost and available parcel space. The second potential solution would be a local community decentralized system or other public sewer. A properly sited community system would likely do more to keep wastewater from eventually ending up in the Bay after public sewer treatment. It is my experience that the common sewerage option has more ability to draw the grants or subsidies that would almost certainly be needed for either of the options.

Respectfully submitted,

Mike Treinen,
California Registered Environmental Health Specialist # 3826

APPENDICES

ABBREVIATIONS USED, DEFINITIONS, & INSPECTION SPREADSHEETS

Abbreviations and Definitions

Date
The date of inspection

Vicinity
Community in which the inspection was performed

Proximity to Waterway
Approximate distance from the septic tank and dispersal field to the bank of the waterway

Type of Waterway
A. *Perennial* – Year-round creek or waterway
B. *Ephemeral* – Seasonal flow in natural creek or waterway
C. *Intermittent* – Natural or manmade drainage courses feeding creeks or waterway
D. *Embayment* – Bay, tidal slough or estuary

Septic Tank Type
Block - Cinder block
Con - Concrete
FG - Fiberglass
Pla - Plastic
Rdw - Redwood

Septic Tank Condition
A - Acceptable – No significant deterioration; approved materials (concrete, fiberglass, plastic); major internal components in place
U - Unacceptable – Significant deterioration; unapproved materials (wood, block, metal, bottomless); missing internal components
Unk - Unknown or not applicable – Unable to view tank due to flooded conditions or lack of ability to view all or a portion of the tank

ET – (Enhanced Treatment)

MF - Media filter such as fabric or peat
ATU - Aerobic treatment unit
SF - Sand filter (prior to final dispersal)

Dispersal Type

BSF - Bottomless sand filter
CP - Cesspool
DF - Drainfield / leachfield
Drp - Drip
Mnd - Mound
PD - Pressure distribution
SP - Seepage pit
Unk - Unknown

Dispersal Condition

A - No sign of surfacing effluent, excessive hydrophilic vegetation, damage, erosion, a Hydraulic Load Test (HLT) of Satisfactory, Good or Excellent (S, G or E)
U - Any of the above factors or an HLT of Marginal, Poor or Failing (M, P or F)
Unk - Unknown or NA – Unable to test due to flooded tank, failed pump, leaking tank and / or leaking pressure transmission line

HLT – (Hydraulic Load Test)*

E - Excellent
G - Good
S - Satisfactory
M - Marginal
P - Poor
F - Failed
NA - Unable to test due to flooded tank, pump failure, lack of tank access, tank or line leaks

*See HLT testing protocol in Marin Environmental Health Policy *Memorandum #1*

Note:

In the spreadsheets seen below, I attempted to follow the format established by Kit Rosefield as much as possible to avoid any confusion. The only notable difference was the last column. Kit noted where possible when corrections had been made or were planned. I used that column for general comments.

Inspection Spreadsheets – Kit Rosefield – 1/26/04 to 1/31/06

Date	Vicinity	Proximity to Waterway		Type of Waterway	Septic Tank		ET	Dispersal		HLT	Corrections Made?	
		Tank	Dispersal	Type	Type	Cond.	Type	Type	Cond.	Rated	Y/N	Determination
1/26/04	Novato	35ft.	15ft.	Tidal slough	Pla.	U	-	DF	-	NA		
2/6/04	Novato	135ft.	102ft.	Perennial	Rdw.	U	-	DF	U	NA	Y	EHS permit # 04-05
2/6/04	Novato	120ft	80ft.	Estuary	Con.	A	SF	PD	A	G		
2/19/04	Woodacre	54ft.	76ft.	Perennial	Con.	A	-	MD	A	G		
3/10/04	Woodacre	50ft.	35ft.	Perennial	Con.	A	-	PD	A	G		
3/10/04	Woodacre	83ft.	115ft.	Perennial	Con.	A	-	MD	A	G		
3/17/04	Marshal	6ft.	6ft.	Bay	Con.	U	-	DF	A	G	Y	Pumped, repaired, risers installed
3/18/04	Lagunitas	124ft.	94ft.	Perennial	Rdw.	U	-	DF	U	F	Y	Soliciting designers
3/18/04	Woodacre	53ft.	10ft.	Perennial	Rdw.	U	-	DF	A	G	N	No action, yet
4/2/04	Inverness	71ft.	80ft.	Perennial	Con.	A	-	DF	A	S		
4/2/04	Inverness	82ft.	112ft.	Perennial	Con.	A	-	DF	U	F	N	No action, yet
4/13/04	Novato	95fr.	70fr.	Intermittent	Fbg.	U	-	DF	A	G	Y	New tank to be installed
4/21/04	Petaluma	130ft.	110ft.	Intermittent	Rdw.	U	-	DF	U	NA	Y	EHS permit #04-P-20
4/22/04	Point Reyes	65fr.	55ft.	Ephemeral	Con.	A	-	DF	A	G		
4/23/04	Woodacre	130fr.	145ft.	Perennial	Fbg.	A	-	PD	A	G		
4/25/04	Forest Knolls	40fr.	20ft.	Perennial	Con.	A	-	DF	A	G		
4/28/04	Novato	60fr.	70ft.	Intermittent	Con.	A	-	DF	U	F	Y	Repair made to diversion valve
4/28/04	Point Reyes	75fr.	75ft.	Ephemeral	Con.	U	-	DF	U	F	N	No action, yet
4/29/04	Forest Knolls	110ft.	98ft.	Perennial	Fbg.	U	-	LF	U	F	N	Dual LF, ½ failed, soliciting des.
5/5/04	Woodacre	35ft.	20ft,	Intermittent	Con.	A	-	DF	A	S		
5/5/04	Woodacre	65ft.	35ft.	Perennial	Con.	A	-	DF	A	G		
5/12/03	Lagunitas	25ft.	10ft.	Ephemeral	Con.	A	SF	PD	A	G		
5/12/04	Forest Knolls	67ft,	55ft.	Perennial	Con.	A	SF	PD	A	G		
6/3/04	Forest Knolls	33fr.	21ft.	Perennial	Rdw.	U	-	DF	A	G		
6/7/04	San Geronimo	130ft.	90ft.	Ephemeral	Con.	U	-	DF	A	G	Y	Inlet and tank crack repaired
6/8/04	Pt. Reyes Sta.	120ft.	80ft.	Ephemeral	Rdw.	U	-	DF	A	M	N	Soliciting designers
6/14/04	Petaluma	35ft.	35ft.	Ephemeral	Con.	A	-	DF	A	G		
6/15/04	Lagunitas	85ft.	95ft.	Ephemeral	Con.	A	-	DF	A	G		
6/28/04	Pt Reyes Sta.	25ft.	35ft.	Ephemeral	Con.	A	-	BSF	A	NA		
6/28/04	Pt. Reyes Sta.	75ft.	85ft.	Ephemeral	Con.	A	-	SFT	A	NA		

6/28/04	Pt. Reyes Sta.	135ft.	120ft.	Ephemeral	Con.	A	-	PD	A	NA		
7/1/04	Woodacre	150ft.	130ft.	Ephemeral	Con.	A	-	DF	U	NA		
7/24/04	Bolinas	110ft.	85fr,	Intermittent	Con.	A	-	DF	A	G		
7/24/04	Bolinas	>100ft.	>100ft.	-	Con.	U	-	DF	U	NA	Y	Repairs scheduled
8/30/04	Bolinas	90ft.	95ft.	Intermittent	FG	U	-	DF	A	NA		
8/30/04	Bolinas	90ft.	115ft.	Intermittent	FG	A	-	DF	U	NA	Y	Repairs scheduled
9/2/04	Bolinas	133fr.	73fr.	Ephemeral	FG	A	-	PD	A	NA		
9//2/04	Lagunitas	87ft.	87ft.	Ephemeral	Con.	A	-	DF	A	G		
9/8/04	Lagunitas	90ft.	75ft.	Ephemeral	FG	U	-	DF	A	NA	Y	Pricing tank replacement
9/30/04	Bolinas	25ft.	20ft.	Ephemeral	Con.	A	-	DF	U	NA	Y	Researching ET options
1/10/05	Inverness	20ft.	20ft.	Embayment	Block	U	-	SP	U	NA	Y	Hiring consultant
1/11/05	Forest Knolls	40ft.	15ft.	Perennial	Con.	A	-	DF	A	G		
1/11/05	Forest Knolls	45ft.	20ft.	Perennial	Rdw.	U	-	DF	A	NA	Y	Pricing tank replacement
1/14/05	Inverness	50ft.	80ft.	Ephemeral	FG	A	MF	DD	A	NA		
1/14/05	Inverness	15ft.	20ft.	Embayment	Con.	A	MF	PD	A	NA		
1/18/05	Forest Knolls	20ft.	30ft.	Perennial	Con.	A	MF	PD	A	NA		
1/27/05	San Geronimo	60ft.	95ft.	Ephemeral	Con.	A	-	PD	A	NA		
1/16/05	Forest Knolls	105ft.	95ft.	Ephemeral	Block .	U	-	DF	U	U	Y	Considering options
2/23/05	Woodacre	30ft.	20ft	Intermittent	Con.	U	ATU	DF	U	NA	Y	Hiring consultant
3/17/05	Forest Knolls	75ft.	120ft	Perennial	Con.	A	SF	PD	U	NA	Y	System under repair
3/29/05	Inverness Park	30ft.	20ft.	Intermittent	Con.	A	-	DF	A	G		
3/29/05	Inverness Park	130ft.	110ft.	Intermittent	Con.	A	-	DF	A	E		
3/30/05	Woodacre	30ft.	10ft.	Intermittent	Con.	NA	-	DF	U	NA	Y	High groundwater – drainage issue
3/30/05	San Geronimo	15ft.	60ft.	Intermittent	Con.	A	-	DF	A	E		
3/30/05	Forest Knolls	50ft.	50ft.	Ephemeral	Rdw.	U	-	CP	U	NA	?	Owner agrees replacement needed
3/30/05	Forest Knolls	35ft.	75ft.	Perennial	Con.	A	SF	DF	A	NA		
4/29/05	Woodacre	40ft.	30ft.	Ephemeral	Con.	A	SF	PD	A	NA		
5/3/05	Lagunitas	45ft.	60 ft.	Ephemeral	Con.	A	-	DF	A	G		
5/3/05	Woodacre	75ft.	50ft.	Ephemeral	FG	A	-	SP	U	F	Y	Repair in process.
5/5/05	Lagunitas	30ft.	45ft.	Ephemeral	Con.	A	-	DF	A	G		
5/5/05	Woodacre	85ft.	60ft.	Ephemeral	Con.	U	-	DF	U	F		Recommendations made.
5/16/05	Inverness	60ft.	50ft.	Ephemeral	Con.	A	-	DF	A	G		
5/18/05	Woodacre	65ft.	60ft.	Intermittent	Con.	A	-	DF	U	NA	Y	Repairs scheduled according to owner.
6/1/05	Forest Knolls	110ft	60ft	Ephemeral	Con	A	-	DF	A	G		

6/1/05	Woodacre	35ft.	20ft.	Perennial	Con.	A	-	DF	A	S		
6/7/05	Woodacre	65ft.	15ft.	Ephemeral	Con.	U	-	DF	A	G	Y	Inquiring about tank replacement
6/8/05	Forest Knolls	55ft.	75ft.	Ephemeral	Con.	A	-	PD	U	P	Y	Scheduled system service
6/9/05	San Geronimo	15ft.	35ft.	Perennial	Con.	A	-	DF	A	G		
6/9/05	Nicasio	50ft.	?	Ephemeral	Con.	A	-	?	U	F	Y	Selecting Designer
6/14/05	Lagunitas	150ft.	175ft.	Ephemeral	Con.	A	-	DF	A	G		
6/21/05	Lagunitas	75ft.	40ft.	Perennial	FG	A	-	DF	A	G		
6/22/05	Inverness	120ft.	130ft.	Ephemeral	Con.	A	-	PG	F	NA	Y	Electrical problem- repairs to be scheduled
6/22/05	Inverness	20ft.	150ft.	Ephemeral	Con.	A	-	PG	A	G		
6/24/05	Forest Knolls	25ft.	25ft.	Perennial	FG	A	-	DF	A	G		
6/24/05	Forest Knolls	35ft.	30ft.	Ephemeral	Con.	A	SF	PD	A	G		
7/12/05	Inverness	100ft. +	100ft. +	N/A	Con.	A	-	DF	A	G		
7/12/05	Inverness	75ft.	95ft.	Intermittent	FG	U	-	DF	A	G	Y	Client to have inlet fitting installed.
7/12/05	Inverness	100ft. +	100ft. +	N/A	Con.	N/A	-	DF	U	N/A	Y	Tank backed up, owner to contact contractor.
7/13/05	San Geronimo	75ft.	75ft.	Perennial	Rdw.	U	-	DF	U	N/A		Tank backed up, owner exploring options.
7/13/05	Forest Knolls	60ft.	30ft.	Intermittent	Con.	A	-	PD	A	G		
7/18/05	Inverness	60ft.	30ft.	Ephemeral	FG	U	-	DF	A	G		Owner contacting contractors for repair.
7/18/05	Inverness	75ft.	65ft.	Ephemeral	Rdw	U	-	DF	N/A	N/A		Tank deterioration disallowed HLT. Owner exploring tank replacement.
7/20/05	Inverness	100ft. +	100ft. +	N/A	Con	U	-	DF	N/A	N/A		Cracked tank not water tight. Owner exploring options.
7/21/05	Woodacre	55ft.	65ft.	Perennial	Con	A	-	DF	A	G		
8/18/05	Woodacre	55ft.	25ft.	Ephemeral	Block	U	-	DF	A	G		
8/24/05	Pt. Reyes	100ft+	100ft +	N/A	Con	A	-	DF	A	G		
8/24/05	Inverness	65ft	35ft	Perennial	Con	A	-	DF	A	M		
8/25/05	Lagunitas	70ft.	70ft.	Perennial	FG	A	-	DF	A	G		
8/29/05	Lagunitas	30ft.	N/A	Intermittent	CP	U	-	CP	U	N/A		Owner evaluating options.
8/29/05	Woodacre	30ft.	20ft.	Perennial	FG	A	-	DF	A	M		
8/31/05	San Geronimo	25ft.	25ft.	Intermittent	FG	A	-	DF	A	G		
9/20/05	San Geronimo	85ft.	65ft.	Perennial	Con	A	-	DF	A	G		
9/20/05	San Geronimo	120ft.	95ft.	Perennial	FG	U	-	DF	A	G		Owner considering tank

												replacement
9/23/05	Lagunitas	40ft.	25ft.	Perennial	FG	U	-	DF	U	N/A		Owner seeking consultant.
1/9/06	Nicasio	135ft.	100ft.	Perennial	Rdw	U	-	DF	NA	NA		Contacting contractors for tan replacement
1/31/06	Marshall	150r5.	110ft.	Bay	Con.	NA	-	DF	U	NA		Seeking designer
1/31/06	Forest Knolls	60ft.	25ft.	Perennial	Con.	U	--	DF	NA	NA		Contacting contractors for tank replacement
1/31/06	Forest Knolls	30ft.	15ft.	Perennial	Rdw.	U	-	DF	U	F		Seeking designer

Inspection Spreadsheets – Mike Treinen – 12/3/07 to 3/22/08

Date	Vicinity	Proximity To Waterway		Type of Waterway	Septic Tank		ET	Dispersal System		HLT	Comments re: the System Constraints
		Septic Tank	Dispersal System	Type	Type	Cond	Type	Type	Cond.	Rating	
12/3/07	Woodacre	50	20	Intermittent	FG	Unk.	-	SP/DF	U	n/a	Tank/Risers flooded
"	"	20	10	"		A	-	DF	U	F	GW & Drainage issues
1/7/08	"	60	60	"	Rdw	U	-	DF	U	n/a	Tank flooded, GW, Graywater
"	"	60	60	"		Unk	-	DF	U	n/a	Tank flooded, GW
"	"	60	60	"	FG	A	-	SP	A	S/M	Graywater, GW(?)
1/11/08	"	100	100+	Perennial	Con	A	-	DF	A	E	DF in Driveway
"	"	70	50	"	"	A	-	SP	U	P	-
1/16/08	"	75	75	Intermittent	"	Unk	-	DF	U	n/a	Tank Flooded, GW
"	"	75	75	"	"	A	-	Unk	A	E	-
1/23/08	"	100	60	"	"	A	-	DF	A	E	-
"	"	100	75	"	"	Unk	-	SPs	U	n/a	GW into tank – pumped into SPs
"	"	75	60	"	"	Unk	-	SP	U	n/a	GW @ 4" – covering tank, Graywater
2/1/08	"	100	75	"	"	Unk	-	DF	U	n/a	Tank flooded
"	"	75	20	"	"	A	MF	MD	A	E	Pump very slow
"	"	25	75	Perennial	"	A	-	DF	A	S/M	-
2/8/08	"	100	20	Intermittent	"	A	MF	MD	A	E	GW @ 12"
"	"	100	100	"	FG	A	-	DF	U	n/a	GW @ 6-8", DF not working
"	"	40	80	Perennial	Con	Unk	-	PD	n/a	n/a	Pump not working
2/11/08	Pt. Reyes	40	90	Embayment	Con	A	-	MD	A	E	-
"	"	50	100	"	"	A	-	MD	A	E	Apparent gravel bed clogging

"	Inverness	100	80	"	FG	A	-	DF	A	E	Dual system – newer
2/19/08	Woodacre	90	60	Perennial	Con	A	-	DF	A	E	Graywater
"	"	85	65	Intermittent	Rdw	U	-	SP/DF	U	n/a	GW, SP not working
"	"	40	20	"	Con	A	-	DF	U	P	GW
"	"	20	30	"	"	Unk	-	SP	A	E	Deep outlet not uncovered

Date	**Vicinity**	**Proximity To Waterway**		**Type of Waterway**	**Septic Tank**		**ET**	**Dispersal System**		**HLT**	**Comments re: the System Constraints**
		Septic Tank	**Dispersal System**	**Type**	**Type**	**Cond**	**Type**	**Type**	**Cond.**	**Rating**	
2/27/08	Woodacre	30	40	Perennial	Con	Unk	-	DF	Unk	n/a	Pump tank flooded
"	"	100	100	Intermittent		U	-	DF	A	S/M	-
"	"	80	50	"	"	U	-	Unk	U	n/a	Tank flooded
3/14/08	"	50	50	"		U	-	Unk	U	n/a	Tank flooded, mosquito breeding
"	Forest Knolls	100	75	"	Con	A	-	DF	U	n/a	DF failing
"	Lagunitas	100	100	Perennial	"	A	-	DF	A	E	Tank leaking, pump in tank to DF
"	Woodacre	50	10	Intermittent	"	A	-	DF	A	E	Pump tank not watertight
3/17/08	"	100+	100+	Perennial	"	A	-	BSF	A	E	Newer bottomless sand filter
"	"	20	30	Intermittent	"	Unk	-	DF	U	n/a	Tank flooded
"	"	100+	100+	Perennial	FG	A	-	DF	Unk	n/a	Pump not working
"	"	20	30	"	Con	A	-	DF	U	P	Blockage or DF not working
3/19/08	"	100	80-100	"	"	A	-	DF	A	E	Evidence of High GW
"	"	100	80-100	"	"	A	-	DF	A	S	-
"	"	75	50-75	Ephemeral	"	U	-	Unk	Unk	n/a	Tank leaking, graywater
3/21/08	"	100	100	Perennial	FG	U	-	DF	Unk	n/a	Tank leaking & pump pipe leak
"	"	100	90	"	Rdw	U	-	SP	A	Unk	Leaks around outlet pipe
"	"	80	80	"	"	U	-	DF	Unk	n/a	Tank had not been uncovered
"	"	60	100+	"	FG	Unk	-	DF	Unk	n/a	Pump not working; both tanks full
"	"	35	45	Intermittent	Con	A	-	DF	U	F	DF under driveway
"	"	75	85	"	"	A	-	DF	A	S/M	Evidence of high GW
3/22	"	100+	100+	"	"	A	-	DF	U	N/A	GW, high water level in tank, Dual
"	"	90	80	"	"	A	-	SP	A	E	-
"	"	100+	100+	Perennial	"	U	-	DF?	Unk	n/a	Bottomless tank

2010 Questa Field Reviews

Field Review Notes for West Subarea
(Woodacre Creek Corridor and SW of Railroad Ave)

System ID	System Address	Site Conditions Summary					Recommended System Upgrade	Creek Setback Compliance with Upgrade		Other Variance Issues
		Bldg. Size	Slopes	Effective Soil Depth	Depth to GW	Drainage Features		with 100% System	with 200% System	
1	Undisclosed	3BR + cottage	<4%, flat	60"+	none to 60"	(E) modern dual low flow mound close to creek (16-23'), 5' elevation drop from S.G. Valley Dr to property	None (Class 2 system)	N	N	None (Class 2 system)
2	Undisclosed	2 BR	35-50%	72"	none to 6'	Seasonal creek is adjacent to existing ST and approx 25' laterally to drainfield. It drains to roadside ditch near DS PL.	Generally not suitable for OWTS, poss segmented raised drip	N	N	Setback variances req'd
3	Undisclosed	2BR	varies, 20%	18"	none to 18"	ST and LF are adjacent to Woodacre Creek. Vertical creek banks are 10-15' high.	Gnerally not suitable for OWTS, poss segmented raised drip	N	N	Setback variances req'd
4	Undisclosed	3BR	flat, <2%	54"+	62" (3/01)	Roadside ditches on Park and Rairoad	None (Class 2 system)	Y	Y	None (Class 2 system)
5	Undisclosed	2BR	approx 50% some small benched areas	48-52"	none to 72"	ST, Pump and PD trenches are adjacent to Woodacre Creek (trenches by 25'-wide flood plane), deep soils are 40' from opposite-side street drainage that collects upslope runoff	Drip w/ curtain drain and setback variances	N	N	Setback variances req'd
6	Undisclosed	2BR	flat, <2%	6" over bedrock	none to 6"	House extends past top of bank on flood plain of Woodacre Creek. Top of bank is 70-75' from opposite PL.	Raised drip w/ setback variance	N	N	Setbacks to Bldgs, pavement and PL's
7	Undisclosed	4BR	flat, <2%	unknown	unknown	Approx 100' to Woodacre Creek (located on neighboring property.)	Drip or raised drip w/ setback variances	N	N	Setback variances req'd
8	Undisclosed	4BR	flat, <2%	6-8" soil over RR bedding & serpentine	none to 8"	1-2' elevation drop (east to west) at side property lines, small elevation drop to streetside ditch	Raised drip w/ setback variance	N	N	Setback variances req'd
9	Undisclosed	1BR	flat, <2%	12"	none to 12"	House partially hangs over creek and sewer line crosses bridge to deep-buried ST and PC. Woodacre Creek is 55-60' from opposite property line. Almost-vertical creek banks.	Shallow drip, possible mound, w/ setback variance	N	N	No development on adjacent lot
10	Undisclosed	1BR	flat, <2%	6' w/ probe	none to 6'	Woodacre Creek is 85-110' from opposite PL. There is a flood plain below top of bank that extends the setback to water approx 40'	Std PD or Drip	N	N	Setbacks to Creek, Bldgs, PL's
11	Undisclosed	unknown	32-35%	unknown	unknown	7' cutbank retaining wall w/ backdrain, 28' setback to LF was maintained	None (apparent Class 1 system)	Y	Y	None (apparent Class 1 system)
12	Undisclosed	26'x44', 2 stories	2 -4%	5' w/ probe	none to 60"	Confluence of two tributaries on two sides of property	Drip or raised drip w/ setback variances	N	N	Creek on two sides w/ no suitable setbacks, property mostly covered w/ pavement and bldgs
13	Undisclosed	1400 ft2	flat, <2%	28"	seeps at 16" and 24"	street ditches along N & W PL's	Drip	Y	Y	Setbacks to Bldgs, pavement and PL's

Field Review Notes for Central Subarea
(NW of Railroad Ave to Central Ave & Park St)

System ID	System Address	Site Conditions Summary					Recommended System Upgrade	Creek Setback Compliance with Upgrade		Other Variance Issues
		Bldg. Size	Slopes	Effecitive Soil Depth	Depth to GW	Drainage Features		with 100% System	with 200% System	
14	Undisclosed	Post office, 200gpd	flat, <2%	18"	none to 32"	No absorbtion area between mound and road (paved sidewalk). Effluent spill would flow to roadside ditch that starts at adjacent property. Also, a tributary is located across S.G. Valley Drive from N side PL.	None (Class 1 system) Reserve mound not built.	Y	N	Almost all property occupied by bldgs or pavement
15	Undisclosed	2BR	flat, <2%	26"	seeps @ 16" (near LF) and 24"(front yard)	Paved curbside in front of property	Raised drip w/setback variances	Y	Y	Setback variances req'd
16	Undisclosed	2+2BR?	flat, <2%	24"	none to 24"	Hand-dug drainage trenches from back corners of lot to street	Generally not suitable for OWTS, possible raised drip w/setback variances	Y	Y	Setback variances req'd
17	Undisclosed	2BR, but has daycare with 12+ kids	flat, <2%	18"	18" near trenches, 8" in (irrigated) front yard	Sump in back corner of lot (near trenches) carries GW to street	Generally not suitable for OWTS, possible raised drip w/setback variances, including exist. landscaping areas	Y	Y	Almost all property occupied by bldgs, pavement, compacted or filled areas
18	Undisclosed	3BR	flat, <2%	14"	none to 14"	Lot adjacent to compacted horse area	None (Class 1 system)	Y	Y	Class 1 system, w/ seasonal high GW
19	Undisclosed	3BR	2-3%	28"	none to 36"	Berm along back PL, shallow V-ditch 5' from east PL outlets to DI on Railroad Ave	Raised drip field	Y	Y	(E) pool on adjacent properties to the east and west
20	Undisclosed	2BR	flat to 2%	54" (dense)	54"	roadside ditch on Central	Dip or raised drip; not enough room for mound w/out setback variances	Y	Y	Bldg and PL setback variances required
21	Undisclosed	1500 ft2 plus conditioned garage (3BR?)	2-3%	18"	moist no GW to 46"	Low area in back yards of adjacent lots (same owner) side-yard french drains to Railroad Ave.	100% (but not 200%) mound for main lot, or drip. Existing PD system on 2nd lot is used in winter	Y	Y	Main lot back yard setbacks possible, but not in front. 2nd lot mostly undeveloped
22	Undisclosed	3BR	flat, <2%	20"	28" seeps	Back PL is low elevation. Side PL concrete ditches from back corners to Railroad ave	Generally not suitable for OWTS, possibly raised drip w/setback variances.	Y	Y	Bldg, pavement and PL setback variances required

Field Notes for Central Subarea (continued)

System ID	System Address	Site Conditions Summary					Recommended System Upgrade	Creek Setback Compliance with Upgrade		Other Variance Issues
		Bldg. Size	Slopes	Effecitive Soil Depth	Depth to GW	Drainage Features		with 100% System	with 200% System	
23	Undisclosed	3BR	flat, <2%	8"	8"	Sub drain down east PL to Railroad	Generally not suitable for OWTS, possibley segmented raised drip w/setback variances in non-paved areas	Y	Y	Small areas in front and side yards will require setbacks variances to bldg, pavement and PLs
24	Undisclosed	2BR	3%	18"	seep at 15" rose to 13" (in vicinity of LF)	House rearyard foundation perimeter drains to DI.	Raised drip with setback variances	Y	Y	Setback to foundation drainage variance req'd. There is available area in front yard but would req PL, bldg and pavement setback variances.
25	Undisclosed	3BR	flat, <2%	36"	moist at 30"	Roadside ditches on both sides of Carson; far side was flowing, lot-side was not	Drip or raised drip with setback variances	Y	Y	Setback variances to PLs, bldg, pool and pavement req'd.

Field Review Notes for East Subaea
(Including Grant St, Taylor Ave, and East End Central Ave)

System ID	System Address	Site Conditions Summary					Recommended System Upgrade	Creek Setback Compliance with Upgrade		Other Variance Issues
		Bldg. Size	Slopes	Effective Soil Depth	Depth to GW	Drainage Features		with 100% System	with 200% System	
26	Undisclosed	2BR	2-20%	36"	30"	Curtain drain at top of slope, appears to outlet above 172-061-09 (Corridor 2)	Mound is ideal	Y	Y	2' cut bank at downslope PL. There is room for other setbacks.
27	Undisclosed	2800 ft2	mostly flat, <2%. 4-35% in small side yard	48"	40"	2' cut bank at downslope PL (very close to DS bldg fdn.)	Segmented drip w/surface drainage & curtain drain	Y	Y	Setback variances req'd
28	Undisclosed	2BR	4%	48"	40"	18" flowing culvert runs under Taylor and oulets to NW corner of properly before disappearing. Possible buried DI that collects flow and carries along west PL.	Drip w/ setback variances and drainage control	Y	Y	Setback variances req'd
29	Undisclosed	3BR	5%	30"	none to 60"	Concrete lined ditch collects street runoof and diverts to SE neighbor's (172-064-08) sump	Raised drip w/ setback variances and drainage control	Y	Y	2' cut bank at downslope PL. There is room for other setbacks.
30	Undisclosed	2BR	3-4%	30"	28"	House foundation subdrain was flowing 5 gpm, and daylights to SW back yard. Downslope parcel 172-064-08 has a DI that collects this flow. Also many cut banks, including downslope PL (2')	Raised drip w/ setback variances and drainage control	Y	Y	Setback variances req'd
31	Undisclosed	2BR	30-70%	6"	none to 6"	Two upslope V-ditches that divert surface flow to street ditch	Extremely shallow soils would require engineered , raised drip beds, including use of extensive landscaping area	Y	Y	Setback variances req'd
32	Undisclosed	3BR	3%	36"	36" in sloping back yard, 42" in front flat	Ct bank at upslope PL is adjacent to 5' trenches that act as curtain drain (GW intrusion backs up to ST)	Drip or raised-drip w/ setback varieances and GW/drainage control	Y	Y	Setback variances req'd
33	Undisclosed	3BR	8-9%	42"	minor seeps to 42", major seep at 60"	House foundation leaks during winter per owner. Wall drains were noted along foundation.	Rom for a mound	Y	Y	PL setback variance req'd but bldg and pavement setbacks can be maintained

Appendix B

Onsite System Technology Literature

- AdvanTex Packed Bed Filter
- Geoflow Drip Dispersal

AdvanTex® Treatment Systems

AdvanTex® is one of the most sustainable wastewater treatment systems available for household use. The filter unit is flush to the ground and blends into landscaping.

Reliable, Sustainable Treatment for Residential Wastewater

NSF

NSF/ANSI • STANDARD 40 • CLASS I

Orenco Systems® Incorporated

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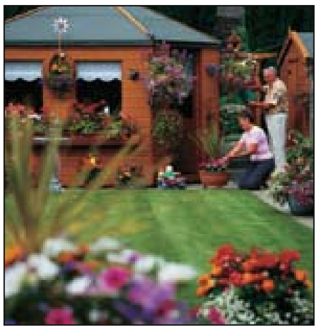
AdvanTex® – Treatment Systems

Finally! Residential Wastewater Treatment — That Works!

Orenco's AdvanTex® Treatment Systems are the ideal solution for environmentally sustainable treatment of residential wastewater flows.

Outstanding Wastewater Treatment

Unlike other onsite wastewater treatment technologies, AdvanTex provides consistent, reliable treatment under real-world conditions. Other systems work OK in a controlled testing environment, but don't hold up to normal household use. AdvanTex does. AdvanTex Treatment Systems process and discharge small amounts of treated wastewater throughout the day. Water so clean it can be reused for drip or subsurface irrigation, or discharged to shallow, inconspicuous trenches.



Fits Small Yards

AdvanTex Treatment Systems require very little space. The filter unit is 7.5 ft × 3 ft × 2.5 ft (2286 mm × 914 mm × 762 mm), small enough to fit under a deck or on top of the processing tank. And some jurisdictions allow a reduction in drainfield area with AdvanTex. So AdvanTex is ideal for small sites, or for homeowners who simply want more use of their yard.

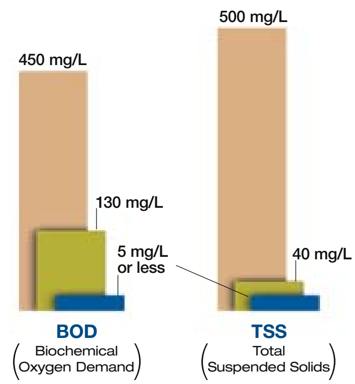
Low Lifetime Cost

AdvanTex Treatment Systems may cost a little more up front than other systems, but, thanks to low maintenance requirements, they cost much, much less over time. Power costs, pumping costs, and equipment replacement costs are a fraction of those for other technologies. Plus, AdvanTex filters protect your drainfield.

AdvanTex turns household wastewater into clear, odorless effluent you can reuse for subsurface irrigation.

AX20 shown here. In addition to being compact, AdvanTex® Treatment Systems are easier to operate and maintain than other wastewater technologies. No odors. No power-hungry, noisy blowers. No activated sludge to manage or pump. No discharge of untreated sewage during peak flows or emergencies.

AdvanTex® Treatment Systems make raw wastewater up to 98% cleaner ... consistently producing effluent in the 5/5 mg/L range



1 Source: Derived from *Small and Decentralized Wastewater Management Systems*, Crites & Tchobanoglous, McGraw-Hill, 1998, p. 183.

2 Actual performance results, based on a six-month accumulative average from NSF (National Sanitation Foundation) testing on the AX20N at 500 gpd (1900 L/d), using composite sampling.

AdvanTex® – Treatment Systems

A Sustainable Technology

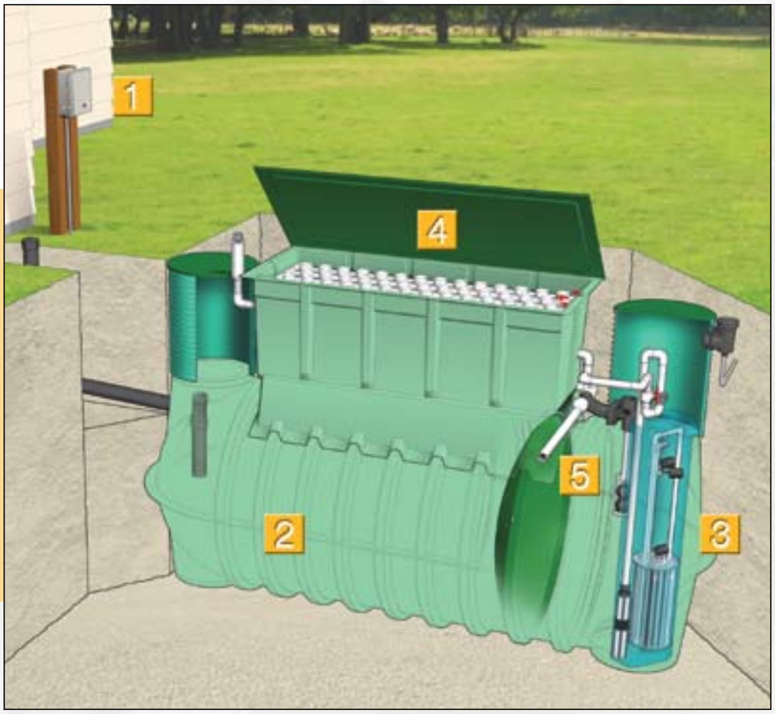
In the patented* AdvanTex Treatment System, household sewage flows into the processing tank, where it separates into scum, sludge, and liquid effluent. Filtered effluent is dosed to the AdvanTex filter pod, where it trickles through sheets of a synthetic textile. There, naturally occurring microorganisms remove impurities from the effluent. After recirculating between the tank and the AdvanTex filter, the effluent is discharged to the soil via irrigation or a drainfield.

The system's pump runs only a few minutes an hour, using just a few cents worth of electricity a day. Because solids decompose in the tank, the tank requires pumping only every 8–12 years, under normal use. Using little energy, generating a minimum of sludge, and purifying wastewater for beneficial reuse, AdvanTex Systems are one of the most environmentally sustainable technologies for home wastewater treatment.

About 20,000 of Orenco's textile filters have been installed at homes, businesses, and community treatment systems throughout the United States, Canada, Europe, and Australasia. Third-party testing shows that AdvanTex Treatment Systems do a better job of treating wastewater than most municipal sewers. And field testing shows that AdvanTex Treatment Systems work under real-world conditions.

"The effluent from the filter units typically was clear with no odor . . . the increased loading rate allows for a decrease in the footprint required by filter units (compared to sand and gravel filters) . . . in an onsite treatment scenario, textile filter effluent could be utilized for landscape irrigation . . ."

Leverenz, Darby, and Tchobanoglous, "Evaluation of Textile Filters for the Treatment of Septic Tank Effluent," University of California at Davis, October 2000.



Typical backyard configuration of an AdvanTex® Treatment System.

The system has five main functional parts:

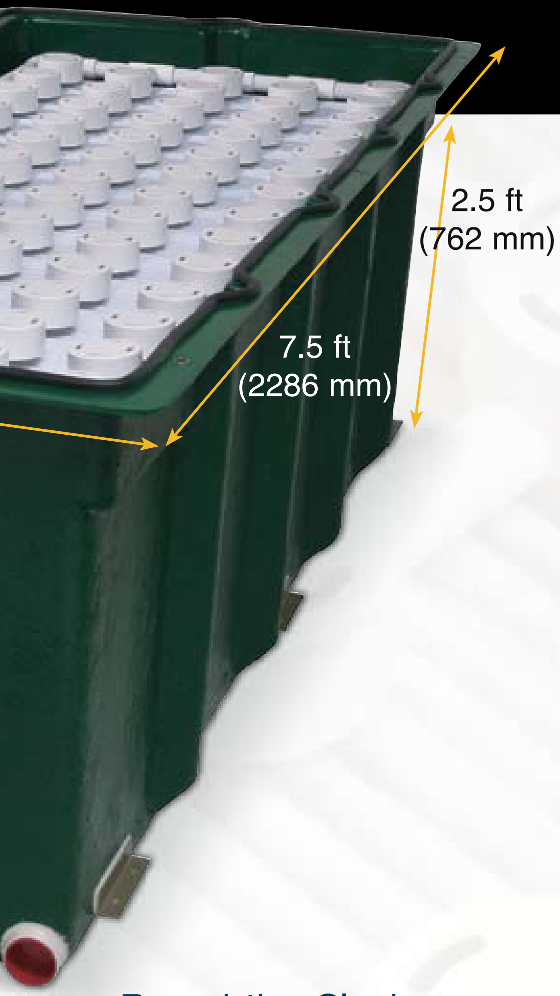
1. *VeriComm® Web-based monitoring system†*
2. *Processing tank*
3. *Biotube® pumping package*
4. *AdvanTex filter*
5. *Recirculating splitter valve*

† MVP digital programmable panels available as an option in some markets.

Other configurations and models available.

NOTE: * Covered by U.S. patent numbers 6,372,137; 5,980,748; 5,531,894; 5,480,561; 5,360,556; 5,492,635; 4,439,323; D461,870; and D445,476. Additional patents pending.

AdvanTex® – Sustainable, Reliabl



AdvanTex® Gives You Peace of Mind

Orenco's AdvanTex Treatment Systems are not just a product. They are part of a comprehensive program, for homeowners' peace of mind.

Authorized Dealers and Trained Installers

AdvanTex Treatment Systems are sold by authorized Dealers, who provide ongoing support and warranty service. Dealers ensure that AdvanTex Treatment Systems are set in place by trained installers, following Orenco's instructions.

Trained Service Providers

Like any onsite technology, your AdvanTex Treatment System benefits from regular maintenance by a trained service provider, following Orenco's instructions. Field maintenance report forms are digitally archived for future reference.

Complete, Carefully Engineered Package

Your AdvanTex Treatment System comes as a totally pre-manufactured package, including AdvanTex textile filter, Biotube® pumping package, and "smart" control panel. AdvanTex can be installed on most lots in less than a day.

Low Routine Maintenance Costs

AdvanTex Treatment Systems are easy to service, easy to clean, and generate no troublesome activated sludge. Since maintenance is minimal, so are the long-term costs. Each system comes with a Homeowner's Manual, with tips for preventive maintenance.

Low Power Costs

AdvanTex uses very little power… an average of $1.75–$2.00 per month (based on the national average of ten cents per kilowatt-hour). Compare that to the average power cost of $30.00–$60.00 per month (depending on your area) for many "activated sludge" aerobic treatment units!

Safe in Emergencies

AdvanTex Treatment Systems that are equipped with VeriComm® Control Panels automatically notify service providers of irregular conditions. And all systems are sized to allow for a minimum of 24 hours of wastewater storage, at average daily flows. So operators can provide "emergency" service during normal working hours, keeping service costs down.

Child-Proof

The lid of the AdvanTex filter is affixed with recessed bolts, making it very tamper-resistant.

Warrantied

Orenco Systems®, Inc. provides a limited, multi-year warranty on all materials and workmanship. Length of warranty varies by region but is at least three years.

Round-the-Clock Monitoring

Your AdvanTex Treatment System may include a control panel with a remote telemetry unit and a round-the-clock, Web-based monitoring system, supervised by your service provider. You'll have even more peace of mind, knowing that the VeriComm® Monitoring System is continually and automatically verifying the operation of your system. For more information, go to **www.orenco.com** or **www.vericomm.net** and click on the icon for VeriComm's "On-Line Demo." (Non-telemetry control panels also available.)

For Every Residential Site

There's a standard AdvanTex Treatment System model for every site condition, design flow, and regulatory requirement.

AdvanTex Treatment Systems are particularly well suited for . . .

- small sites
- failing systems
- poor soils
- nitrogen reduction
- environmentally sensitive sites
- stringent treatment standards
- pretreatment of moderately high-strength waste

Alberta, Canada

"We've installed about 500 AdvanTex Treatment Systems for all sizes of homes, and, typically, the treated wastewater looks just like water. Our winter temperatures can be as low as –38° F (–39° C). In the middle of December, we started up an AdvanTex Treatment System on a 13,000 ft^2 (1200 m^2) home that averages 1200 gpd (4500 L/d). Two weeks after start-up, the owners entertained 30 family members and guests for a full week. It worked great!"

Bruce Silvester, Onsite Specialties, Inc.

"It worked great!"

Deschutes County, Oregon

"I specified an AdvanTex Treatment System for a cluster of 12 luxury homes in the Metolius River Resort, along a premier trout stream in eastern Oregon. AdvanTex worked well because the site has an extremely small footprint and the system was easy to install. Also, the treatment unit is right in front of the Resort's office, so it was super important that there be absolutely no smell, and there isn't. Plus, we didn't have to search for the right treatment media, since it's all included. I would use AdvanTex any place you'd use a conventional recirculating filter."

Steve Wert, CPSS, WWS
Wert & Associates, Bend, Oregon

Tucson, Arizona

"Nearly 1,000 AdvanTex Treatment Systems have been installed in Arizona, primarily due to poor soils, seasonal high water tables and/or nitrogen in the groundwater. In Tucson, homeowners and their treatment system designers have also had to deal with limiting site constraints, shallow rock shelves, and small building envelopes. The AdvanTex system, followed by a subsurface drip system, was the answer. Plus, the installed systems go almost unnoticed in yards and landscaping."

Todd Christianson,
Premier Environmental
Products, LLC

Newport, Rhode Island

"I spent six years looking for the right wastewater system for my second home, which is on a small island. Even with seasonal flows, our AdvanTex Treatment System is working great . . . so great, I decided to become a dealer! We entertain often, so we use a lot of water, but we've never had a problem. And the system was easy to transport and install."

Peter Kent, Atlantic Solutions, Ltd.

AdvanTex® – Treatment Systems

Orenco Systems is owned and managed by engineers who develop wastewater systems that work — systems based on sound science.

Clockwise from left: Eric Ball, P.E., Jeff Ball, P.E., Hal Ball, P.E., (front) Terry Bounds, P.E.

AdvanTex® Treatment System AXN Models meet the requirements of NSF-ANSI Standard 40 for Class I Systems.

NSF/ANSI STANDARD 40

Certified Product
Australian Standard

C UL US LISTED

Powered by **Franklin Electric**

Orenco Systems® Incorporated

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Carefully Engineered by Orenco

Your health is our priority. At Orenco Systems, we are committed to "Changing the Way the World Does Wastewater®."

Orenco Systems has been researching, designing, manufacturing, and selling leading-edge products for small-scale wastewater treatment systems since 1981. The company has grown to become an industry leader, with about 200 employees and with more than 100 distributors and dealers representing most of the United States, Canada, Australia, New Zealand, and parts of Europe. Our products and technologies have been installed in more than 50 countries all over the world.

Orenco maintains an environmental lab and employs dozens of scientists and engineers. Orenco's systems are based on sound scientific principles of chemistry, biology, mechanical structure, and hydraulics. As a result, our research appears in numerous publications, and our engineers are regularly asked to give workshops and offer trainings.

Distributed by:

AdvanTex® AX100 Treatment Systems

For Onsite Treatment of Commercial and Multi-Family Wastewater

Ideal for:

- Multi-family residential properties
- Cluster systems, community systems
- Subdivisions, resorts, golf course developments
- Mobile and manufactured home communities
- Parks, RV parks, rest areas
- Truck stops, restaurants, casinos
- Schools, office buildings

Orenco Systems® Incorporated

Changing the Way the World Does Wastewater®

800-348-9843
orenco.com

We’ve Written the Blueprint for the Dece

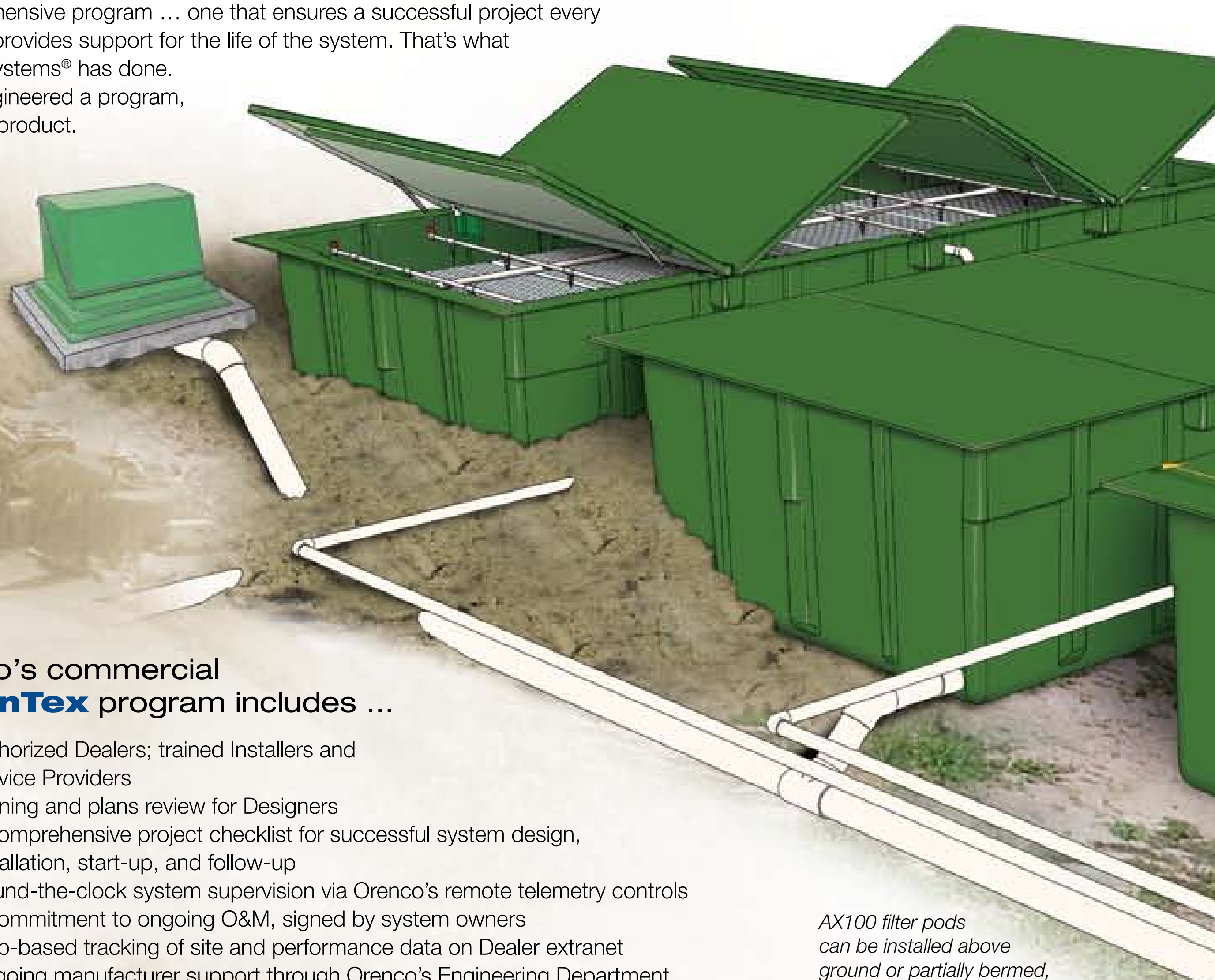
The Product

Orenco’s AdvanTex® Treatment Systems utilizing the commercial-sized AX100 can make raw wastewater up to 98% cleaner, meeting stringent regulatory requirements. It can also reduce nitrogen significantly, depending on influent and configuration. And the AX100 offers all the benefits of Orenco’s residential-sized AdvanTex Treatment Systems:

- Consistent, reliable treatment, even under peak flows
- Compact package, small footprint, for small sites
- Premanufactured package, including textile medium, for quality control
- Low maintenance requirements; low life-cycle costs
- Production of clear, odorless effluent that’s ideal for reuse

The Program

It takes more than a product, however, to solve onsite wastewater problems. It takes a comprehensive program … one that ensures a successful project every time and provides support for the life of the system. That’s what Orenco Systems® has done. We’ve engineered a program, not just a product.



Orenco’s commercial **AdvanTex** program includes ...

- Authorized Dealers; trained Installers and Service Providers
- Training and plans review for Designers
- A comprehensive project checklist for successful system design, installation, start-up, and follow-up
- Round-the-clock system supervision via Orenco’s remote telemetry controls
- A commitment to ongoing O&M, signed by system owners
- Web-based tracking of site and performance data on Dealer extranet
- Ongoing manufacturer support through Orenco’s Engineering Department

AX100 filter pods can be installed above ground or partially bermed, depending upon site conditions.

* NOTE: Covered by U.S. patent numbers 6,540,920; 6,372,137; 5,980,748; 5,531,894; 5,492,635; 5,480,561; 5,360,556; 4,439,323

Decades of Research, Thousands of Installations

Orenco's patented* AdvanTex Treatment System is a recirculating filter that's configured like a recirculating sand filter — a packed bed filter technology that Orenco engineers have helped to perfect since the 1970s. Like recirculating sand filters, AdvanTex is reliable and low-maintenance. It is superior to other packed bed filters, however, in its serviceability and longevity.

It is also superior in its treatment media. AdvanTex uses a highly efficient, lightweight textile that has a large surface area, lots of void space, and a high degree of water-holding capacity. Consequently, AdvanTex Treatment Systems can provide treatment equivalent to that of sand filters at loading rates as high as 25-50 gpd/ft^2 (1000-2000 L/d/m^2). That means AdvanTex can treat high volume commercial and multi-family flows in a very compact space.

Our textile-based, multi-pass treatment technology has undergone third-party testing and evaluation to ANSI Standards. About 20,000 residential-sized AdvanTex filters have been installed since 2000. And more than 2,500 commercial-sized AX100 units are now in operation, including the installations described on the back page.

Textile Media

The treatment medium is a uniform, engineered textile, which is easily serviceable and allows loading rates as high as 50 gpd/ft^2 (2000 L/d/m^2).

Spray Nozzles

Efficient distribution is accomplished via specially-designed spray nozzles.

Laterals and Lids

Isolation valves, flushing valves, and hinged lids with gas springs allow easy access and servicing by a single operator.

Telemetry Controls

Orenco's telemetry-enabled control panels use a dedicated phone line and ensure round-the-clock system supervision and real-time, remote control.

AdvanTex® AX100 Treatment Systems

Carefully Engineered by Orenco

Orenco Systems has been researching, designing, manufacturing, and selling leading-edge products for small-scale wastewater treatment systems since 1981. The company has grown to become an industry leader, with about 250 employees and 150 distributors and dealers representing most of the United States, Canada, Mexico, Australia, New Zealand, and parts of Europe. Our systems have been installed in more than 60 countries around the world.

Orenco maintains an environmental lab and employs dozens of civil, electrical, mechanical, and manufacturing engineers, as well as wastewater treatment operators. Orenco's systems are based on sound scientific principles of chemistry, biology, mechanical structure, and hydraulics. As a result, our research appears in numerous publications and our engineers are regularly asked to give workshops and offer trainings.

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Oregon Riverside Community

Since 2003, twelve AX100s have been providing advanced secondary wastewater treatment in Hebo, Oregon, for a small community collection system that discharges directly into Three Rivers, after UV disinfection. The average annual design flow is 17,000 gpd (64,400 L/d) with a peak daily design flow of 80,000 gpd (303,000 L/d) to account for I&I contributions from the collection system. Effluent BOD_5 and TSS are averaging 4.4 and 4.5 mg/L, respectively.

Malibu, California Restaurant

Ten AX100s at the top of a Malibu bluff are treating high-strength waste from a large (200+ seat) beachfront restaurant, 100 feet (30 m) below. This high-visibility tourist destination requires reliable, odor-free operation. Effluent sampling indicates excellent treatment, including nitrogen reduction. At an adjacent residential community, another system, consisting of 20 AX100s capable of treating up to 60,000 gpd (227,000 L/d) peak flows, has also been installed.

Mobile, Alabama Utility-Managed Subdivisions

South Alabama Utilities (SAU) in Mobile County, Alabama, has become the subject of nationwide classes, presentations, and tours because of its ambitious and innovative solution for serving nearly 4,000 new customers in 47 new subdivisions (as well as a number of new schools and commercial properties) northwest of Mobile. How? By installing more than 60 miles (96.5 km) of interconnected Orenco Effluent Sewers that are followed by 141 AdvanTex AX100s to treat nearly half a million gpd (1.9 million L/d) of effluent, at better than 10 mg/L.

Champion Hills is one of the many subdivisions in rural Mobile County served by Orenco's effluent sewers and treatment systems.

Under SAU's program, developers, builders, homeowners, and the utility all share the cost of extending wastewater infrastructure. Overall costs vary by development, but SAU currently charges each homeowner about $2,000 to provide and install the on-lot equipment. Overall costs are about half the cost of conventional sewers.

To order a complete design/engineering package for Orenco's Commercial AdvanTex Treatment Systems, contact your local Commercial AdvanTex Dealer. To find a Commercial Dealer, go to www.orenco.com/systems and click on "Locate a Dealer." Or call 800-348-9843 and ask for Systems Engineering.

And this is a wastewater dispersal field.

No Worries.

GEOFLOW

SUBSURFACE DRIP SYSTEMS

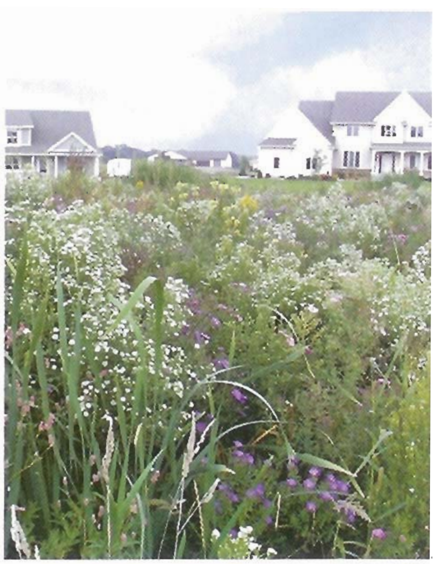
Geoflow WASTEFLOW®

Geoflow's subsurface drip systems solve many of the problems that plague traditional methods of wastewater dispersal. Since the effluent is dispersed underground where it is absorbed in the biologically active soil layer, there is no surface contamination, no ponding, no run-off problems, no bad smells.

Issues such as overspray and aerosol drift are eliminated, dose scheduling is unaffected by land use or weather, and it is a politically and environmentally favorable means of dispersing wastewater.

With subsurface drip, secondary reclaimed wastewater can be used, eliminating the ongoing cost of additional effluent treatment.

Geoflow drip dispersal is recommended for commercial, municipal, industrial, residential and agricultural applications.



Subdivision in Minnesota.

How It Works

The WASTEFLOW dripline has factory-installed emitters evenly spaced along the tubing. The dripline is usually installed six to ten inches below the surface, directly into the biologically active soil horizon where the treated effluent can be absorbed by the plants, animal life, and soil.

Wastewater is pumped to the dripfield on a time-activated dose cycle. The slow, even application of effluent with resting periods is key to the drip system's success.

Easy To Install — New or Retrofit

Geoflow subsurface systems are simple to install. The tubing can be laid on a graded parcel then covered with topsoil or installed using a tubing plow or trencher.

Subsurface drip also solves the problem of small or odd-shaped areas, such as property edges and around buildings and other structures. The flexible tubing can easily be fit to uneven spaces. Since the wetted area is within close proximity of each emitter, run-off problems are easily eliminated.

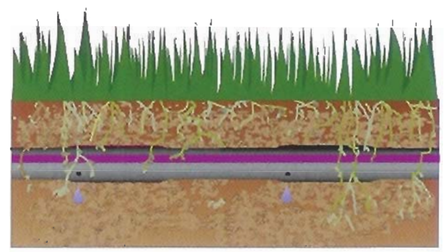
Plow single or multiple driplines at a time.

But What About...?

Clogging — Geoflow drip systems are installed with self-cleaning filters to keep large particles from entering the drip field.

WASTEFLOW emitters are also self-cleaning and have been used for over 15 years in actual onsite applications. They are made with large orifices, raised entry ports, and turbulent flow paths to keep smaller particles from collecting in the emitters.

Root intrusion — Each emitter features ROOTGUARD®, patented protection against roots entering the emitters. The non-toxic active ingredient, Treflan®, directs root growth away from the emitters. Treflan is impregnated into the emitters during the molding process.



Rootguard keeps roots from penetrating and clogging the emitters.

Bacterial growth — Geoflow's WASTEFLOW dripline is coated inside with the anti-bacterial, *Ultra-Fresh*® to inhibit bacterial growth on the walls of the tube and in the emitters. *Ultra-Fresh* has been found to be effective in preventing slime build-up inside the tube, even with effluent that has very high BOD.

Look for the anti-bacterial turquoise lining.

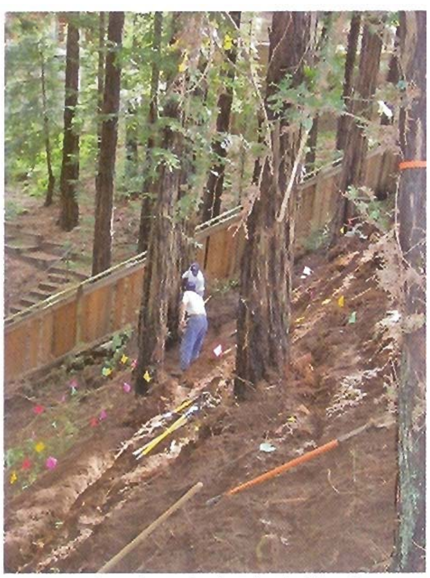
This eliminates the need to scour the dripline with high flush velocities.

There is virtually no discharge into the environment because the active ingredient, TBT-maleate, does not migrate readily through plastic (Note: Ultra-Fresh does not treat the water flowing through the tube.)

Freezing climates – Geoflow systems can be used year round, even in freezing conditions. The polyethylene dripline is flexible enough so as not to crack when it freezes. The dripline self-drains through the emitters every time the system is turned off, and will not hold water. Sound design, including drainback of the system, air vacuum breakers and insulation of the more rigid parts of the system keep the system working even in the coldest climates.

Difficult sites – Geoflow systems can be effective in areas with
- tight soils,
- rocky terrains,
- steep slopes,
- high water tables.

Design guidelines are available directly from Geoflow and at www.geoflow.com.



A steep slope installation in California – 65% slope.

Testimonials

Higgins Corner Retail Development
Nevada County, California

"The Geoflow dripline system proved to be successful in four areas: Foremost, there was a tremendous cost saving in installing the Geoflow system. Secondly, the time and effort saved in installing Geoflow as compared to the construction of deep absorption trenches was also a benefit. Thirdly, one and a half acres of land could be used for other monetary-inducing projects; and fourth, the final disposal site looks like the original untouched property. Neighbors are pleasantly surprised at the final effluent disposal field."

Mark Kahl, Design Engineer
7H Technical Services Group Inc.

Higgins Corner, Nevada County, CA.

Ocala Airport
Ocala, Florida

"The [44-acre] site has operated successfully at an average of 500,000 gpd over a three-year period. Monitoring data reveals that groundwater quality has not been adversely effected despite high loading rates... The cost to operate and maintain a subsurface reuse system is much less than a conventional irrigation system..."

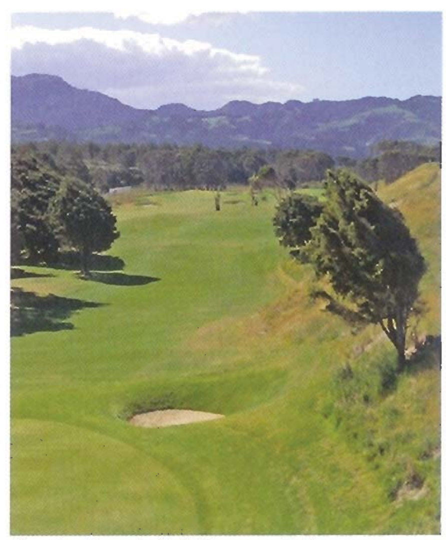
Ed T. Earnest, P.E. Utility Engineer.
City of Ocala Engineering Dept.

Ocala Airport.

Omaha Beach Golf Course
Matakana, New Zealand

"As part of the construction of the new 9-holes the developer installed a new subsurface drip irrigation system on some of the new fairways to act as part of the overall community treated effluent disposal system... We are extremely pleased with the system, which gives a very even deep green appearance to the fairways where it was been installed. The fairways that are irrigated with the subsurface drip system are in better condition than those that do not yet have the system."

Allan Anderson,
Head Greenkeeper



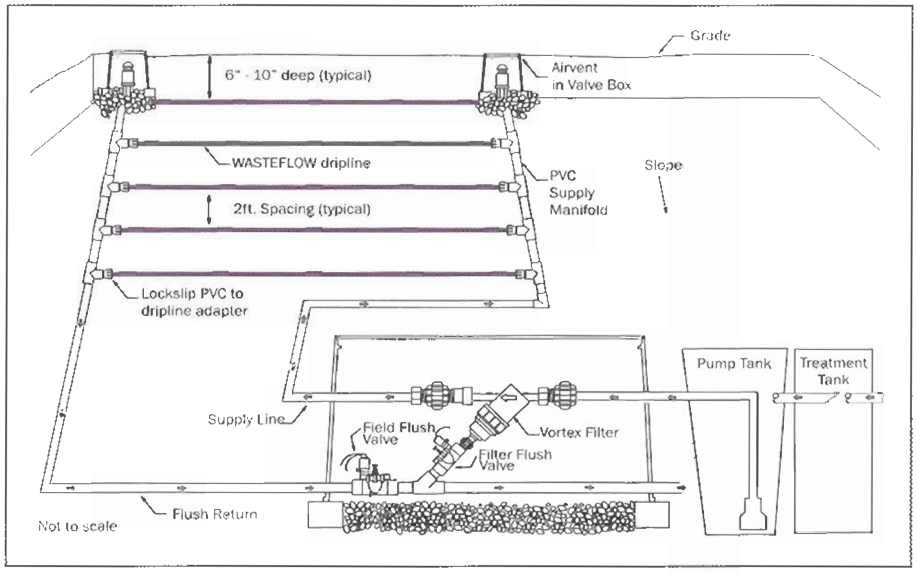
Omaha Beach Golf Course, N.Z.

Typical Layout

WASTEFLOW dripline is made of flexible ½" polyethylene tubing coated on the inside with an anti-bacterial lining to inhibit bacterial growth. The factory-installed emitters are spaced evenly along the tubing.

The dripline is placed six to ten inches below the surface, directly into the biologically active soil horizon. Effluent is pumped on a time-activated dose cycle through a self-cleaning filter out to the dripfield, providing slow, even application of effluent.

The system returns back to the pump tank or treatment tank in a closed loop, and is kept clean with regular flushing.

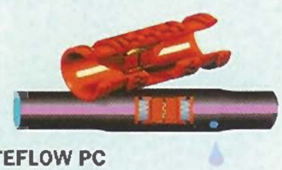


Typical disposal field elements and layout

The Drip Emitters

Geoflow offers two different emitters, the Classic and the PC.

WASTEFLOW Classic



WASTEFLOW PC

Each dripper has a filter built in at the entry port to to keep particles out.

Turbulent flow path

Effluent travels through a turbulent flow path that helps keep any fine particles from settling inside the dripper.

CUTAWAY OF THE PC EMITTER

Dose mode – When pressurized, the rubber diaphragm flexes across the compensating chamber to regulate flow across 7 to 60 psi.

Flushing mode – As the pump is powered on and off again, the rubber diaphragm relaxes across the exit hole enabling the dripper to self-flush every cycle.

Geoflow Team

The people at Geoflow are the subsurface drip experts. We offer training, answers to your questions, and support every step of the way from concept through design and installation.

Geoflow dripline comes with an unprecedented 10-year limited warranty for root intrusion, workmanship and materials.

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GEOFLOW
SUBSURFACE DRIP SYSTEMS

Look for the purple stripe on the tubing to be sure you are getting Geoflow!

Appendix C

Cost Estimates for Onsite Upgrades – Alternative 2

- Construction Costs
- Annual O&M Costs

Construction Cost Estimates

Preliminary Construction Cost Estimate
Alternative 2 - Onsite Upgrades & Management Program

MODERATE LEVEL WORK
Add Supplemental Treatment & Drainage Improvements

ITEM	UNIT	QTY	UNIT COST ($)	TOTAL COST ($)
I. SITE PREPARATION & MOBILIZATION	LS	1		$1,500
II. SEPTIC TANK				
Inspect, waterproof, upgrade risers, inlet & outlet	LS	1		$1,000
III. SUPPLEMENTARY TREATMENT				
Install AdvanTex & Controls	LS	1		$9,500
IV. DISPERSAL SYSTEM - EXISTING GRAVITY				
Inspect, add observation wells, pipe connections	LS	1		$1,000
V. DRAINAGE IMPROVEMENTS				
Install new curtain drain	LF	100	75	$7,500
Surface drainage improvments	LS	1		$1,500
VI. ELECTRICAL	LS	1		$1,500
VII. SITE RESTORATION & DEMOBILIZATION	LS	1		$1,500
VII. INSPECTION/TESTING	LS	1		$500
IX. PERMITTING	LS	1		$2,000
			TOTAL	$27,500

Preliminary Construction Cost Estimate
Alternative 2 - Onsite Upgrades & Management Program

MODERATE LEVEL WORK
Add PD Leachfield & Drainage Improvements

ITEM	UNIT	QTY	UNIT COST ($)	TOTAL COST ($)
I. SITE PREPARATION & MOBILIZATION	LS	1		$1,500
II. SEPTIC TANK				
Inspect, waterproof, upgrade risers, inlet & outlet	LS	1		$1,000
III. CONVERT/ADD NEW PD LEACHFIELD				
New dosing tank	LS	1		$5,000
Dosing pump & controls	LS	1		$2,500
New PD leachfield	LF	100	50	$5,000
Modify existing leachfield piping	LS	1		$500
V. DRAINAGE				
Install new curtain drain	LF	100	75	$7,500
Surface drainage improvements	LS	1		$1,500
VI. ELECTRICAL (UPGRADE)	LS	1		$1,500
VII. SITE RESTORATION & DEMOBILIZATION	LS	1		$1,500
VII. INSPECTION/TESTING	LS	1		$500
IX. PERMITTING	LS	1		$2,000
			TOTAL	$30,000

Preliminary Construction Cost Estimate
Alternative 2 - Onsite Upgrades & Management Program
HIGH CONSTRAINTS AND WORK LEVEL
Add Treatment, Drip Field & Drainage Improvements

ITEM	COST RANGE ($)	
	Low Estimate	High Estimate
I. SITE PREPARATION & MOBILIZATION	$1,500	$1,500
III. SEPTIC TANK		
Inspect, waterproof, upgrade risers, inlet & outlet	$1,000	
Abandon existing septic tank		$1,500
Install new septic tank		$5,500
IV. SUPPLEMENTARY TREATMENT		
AdvanTex & Controls	$9,500	$9,500
UV Unit		$1,000
IV. DRIP DISPERSAL SYSTEM		
Dosing Tank	$4,500	$5,000
Pump and Controls	$2,500	$2,500
Drip Piping and Valves	$2,500	$3,500
Raised Bed Soil Fill		$5,000
V. DRAINAGE IMPROVEMENTS		
Install new curtain drain	$7,500	$7,500
Surface drainage improvements	$1,000	$1,500
VII. ELECTRICAL (UPGRADE)	$1,500	$1,500
VIII. SITE RESTORATION & DEMOBILIZATION	$1,500	$2,500
VIIII. INSPECTION/TESTING	$1,000	$1,000
IX: PERMITTING	$2,000	$2,000
TOTAL	$36,000	$51,000

Annual O&M Cost Estimates

O&M Cost Estimate
Alternative 2 -Onsite Upgrades and Management Program

100% Service Connections - 150 Parcels				
Item	**Units**	**No. of Units**	**Unit Cost**	**Cost ($)**
District/Program Administration				
Insurance, legal, financial	Month	12	$1,000	$12,000
Operating Permits	EA	150	$100	$15,000
RWQCB Permit	LS	1	$1,500	$1,500
On-lot System Inspections/Monitoring				
Annual inspection of each onsite system	EA	150	$150.00	$22,500
Reporting - Data compilation & annual report	EA	150	$75.00	$11,250
Engineering Consultation (as needed)	Month	12	$400	$4,800
Remote Monitoring Fees	Month	12	$200	$2,400
Maintenance				
Equip, Materials, Maintenance & Replacement	EA	150	$200	$30,000
Expenses				
Laboratory - Treatment Systems, 20% per year	EA	30	$150	$4,500
Laboratory - 10 Surface/GW locations, 4 times/yr	EA	40	$75	$3,000
Travel, Equip, Supplies	Month	12	$250	$3,000
Electrical				
Treatment/Disperal Systems	EA	150	$30	$4,500
Septic Tank Pumpouts				
Septic Tank Pumpouts, ~25% of systems annually	EA	40	$350	$14,000
			Sub-total	$128,450
			10% Contingency	$12,845
			Estimated Total Annual Cost	$141,295
			Estimated Annual Cost per Connection	**$942**

O&M Cost Estimate
Alternative 2 -Onsite Upgrades and Management Program

75% Service Connections - 112 Parcels				
Item	**Units**	**No. of Units**	**Unit Cost**	**Cost ($)**
District/Program Administration				
Insurance, legal, financial	Month	12	$750	$9,000
Operating Permits	EA	112	$100	$11,200
RWQCB Permit	Ls	1	$1,500	$1,500
On-lot System Inspections/Monitoring				
Annual inspection of each onsite system	EA	112	$150.00	$16,800
Reporting - Data compilation & annual report	EA	112	$75.00	$8,400
Engineering Consultation (as needed)	Month	12	$300	$3,600
Remote Monitoring Fee	Month	12	$200	$2,400
Maintenance				
Equip, Supplies, Maintenance & Replacement	EA	110	$200	$22,000
Expenses				
Laboratory - Treatment Systems, ~20% per year	EA	22	$150	$3,300
Laboratory - 10 Surface/GW locations, 4 times/yr	EA	40	$75	$3,000
Travel, Equip, Supplies	Month	12	$200	$2,400
Electrical				
Treatment/Disperal Systems	EA	112	$30	$3,360
Septic Tank Pumpouts				
Septic Tank Pumpouts, ~25% of systems annually	EA	30	$350	$10,500
			Sub-total	$97,460
			10% Contingency	$9,746
			Estimated Total Annual Cost	$107,206
			Estimated Annual Cost per Connection	**$975**

Appendix D

Collection Systems Analysis

APPENDIX D
COLLECTION SYSTEMS ANALYSIS
WOODACRE FLATS WASTEWATER FEASIBILITY STUDY

1.0 INTRODUCTION

Provided here is a review and comparative analysis of sewage collection system alternatives for use in connection with a community wastewater system for the Woodacre Flats service area. The basic types of sewage collection methods reviewed include:

- Conventional Gravity Sewers
- Pressure Sewers, with individual grinder pumps
- Small Diameter Effluent Sewers, including Septic Tank Effluent Pump (STEP) and Gravity (STEG).

The analysis begins with a general overview of each sewage collection method, along with a review of the typical advantages and disadvantages of each method. This is followed by a description, preliminary layout, cost comparison and review of various collection system options for each of the two community wastewater system alternatives (Alternative 3 - Fire Road Leachfield and Alternative 4 - Golf Course Water Recycling). The results of this analysis provide information on collection facilities requirements and costs for use in the overall project alternatives analysis (Section 6).

The layout of collection system options was done based on review of topographic mapping of the service area, supplemented with field reconnaissance inspections. These represent our best professional judgement of the range of options for sewage collection suitable for this level of feasibiltiy analysis. However, further study (e.g., during design) could reveal slightly different alignments or other refinements that may result in improvements or cost savings. The collection system layouts provide the information needed to define the expected routing of sewer lines, estimation of the need for individual pump systems, and the probable locations of sanitary lift stations. It also provides basic data for preliminary hydraulic analysis of pumping requirements and an estimation of pipe sizes and corresponding costs.

The cost assumptions were developed through discussions with local contractors and suppliers, and review of construction costs for other similar work, including the Marshall Phase 1 sewer project. The costs are planning-level estimates. The estimates do not include allowances for engineering, environmental and administrative costs, which are accounted for in the overall project cost estimates in Section 6 of the report

2.0 SEWER COLLECTION METHODS

2.1 Conventional Gravity Sewers

General Description

In a conventional gravity sewer, untreated wastewater travels through a system of sewer pipes installed at a minimum grade to maintain gravity flow. Sewer pipes are usually six or eight-inch minimum diameter, with four-inch diameter lateral connections from buildings, and typically require a minimum of 4.5 feet of backfill cover. Pipe and fitting material can be PVC, ABS, high density polyethelyene (HDPE) or ductile iron. Conventional gravity sewers require manholes generally: (a) at all intersections of sewer lines other than side sewer connections less than six inches in diameter; (b) at all vertical or horizontal angle points; and (c) at intervals not greater than 400 feet. Manholes provide access for maintenance and cleaning. Since conventional gravity sewers require a constant downhill grade, gravity sewer mains may need to be installed at considerable depths where the terrain is flat or undulating.

Advantages and Disadvantages

Advantages. Conventional sewers are normally cost effective and appropriate in densely developed areas. The primary advantage of conventional sewers is the proven long-term reliability, long service life, and relatively low operation and maintenance (O&M) costs. Maintenance requirements for gravity sewers consist of routine cleaning of the sewer pipes and maintenance of lift stations. Another advantage is that construction techniques for conventional gravity sewers are familiar to most construction contractors and maintenance personnel.

Disadvantages. The typical disadvantages of conventional gravity sewers include costly and infeasible construction due to sparse population, flat terrain, high groundwater, shallow bedrock, or unstable soils. Infiltration from groundwater leaking into the sewers and inflow from direct storm water runoff into the sewers are an almost unavoidable component of conventional gravity sewers. Infiltration and inflow (I/I) may burden the treatment facility with sewage flows beyond capacity during wet weather. However, I/I can be at mitigated by using high-quality pipe materials and construction and an ongoing preventative maintenance program.

Operation and Maintenance

Operation and maintenance activities for a conventional gravity sewer system consist of cleaning the sewers, monitoring sewers for illegal inflow connections, and pump station operation and maintenance. Pump station O&M involves repair and maintenance of mechanical, electrical and structural equipment. Access for cleaning is provided by manholes (6-inch and 8-inch gravity sewers) and by clean-outs (for 4-inch laterals). Cleaning of gravity sewers may require removal of obstructions from time to time, as well as flushing. Video inspection of sewer lines is also typically performed periodically as a preventative measure and/or to investigate specific sections of sewer lines.

2.2 Pressure Sewers

General Description

Pressure sewers are one of the most popular and successful alternatives to conventional gravity sewers. A pressure sewer is a small diameter pipeline, which is installed following the profile of the ground. Typical main diameters are 2 to 6 inches, and PVC and HDPE are the usual piping material. Burial depths usually have a 30-inch minimum cover.

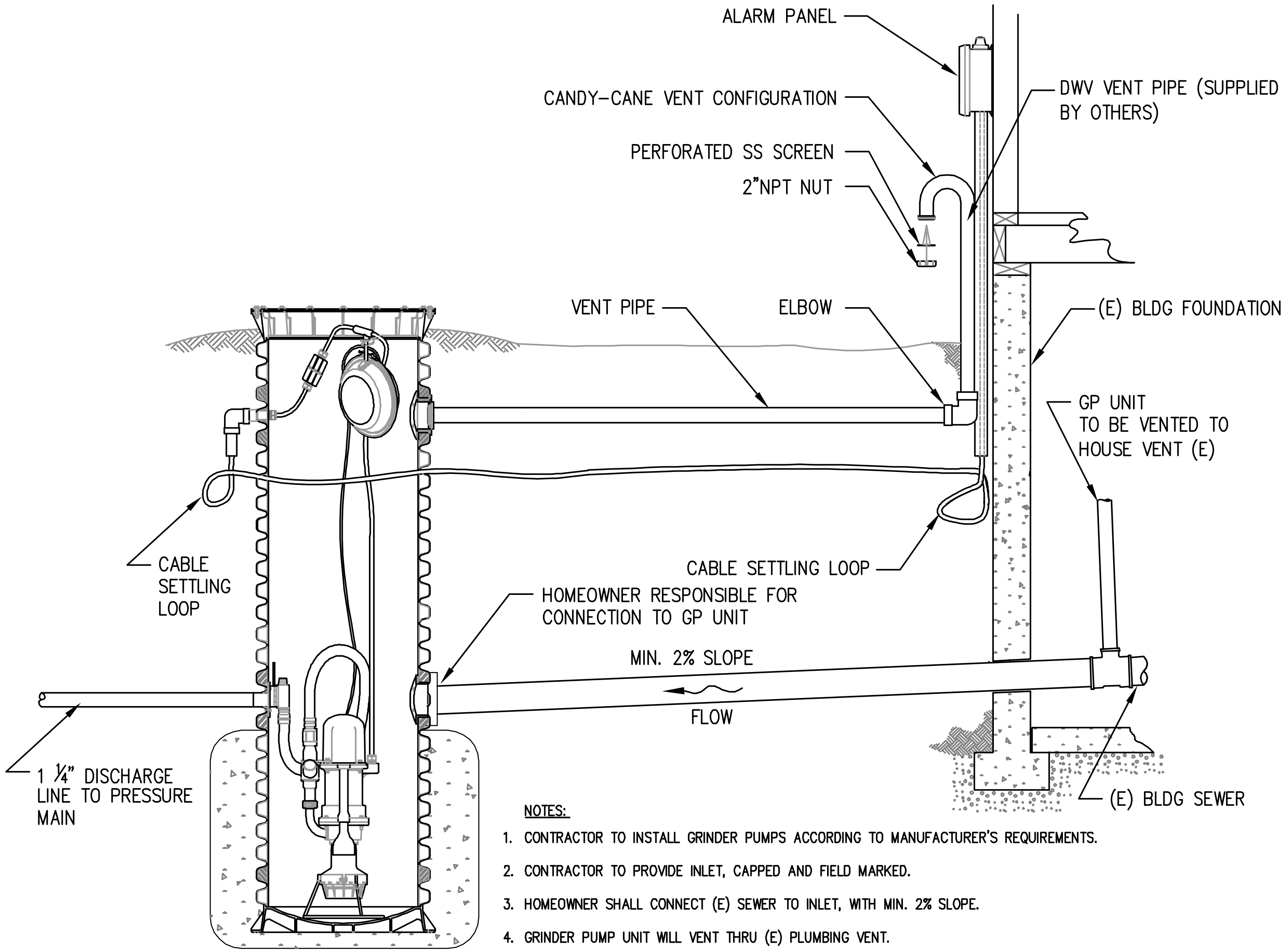
In residential areas served by a pressure sewer, each home uses a small grinder pump to discharge to the main line. A typical grinder pump and connection detail is provided in **Figure D-1**. The pump grinds the solids in the wastewater into slurry in the manner of a kitchen sink garbage grinder. Grinder pumps to serve individual homes usually range from one to two-horsepower in size. Installations using three to five-horsepower motors can be used to serve several homes with one pumping unit. Multifamily and commercial properties may make use of duplex pump stations designed for larger flows.

The service line leading from the pumping unit to the main is usually 1.25-inch diameter PVC or HDPE. A check valve on the service line prevents backflow, which is insured with a redundant check valve at the pumping unit. If a malfunction occurs, a high liquid level alarm is activated. This alarm may be a light mounted on the outside wall of the home, or it may be an audible alarm that can be silenced by the resident. In the instance of an activated alarm, the resident would notify the sewer service district, which would respond to make the necessary repair.

Advantages and Disadvantages

Advantages. With a typical pipe depth of about 36 inches, pressure sewers eliminate the need for the deep excavation, multiple lift stations, and groundwater dewatering and shoring involved in the installation of conventional gravity sewers. The shallow depth, positive pressure, and tight-glued PVC joints or fused HDPE joints also prevent groundwater infiltration and exfiltration, and substantially reduce the potential for stormwater inflow. In many instances, small diameter HDPE pipe can be installed using Horizontal Directional Drilling (HDD) methods, which is typically much less expensive than open-cut trench installation, and greatly reduces the impacts to road pavement, traffic interruption, and hauling requirements for trench bedding material and excvated soils.

Disadvantages. The main disadvantage of pressure sewers is the added complexity of the large number of pumps and controls that would have to be installed and maintained at the individual residences. Most modern grinder pump units are very reliable, have a relatively long service life, and include built-in alarms to alert the homeowner in the event of a pump failure. Nevertheless, the impact during extended power outages is much greater with pressure sewers due to limited reserve storage at individual pump units



NOTES:

1. CONTRACTOR TO INSTALL GRINDER PUMPS ACCORDING TO MANUFACTURER'S REQUIREMENTS.
2. CONTRACTOR TO PROVIDE INLET, CAPPED AND FIELD MARKED.
3. HOMEOWNER SHALL CONNECT (E) SEWER TO INLET, WITH MIN. 2% SLOPE.
4. GRINDER PUMP UNIT WILL VENT THRU (E) PLUMBING VENT.
5. IF (E) PLUMBING VENTILATION IS NOT PER 1997 UPC, CONTRACTOR SHALL CONNECT OPTIONAL 2" VENT PIPE TO EXTERIOR OF BUILDING.

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TYPICAL GRINDER PUMP UNIT

WOODACRE FLATS
WASTEWATER FEASIBILITY STUDY

FIGURE
D-1

and lack of readily available back-up power. Grinder pump units normally provide emergency storage capacity of about 50 to 100 gallons, unless an additional storage tank is added. Some sanitary districts require grinder pumps to be installed with a transfer switch to allow pump operation using a portable generator. Larger commercial or multi-family complexes can be equipped with an automatic backup generator.

Another disadvantage of pressure sewers is the greater reliance upon on-lot facilities. The facilities located on private property require access easements for system maintenance or repair, and much more ongoing interaction with property owners and attention to public relations by the sewer district personnel.

Operation and Maintenance

On-lot grinder pumps require periodic maintenance and cleaning, which are normally handled by the sewer district; the associated electrical energy costs are absorbed directly by the property owner. Additionally, high-pressure flushing of the pressure sewer lines may be required every few years to scour slime and solids buildup.

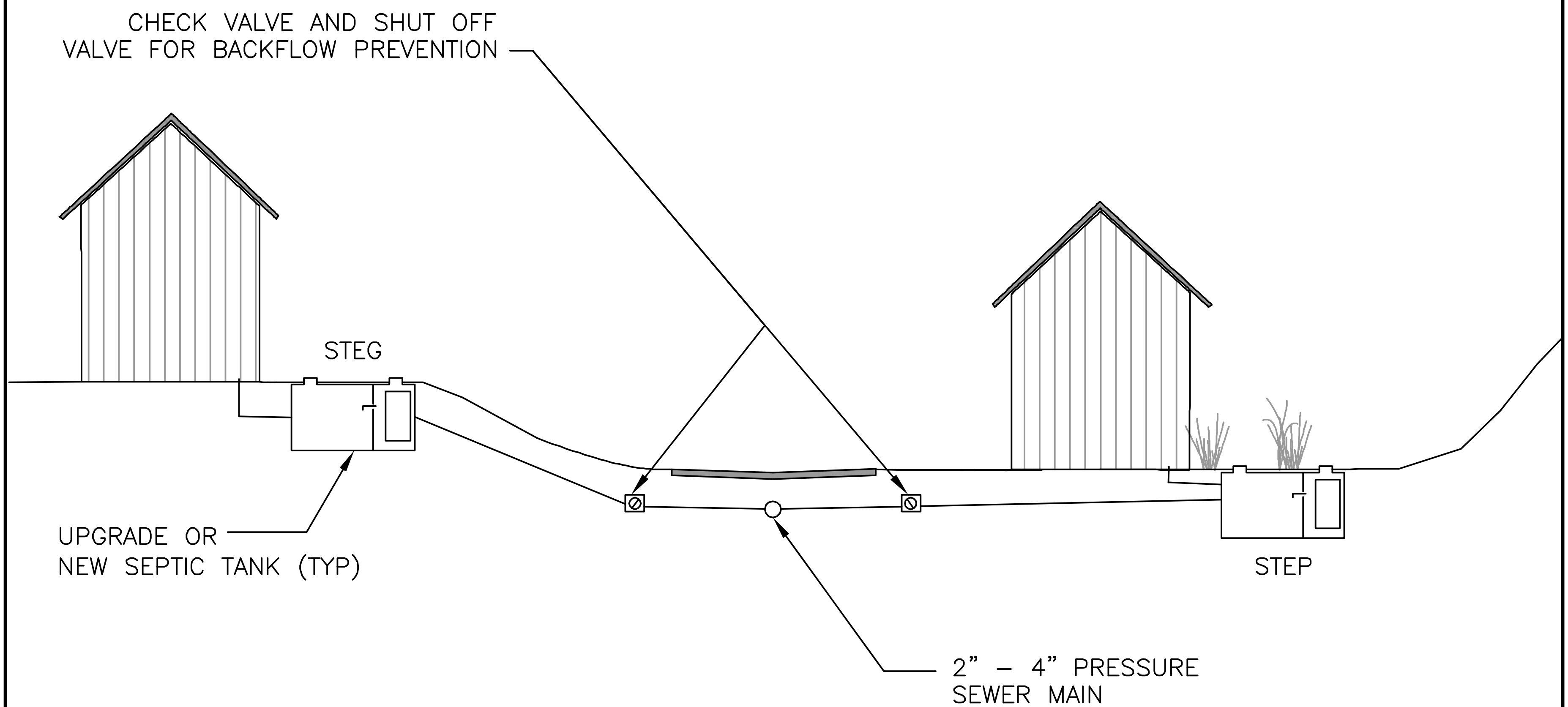
2.3 Small Diameter Effluent Sewers – Pump (STEP) and Gravity (STEG)

General Description

Small diameter, septic tank effluent pump (STEP) and gravity (STEG) sewers are gaining popularity in unsewered areas, especially for low density areas and to minimize sewer pipe sizes and deep trench construction. Unlike conventional sewers, primary treatment is provided at each connection by a septic tank, and only the settled wastewater is collected. Where the terrain is appropriate, the septic tank effluent can be collected by gravity flow (STEG system) in a common small diameter collection main. Where the terrain is flat or undulating individual pumping units (STEP) can be used. In these cases, each connection includes one or more effluent pumps located either in the septic tank or in a separate pump chamber. The septic tank effluent is then pumped into a small diameter force main (2 to 4-inch PVC or HDPE). Grit, grease, and other troublesome solids which might cause obstructions in the pumps or collector mains are separated from the waste flow and retained in septic tanks installed upstream of each connection. With the solids removed, the collector main need not be designed to carry solids, unlike conventional sewers. **Figure D-2** illustrates typical STEP/STEG sewer layout; **Figure D-3** provides details of a typical STEP unit.

Advantages and Disadvantages

Advantages. Effluent STEP/STEG sewers have many of the same advantages cited for pressure sewers. An added advantage is the absence of solids in the sewer lines, since the solids are retained in septic tanks. This reduces the stress on pumping facilities and eases the passage of wastewater through the system. The removal of solids from the waste flow also significantly reduces the load on the treatment plant. Because of their smaller



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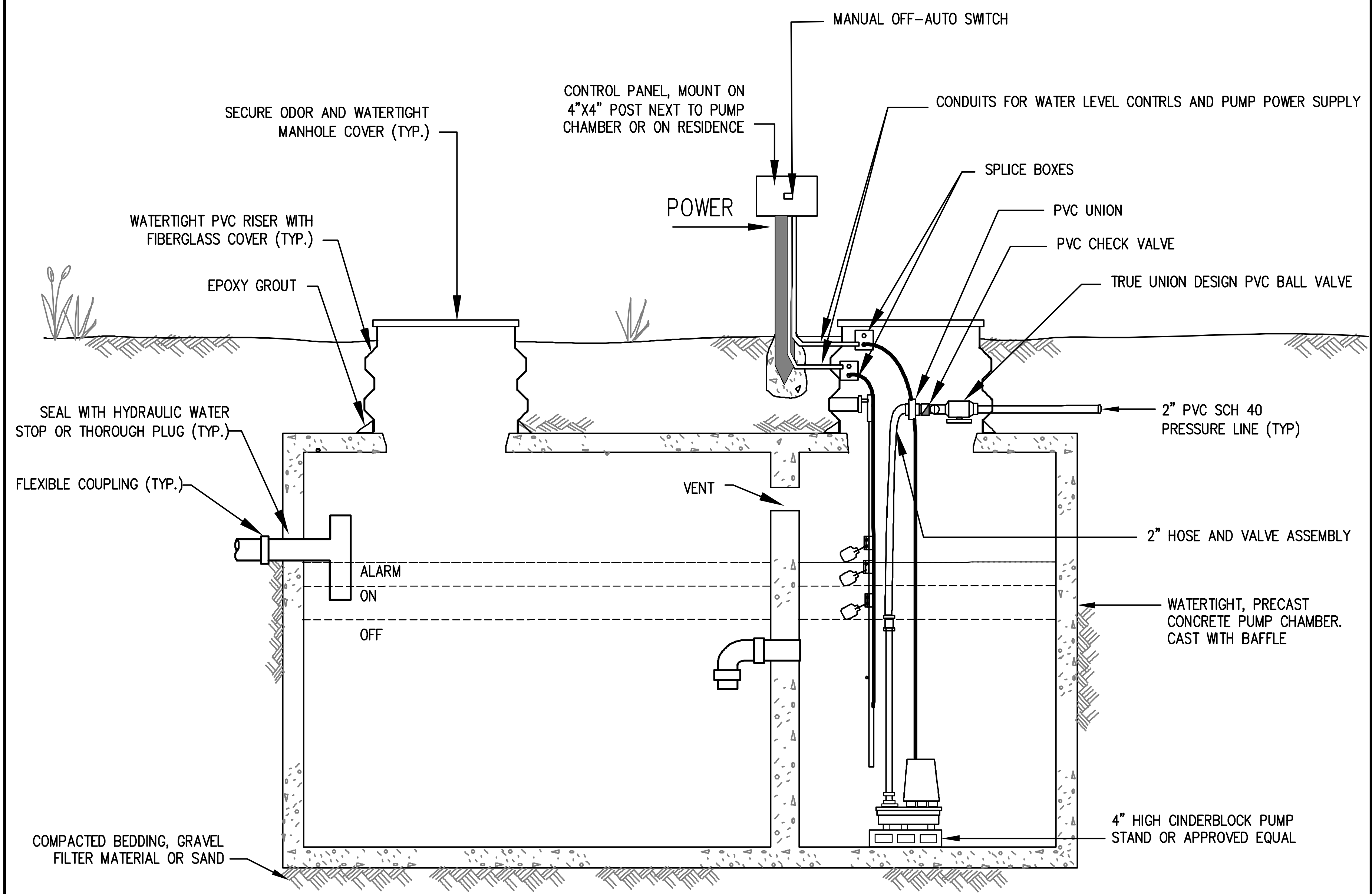
TYPICAL STEP SEWER SYSTEM

WOODACRE FLATS
FEASIBILITY STUDY

FIGURE
D-2



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TYPICAL SEPTIC TANK WITH EFFLUENT PUMP (STEP)

WOODACRE FLATS WASTEWATER FEASIBILITY STUDY

FIGURE

D-3

size, reduced gradients and lack of manholes, STEP/STEG systems can also have a distinct cost advantage over conventional gravity sewers where adverse conditions create excavation problems or where roadway restoration costs in developed areas can be excessive.

Disadvantages. STEP/STEG sewers usually are not well suited in high-density developments because of the cost of installing and maintaining the septic tanks. Since sewage is maintained in an anaerobic or septic state in STEP/STEG systems, nuisance gases are produced that may cause odor problems at individual connections. However, the venting of odors is no different from the conditions with individual septic systems; odors are vented through the house plumbing stacks. Another disadvantage of STEP/STEG sewers is the reliance upon septic tank pump-outs and disposal of septage. Accumulated digested sludge and scum must be removed from the septic tank and disposed of on a periodic basis (every three to five years, on average). However, once again, this is no different from existing conditions.

The main disadvantage of STEP sewers is the added complexity of the large number of pumps and controls that would have to be installed and maintained at the individual residences. Most modern STEP units are very reliable, have a relatively long service life, and include built-in alarms to alert the homeowner in the event of a pump failure. Nevertheless, the impact during extended power outages can be a concern with STEP sewers depending on the amount of reserve storage capacity provided at the STEP unit and lack of readily available back-up power. STEP units are normally configured to provide emergency storage capacity of about 100 to 200 gallons in the septic tank or a separate pump basin, which should normally be sufficient for a one to two-day power outage. Some sanitary districts require STEP units to be installed with a transfer switch to allow pump operation using a portable generator. Larger commercial or multi-family complexes can be equipped with an automatic backup generator.

Finally, as noted previously under the discussion of pressure sewers, STEP/STEG sewers require easements for maintenance and repair of on-lot facilities along with greater attention to public relations and considerable interaction between the district personnel and property owners.

Operation and Maintenance

Operation and maintenance activities for a STEP/STEG sewer system consist mainly of septic tank pump-outs and maintenance, annual inspection and repair, and cleaning out of individual on-lot pump facilities, as needed. Because STEP collection lines are pressurized and do not transport any solids, solids accumulation and associated cleaning of the sewer lines are not normally required to the same degree as for conventional sewers. High-pressure flushing of the main collection lines may be required every few years to scour slime and solids buildup.

3.0 COLLECTION ANALYSIS - FIRE ROAD COMMUNITY ALTERNATIVE

The Fire Road Community Leachfield Alternatives (3A, 3B & 3C) would require collection of sewage at a central location at the northeast end of Woodacre in the vicinity of Park Street and Central Avenue. At this point the sewage would either: (a) be collected in a main lift station and pumped uphill to the Fire Road Community Leachfield site for dispersal (Alternative 3A) or; (b) be treated in a secondary treatment plant at this location, afterwhich the treated water would be pumped uphill to the Fire Road Community Leachfield site for dispersal (Alternatives 3B & 3C). Conventional gravity sewers, pressure sewers or effluent (STEP/STEG) sewers could all potentially be used for local sewage collection in Woodacre Flats. Sewage collection options using each of these methods were formulated to determine and compare the facility requirements and costs of different methods, and to identify the apparent best option for use in conection with the Fire Road Community Leachfield Alternative. This analysis is presented below.

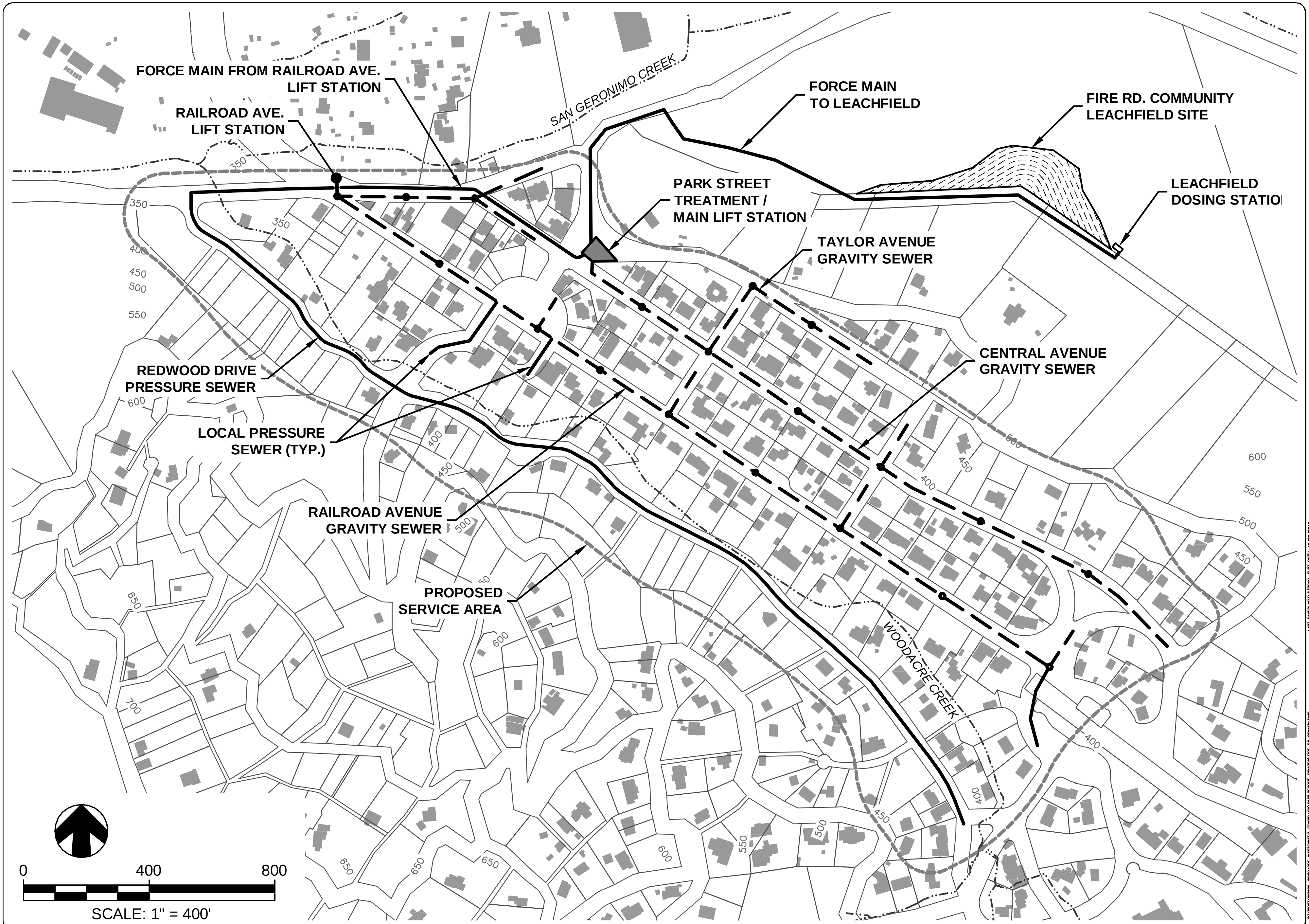
3.1.1 *Option 1 – Conventional Gravity Sewer*

Description. The gently-sloping terrain in Woodacre Flats is generally well-suited for conventional gravity sewers. Under this option gravity sewer lines would be installed on Railroad, Central and Taylor Avenues and connecting streets. The lines on Central and Taylor would terminate at the Park Street treatment/main lift station location. The Railroad Avenue sewer line would terminate at a neighborhood lift station located on the northeast corner of Railroad Ave and San Geronimo Valley Drive. From this lift station, the sewage would be pumped via a sewer force main (pressure line) to the Park Street treatment/main lift station location. Most properties along these streets would be able to be served with a direct gravity sewer lateral connection from the house plumbing to the street sewer, with only a small percentage (less than 10%) requiring individual pump units to pump into the street sewer.

Along Redwood Avenue, because of the undulating grade of the street, a pressure sewer rather then gravity sewers, would likely be the preferred collection method. The pressure sewer would eliminate the need for deep sewer construction and/or multiple lift stations that would be needed for a gravity sewer line in this area. The properties along the Redwood Avenue pressure sewer branch would all have individual on-lot grinder pumps. The pressure sewer line could connect to the sewer force main from Railroad Avenue lift station. **Figure D-4** shows the layout of this sewage collection option.

Facility Requirements. Per the preliminary layout the facility rquiremens of this gravity sewer collection option include the following:

- **Standard Sewers**. Approximately 7,250 lineal feet of conventional 6-inch diameter gravity sewers, installed at a standard depth of approximately 4.5 to 6 feet deep.



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Drawn: ML
Checked: PP
Appr'd: NH

FIRE ROAD LEACHFIELD ALTERNATIVE
GRAVITY SEWER SYSTEM

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- **Manholes**. Approximately 20 manholes would be required in the collection system.

- **Pressure Sewers.** Approximately 5,275 lineal feet of small diameter (2”-3”) pressure sewers to collect and convey sewage from the properties along Redwood Avenue to the point of connection with the force main from the Railroad Ave Lift Station, and to the Park Street Teatment/Main Lift Station location.

- **Individual Pump Connections**. An estimated 50 parcels would require a pump system to convey sewage from the house to the main in the street or for connection to the Redwood Ave pressure sewer branch.

- **Railroad Ave Lift Station**. An intermediate neighborhood lift station would be included within the collection system to pump collected wastewater from the Railroad Ave branch to the Park Street Treatment/Main Lift Station location.

The treatment and lift station requirements at the Park Street location and the force main to the Fire Road leachfield site are addressed under the treatment and disposal faclities requirments for each of the three Fire Road Community Leachfield alternatives.

Estimated Costs. Estimated construction costs for the conventional gravity sewer alternative are presented in **Table D-1,** including quantities and unit cost assumptions, based on service to all 150 existing developed parcels in the Woodacre Flats study area. For comparison, **Table D-2** shows the adjusted costs for service to 75% of the developed parcels (112 parcels). The quantities were taken directly from the preliminary sewer plan layout. Unit costs for on-lot facilities include abandoning existing septic tanks, excavation and installation of building sewers to the property line, materials, installation of grinder pumps where necessary, and required permitting. Unit costs for gravity sewer collection mains, service laterals and force mains include costs for trench excavation, pipeline installation, backfilling, pavement repair and clean-up. A preliminary lump-sum estimate is included for the neighborhood lift station at Railroad Avenue. Costs for septic tank treatmet and main lift station at Park Street and the force main to the leachfield are included separately as part of the treatment and disposal costs.

Table D-1: Gravity Sewer - Fire Road Leachfield (100% Service Connections)

Item	Units	No. of Units	Cost per Unit ($)	Total Cost ($)
On-Lot Facilities				
Abandon existing septic tank	EA	150	$ 1,500	$ 225,000
Individual Grinder Pump	EA	50	$ 8,000	$ 400,000
Reroute Housing Plumbing (Building Sewer)	EA	50	$ 1,500	$ 75,000
4" lateral to Sewer Line (50' ave distance)	EA	100	$ 2,000	$ 200,000
1.25" lateral to Pressure Sewer Line (50' ave distance)	EA	50	$ 1,250	$ 62,500
Collection System				
6" Gravity Sewer Line	LF	7,250	$ 90	$ 652,500
3.0" Pressure Sewer Line	LF	4,600	$ 45	$ 207,000
2.0" Pressure Sewer Line	LF	675	$ 40	$ 27,000
Service Connection (1.25"Isolation Valve and Traffic-Rated Box)	EA	50	$ 1,000	$ 50,000
48" Dia Manhole	EA	20	$ 8,000	$ 160,000
Air Release Valves	EA	2	$ 3,500	$ 7,000
Lift Stations (including pumps, panels, etc.)				
Railroad Ave Lift Station (Tanks, Pumps, Controls, Gen)	LS	1	$ 125,000	$ 125,000
			TOTAL	**$ 2,191,000**

Table D-2: Gravity Sewer - Fire Road Leachfield (75% Service Connections)

Item	Units	No. of Units	Cost per Unit ($)	Total Cost ($)
On-Lot Facilities				
Abandon existing septic tank	EA	112	$ 1,500	$ 168,000
Individual Grinder Pump	EA	37	$ 8,000	$ 296,000
Reroute Housing Plumbing (Building Sewer)	EA	37	$ 1,500	$ 55,500
4" lateral to Sewer Line (50' ave distance)	EA	75	$ 2,000	$ 150,000
1.25" lateral to Pressure Sewer Line (50' ave distance)	EA	37	$ 1,250	$ 46,250
Collection System				
6" Gravity Sewer Line	LF	7,250	$ 90	$ 652,500
3.0" Pressure Sewer Line	LF	4,600	$ 45	$ 207,000
2.0" Pressure Sewer Line	LF	675	$ 40	$ 27,000
Service Connection (1.25"Isolation Valve and Traffic-Rated Box)	EA	37	$ 1,000	$ 37,000
48" Dia Manhole	EA	20	$ 8,000	$ 160,000
Air Release Valves	EA	2	$ 3,500	$ 7,000
Lift Stations (including pumps, panels, etc.)				
Railroad Ave Lift Station (Tanks, Pumps, Controls, Gen)	LS	1	$ 125,000	$ 125,000
			TOTAL	**$ 1,931,250**

3.1.2 *Option 2 – Pressure Sewer*

Description. A pressure sewer collection system for the Woodacre Flats service area would be suitable for conveying sewage flows directly to the Park Street treatment/main lift station site without the need for any intermediate neighborhood lift stations. The pressure sewer lines, ranging from 2 to 3 inches in diameter, would be installed along most all streets in the service area, typically at a minimum depth of 3 to 4 feet or as needed to provide at least one foot clearance below existing water mains and service laterals. **Figure D-5** shows the layout of this sewage collection option.

Facility Requirements. Per the preliminary layout, the facility requirements for this pressure sewer option include the following:

- **Grinder Pump Units.** An individual grinder pump would be installed at each service connection. Almost every residence would have its own standard simplex grinder pump; in some cases, two or more residences located on the on the same property would either share a simplex or a duplex grinder pump. Some of the grinder pumps could be provided with a remote monitoring unit, with access via modem connection and programming for automatic shut-off for emergency conditions. We estimate the need for approximately 150 standard simplex grinder pump units.

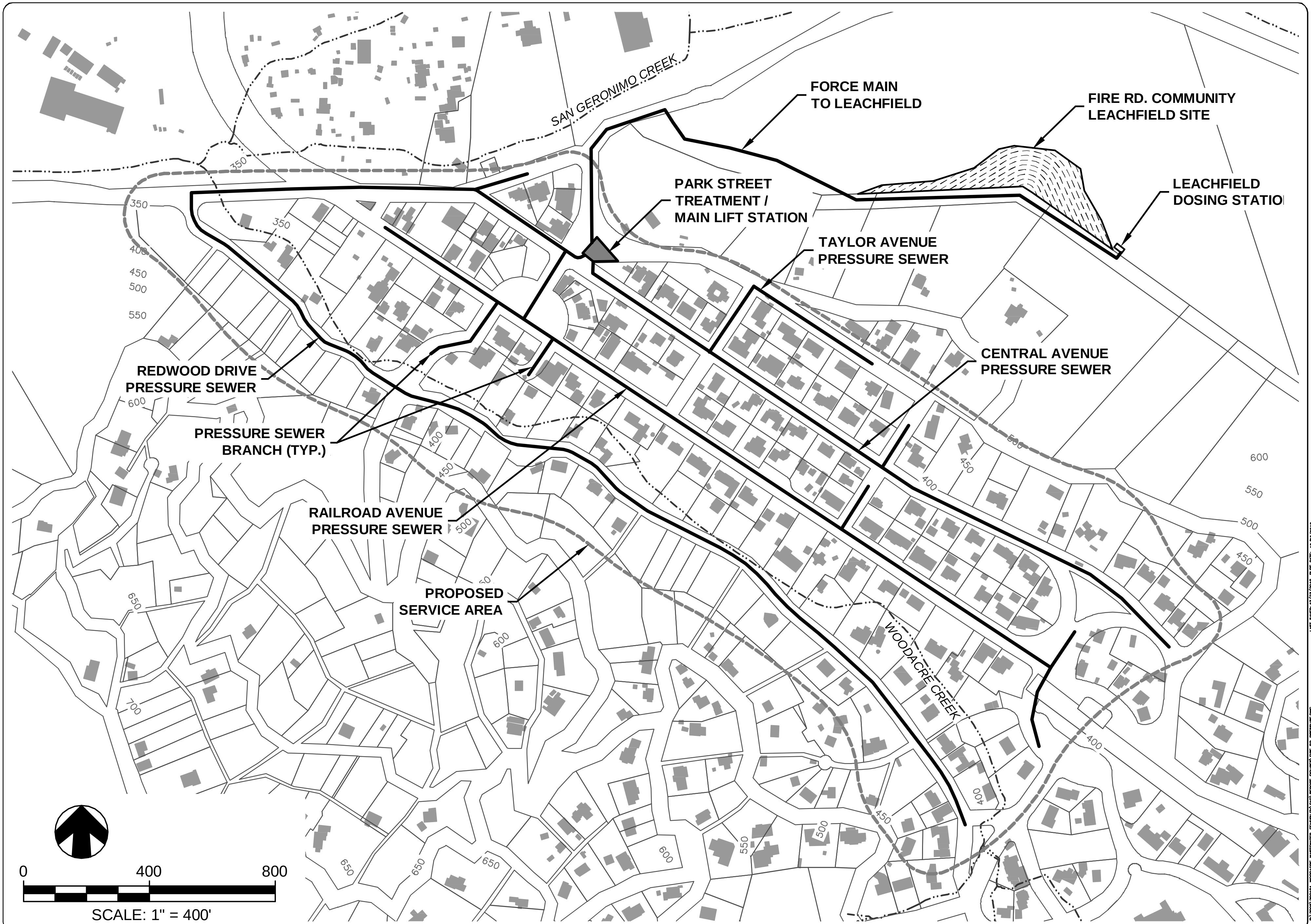
- **Pressure Sewers.** Pressure sewers, ranging in size from 2 to 3 inches diameter, would be installed in a continuous collection network, leading to a force main for transmission of sewage to the Park Street treatment/main lift station site. The complete system would require approximately 11,640 lineal feet of pressure sewers.

- **Cleanouts.** Cleanouts would be placed at the beginning of pressure sewer branches, at intersections, and at every 1,000 to 1,500 feet along straight runs of pipe.

- **Air Release Valves.** Air release valves would be placed at high points in the pressure sewer lines;

The treatment and lift station requirements at the Park Street location and the force main to the Fire Road leachfield site are addressed under the treatment and disposal faclities requirments for each of the three Fire Road Community Leachfield alternatives.

Estimated Costs. Estimated construction costs for the pressure sewer option are presented in **Table D-3,** including quantities and unit cost assumptions, based on service to all 150 existing developed parcels in the Woodacre Flats study area. For comparison, **Table D-4** shows the adjusted costs for service to 75% of the developed parcels (112 parcels). The quantities were taken directly from the preliminary sewer plan layout. Unit costs for on-lot facilities include abandoning existing septic tanks, excavation and installation of building sewers to the grinder pump unit, installation of grinder pumps, and required permitting. Unit costs for pressure sewer collection mains, service laterals



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Checked: PP
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FIRE ROAD LEACHFIELD ALTERNATIVE
PRESSURE SEWER SYSTEM

Size: D
Project: 290191
Scale: AS NOTED
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and force mains include costs for trench excavation, pipeline installation, backfilling, pavement repair and clean-up. The soil conditions and terrain in many parts of the Woodacre Flats service area are suitable for HDD installation methods; our estimates for pipeline installation assume that significant portions of the work will be by HDD methods.

Table D-3: Pressure Sewer - Fire Road Leachfield (100% Service Connections)

Item	Units	No. of Units	Cost per Unit ($)	Total Cost ($)
On-Lot Facilities				
Abandon existing septic tank	EA	150	$ 1,500	$ 225,000
Individual Grinder Pump	EA	150	$ 8,000	$ 1,200,000
Reroute Housing Plumbing (Building Sewer)	EA	150	$ 1,500	$ 225,000
1.25" lateral to Pressure Sewer Line (50' ave distance)	EA	150	$ 1,250	$ 187,500
Collection System				
3.0" Pressure Sewer Line	LF	10,340	$ 45	$ 465,300
2.0" Pressure Sewer Line	LF	1,300	$ 40	$ 52,000
Service Connection (1.25"Isolation Valve and Traffic-Rated Box)	EA	150	$ 1,000	$ 150,000
Air Release Valves	EA	3	$ 3,500	$ 10,500
Lift Stations (including pumps, panels, etc.)				
None Required - Individual Grinder Pumps				
			TOTAL	**$ 2,515,300**

Table D-4: Pressure Sewer - Fire Road Leachfield (75% Service Connections)

Item	Units	No. of Units	Cost per Unit ($)	Total Cost ($)
On-Lot Facilities				
Abandon existing septic tank	EA	112	$ 1,500	$ 168,000
Individual Grinder Pump	EA	112	$ 8,000	$ 896,000
Reroute Housing Plumbing (Building Sewer)	EA	112	$ 1,500	$ 168,000
1.25" lateral to Pressure Sewer Line (50' ave distance)	EA	112	$ 1,250	$ 140,000
Collection System				
3.0" Pressure Sewer Line	LF	10,340	$ 45	$ 465,300
2.0" Pressure Sewer Line	LF	1,300	$ 40	$ 52,000
Service Connection (1.25"Isolation Valve and Traffic-Rated Box)	EA	112	$ 1,000	$ 112,000
Air Release Valves	EA	3	$ 3,500	$ 10,500
Lift Stations (including pumps, panels, etc.)				
None				
			TOTAL	**$ 2,011,800**

3.1.3 *Option 3 –Effluent STEG/STEP Sewer*

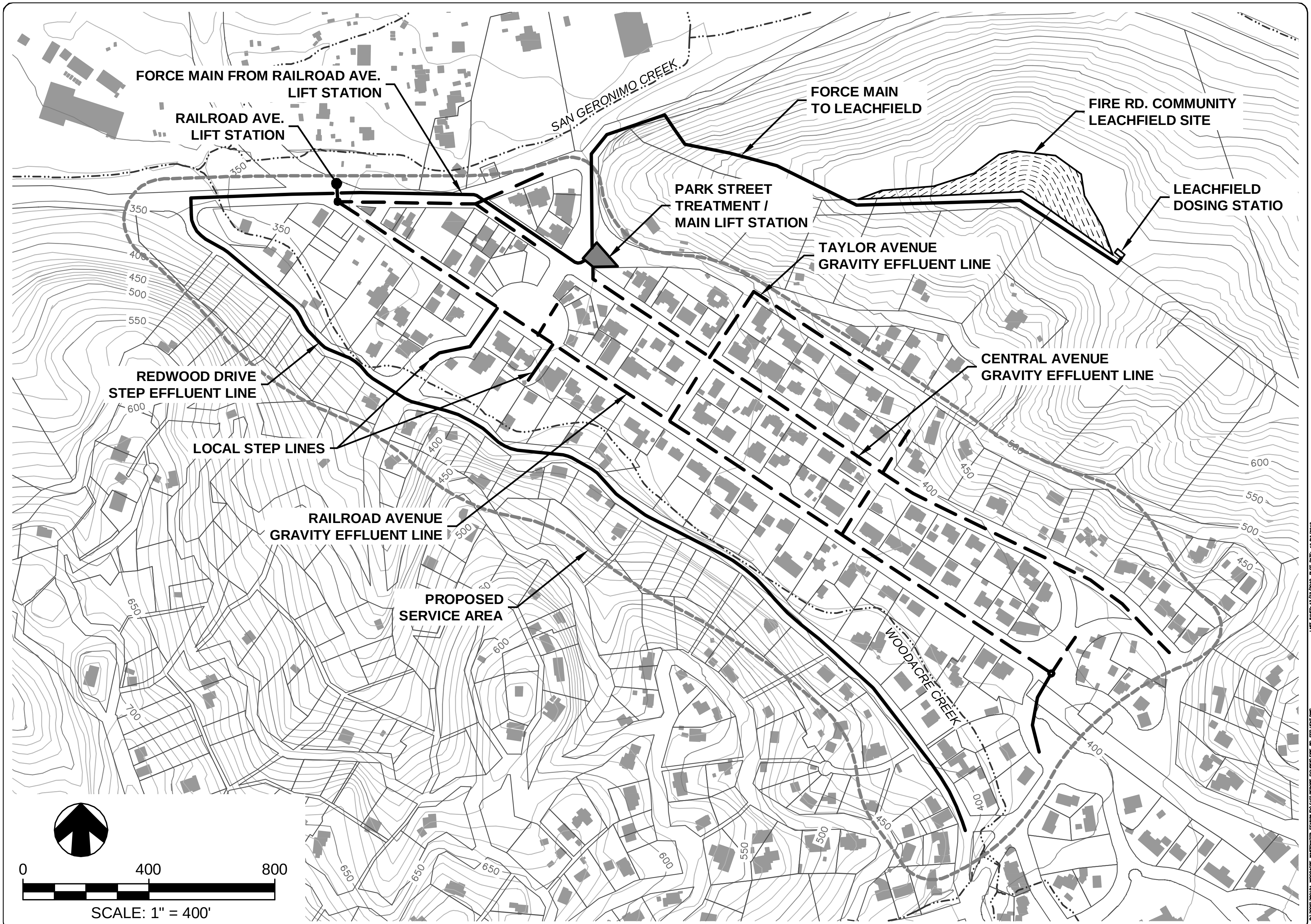
Description. Under this collection alternative, each property would retain an on-lot septic tank for primary treatment, and the clarified effluent would be conveyed from the tank to a network of small diameter effluent collection lines extending throughout the service area. The connection to the effluent sewer system would be either by gravity (STEG) or with a pump unit (STEP) located in the second compartment of the septic tank or an adjacent pump basin. Based on the gently sloping terrain of the Woodacre Flats service area, most of the properties could be served by STEG connections. Gravity effluent sewer lines would be installed on Railroad, Central and Taylor Avenues and connecting streets. The lines on Central and Taylor would terminate at the Park Street treatment/main lift station location. The Railroad Avenue sewer line would terminate at a lift station located on the northeast corner of Railroad Ave and San Geronimo Valley Drive. From this lift station, the septic tank effluent would be pumped via an effluent force main (pressure line) to the Park Street treatment/main lift station location. Most properties along these streets would be able to be served with a STEG connection from the house plumbing to the street sewer, with only a small percentage (less than 10%) requiring STEP units.

Because of the undulating grade of the street, the effluent collection line on Redwood Avenue would be a pressure line. Accordingly, all of the properites along this branch line would require STEP connections. The STEP pressure line would connect to the effluent force main from Railroad Avenue lift station leading to the Park Street treatment/main lift station location. STEP and gravity effluent lines would be installed typically at a minimum depth of 3 to4 feet or as needed to provide at least one foot clearance below existing water mains and service laterals. **Figure D-6** shows the layout of this sewage collection option.

Facility Requirements. Per the preliminary layout, the facility requirements of this STEP/STEG effluent sewer option include the following:

- **Septic Tanks.** Watertight septic tanks would be required for each property (some commercial or multi-residential properties might have more than one tank). Based on prior septic systems inspections (Rosefield and Trienen) along with our field review of exiting systems, we estimate that no more than approximatly half of existing septic tanks could be salvaged and continue to be utilized, and due to their age, size and condition the other half would have to be replaced with new tanks. All tanks would require watertight access risers. Any existing tanks that remain in service would be subject to inspection and testing to verify their conformance with minimum standards for continued use.

- **STEP and STEG Units.** We estimate that approximately one-third of the properties (50 systems) in the service area would require pumping (STEP) units. All others (100 systems) would accommodate gravity connections and be classified as STEG units. The STEP unit includes a submersible effluent pump installed in a separate tank following the septic or in the second compartment of



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FIRE ROAD LEACHFIELD ALTERNATIVE
EFFLUENT STEP/STEG SYSTEM

Size: D
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the septic tank, along with associated electrical control and float-activated switches programmed to operate on demand (i.e., in response to flow from the property). Power is supplied from the house or commercial building, where an audio and visual alarm is located. Emergency/reserve storage capacity of 150 to 200 gallons is normally provided in the septic tank for pump malfunction or power outages. STEG units would have no additional equipment requirments other than a standard septic tank with access risersa and effluent filter.

- **Service Laterals.** Every property will have a service lateral connection to effluent sewer line in the street. Service laterals connecting the STEP unit to the collection main are usually 1.25-inch for pressure lines for residences and 2-inch diameter for commercial and multi-family connections. Service laterals for STEG units would be 3-inch diameter lines. All piping and valves are Schedule 40 PVC or HDPE. A check valve and shutoff valve would be installed on each service lateral at the property line to prevent backflow of effluent from the public sewer into the on-lot facilities.

- **Gravity Effluent Sewers.** Approximately 7,250 lineal feet of 4-inch diameter gravity effluent sewers would be required. Effluent sewers would be either PVC or HDPE pipe.

- **STEP Sewers.** Approximately 5,275 lineal feet of STEP sewers would be required, primarily along Redwood Avenue. STEP sewers, consisting of PVC or HDPE pipe, would have diameters 2 to 3 inches.

- **Clean-Outs.** Manholes are not required in STEP sewers; clean-outs and isolation valves are included for maintenance purposes.

The treatment and lift station requirements at the Park Street location and the force main to the Fire Road leachfield site are addressed under the treatment and disposal faclities requirments for each of the three Fire Road Community Leachfield alternatives.

Estimated Costs. Estimated construction costs for the STEP/STEG effluent sewer system option are presented in **Table D-5,** including quantities and unit cost assumptions, based on service to all 150 existing developed parcels in the Woodacre Flats study area. For comparison, **Table D-6** shows the adjusted costs for service to 75% of the developed parcels (112 parcels). The quantities were taken directly from the preliminary sewer plan layout. Unit costs for on-lot facilities include the cost of abandoning existing septic tanks, plus the costs of materials and installation of STEP/STEG units, new septic tanks or upgrade of existing tanks, and the excavation and installation of building sewers and service laterals. Unit costs for the collection system include material costs for sewer pipes and valves, trench excavation, pipeline installation, backfilling, pavement repair, and clean-up. The soil conditions and terrain in many parts of the Woodacre Flats service area are suitable for HDD installation methods; our estimates for pipeline installation assume that significant portions of the work will be by HDD methods.

Table D-5: Effluent STEP/STEG Sewer - Fire Road Leachfield (100% Service Connections)

Item	Units	No. of Units	Cost per Unit ($)	Total Cost ($)
On-Lot Facilities				
Abandon existing septic tank	EA	75	$ 1,500	$ 112,500
Inspect/Upgrade existing septic tank	EA	75	$ 2,500	$ 187,500
New 1,200-Gallon Septic Tank	EA	75	$ 5,500	$ 412,500
STEP Unit (including vault, risers, effluent pump, lids, panel, add'l accessories)	EA	50	$ 8,000	$ 400,000
Reroute Housing Plumbing (Building Sewer)	EA	75	$ 1,500	$ 112,500
3" Gravity lateral to STEG Line (50' ave distance)	EA	100	$ 2,000	$ 200,000
1.25" Pressure lateral to STEP Line (50' ave distance)	EA	50	$ 1,250	$ 62,500
Collection System				
4.0" Gravity Effluent Sewer (STEG)	LF	7,250	$ 55	$ 398,750
3.0" Pressure Line (STEP)	LF	4,600	$ 45	$ 207,000
2.0" Pressure Line (STEP)	LF	675	$ 40	$ 27,000
Service Connection (2.0" Isolation Valve and Traffic-Rated Box)	EA	150	$ 1,000	$ 150,000
Air Release Valves	EA	3	$ 3,500	$ 10,500
Clean Outs	EA	30	$ 500	$ 15,000
Lift Stations (including pumps, panels, etc.)				
Effluent Lift Station @ Railroad Ave	LS	1	$ 75,000	$ 75,000
			TOTAL	**$ 2,370,750**

Table D-6: Effluent STEP/STEG Sewer - Fire Road Leachfield (75% Service Connections)

Item	Units	No. of Units	Cost per Unit ($)	Total Cost ($)
On-Lot Facilities				
Abandon existing septic tank	EA	56	$ 1,500	$ 84,000
Inspect/Upgrade existing septic tank	EA	56	$ 2,500	$ 140,000
New 1,200-Gallon Septic Tank	EA	56	$ 5,500	$ 308,000
STEP Unit (including vault, risers, effluent pump, lids, panel, add'l accessories)	EA	37	$ 8,000	$ 296,000
Reroute Housing Plumbing (Building Sewer)	EA	56	$ 1,500	$ 84,000
3" Gravity lateral to STEG Line (50' ave distance)	EA	75	$ 2,000	$ 150,000
1.25" Pressure lateral to STEP Line (50' ave distance)	EA	37	$ 1,250	$ 46,250
Collection System				
4.0" Gravity Effluent Sewer (STEG)	LF	7,250	$ 55	$ 398,750
3.0" Pressure Line (STEP)	LF	4,600	$ 45	$ 207,000
2.0" Pressure Line (STEP)	LF	675	$ 40	$ 27,000
Service Connection (2.0" Isolation Valve and Traffic-Rated Box)	EA	112	$ 1,000	$ 112,000
Air Release Valves	EA	3	$ 3,500	$ 10,500
Clean Outs	EA	30	$ 500	$ 15,000
Lift Stations (including pumps, panels, etc.)				
Railroad Ave Lift Station	LS	1	$ 75,000	$ 75,000
			TOTAL	**$ 1,953,500**

4.0 COLLECTION ANALYSIS - GOLF COURSE WATER RECYCLING ALTERNATIVE

The Golf Course Water Recycling Alternative (4) would require local collection of sewage at the northern end of Woodacre and then conveyance to a treatment plant located at the San Geronimo Golf Course (maintenace area) by one of two routes, either: (a) west along San Geronimo Valley Drive; or (b) north on Railroad Avenue, west along Sir Francis Drake Bulevard, and then across a portion of the golf course. Conventional gravity sewers, pressure sewers or effluent (STEP/STEG) sewers could all potentially be used for local sewage collection in Woodacre Flats. Sewage collection options using each of these methods were formulated to determine and compare the facility requirements and costs of different methods, and to identify the apparent best option for use in conection with the Golf Course Water Recycling Alternative. This analysis is presented below.

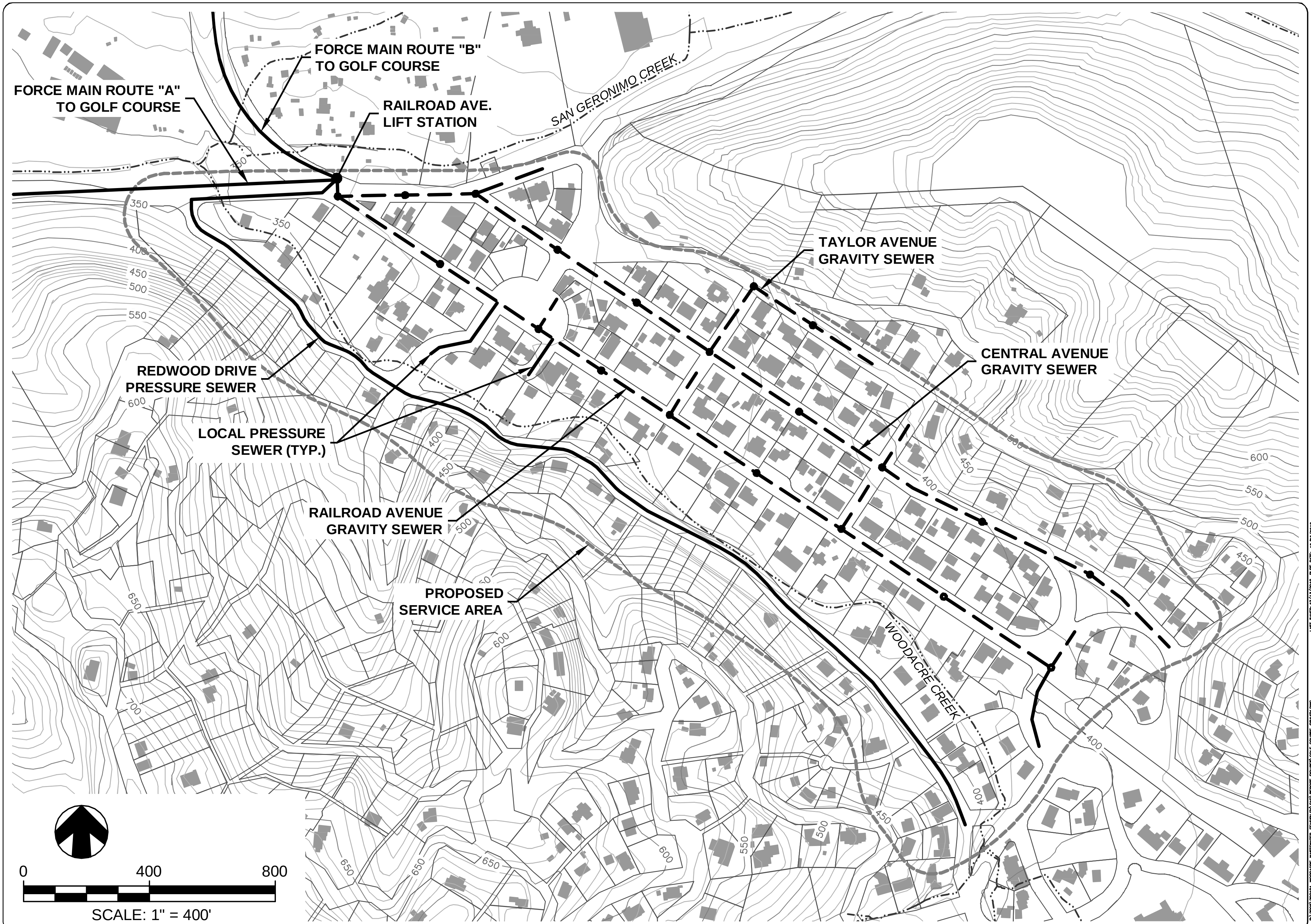
4.1.1 *Option 1 – Conventional Gravity Sewer*

Description. As previously noted, the gently-sloping terrain in Woodacre Flats is generally well-suited for conventional gravity sewers. Under this sewer option gravity sewer lines would be installed on Railroad, Central and Taylor Avenues and connecting streets, leading to a main lift station located on the northeast corner of Railroad Ave. and San Geronimo Valley Drive. From this main lift station, the effluent would be pumped via a sewer force main (pressure line) to the treatment location at the San Geronimo Golf Course by either of the two alternative routes. Most properties along these streets would be able to be served with a direct gravity sewer lateral connection from the house plumbing to the street sewer, with only a small percentage (less than 10%) requiring individual pump units to pump into the street sewer.

For Redwood Avenue, because of the undulating grade of the street, a pressure sewer rather then gravity sewers, would be the preferred collection method. The pressure sewer would eliminate the need for deep sewer construction and/or multiple lift stations that would be needed for a gravity sewer line in this area. The properties along the Redwood Avenue pressure sewer branch would all have individual on-lot grinder pumps. The pressure sewer line would connect to main lift station at Railroad/San Geronimo Valley Drive, with a bypass option for direct pumping into the force main leading to the treatment plant. **Figure D-7** shows the layout of this sewage collection option.

Facility Requirements. Per the preliminary layout of this gravity sewer collection option the facility requirements would include the following:

- **Standard Sewers**. Approximately 7,250 lineal feet of conventional 6-inch diameter gravity sewers, installed at a standard depth of approximately 4.5 to 6 feet deep.



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GOLF COURSE DISPOSAL ALTERNATIVE
GRAVITY SEWER SYSTEM

Size: D
Project: 290191
Scale: AS NOTED
Sheet: D-7

- **Manholes**. Approximately 20 manholes would be required in the collection system.

- **Pressure Sewers.** Approximately 5,275 lineal feet of small diameter (2”-3”) pressure sewers to collect and convey sewage from the properties along Redwood Avenue to the point of connection at the main lift station.

- **Individual Pump Connections**. An estimated 50 parcels would require a pump system to convey sewage from the house to the street sewer.

- **Main Lift Station**. A main lift station would be located in the north end of the service area on the northeast side of the intersection of Railroad Ave and San Geronimo Valley Drive.

- **Force Main.** A 4-inch diameter force main will run from the main lift station to the proposed treatment plant location at the San Geronimo Golf Course maintanance area. For the San Geronimo Valley Drive Route A, the force main would be approximately 5,860 feet long; for the Sir Francis Drake Blvd Route B, the force main would be approximately 5,350 feet long. Force main Route A would require special provisions (ductile iron sleeve) for the bridge crossing over San Geronimo Creek near Meadow Way. Force main Route B would be buried in the road bed of Railroad Avenue where it crosses San Geronimo Creek.

Estimated Costs. Estimated construction costs for the conventional gravity sewer alternative are presented in **Table D-7,** including quantities and unit cost assumptions, based on service to all 150 existing developed parcels in the Woodacre Flats study area. For comparison, **Table D-8** shows the adjusted costs for service to 75% of the developed parcels (112 parcels). The quantities were taken directly from the preliminary sewer plan layout. Unit costs for on-lot facilities include abandoning existing septic tanks, excavation and installation of building sewers to the property line, materials, installation of grinder pumps where necessary, and required permitting. Unit costs for gravity sewer collection mains, service laterals and force mains include costs for trench excavation, pipeline installation, backfilling, pavement repair and clean-up. A preliminary lump-sum estimate is included for the main lift station. Separate esitmates are provided for the two alternate force main routes from Woodacre to the treatment plant site at the Golf Course.

Table D-7: Gravity Sewer - Golf Course Recycle (100% Service Connections)

Item	Units	No. of Units	Cost per Unit ($)	Total Cost ($)	Total Cost ($)
On-Lot Facilities				**Route A**	**Route B**
Abandon existing septic tank	EA	150	$ 1,500	$ 225,000	$ 225,000
Individual Grinder Pump	EA	50	$ 8,000	$ 400,000	$ 400,000
Reroute Housing Plumbing (Building Sewer)	EA	50	$ 1,500	$ 75,000	$ 75,000
4" lateral to Sewer Line (50' ave distance)	EA	100	$ 2,000	$ 200,000	$ 200,000
1.25" lateral to Pressure Sewer Line (50' ave distance)	EA	50	$ 1,250	$ 62,500	$ 62,500

Collection System					
6" Gravity Sewer Line	LF	7,250	$ 90	$ 652,500	$ 652,500
3.0" Pressure Sewer Line	LF	4,600	$ 45	$ 207,000	$ 207,000
2.0" Pressure Sewer Line	LF	675	$ 40	$ 27,000	$ 27,000
Service Connection (1.25"Isolation Valve and Traffic-Rated Box)	EA	50	$ 1,000	$ 50,000	$ 50,000
48" Dia Manhole	EA	20	$ 8,000	$ 160,000	$ 160,000
Air Release Valves	EA	3	$ 3,500	$ 10,500	$ 10,500
Lift Stations (including pumps, panels, etc.)					
Main Lift Station at Railroad Ave	LS	1	$ 125,000	$ 125,000	$ 125,000
Transmission Line to Golf Course					
4-inch HDPE Force Main, Route A, SG Valley Dr.	LF	5,860	$ 55	$ 322,300	
SG Creek/Bridge Crossing, Route A only	LS	1	$ 25,000	$ 25,000	
4-inch HDPE Force Main, Route B, SF Drake Blvd.	LF	5,350	$ 55		$ 294,250
			TOTAL	**$ 2,541,800**	**$ 2,488,750**

Table D-8: Gravity Sewer - Golf Course Recycle (75% Service Connections)

Item	Units	No. of Units	Cost per Unit ($)	Total Cost ($)	Total Cost ($)
				Route A	**Route B**
On-Lot Facilities					
Abandon existing septic tank	EA	112	$ 1,500	$ 168,000	$ 168,000
Individual Grinder Pump	EA	37	$ 8,000	$ 296,000	$ 296,000
Reroute Housing Plumbing (Building Sewer)	EA	37	$ 1,500	$ 55,500	$ 55,500
4" lateral to Sewer Line (50' ave distance)	EA	75	$ 2,000	$ 150,000	$ 150,000
1.25" lateral to Pressure Sewer Line (50' ave distance)	EA	37	$ 1,250	$ 46,250	$ 46,250
Collection System					
6" Gravity Sewer Line	LF	7,250	$ 90	$ 652,500	$ 652,500
3.0" Pressure Sewer Line	LF	4,600	$ 45	$ 207,000	$ 207,000
2.0" Pressure Sewer Line	LF	675	$ 40	$ 27,000	$ 27,000
Service Connection (1.25"Isolation Valve and Traffic-Rated Box)	EA	37	$ 1,000	$ 37,000	$ 37,000
48" Dia Manhole	EA	20	$ 8,000	$ 160,000	$ 160,000
Air Release Valves	EA	3	$ 3,500	$ 10,500	$ 10,500
Lift Stations (including pumps, panels, etc.)					
Main Lift Station at Railroad Ave	LS	1	$ 125,000	$ 125,000	$ 125,000
Transmission Line to Golf Course					
4-inch HDPE Force Main, Route A, SG Valley Dr.	LF	5,860	$ 55	$ 322,300	
SG Creek/Bridge Crossing, Route A only	LS	1	$ 25,000	$ 25,000	
4-inch HDPE Force Main, Route B, SF Drake Blvd.	LF	5,350	$ 55		$ 294,250
			TOTAL	**$ 2,282,050**	**$ 2,229,000**

4.1.2 *Option 2 – Pressure Sewer*

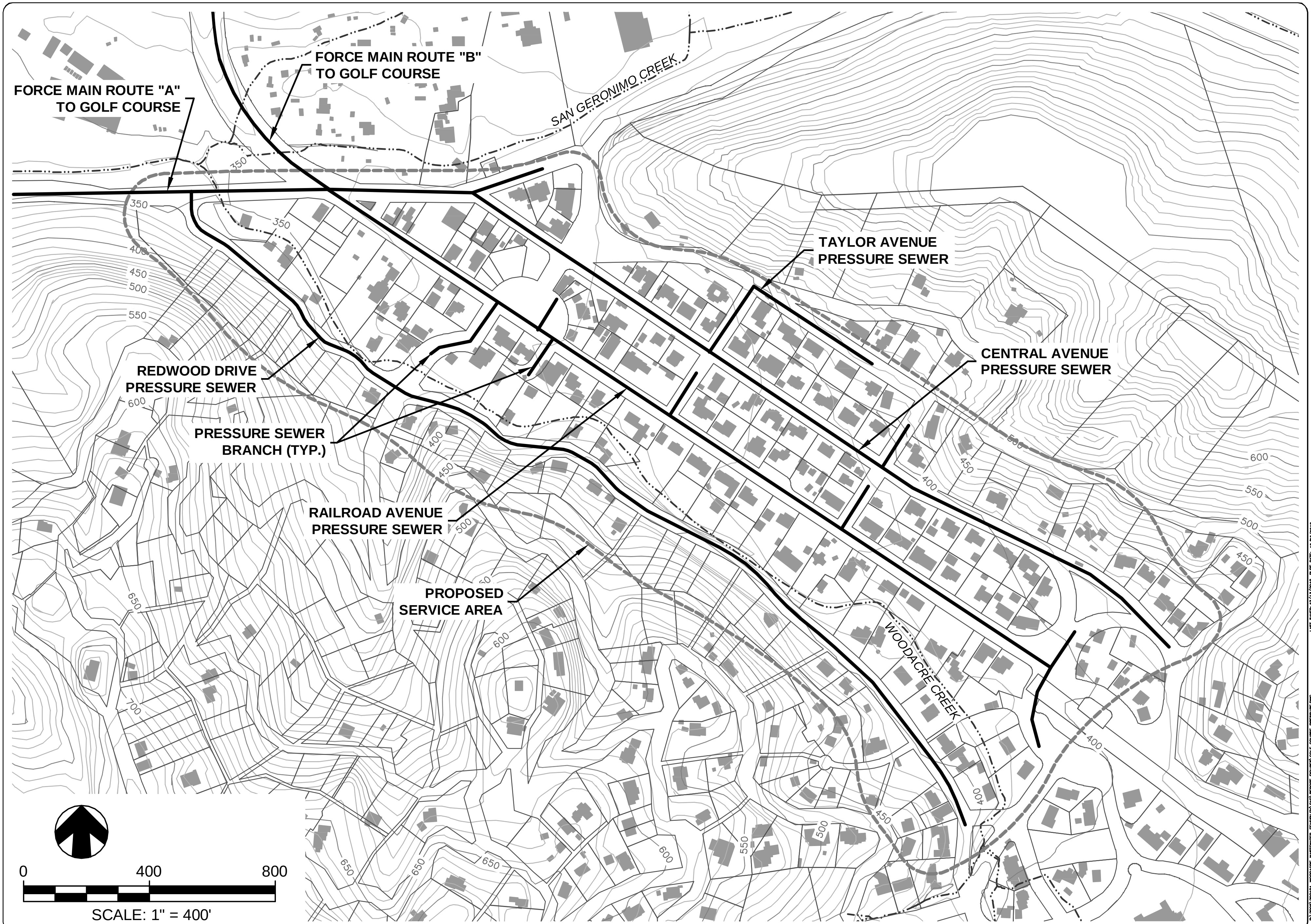
Description. A pressure sewer collection system for the Woodacre Flats service area would be suitable for conveying sewage flows directly to treatment plant location at the Golf Course, without the need for any intermediate lift staions within the community. The individual grinder pump units would have sufficient capacity to overcome the small elevation differences and frictional losses in the piping system. Typical grinder pump units can deliver flows in the range of 10 to 12 gallons per minute against lifting (pressure) requirements of over 100 feet. The pressure sewer lines, ranging from 2 to 3 inches in diameter, would be installed along most all streets in the service area, typically at a minimum depth of 3 to4 feet or as needed to provide at least one foot clearance below existing water mains and service laterals. The pressure sewer lines would combine into a single4-inch diameter force main leading to the treatment location at the San Geronimo Golf Course by either of the two alternative routes (i.e., via Rte A, San Geronimo Valley Dr. or Rte. B, Sir Francis Drake Blvd.) **Figure D-8** shows the layout of this sewage collection option.

Facility Requirements. Per the preliminary layout, the facility requirements for this pressure sewer option include the following:

- **Grinder Pump Units.** An individual grinder pump would be installed at each service connection. Almost every residence would have its own standard simplex grinder pump; in some cases, two or more residences located on the on the same property would either share a simplex or a duplex grinder pump. Some of the grinder pumps could be provided with a remote monitoring unit, with access via modem connection and programming for automatic shut-off for emergency conditions. We estimate the need for approximately 150 standard simplex grinder pump units.

- **Pressure Sewers.** Pressure sewers, ranging in size from 2 to 3 inches diameter, would be installed in a continuous collection network, leading to a common junction in the vicinity of Railroad Ave. and San Geronimo Valley Dr. The complete system would require approximately 11,510 lineal feet of pressure sewers. No lift station would be required for this sewer option, as the individual grinder pump units would be sufficient to pump the sewage all the way to the treatment plant on the golf course.

- **Force Main.** From the pressure sewer junction point near the foot of Railroad Ave. a 4-inch diameter force main will run to the proposed treatment plant location at the San Geronimo Golf Course maintanance area. For the San Geronimo Valley Drive route, the force main would be approximately 5,860 feet long; for the Sir Francis Drake Blvd route, the force main would be approximately 5,780 feet long.



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GOLF COURSE DISPOSAL ALTERNATIVE
PRESSURE SEWER SYSTEM

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- **Cleanouts and Air Release Valves.** Cleanouts would be placed at the beginning of pressure sewer branches, at intersections, and at every 1,000 to 1,500 feet along straight runs of pipe. Air release valves would be installed at the high points of the pressure lines.

Estimated Costs. Estimated construction costs for the pressure sewer option are presented in in **Table D-9,** including quantities and unit cost assumptions, based on service to all 150 existing developed parcels in the Woodacre Flats study area. For comparison, **Table D-10** shows the adjusted costs for service to 75% of the developed parcels (112 parcels). The quantities were taken directly from the preliminary sewer plan layout. Unit costs for on-lot facilities include abandoning existing septic tanks, excavation and installation of building sewers to the pump unit, materials, installation of grinder pumps, and required permitting. Unit costs for pressure sewer collection mains, service laterals and force mains include costs for trench excavation, pipeline installation, backfilling, pavement repair and clean-up. The soil conditions and terrain in many parts of the Woodacre Flats service area are suitable for HDD installation methods; our estimates for pipeline installation assume that significant portions of the work will be by HDD methods. Separate esitmates are provided for the two alternate force main routes from Woodacre to the treatment plant site at the Golf Course.

Table D-9: Pressure Sewer - Golf Course Recycle (100% Service Connections)

Item	Units	No. of Units	Cost per Unit ($)	Total Cost ($)	Total Cost ($)
				Route A	Route B
On-Lot Facilities					
Abandon existing septic tank	EA	150	$ 1,500	$ 225,000	$ 225,000
Individual Grinder Pump	EA	150	$ 8,000	$ 1,200,000	$ 1,200,000
Reroute Housing Plumbing (Building Sewer)	EA	150	$ 1,500	$ 225,000	$ 225,000
1.25" lateral to Pressure Sewer Line (50' ave distance)	EA	150	$ 1,250	$ 187,500	$ 187,500
Collection System					
3.0" Pressure Sewer Line	LF	9,870	$ 45	$ 444,150	$ 444,150
2.0" Pressure Sewer Line	LF	1,640	$ 40	$ 65,600	$ 65,600
Service Connection (1.25"Isolation Valve and Traffic-Rated Box)	EA	150	$ 1,000	$ 150,000	$ 150,000
Air Release Valves	EA	4	$ 3,500	$ 14,000	$ 14,000
Lift Stations (including pumps, panels, etc.)					
None required					
Transmission Line to Gold Course					
4-inch HDPE Force Main - Route A, SG Valley Dr	LF	5,860	$ 55	$ 322,300	
SG Creek/Bridge Crossing - Route A only	LS	1	$ 25,000	$ 25,000	
4-inch HDPE Force Main - Route B, SF Drake Blvd	LF	5,780	$ 55		$ 317,900
			TOTAL	**$ 2,858,550**	**$ 2,829,150**

Table D-10: Pressure Sewer - Golf Course Recycle (75% Service Connections)

Item	Units	No. of Units	Cost per Unit ($)	Total Cost ($)	Total Cost ($)
				Route A	Route B
On-Lot Facilities					
Abandon existing septic tank	EA	112	$ 1,500	$ 168,000	$ 168,000
Individual Grinder Pump	EA	112	$ 8,000	$ 896,000	$ 896,000
Reroute Housing Plumbing (Building Sewer)	EA	112	$ 1,500	$ 168,000	$ 168,000
1.25" lateral to Pressure Sewer Line (50' ave distance)	EA	112	$ 1,250	$ 140,000	$ 140,000
Collection System					
3.0" Pressure Sewer Line	LF	3,750	$ 45	$ 168,750	$ 168,750
2.0" Pressure Sewer Line	LF	1,640	$ 40	$ 65,600	$ 65,600
Service Connection (1.25"Isolation Valve and Traffic-Rated Box)	EA	112	$ 1,000	$ 112,000	$ 112,000
Air Release Valves	EA	4	$ 3,500	$ 14,000	$ 14,000
Lift Stations (including pumps, panels, etc.)					
None required					
Transmission Line to Gold Course					
4-inch HDPE Force Main - Route A, SG Valley Dr	LF	5,860	$ 55	$ 322,300	
SG Creek/Bridge Crossing - Route A only	LS	1	$ 25,000	$ 25,000	
4-inch HDPE Force Main - Route B, SF Drake Blvd	LF	5,780	$ 55		$ 317,900
			TOTAL	**$ 2,079,650**	**$ 2,050,250**

4.1.3 *Option 3 – Effluent STEG/STEP Sewer*

Description. Under this collection alternative, each property would retain an on-lot septic tank for primary treatment, and the clarified effluent would be conveyed from the tank to a network of small diameter effluent collection lines extending throughout the service area. The connection to the effluent sewer system would be either by gravity (STEG) or with a pump unit (STEP) located in the second compartment of the septic tank or an adjacent pump basin. Based on the gently sloping terrain of the Woodacre Flats service area, most of the properties could be served by STEG connections, with only a small percentage (less than 10%) requiring STEP units. Gravity effluent sewer lines would be installed on Railroad, Central and Taylor Avenues and connecting streets, leading to a main lift station located on the northeast corner of Railroad Ave and San Geronimo Valley Drive. From this main lift station, the effluent would be pumped via an effluent force main (pressure line) to the treatment location at the San Geronimo Golf Course by either of the two alternative routes (A or B).

Because of the undulating grade of the street, the effluent collection line on Redwood Avenue would be a pressure line. Accordingly, all of the properites along this branch line would require STEP connections. The STEP pressure line would connect to the main lift station at Railroad/San Geronimo Valley Dr, with a bypass option for direct pumping into the force main leading to the treatment plant. STEP and gravity effluent sewers would be installed typically at a minimum depth of 3 to4 feet or as needed to provide at least one foot clearance below existing water mains and service laterals. **Figure D-9** shows the layout of this sewage collection option.

Facility Requirements. Per the preliminary layout, the facility requirements for this effluent STEP/STEG sewer option include the following:

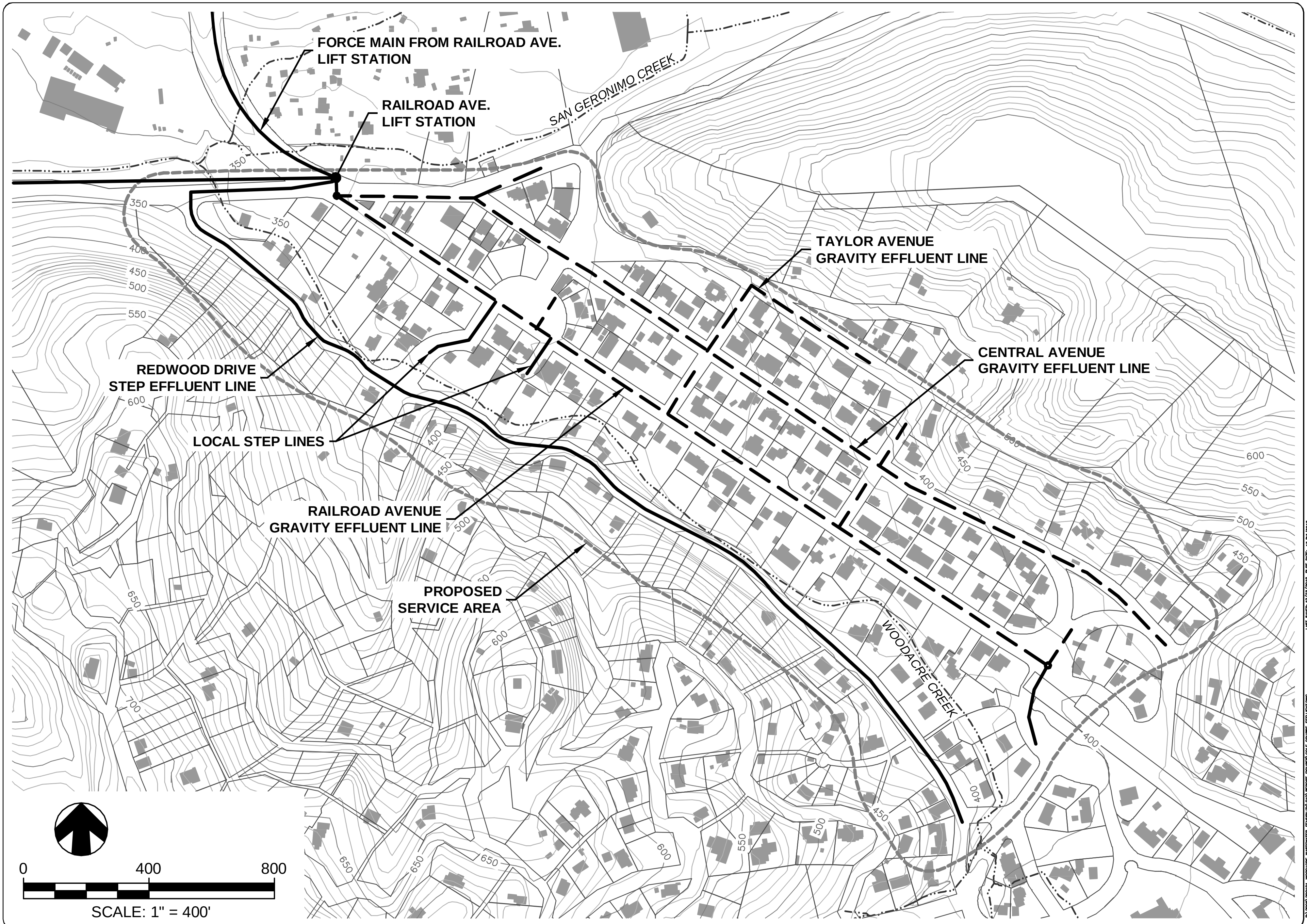
- **Septic Tanks.** Watertight septic tanks would be required for each property (some commercial or multi-residential properties might have more than one tank). Based on prior septic systems inspections (Rosefield and Trienen) along with our field review of exiting systems, we estimate that no more than approximatly half of existing septic tanks could be salvaged and continue to be utilized, and due to their age, size and condition the other half would have to be replaced with new tanks. All tanks would require watertight access risers. Any existing tanks that remain in service would be subject to inspection and testing to verify their conformance with minimum standards for continued use.

- **STEP and STEG Units.** We estimate that approximately one-third % of the properties (50 systems) in the service area would require pumping (STEP) units. All others (100 systems) would accommodate gravity connections and be classified as STEG units. The STEP unit includes a submersible effluent pump installed in a separate tank following the septic or in the second compartment of the septic tank, along with associated electrical control and float-activated switches programmed to operate on demand (i.e., in response to flow from the property). Power is supplied from the house or commercial building, where an audio and visual alarm is located. Emergency/reserve storage capacity of 150 to 200 gallons is normally provided in the septic tank for pump malfunction or power outages. STEG units would have no additional equipment requirments other than a standard septic tank with access risersa and effluent filter.

- **Service Laterals.** Every property will have a service lateral connection to effluent sewer line in the street. Service laterals connecting the STEP unit to the collection main are usually 1.25-inch for pressure lines for residences and 2-inch diameter for commercial and multi-family connections. Service laterals for STEG units would be 3-inch diameter lines. All piping and valves are Schedule 40 PVC or HDPE. A check valve and shutoff valve would be installed on each service lateral at the property line to prevent backflow of effluent from the public sewer into the on-lot facilities.

- **Gravity Effluent Sewers.** Approximately 7,460 lineal feet of 4-inch gravity effluent sewers would be required. Effluent sewers would consist of PVC or HDPE pipe.

- **STEP Sewers.** Approximately 4,450 lineal feet of STEP sewers would be required, primarily along Redwood Avenue. STEP sewers, consisting of PVC or HDPE pipe, would have diameters of 2 to 3 inches.



WOODACRE FLATS
WASTEWATER FEASIBILITY STUDY
WOODACRE, CALIFORNIA

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Design: NH/PP
Drawn: ML
Checked: PP
Appr'd: NH

GOLF COURSE DISPOSAL ALTERNATIVE
EFFLUENT STEP/STEG SYSTEM

Size: D
Project: 290191
Scale: AS NOTED
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- **Clean-Outs and Air Release Valves.** Manholes are not required in STEP sewers; clean-outs and isolation valves are included for maintenance purposes. Air release valves would be installed at high points in pressure lines.

Estimated Costs. Estimated construction costs for the STEP/STEG effluent sewer system option are presented in **Table D-11,** including quantities and unit cost assumptions, based on service to all 150 existing developed parcels in the Woodacre Flats study area. For comparison, **Table D-12** shows the adjusted costs for service to 75% of the developed parcels (112 parcels). Unit costs for on-lot facilities include the cost of abandoning existing septic tanks, plus the costs of materials and installation of STEP/STEG units, new septic tanks or upgrade of existing tanks, and the excavation and installation of building sewers and service laterals. Unit costs for the collection system include material costs for sewer pipes and valves, trench excavation, pipeline installation, backfilling, pavement repair, and clean-up. The soil conditions and terrain in many parts of the Woodacre Flats service area are suitable for HDD installation methods; our estimates for pipeline installation assume that significant portions of the work will be by HDD methods. A preliminary lump-sum estimate is included for the main lift station. Separate esitmates are provided for the two alternate force main routes from Woodacre to the treatment plant site at the Golf Course.

Table D-11: Effluent STEP/STEG Sewer - Golf Course Recycle (100% Service Connections)

Item	Units	No. of Units	Cost per Unit ($)		Total Cost (4)		Total Cost ($)	
					Route A		Route B	
On-Lot Facilities								
Abandon existing septic tank	EA	75	$	1,500	$	112,500	$	112,500
Inspect/Upgrade existing septic tank	EA	75	$	2,500	$	187,500	$	187,500
New 1,200-Gallon Septic Tank	EA	75	$	5,500	$	412,500	$	412,500
STEP Unit (including vault, risers, effluent pump, lids, panel, add'l accessories)	EA	50	$	8,000	$	400,000	$	400,000
Reroute Housing Plumbing (Building Sewer)	EA	75	$	1,500	$	112,500	$	112,500
3" Gravity lateral to STEG Line (50' ave distance)	EA	100	$	2,000	$	200,000	$	200,000
1.25" Pressure lateral to STEP Line (50' ave distance)	EA	50	$	1,250	$	62,500	$	62,500
Collection System								
4.0" Gravity Effluent Sewer (STEG)	LF	7,460	$	55	$	410,300	$	410,300
3.0" Pressure Line (STEP)	LF	3,760	$	45	$	169,200	$	169,200
2.0" Pressure Line (STEP)	LF	690	$	40	$	27,600	$	27,600
Service Connection (2.0" Isolation Valve and Traffic-Rated Box)	EA	150	$	1,000	$	150,000	$	150,000
Air Release Valves	EA	4	$	3,500	$	14,000	$	14,000
Clean Outs	EA	30	$	500	$	15,000	$	15,000
Lift Stations (including pumps, panels, etc.)								
Railroad Ave Lift Station	LS	1	$	75,000	$	75,000	$	75,000
Tramsmission Line to Golf Course								
4-inch HDPE Force Main - Route A, SG Vallley Dr	LF	5,860	$	55	$	322,300		
SG Creek Bridge/Crossing - Route A only	LS	1	$	25,000	$	25,000		
4-inch HDPE Force Main - Route B, SFDrake Blvd	LF	5,350	$	55			$	294,250
				TOTAL	**$**	**2,695,900**	**$**	**2,642,850**

Table D-12: Effluent STEP/STEG Sewer - Golf Course Recycle (75% Service Connections)

Item	Units	No. of Units	Cost per Unit ($)	Total Cost (4)	Total Cost ($)
				Route A	Route B
On-Lot Facilities					
Abandon existing septic tank	EA	56	$ 1,500	$ 84,000	$ 84,000
Inspect/Upgrade existing septic tank	EA	56	$ 2,500	$ 140,000	$ 140,000
New 1,200-Gallon Septic Tank	EA	56	$ 5,500	$ 308,000	$ 308,000
STEP Unit (including vault, risers, effluent pump, lids, panel, add'l accessories)	EA	37	$ 8,000	$ 296,000	$ 296,000
Reroute Housing Plumbing (Building Sewer)	EA	56	$ 1,500	$ 84,000	$ 84,000
3" Gravity lateral to STEG Line (50' ave distance)	EA	75	$ 2,000	$ 150,000	$ 150,000
1.25" Pressure lateral to STEP Line (50' ave distance)	EA	37	$ 1,250	$ 46,250	$ 46,250
Collection System					
4.0" Gravity Effluent Sewer (STEG)	LF	7,460	$ 55	$ 410,300	$ 410,300
3.0" Pressure Line (STEP)	LF	3,760	$ 45	$ 169,200	$ 169,200
2.0" Pressure Line (STEP)	LF	690	$ 40	$ 27,600	$ 27,600
Service Connection (2.0" Isolation Valve and Traffic-Rated Box)	EA	112	$ 1,000	$ 112,000	$ 112,000
Air Release Valves	EA	4	$ 3,500	$ 14,000	$ 14,000
Clean Outs	EA	30	$ 500	$ 15,000	$ 15,000
Lift Stations (including pumps, panels, etc.)					
Railroad Ave Lift Station	LS	1	$ 75,000	$ 75,000	$ 75,000
Tramsmission Line to Golf Course					
4-inch HDPE Force Main - Route A, SG Vallley Dr	LF	5,860	$ 55	$ 322,300	
SG Creek Bridge/Crossing - Route A only	LS	1	$ 25,000	$ 25,000	
4-inch HDPE Force Main - Route B, SFDrake Blvd	LF	5,350	$ 55		$ 294,250
			TOTAL	**$ 2,278,650**	**$ 2,225,600**

5.0 SUMMARY AND CONCLUSIONS

5.1 Collection for Fire Road Community Leachfield Alternatives.

Table D-13 summarizes the estimated costs for each of the three collection system options for use in connection with the Fire Road Community Leachfield project alternatives:

Table D-13. Cost Summary
Collection Options for Fire Road Community Leachfield

Collection Option	Estimated Construction Cost ($)	
	100% Connections (150 Parcels)	75% Connections (112 Parcels)
Conventional Gravity Sewers	2,191,000	1,931,250
Pressure Sewers	2,515,300	2,011,800
Effluent STEP/STEG Sewers	2,370,750	1,953,500

Based on the above review and cost estimates, with respect to wastewater collection options for Fire Road Community Leachfield Alternatives 3A, 3B and 3C:

1) All collection methods are feasible for use in the Woodacre Flats service area, and the cost differences between the different options are relatively small.

2) Because of the terrain, a pressure sewer or STEP collection line would be the preferable option for service to properties located along Redwood Drive.

3) Recommended locations for two required lift stations are within existing County right-of-way areas: (a) local lift station at intersection of Railroad Avenue and San Geronimo Valley Drive; and (b) main lift station at intersection Park Street and Central Ave.

4) Conventional gravity and pressure sewer options would have additional treatment costs for primary treatment (septic tanks), which are already accounted for in the effluent sewer option through the inclusion of on-lot septic tanks.

5) In connection with the use of a community leachfield for final effluent disposal, effluent STEP/STEG sewers would most probably be favored on the basis of: (a) cost; (b) greater compatibilty of septic tank effluent with community leachfields and with secondary treatment options that could be used; and (c) the ability to limit entry of extraneous water into the sewer system from groundwater and rainwater infiltration and inflow (I/I), which could be damaging and of significant concern for a community leachfield system.

5.2 Collection for Golf Course Water Recycling Alternative

Table D-14 summarizes the estimated costs for each of the three collection system options for use in connection with the Golf Course Water Recycling alternative:

Table D-14. Cost Summary
Collection Options for Golf Course Recycled Water Alternative

Collection Option	Estimated Construction Cost ($)			
	100% Connections (150 Parcels)		75% Connections (112 Parcels)	
	Route A	Route B	Route A	Route B
Conventional Gravity Sewers	2,541,800	2,488,750	2,282,050	2,229,000
Pressure Sewers	2,858,550	2,829,150	2,079,650	2,050,250
Effluent STEP/STEG Sewers	2,695,900	2,642,850	2,278,650	2,225,600

Based on the above review and cost estimates, with respect to wastewater collection options for Alternative 4, Golf Course Water Recycling:

1) All collection methods are feasible for use in the Woodacre Flats service area, and the cost differences between the different options are relatively small.

2) Because of the terrain, a pressure sewer or STEP collection line would be the preferable option for service to properties located along Redwood Drive.

3) Conventional gravity sewers would be favored on the basis of cost and the compatibilty of raw sewage (as compared with septic tank effluent) with the operation of a recycled water treatment system.

4) A single lift station would be needed, at the intersection of Railroad Avenue and San Geronimo Valley Drive.

5) The preferred route for a wastewater transmission line from Woodacre to the Golf Course was determined to be via Railroad Avenue and Sir Francis Drake Blvd, rather than via San Geronimo Valley Drive.

Appendix E

Cost Estimates for Fire Road Community Leachfield Alternatives 3A, 3B & 3C

- Construction Costs
- Annual O&M Costs

Construction Cost Estimates

Preliminary Construction Cost Estimate
Alternative 3A - Primary Treatment w/PD Leachfield System - Fire Road
Treatment and Disposal

100% Service Connections - 150 Parcels					
Item	**Units**	**No. of Units**	**Cost per Unit ($)**	**Total Cost ($)**	**Total Cost ($)**
				Sewer Options 1 & 2	**Sewer Option 3**
Treatment					
Community Septic Tanks (2 @ 30,000 gal. each)	GAL	60,000	$3.50	$210,000	*
Park Street Main Lift Station, - Tanks, Pumps, Controls	LS	1	$50,000	$50,000	$50,000
Site Improvements, Control Building and Fencing	LS	1	$30,000	$30,000	$30,000
Emergency Generator	LS	1	$50,000	$50,000	$50,000
Treatment Subtotal				**$340,000**	**$130,000**
PD Chamber Leachfield System					
Access Road Improvements	SF	15,000	$3.60	$54,000	$54,000
4" Force Main from Park Street	LF	2,200	$55	$121,000	$121,000
(1) 15,000-gal Leachfield Dosing Tank	GAL	15,000	$3.50	$52,500	$52,500
Pumps and Controls	LS	1	$20,000	$20,000	$20,000
PD Chamber Leachfield	LF	6,600	$40.00	$264,000	$264,000
Piping, Valves & Appurtenances	LF	2,000	$25.00	$50,000	$50,000
Emergency Overflow Dosing Tank & Siphons	LS	1	$25,000	$25,000	$25,000
Electrical Service and Wiring	LS	1	$60,000	$60,000	$60,000
Monitoring Wells	EA	6	$2,000	$12,000	$12,000
Leachfield Fencing	LF	2,500	$15	$37,500	$37,500
Disposal Subtotal				**$696,000**	**$696,000**
			Total	**$1,036,000**	**$826,000**

NOTE - Sewer Options:
1. Conventional Gravity Sewer
2. Pressure Sewer
3. Effluent STEP/STEG Sewer

** Primary treatment provided by on-lot septic tanks*

Preliminary Construction Cost Estimate
Alternative 3B - Secondary Treatment w/PD Leachfield System - Fire Road
Treatment and Disposal

100% Service Connections - 150 Parcels					
Item	**Units**	**No. of Units**	**Cost per Unit ($)**	**Total Cost ($)**	**Total Cost ($)**
				Sewer Options 1 & 2	**Sewer Option 3**
Treatment					
Community Septic Tanks (2 @ 30,000 gal. each)	GAL	60,000	$3.50	$210,000	*
(1) 30,000-gal Recirculation Tank	GAL	30,000	$3.50	$105,000	$105,000
(1) 15,000-gal Equalization Influent/Effluent Tank	GAL	15,000	$3.50	$52,500	$52,500
AdvanTex Treatment Units	EA	13	$25,000	$325,000	$325,000
Electrical and Control System	EA	1	$40,000	$40,000	$40,000
Park Street Main Lift Station - Tanks, Pumps, Controls	LS	1	$50,000	$50,000	$50,000
Site Improvements, Control Building and Fencing	LF	1	$60,000	$60,000	$60,000
Emergency Generator	EA	1	$50,000	$50,000	$50,000
Treatment Subtotal				**$892,500**	**$682,500**
PD Chamber Leachfield System					
Access Road Improvements	SF	15,000	$3.60	$54,000	$54,000
4" Force Main from Park Street	LF	2,200	$55	$121,000	$121,000
(1) 15,000-gal Leachfield Dosing Tank	GAL	15,000	$3.50	$52,500	$52,500
Pumps and Controls	LS	1	$20,000	$20,000	$20,000
PD Chamber Leachfield	LF	3,300	$40.00	$132,000	$132,000
Piping, Valves & Appurtenances	LF	1,500	$25	$37,500	$37,500
Emergency Overlfow Dosing Tank & Siphons	LS	1	$25,000	$25,000	$25,000
Electrical Service and Wiring	LS	1	$60,000	$60,000	$60,000
Monitoring Wells	EA	6	$2,000	$12,000	$12,000
Leachfield Fencing	LF	2,500	$15	$37,500	$37,500
Disposal Subtotal				**$551,500**	**$551,500**
			Total	**$1,444,000**	**$1,234,000**

NOTE - Sewer Options:
1. Conventional Gravity Sewer
2. Pressure Sewer
3. Effluent STEP/STEG Sewer

** Primary treatment provided by on-lot septic tanks*

Preliminary Construction Cost Estimate
Alternative 3C - Secondary Treatment w/Drip Dispersal System - Fire Road
Treatment and Disposal

100% Service Connections - 150 Parcels					
Item	**Units**	**No. of Units**	**Cost per Unit ($)**	**Total Cost ($)**	**Total Cost ($)**
				Sewer Options 1 & 2	**Sewer Option 3**
Treatment					
Community Septic Tanks (2 @ 30,000 gal. each)	GAL	60,000	$3.50	$210,000	*
(1) 30,000-gal Recirculation Tank	GAL	30,000	$3.50	$105,000	$105,000
(1) 15,000-gal Equalization Influent/Effluent Tank	GAL	15,000	$3.50	$52,500	$52,500
AdvanTex Treatment Units	EA	13	$25,000	$325,000	$325,000
Electrical and Control System	EA	1	$40,000	$40,000	$40,000
Park Street Main Lift Station - Tanks, Pumps, Controls	LS	1	$50,000	$50,000	$50,000
Site Improvements and Fencing	LF	1	$60,000	$60,000	$60,000
Standby Generator	EA	1	$50,000	$50,000	$50,000
Treatment Subtotal				**$892,500**	**$682,500**
Drip Dispersal System					
Access Road Improvements	SF	15,000	$3.60	$54,000	$54,000
4" Force Main from Park Street	LF	2,200	$55	$121,000	$121,000
(1) 15,000-gal Leachfield Dosing Tank	GAL	15,000	$3.50	$52,500	$52,500
Dripline	LF	32,000	$6.00	$192,000	$192,000
Piping, Valves & Appurtenances	LF	2,000	$25.00	$50,000	$50,000
Emergency Overflow and Flush Dispersal Trench	LF	500	$40.00	$20,000	$20,000
Emergency Overflow Dosing Tank & Siphons	LS	1	$25,000	$25,000	$25,000
Electrical Service and Wiring	LS	1	$60,000	$60,000	$60,000
Monitoring Wells	EA	6	$2,000	$12,000	$12,000
Dripfield Fencing	LF	2,500	$15	$37,500	$37,500
Disposal Subtotal				**$624,000**	**$624,000**
			Total	**$1,516,500**	**$1,306,500**

NOTE - Sewer Options:
1. Conventional Gravity Sewer
2. Pressure Sewer
3. Effluent STEP/STEG Sewer

** Primary treatment provided by on-lot septic tanks*

Preliminary Construction Cost Estimate
Alternative 3A - Primary Treatment w/PD Leachfield System - Fire Road
Treatment and Disposal

75% Service Connections - 112 Parcels					
Item	**Units**	**No. of Units**	**Cost per Unit ($)**		**Total Cost ($)**
				Sewer Options 1 & 2	**Sewer Option 3**
Treatment					
Community Septic Tanks (2 @ 24,000 gal. each)	GAL	48,000	$3.50	$168,000	*
Park Street Main Lift Station, - Tanks, Pumps, Controls	LS	1	$50,000	$50,000	$50,000
Site Improvements, Control Building and Fencing	LS	1	$30,000	$30,000	$30,000
Emergency Generator	LS	1	$50,000	$50,000	$50,000
Treatment Subtotal				**$298,000**	**$130,000**
PD Chamber Leachfield System					
Access Road Improvements	SF	15,000	$3.60	$54,000	$54,000
4" Force Main from Park Street	LF	2,200	$55	$121,000	$121,000
(1) 12,000-gal Leachfield Dosing Tank	GAL	12,000	$3.50	$42,000	$42,000
Pumps and Controls	LS	1	$20,000	$20,000	$20,000
PD Chamber Leachfield	LF	5,000	$40.00	$200,000	$200,000
Piping, Valves & Appurtenances	LF	2,000	$25.00	$50,000	$50,000
Emergency Overflow Dosing Tank & Siphons	LS	1	$25,000	$25,000	$25,000
Electrical Service and Wiring	LS	1	$60,000	$60,000	$60,000
Monitoring Wells	EA	6	$2,000	$12,000	$12,000
Leachfield Fencing	LF	2,500	$15	$37,500	$37,500
Disposal Subtotal				**$621,500**	**$621,500**
			Total	**$919,500**	**$751,500**

NOTE - Sewer Options:
1. Conventional Gravity Sewer
2. Pressure Sewer
3. Effluent STEP/STEG Sewer

** Primary treatment provided by on-lot septic tanks*

Preliminary Construction Cost Estimate
Alternative 3B - Secondary Treatment w/PD Leachfield System - Fire Road Treatment and Disposal

75% Service Connections - 112 Parcels					
Item	**Units**	**No. of Units**	**Cost per Unit ($)**	**Total Cost ($) Sewer Options 1 & 2**	**Total Cost ($) Sewer Option 3**
Treatment					
Community Septic Tanks (2 @ 24,000 gal. each)	GAL	48,000	$3.50	$168,000	*
(1) 24,000-gal Recirculation Tank	GAL	24,000	$3.50	$84,000	$84,000
(1) 12,000-gal Equalization Influent/Effluent Tank	GAL	12,000	$3.50	$42,000	$42,000
AdvanTex Treatment Units	EA	10	$25,000	$250,000	$250,000
Electrical and Control System	EA	1	$40,000	$40,000	$40,000
Park Street Main Lift Station - Tanks, Pumps, Controls	LS	1	$50,000	$50,000	$50,000
Site Improvements, Control Building and Fencing	LF	1	$60,000	$60,000	$60,000
Emergency Generator	EA	1	$50,000	$50,000	$50,000
Treatment Subtotal				**$744,000**	**$576,000**
PD Chamber Leachfield System					
Access Road Improvements	SF	15,000	$3.60	$54,000	$54,000
4" Force Main from Park Street	LF	2,200	$55	$121,000	$121,000
(1) 12,000-gal Leachfield Dosing Tank	GAL	12,000	$3.50	$42,000	$42,000
Pumps and Controls	LS	1	$20,000	$20,000	$20,000
PD Chamber Leachfield	LF	2,500	$40.00	$100,000	$100,000
Piping, Valves & Appurtenances	LF	1,500	$25	$37,500	$37,500
Emergency Overlfow Dosing Tank & Siphons	LS	1	$25,000	$25,000	$25,000
Electrical Service and Wiring	LS	1	$60,000	$60,000	$60,000
Monitoring Wells	EA	6	$2,000	$12,000	$12,000
Leachfield Fencing	LF	2,500	$15	$37,500	$37,500
Disposal Subtotal				**$509,000**	**$509,000**
			Total	**$1,253,000**	**$1,085,000**

NOTE - Sewer Options:
1. Conventional Gravity Sewer
2. Pressure Sewer
3. Effluent STEP/STEG Sewer

** Primary treatment provided by on-lot septic tanks*

Preliminary Construction Cost Estimate
Alternative 3C - Secondary Treatment w/Drip Dispersal System - Fire Road
Treatment and Disposal

75% Service Connections - 112 Parcels					
Item	**Units**	**No. of Units**	**Cost per Unit ($)**	**Total Cost ($)**	**Total Cost ($)**
				Sewer Options 1 & 2	**Sewer Option 3**
Treatment					
Community Septic Tanks (2 @ 24,000 gal. each)	GAL	48,000	$3.50	$168,000	*
(1) 24,000-gal Recirculation Tank	GAL	24,000	$3.50	$84,000	$84,000
(1) 12,000-gal Equalization Influent/Effluent Tank	GAL	12,000	$3.50	$42,000	$42,000
AdvanTex Treatment Units	EA	10	$25,000	$250,000	$250,000
Electrical and Control System	EA	1	$40,000	$40,000	$40,000
Park Street Main Lift Station - Tanks, Pumps, Controls	LS	1	$50,000	$50,000	$50,000
Site Improvements and Fencing	LF	1	$60,000	$60,000	$60,000
Standby Generator	EA	1	$50,000	$50,000	$50,000
Treatment Subtotal				**$744,000**	**$576,000**
Drip Dispersal System					
Access Road Improvements	SF	15,000	$3.60	$54,000	$54,000
4" Force Main from Park Street	LF	2,200	$55	$121,000	$121,000
(1) 12,000-gal Leachfield Dosing Tank	GAL	12,000	$3.50	$42,000	$42,000
Dripline	LF	20,000	$6.00	$120,000	$120,000
Piping, Valves & Appurtenances	LF	2,000	$25.00	$50,000	$50,000
Emergency Overflow and Flush Dispersal Trench	LF	400	$40.00	$16,000	$16,000
Emergency Overflow Dosing Tank & Siphons	LS	1	$25,000	$25,000	$25,000
Electrical Service and Wiring	LS	1	$60,000	$60,000	$60,000
Monitoring Wells	EA	6	$2,000	$12,000	$12,000
Dripfield Fencing	LF	2,500	$15	$37,500	$37,500
Disposal Subtotal				**$537,500**	**$537,500**
			Total	**$1,281,500**	**$1,113,500**

NOTE - Sewer Options:
1. Conventional Gravity Sewer
2. Pressure Sewer
3. Effluent STEP/STEG Sewer

** Primary treatment provided by on-lot septic tanks*

Annual O&M Cost Estimates

O&M Cost Estimate
Alternative 3A - Primary Treatment w/PD Leachfield - Fire Road Site

100% Service Connections - 150 Parcels		
Item	**Assumptions**	**Cost ($)**
Administrative		
Permits	RWQCB permit	$1,500
District Administration	Insurance, legal, accounting @ $1,000/mo	$12,000
Labor		
On-lot Septic Tank Inspections/Monitoring	2 days/mo @ $600/hr	$14,400
Lift Stations/Leachfeld Inspections/Monitoring	2 days/mo @ $600/hr	$14,400
Reporting	Monthly, $500/report	$6,000
Engineering	As-needed consultation @ $400/mo	$4,800
Maintenance		
Sewer line cleaning	$2,000/yr	$2,000
Equipment Maintenance & Replacement	$1,500/mo	$18,000
Site Maintenance	$150/mo	$1,800
Expenses		
Laboratory - Treatment System (septic tank effl)	Monthly, (1) sample @ $75 each	$900
Laboratory - Monitoring Wells	Quarterly, (6) wells @ $75 each	$1,800
Travel, Equip, Supplies	$200/mo	$2,400
Remote Monitoring Service	$200/mo standby charge	$2,400
Electrical		
Treatment System	Not applicable	$0
Lift Stations & Leachfield Pumps	$300/mo	$3,600
Septic Tank Pumpouts	40/year @ $350 each	$14,000
	Sub-total	$100,000
	10% Contingency	$10,000
	Estimated Total Annual Cost	$110,000
	Estimated Annual Cost per Connection	**$733**

O&M Cost Estimate
Alternative 3B - Secondary Treatment w/PD Leachfield - Fire Road Site

100% Service Connections - 150 Parcels		
Item	**Assumptions**	**Cost ($)**
Administrative		
Permits	RWQCB permit	$4,500
District Administration	Insurance, legal, accounting @ $1,000/mo	$12,000
Labor		
On-lot Septic Tank Inspections/Monitoring	2 days/mo @ $600/day	$14,400
Lift Stations/Treatment/LF Inspections/Monitoring	3 days/mo @ $600/day	$21,600
Reporting	Monthly; $500/report	$6,000
Engineering	As-needed consultation @ $400/mo	$4,800
Maintenance		
Sewer line cleaning	$2,000/yr	$2,000
Equipment Maintenance & Replacement	$1,800/mo	$21,600
Site Maintenance	$150/mo	$1,800
Expenses		
Laboratory - Treatment System	Monthly, (2) samples @ $100 each	$2,400
Laboratory - Monitoring Wells	Quarterly, (6) wells @ $75 each	$1,800
Travel, Equip, Supplies	$300	$3,600
Remote Monitoring Service	$200/mo	$2,400
Electrical		
Treatment System	$350/mo	$4,200
Lift Stations & Leachfield Pumps	$300/mo	$3,600
Septic Tank Pumpouts	40/year @ $350 each	$14,000
	Sub-total	$120,700
	10% Contingency	$12,070
	Estimated Total Annual Cost	$132,770
	Estimated Annual Cost per Connection	**$885**

O&M Cost Estimate
Alternative 3C - Secondary Treatment w/Drip Dispersal Field - Fire Road Site

100% Service Connections - 150 Parcels		
Item	**Assumptions**	**Cost ($)**
Administrative		
Permits	RWQCB permit	$4,500
District Administration	Insurance, legal, accounting @ $1,000/mo	$12,000
Labor		
On-lot Septic Tank Inspections/Monitoring	2 days/mo @ $600/day	$14,400
Lift Sta/Treat/Drip Field Inspections/Monitoring	5 days/mo @ $600/day	$36,000
Reporting	Monthly; $500/report	$6,000
Engineering	As-needed consultation @ $400/mo	$4,800
Maintenance		
Sewer line cleaning	$2,000/yr	$2,000
Equipment Maintenance & Replacement	$1,800/mo	$21,600
Site Maintenance	$150/mo	$1,800
Expenses		
Laboratory - Treatment System	Monthly, (2) samples @ $100 each	$2,400
Laboratory - Monitoring Wells	Quarterly, (6) wells @ $75 each	$1,800
Travel, Equip, Supplies	$400/mo	$4,800
Remote Monitoring Service	$200/mo	$2,400
Electrical		
Treatment System	$350/mo	$4,200
Lift Stations & Leachfield Pumps	$300/mo	$3,600
Septic Tank Pumpouts	40/year @ $350 each	$14,000
	Sub-total	$136,300
	10% Contingency	$13,630
	Estimated Total Annual Cost	$149,930
	Estimated Annual Cost per Connection	**$1,000**

O&M Cost Estimate
Alternative 3A - Primary Treatment w/PD Leachfield - Fire Road Site

75% Service Connections - 112 Parcels		
Item	**Assumptions**	**Cost ($)**
Administrative		
Permits	RWQCB permit	$1,500
District Administration	Insurance, legal, accounting @ $750/mo	$9,000
Labor		
On-lot Septic Tank Inspections/Monitoring	1.5 days/mo @ $600/day	$10,800
Lift Stations/Leachfeld Inspections/Monitoring	2 days/mo @ $600/day	$14,400
Reporting	Monthly; $400/report	$4,800
Engineering	As-needed consultation @ $300/mo	$3,600
Maintenance		
Sewer line cleaning	$2,000/yr	$2,000
Equipment Maintenance & Replacement	$1,200/mo	$14,400
Site Maintenance	$150/mo	$1,800
Expenses		
Laboratory - Treatment System	Monthly, (1) sample @ $75 each	$900
Laboratory - Monitoring Wells	Quarterly, (6) wells @ $75 each	$1,800
Travel, Equip, Supplies	$150/mo	$1,800
Remote Monitoring Service	$200/mo standby charge	$2,400
Electrical		
Treatment System	Not applicable	$0
Lift Stations & Leachfield Pumps	$250/mo	$3,000
Septic Tank Pumpouts	30/year @ $350 each	$10,500
	Sub-total	$82,700
	10% Contingency	$8,270
	Estimated Total Annual Cost	$90,970
	Estimated Annual Cost per Connection	**$812**

O&M Cost Estimate
Alternative 3B - Secondary Treatment w/PD Leachfield - Fire Road Site

75% Service Participation - 112 Parcels		
Item	**Assumptions**	**Cost ($)**
Administrative		
Permits	RWQCB permit	$4,500
District Administration	Insurance, legal, accounting @ $750/mo	$9,000
Labor		
On-lot Septic Tank Inspections/Monitoring	1.5 days/mo @ $600/day	$10,800
Lift Stations/Treatment/LF Inspections/Monitoring	3 days/mo @ $600/day	$21,600
Reporting	Monthly; $400/report	$4,800
Engineering	As-needed consultation @ $300/mo	$3,600
Maintenance		
Sewer line cleaning	$2,000/yr	$2,000
Equipment Maintenance & Replacement	$1,500/mo	$18,000
Site Maintenance	$150/mo	$1,800
Expenses		
Laboratory - Treatment System	Monthly, (2) samples @ $100 each	$2,400
Laboratory - Monitoring Wells	Quarterly, (6) wells @ $75 each	$1,800
Travel, Equip, Supplies	$250/mo	$3,000
Remote Monitoring Service	$200/mo	$2,400
Electrical		
Treatment System	$250/mo	$3,000
Lift Stations & Leachfield Pumps	$250/mo	$3,000
Septic Tank Pumpouts	30/year @ $350 each	$10,500
	Sub-total	$102,200
	10% Contingency	$10,220
	Estimated Total Annual Cost	$112,420
	Estimated Annual Cost per Connection	**$1,004**

O&M Cost Estimate
Alternative 3C - Secondary Treatment w/Drip Dispersal Field - Fire Road Site

75% Service Connections - 112 Parcels		
Item	**Assumptions**	**Cost ($)**
Administrative		
Permits	RWQCB permit	$4,500
District Administration	Insurance, legal, accounting @ $750/mo	$9,000
Labor		
On-lot Septic Tank Inspections/Monitoring	1.5 days/mo @ $600/day	$10,800
Lift Sta/Treat/Drip Field Inspections/Monitoring	5 days/mo @ $600/day	$36,000
Reporting	Monthly; $400/report	$4,800
Engineering	As-needed consultation @ $300/mo	$3,600
Maintenance		
Sewer line cleaning	$2,000/yr	$2,000
Equipment Maintenance & Replacement	$1,500/mo	$18,000
Site Maintenance	$150/mo	$1,800
Expenses		
Laboratory - Treatment System	Monthly, (2) samples @ $100 each	$2,400
Laboratory - Monitoring Wells	Quarterly, (6) wells @ $75 each	$1,800
Travel, Equip, Supplies	$350/mo	$4,200
Remote Monitoring Service	$200/mo	$2,400
Electrical		
Treatment System	$250/mo	$3,000
Lift Stations & Drip Field Pumps	$250/mo	$3,000
Septic Tank Pumpouts	30/year @ $350 each	$10,500
	Sub-total	$117,800
	10% Contingency	$11,780
	Estimated Total Annual Cost	$129,580
	Estimated Annual Cost per Connection	**$1,157**

Appendix F

Membrane Bioreactor (MBR) Technology Fact Sheet

United States Environmental Protection Agency

Wastewater Management Fact Sheet

Membrane Bioreactors

INTRODUCTION

The technologies most commonly used for performing secondary treatment of municipal wastewater rely on microorganisms suspended in the wastewater to treat it. Although these technologies work well in many situations, they have several drawbacks, including the difficulty of growing the right types of microorganisms and the physical requirement of a large site. The use of microfiltration membrane bioreactors (MBRs), a technology that has become increasingly used in the past 10 years, overcomes many of the limitations of conventional systems. These systems have the advantage of combining a suspended growth biological reactor with solids removal via filtration. The membranes can be designed for and operated in small spaces and with high removal efficiency of contaminants such as nitrogen, phosphorus, bacteria, biochemical oxygen demand, and total suspended solids. The membrane filtration system in effect can replace the secondary clarifier and sand filters in a typical activated sludge treatment system. Membrane filtration allows a higher biomass concentration to be maintained, thereby allowing smaller bioreactors to be used.

APPLICABILITY

For new installations, the use of MBR systems allows for higher wastewater flow or improved treatment performance in a smaller space than a conventional design, i.e., a facility using secondary clarifiers and sand filters. Historically, membranes have been used for smaller-flow systems due to the high capital cost of the equipment and high operation and maintenance (O&M) costs. Today however, they are receiving increased use in larger systems. MBR systems are also well suited for some industrial and commercial applications. The high-quality effluent produced by MBRs makes them particularly applicable to reuse applications and for surface water discharge applications requiring extensive nutrient (nitrogen and phosphorus) removal.

ADVANTAGES AND DISADVANTAGES

The advantages of MBR systems over conventional biological systems include better effluent quality, smaller space requirements, and ease of automation. Specifically, MBRs operate at higher volumetric loading rates which result in lower hydraulic retention times. The low retention times mean that less space is required compared to a conventional system. MBRs have often been operated with longer solids residence times (SRTs), which results in lower sludge production; but this is not a requirement, and more conventional SRTs have been used (Crawford et al. 2000). The effluent from MBRs contains low concentrations of bacteria, total suspended solids (TSS), biochemical oxygen demand (BOD), and phosphorus. This facilitates high-level disinfection. Effluents are readily discharged to surface streams or can be sold for reuse, such as irrigtion.

The primary disadvantage of MBR systems is the typically higher capital and operating costs than conventional systems for the same throughput. O&M costs include membrane cleaning and fouling control, and eventual membrane replacement. Energy costs are also higher because of the need for air scouring to control bacterial growth on the membranes. In addition, the waste sludge from such a system might have a low settling rate, resulting in the need for chemicals to produce biosolids acceptable for disposal (Hermanowicz et al. 2006). Fleischer et al. 2005 have demonstrated that waste sludges from MBRs can be processed using standard technologies used for activated sludge processes.

Membrane Filtration

Membrane filtration involves the flow of water-containing pollutants across a membrane. Water permeates through the membrane into a separate channel for recovery (Figure 1). Because of the cross-flow movement of water and the waste constituents, materials left behind do not accumulate at the membrane surface but are carried out of the system for later recovery or disposal. The water passing through the membrane is called the *permeate*, while the water with the more-concentrated materials is called the *concentrate* or *retentate*.

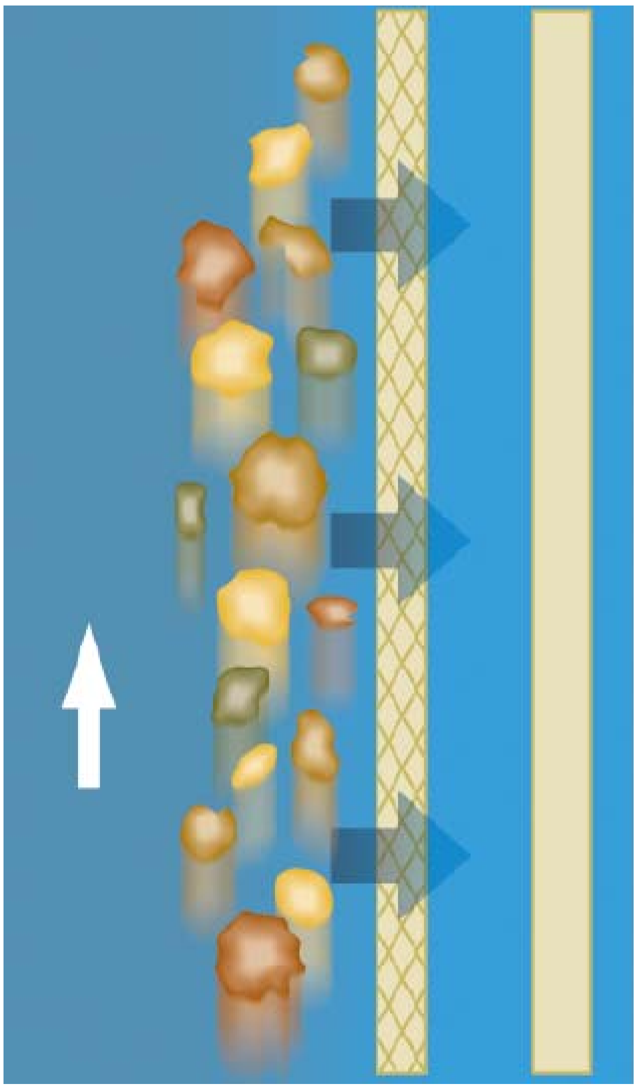

Figure 1. Membrane filtration process (Image from Siemens/U.S. Filter)

Membranes are constructed of cellulose or other polymer material, with a maximum pore size set during the manufacturing process. The requirement is that the membranes prevent passage of particles the size of microorganisms, or about 1 micron (0.001 millimeters), so that they remain in the system. This means that MBR systems are good for removing solid material, but the removal of dissolved wastewater components must be facilitated by using additional treatment steps.

Membranes can be configured in a number of ways. For MBR applications, the two configurations most often used are hollow fibers grouped in bundles, as shown in Figure 2, or as flat plates. The hollow fiber bundles are connected by manifolds in units that are designed for easy changing and servicing.

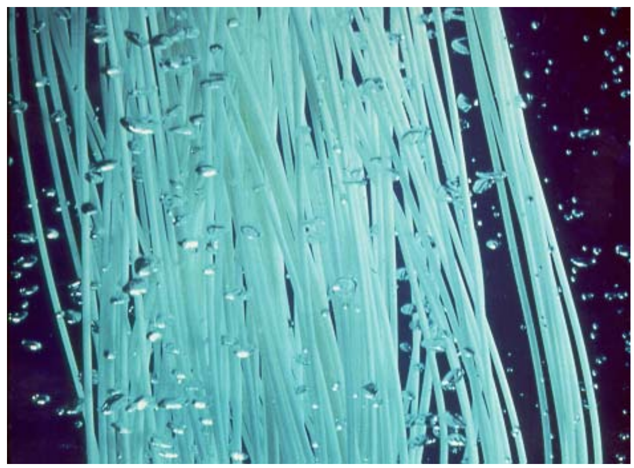

Figure 2. Hollow-fiber membranes (Image from GE/Zenon)

Design Considerations

Designers of MBR systems require only basic information about the wastewater characteristics, (e.g., influent characteristics, effluent requirements, flow data) to design an MBR system. Depending on effluent requirements, certain supplementary options can be included with the MBR system. For example, chemical addition (at various places in the treatment chain, including: before the primary settling tank; before the secondary settling tank [clarifier]; and before the MBR or final filters) for phosphorus removal can be included in an MBR system if needed to achieve low phosphorus concentrations in the effluent.

MBR systems historically have been used for small-scale treatment applications when portions of the treatment system were shut down and the wastewater routed around (or bypassed) during maintenance periods.

However, MBR systems are now often used in full-treatment applications. In these instances, it is recommended that the installation include one additional membrane tank/unit beyond what the design would nominally call for. This “N plus 1” concept is a blend between conventional activated sludge and membrane process design. It is especially important to consider both operations and maintenance requirements when selecting the number of units for MBRs. The inclusion of an extra unit gives operators flexibility and ensures that sufficient operating capacity will be available (Wallis-Lage et al. 2006). For example, bioreactor sizing is often limited by oxygen transfer, rather than the volume required to achieve the required SRT—a factor that significantly affects bioreactor numbers and sizing (Crawford et al. 2000).

Although MBR systems provide operational flexibility with respect to flow rates, as well as the ability to readily add or subtract units as conditions dictate, that flexibility has limits. Membranes typically require that the water surface be maintained above a minimum elevation so that the membranes remain wet during operation. Throughput limitations are dictated by the physical properties of the membrane, and the result is that peak design flows should be no more than 1.5 to 2 times the average design flow. If peak flows exceed that limit, either additional membranes are needed simply to process the peak flow, or equalization should be included in the overall design. The equalization is done by including a separate basin (external equalization) or by maintaining water in the aeration and membrane tanks at depths higher than those required and then removing that water to accommodate higher flows when necessary (internal equalization).

DESIGN FEATURES

Pretreatment

To reduce the chances of membrane damage, wastewater should undergo a high level of debris removal prior to the MBR. Primary treatment is often provided in larger installations, although not in most small to medium sized installations, and is not a requirement. In addition, all MBR systems require 1- to 3-mm-cutoff fine screens immediately before the membranes, depending on the MBR manufacturer. These screens require frequent cleaning. Alternatives for reducing the amount of material reaching the screens include using two stages of screening and locating the screens after primary settling.

Membrane Location

MBR systems are configured with the mem-

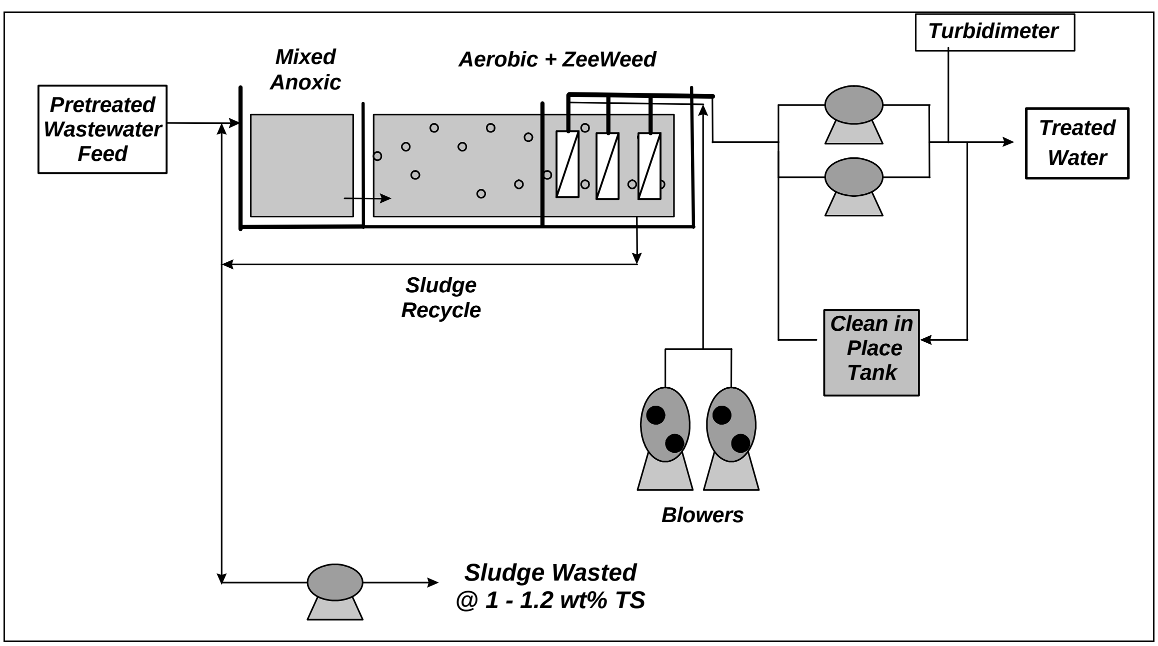

Figure 3. Immersed membrane system configuration (Image from GE/Zenon)

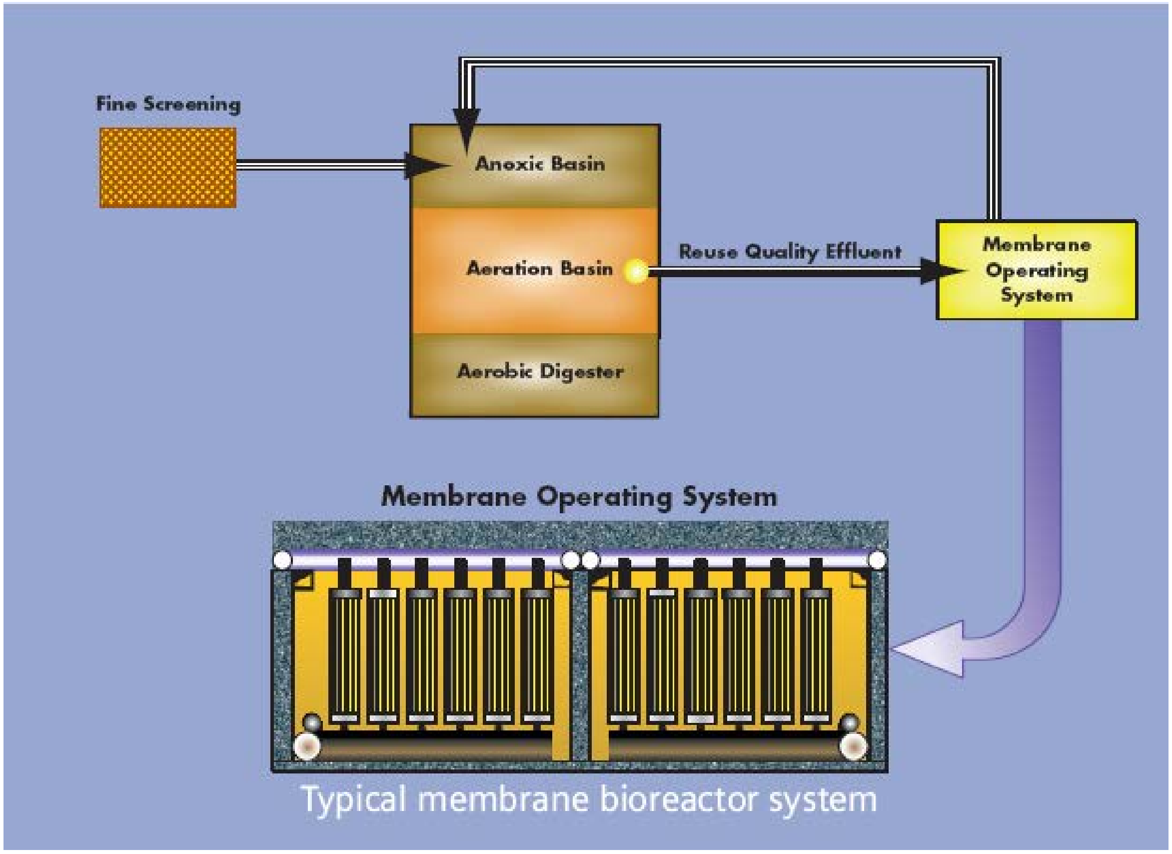

Figure 4. External membrane system configuration (Image from Siemens/U.S. Filter)

branes actually immersed in the biological reactor or, as an alternative, in a separate vessel through which mixed liquor from the biological reactor is circulated. The former configuration is shown in Figure 3; the latter, in Figure 4.

Membrane Configuration

MBR manufacturers employ membranes in two basic configurations: hollow fiber bundles and plate membranes. Siemens/U.S.Filter's Memjet and Memcor systems, GE/Zenon's ZeeWeed and ZenoGem systems, and GE/Ionics' system use hollow-fiber, tubular membranes configured in bundles. A number of bundles are connected by manifolds into units that can be readily changed for maintenance or replacement. The other configuration, such as those provided by Kubota/Enviroquip, employ membranes in a flat-plate configuration, again with manifolds to allow a number of membranes to be connected in readily changed units. Screening requirements for both systems differ: hollow-fiber membranes typically require 1- to 2-mm screening, while plate membranes require 2- to 3-mm screening (Wallis-Lage et al. 2006).

System Operation

All MBR systems require some degree of pumping to force the water flowing through the membrane. While other membrane systems use a pressurized system to push the water through the membranes, the major systems used in MBRs draw a vacuum through the membranes so that the water outside is at ambient pressure. The advantage of the vacuum is that it is gentler to the membranes; the advantage of the pressure is that throughput can be controlled. All systems also include techniques for continually cleaning the system to maintain membrane life and keep the system operational for as long as possible. All the principal membrane systems used in MBRs use an air scour technique to reduce buildup of material on the membranes. This is done by blowing air around the membranes out of the manifolds. The GE/Zenon systems use air scour, as well as a back-pulsing technique, in which permeate is occasionally pumped back into the membranes to keep the pores cleared out. Back-pulsing is typically done on a timer, with the time of pulsing accounting for 1 to 5 percent of the total operating time.

Downstream Treatment

The permeate from an MBR has low levels of suspended solids, meaning the levels of bacteria, BOD, nitrogen, and phosphorus are also low. Disinfection is easy and might not be required, depending on permit requirements..

The solids retained by the membrane are recycled to the biological reactor and build up in the system. As in conventional biological systems, periodic sludge wasting eliminates sludge buildup and controls the SRT within the MBR system. The waste sludge from MBRs goes through standard solids-handling technologies for thickening, dewatering, and ultimate disposal. Hermanowicz et al. (2006) reported a decreased ability to settle in waste MBR sludges due to increased amounts of colloidal-size particles and filamentous bacteria. Chemical addition increased the ability of the sludges to settle. As more MBR facilities are built and operated, a more definitive understanding of the characteristics of the resulting biosolids will be achieved. However, experience to date indicates that conventional biosolids processing unit operations are also applicable to the waste sludge from MBRs.

Membrane Care

The key to the cost-effectiveness of an MBR system is membrane life. If membrane life is curtailed such that frequent replacement is required, costs will significantly increase. Membrane life can be increased in the following ways:

- Good screening of larger solids before the membranes to protect the membranes from physical damage.

- Throughput rates that are not excessive, i.e., that do not push the system to the limits of the design. Such rates reduce the amount of material that is forced into the membrane and thereby reduce the amount that has to be removed by cleaners or that will cause eventual membrane deterioration.

- Regular use of mild cleaners. Cleaning solutions most often used with MBRs include regular bleach (sodium) and citric acid. The cleaning should be in accord with manufacturer-recommended maintenance protocols.

Membrane Guarantees

The length of the guarantee provided by the membrane system provider is also important in determining the cost-effectiveness of the system. For municipal wastewater treatment, longer guarantees might be more readily available compared to those available for industrial systems. Zenon offers a 10-year guarantee; others range from 3 to 5 years. Some guarantees include cost prorating if replacement is needed after a certain service time. Guarantees are typically negotiated during the purchasing process. Some manufacturers' guarantees are tied directly to screen size: longer membrane warranties are granted when smaller screens are used (Wallis-Lage et al. 2006). Appropriate membrane life guarantees can be secured using appropriate membrane procurement strategies (Crawford et al. 2002).

SYSTEM PERFORMANCE

Siemens/U.S. Filter Systems

Siemens/U.S.Filter offers MBR systems under the Memcor and Memjet brands. Data provided by U.S. Filter for its Calls Creek (Georgia) facility are summarized below. The system, as Calls Creek retrofitted it, is shown in Figure 5. In essence, the membrane filters were used to replace secondary clarifiers downstream of an Orbal oxidation ditch. The system includes a fine screen (2-mm cutoff) for inert solids removal just before the membranes.

The facility has an average flow of 0.35 million gallons per day (mgd) and a design flow of 0.67 mgd. The system has 2 modules, each containing 400 units, and each unit consists of a cassette with manifold-connected membranes. As shown in Table 1, removal of BOD, TSS, and ammonia-nitrogen is excellent; BOD and TSS in the effluent are around the detection limit. Phosphorus is also removed well in the system, and the effluent

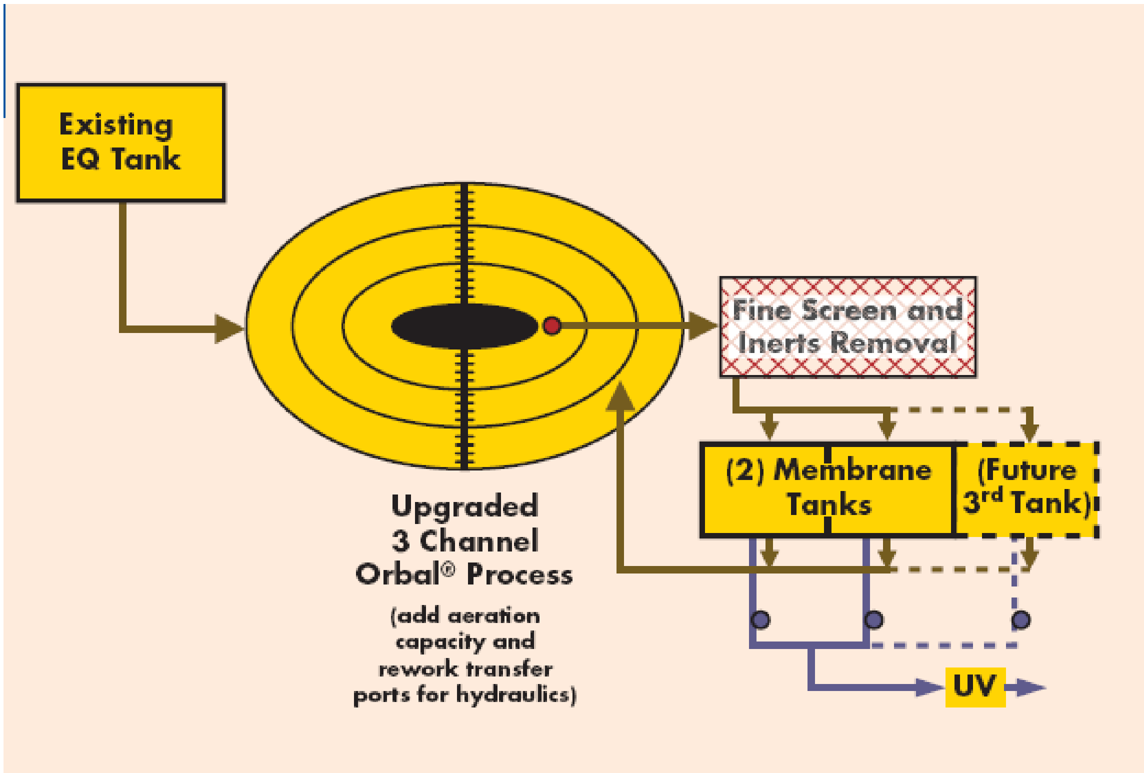

Figure 5. Calls Creek flow diagram (courtesy of Siemens/U.S. Filter)

Table 1.
Calls Creek results 2005

Parameter	Influent	Effluent		
	Average	Average	Max Month	Min Month
Flow (mgd)	0.35	--	0.44	0.26
BOD (mg/L)	145	1	1	1
TSS (mg/L)	248	1	1	1
Ammonia-N (mg/L)	14.8	0.21	0.72	0.10
P (mg/L)	0.88	0.28	0.55	0.12
Fecal coliforms (#/100 mL)	--	14.2	20	0
Turbidity (NTU)	--	0.30	1.31	0.01

has very low turbidity. The effluent has consistently met discharge limits.

Zenon Systems

General Electric/Zenon provides systems under the ZenoGem and ZeeWeed brands. The ZeeWeed brand refers to the membrane, while ZenoGem is the process that uses ZeeWeed.

Performance data for two installed systems are shown below.

Cauley Creek, Georgia. The Cauley Creek facility in Fulton County, Georgia, is a 5-mgd wastewater reclamation plant. The system includes biological phosphorus removal, mixed liquor surface wasting, and sludge thickening using a ZeeWeed system to minimize the required volume of the aerobic digester, according to information provided by GE. Ultraviolet disinfection is employed to meet regulatory limits. Table 2 shows that the removal for all parame-

Table 2.
Cauley Creek, Georgia, system performance

Parameter	Influent	Effluent		
	Average	Average	Max Month	Min Month
Flow (mgd)	4.27	--	4.66	3.72
BOD (mg/L)	182	2.0	2.0	2.0
COD (mg/L)	398	12	22	5
TSS (mg/L)	174	3.2	5	3
TKN (mg/L)	33.0	1.9	2.9	1.4
Ammonia-N (mg/L)	24.8	0.21	0.29	0.10
TP (mg/L)	5.0	0.1	0.13	0.06
Fecal coliforms (#/100 mL)	--	2	2	2
NO3-N (mg/L)	--	2.8		

ters is over 90 percent. The effluent meets all permit limits, and is reused for irrigation and lawn watering.

Traverse City, Michigan. The Traverse City Wastewater Treatment Plant (WWTP) went through an upgrade to increase plant capacity and produce a higher-quality effluent, all within the facility's existing plant footprint (Crawford et al. 2005). With the ZeeWeed system, the facility was able to achieve those goals. As of 2006, the plant is the largest-capacity MBR facility in North America. It has a design average annual flow of 7.1 mgd, maximum monthly flow of 8.5 mgd, and peak hourly flow of 17 mgd. The membrane system consists of a 450,000-gallon tank with eight compartments of equal size. Secondary sludge is distributed evenly to the compartments. Blowers for air scouring, as well as permeate and back-pulse pumps, are housed in a nearby building.

Table 3 presents a summary of plant results over a 12-month period. The facility provides excellent removal of BOD, TSS, ammonia-nitrogen, and phosphorus. Figure 6 shows the influent, effluent, and flow data for the year.

Operating data for the Traverse City WWTP were obtained for the same period. The mixed liquor suspended solids over the period January to August averaged 6,400 mg/L, while the mixed liquor volatile suspended solids averaged 4,400 mg/L. The energy use for the air-scouring blowers averaged 1,800 kW-hr/million gallons (MG) treated.

COSTS

Capital Costs

Capital costs for MBR systems historically have tended to be higher than those for conventional systems with comparable throughput because of the initial costs of the membranes. In certain situations, however, including retrofits, MBR systems can have lower or competitive capital costs compared with alternatives because MBRs have lower land requirements and use smaller tanks, which can reduce the costs for concrete. U.S. Filter/Siemen's Memcor package plants have installed costs of $7–$20/gallon treated.

Fleischer et al. (2005) reported on a cost comparison of technologies for a 12-MGD design in Loudoun County, Virginia. Because of a chemical oxygen demand limit, activated carbon adsorption was included with the MBR system. It was found that the capital cost for MBR plus granular activated carbon at $12/gallon treated was on the same order of magnitude as alternative processes, including multiple-point alum addition, high lime treatment, and post-secondary membrane filtration.

Operating Costs

Operating costs for MBR systems are typically higher than those for comparable conventional systems. This is because of the higher energy

Table 3.
Summary of Traverse City, Michigan, Performance Results

Parameter	Influent	Effluent		
	Average	Average	Max Month	Min Month
Flow (mgd)	4.3	--	5.1	3.6
BOD (mg/L)	280	< 2	< 2	< 2
TSS (mg/L)	248	< 1	< 1	< 1
Ammonia-N (mg/L)	27.9	< 0.08	< 0.23	< 0.03
TP (mg/L)	6.9	0.7	0.95	0.41
Temperature (deg C)	17.2	--	23.5	11.5

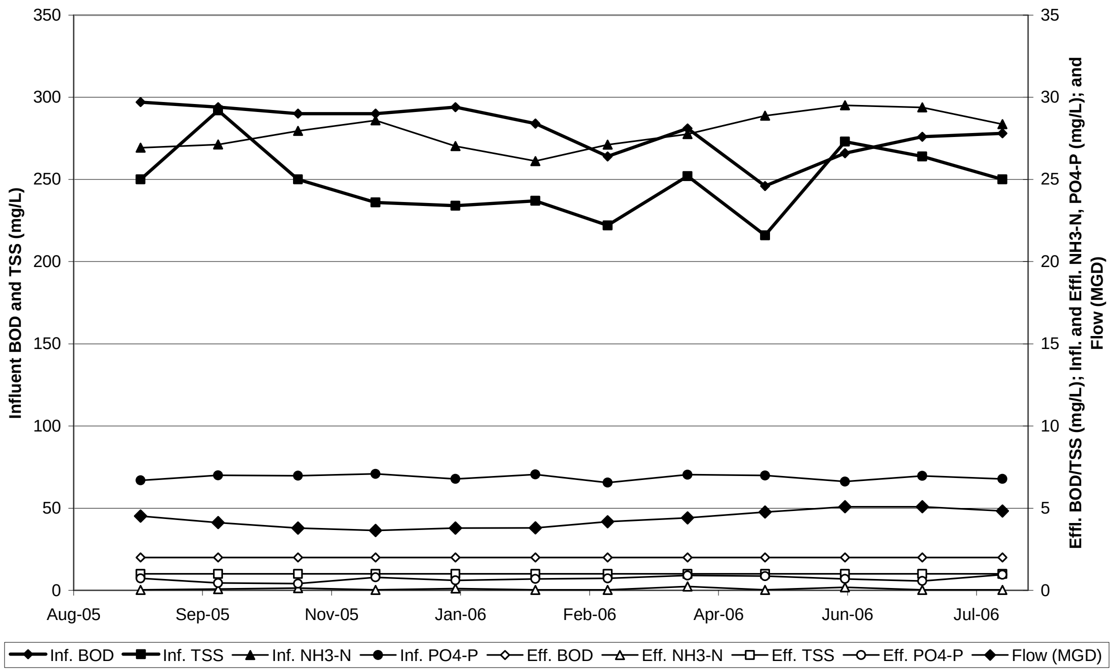

Figure 6. Performance of the Traverse City plant

costs if air scouring is used to reduce membrane fouling. The amount of air needed for the scouring has been reported to be twice that needed to maintain aeration in a conventional activated sludge system (Scott Blair, personal communication, 2006). These higher operating costs are often partially offset by the lower costs for sludge disposal associated with running at longer sludge residence times and with membrane thickening/dewatering of wasted sludge.

Fleischer et al. (2005) compared operating costs. They estimated the operating costs of an MBR system including activated carbon adsorption at $1.77 per 1,000 gallons treated. These costs were of the same order of magnitude as those of alternative processes, and they compared favorably to those of processes that are chemical-intensive, such as lime treatment.

ACKNOWLEDGMENTS

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reviewers Pat Brooks, Alan Cooper, and Glenn Daigger for their contribution.

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EPA United States Environmental Protection Agency
September 2007

Appendix G

Water Balance Calculations for Recycled Water Storage Pond

WOODACRE FLATS WASTEWATER FEASIBILITY STUDY
POND WATER BALANCE FOR AVERAGE RAINFALL - 29,000 GPD FLOW

WASTEWATER FLOW	29,000	GPD
MAX POND SURFACE AREA	84,400	SQUARE FEET
AVERAGE BANK SLOPE	2.00	:1
MAXIMUM VOLUME	**6,930,398**	GALLONS
	926,400	CUBIC FEET
MAXIMUM WATER DEPTH	**16.0**	FEET

Month	Days in Month	Wastewater Inflow WW (gal)	Wastewater Inflow WW (ft^3)	Precipitation P (in)	Precipitation P (ft^3)	Evaporation* Eto (in)	Evaporation* Eto (ft^3)	Spray Irrigation Irr. (gpd)	Spray Irrigation Irr. (ft^3)	Volume Change ΔV (ft^3)	Total Balance Volume V (ft^3)	Total Balance Volume V (gal)	End Water Depth D (ft)
NOV	30	870,000	116,319	5.13	36,046	2.40	14,538	0	0	137,827	137,827	1,031,086	3.67
DEC	31	899,000	120,196	8.01	56,302	1.86	11,267	0	0	165,231	303,059	2,267,182	7.04
JAN	31	899,000	120,196	9.39	66,008	1.86	11,267	0	0	174,937	477,996	3,575,890	9.98
FEB	28	812,000	108,564	7.53	52,926	2.24	13,568	0	0	147,922	625,918	4,682,493	12.16
MAR	31	899,000	120,196	5.29	37,171	3.41	20,656	0	0	136,712	762,630	5,705,235	14.00
APR	30	870,000	116,319	2.40	16,880	4.50	27,258	50,000	200,550	-94,609	668,021	4,997,465	12.64
MAY	31	899,000	120,196	1.03	7,209	5.27	31,922	50,000	207,235	-111,752	556,269	4,161,451	11.16
JUN	30	870,000	116,319	0.28	1,969	5.70	34,527	50,000	200,550	-116,788	439,481	3,287,756	9.37
JUL	31	899,000	120,196	0.05	317	5.89	35,678	50,000	207,235	-122,400	317,081	2,372,083	7.29
AUG	30	870,000	116,319	0.09	598	5.58	33,800	50,000	200,550	-117,433	199,648	1,493,566	5.03
SEP	30	870,000	116,319	0.39	2,743	4.50	27,258	50,000	200,550	-108,746	90,902	680,037	2.54
OCT	31	899,000	120,196	2.05	14,383	3.41	20,656	50,000	207,235	-93,311	-2,409	-18,023	0.00
	Totals:	**10,556,000**	**1,411,337**	**41.6**	**292,552**	**46.6**	**282,393**	**10,700,000**	**1,423,905**	**-2,409**	**4,576,423**	**34,236,219**	

*WATER SURFACE AREA ASSUMED FOR EVAPORATION CALCULATIONS.
POND BOTTOM AREA, SQ FT 31400

WOODACRE FLATS WASTEWATER FEASIBILITY STUDY
POND WATER BALANCE FOR 10-YR. RAINFALL - 29,000 GPD FLOW

WASTEWATER FLOW	29,000	GPD
MAX POND SURFACE AREA	84,400	SQUARE FEET
AVERAGE BANK SLOPE	2.00	:1
MAXIMUM VOLUME	**6,930,398**	GALLONS
	926,400	CUBIC FEET
MAXIMUM WATER DEPTH	**16.0**	FEET

Month	Days in Month	Wastewater Inflow WW		Precipitation P		Evaporation* Eto		Spray Irrigation Irr.		Volume Change ΔV	Total Balance Volume V		End Water Depth
		(gal)	(ft^3)	(in)	(ft^3)	(in)	(ft^3)	(gpd)	(ft^3)	(ft^3)	(ft^3)	(gal)	ft
NOV	30	870,000	116,319	7.56	53,159	2.40	14,538	0	0	154,941	154,941	1,159,111	4.06
DEC	31	899,000	120,196	11.81	83,032	1.86	11,267	0	0	191,962	346,902	2,595,176	7.82
JAN	31	899,000	120,196	13.84	97,346	1.86	11,267	0	0	206,276	553,178	4,138,326	11.12
FEB	28	812,000	108,564	11.10	78,053	2.24	13,568	0	0	173,049	726,227	5,432,907	13.52
MAR	31	899,000	120,196	7.79	54,819	3.41	20,656	0	0	154,360	880,587	6,587,671	15.45
APR	30	870,000	116,319	3.54	24,894	4.50	27,258	54,800	219,803	-105,848	774,739	5,795,824	14.15
MAY	31	899,000	120,196	1.51	10,632	5.27	31,922	54,800	227,130	-128,224	646,516	4,836,584	12.44
JUN	30	870,000	116,319	0.41	2,904	5.70	34,527	54,800	219,803	-135,106	511,409	3,825,854	10.49
JUL	31	899,000	120,196	0.07	467	5.89	35,678	54,800	227,130	-142,144	369,265	2,762,473	8.21
AUG	30	870,000	116,319	0.13	882	5.58	33,800	54,800	219,803	-136,402	232,863	1,742,049	5.70
SEP	30	870,000	116,319	0.58	4,045	4.50	27,258	54,800	219,803	-126,697	106,167	794,233	2.93
OCT	31	899,000	120,196	3.02	21,212	3.41	20,656	54,800	227,130	-106,377	-210	-1,573	0.00
	Totals:	**10,556,000**	**1,411,337**	**61.3**	**431,445**	**46.6**	**282,393**	**11,727,200**	**1,560,600**	**-210**	**5,302,585**	**39,668,636**	

*WATER SURFACE AREA ASSUMED FOR EVAPORATION CALCULATIONS.
POND BOTTOM AREA, SQ FT 31400

WOODACRE FLATS WASTEWATER FEASIBILITY STUDY
POND WATER BALANCE FOR AVERAGE RAINFALL; 22,000 GPD FLOW

WASTEWATER FLOW	22,000	GPD
MAX POND SURFACE AREA	84,400	SQUARE FEET
AVERAGE BANK SLOPE	2.00	:1
MAXIMUM VOLUME	**6,930,398**	GALLONS
	926,400	CUBIC FEET
MAXIMUM WATER DEPTH	**16.0**	FEET

Month	**Days in Month**	**Wastewater Inflow**		**Precipitation**		**Evaporation***		**Spray Irrigation**		**Volume Change**	**Total Balance Volume**		**End Water Depth**
		WW		**P**		**Eto**		**Irr.**		**ΔV**	**V**		**D**
		(gal)	(ft^3)	(in)	(ft^3)	(in)	(ft^3)	(gpd)	(ft^3)	(ft^3)	(ft^3)	(gal)	(ft)
NOV	30	660,000	88,242	5.13	36,046	2.40	14,538	0	0	109,750	109,750	821,041	3.02
DEC	31	682,000	91,183	8.01	56,302	1.86	11,267	0	0	136,219	245,969	1,840,093	5.96
JAN	31	682,000	91,183	9.39	66,008	1.86	11,267	0	0	145,925	391,893	2,931,755	8.59
FEB	28	616,000	82,359	7.53	52,926	2.24	13,568	0	0	121,717	513,610	3,842,317	10.52
MAR	31	682,000	91,183	5.29	37,171	3.41	20,656	0	0	107,699	621,309	4,648,013	12.10
APR	30	660,000	88,242	2.40	16,880	4.50	27,258	38,000	152,418	-74,554	546,755	4,090,275	11.02
MAY	31	682,000	91,183	1.03	7,209	5.27	31,922	38,000	157,499	-91,028	455,727	3,409,293	9.63
JUN	30	660,000	88,242	0.28	1,969	5.70	34,527	38,000	152,418	-96,733	358,993	2,685,630	8.04
JUL	31	682,000	91,183	0.05	317	5.89	35,678	38,000	157,499	-101,676	257,317	1,924,989	6.18
AUG	30	660,000	88,242	0.09	598	5.58	33,800	38,000	152,418	-97,378	159,939	1,196,503	4.17
SEP	30	660,000	88,242	0.39	2,743	4.50	27,258	38,000	152,418	-88,691	71,248	533,006	2.05
OCT	31	682,000	91,183	2.05	14,383	3.41	20,656	38,000	157,499	-72,588	-1,340	-10,021	0.00
	Totals:	**8,008,000**	**1,070,670**	**41.6**	**292,552**	**46.6**	**282,393**	**8,132,000**	**1,082,168**	**-1,340**	**3,731,171**	**27,912,893**	

*WATER SURFACE AREA ASSUMED FOR EVAPORATION CALCULATIONS.
POND BOTTOM AREA, SQ FT 31400

WOODACRE FLATS WASTEWATER FEASIBILITY STUDY
POND WATER BALANCE FOR 10-YR. RAINFALL - 22,000 GPD FLOW

WASTEWATER FLOW	22,000	GPD
MAX POND SURFACE AREA	84,400	SQUARE FEET
AVERAGE BANK SLOPE	2.00	:1
MAXIMUM VOLUME	**6,930,398**	GALLONS
	926,400	CUBIC FEET
MAXIMUM WATER DEPTH	**16.0**	FEET

Month	Days in Month	Wastewater Inflow		Precipitation		Evaporation*		Spray Irrigation		Volume Change	Total Balance Volume		End Water Depth
		WW		P		Eto		Irr.		ΔV	V		D
		(gal)	(ft^3)	(in)	(ft^3)	(in)	(ft^3)	(gpd)	(ft^3)	(ft^3)	(ft^3)	(gal)	(ft)
NOV	30	660,000	88,242	7.56	53,159	2.40	14,538	0	0	126,864	126,864	949,067	3.41
DEC	31	682,000	91,183	11.81	83,032	1.86	11,267	0	0	162,949	289,812	2,168,087	6.79
JAN	31	682,000	91,183	13.84	97,346	1.86	11,267	0	0	177,263	467,075	3,494,191	0.81
FEB	28	616,000	82,359	11.10	78,053	2.24	13,568	0	0	146,844	613,919	4,592,731	11.99
MAR	31	682,000	91,183	7.79	54,819	3.41	20,656	0	0	125,347	739,266	5,530,450	13.69
APR	30	660,000	88,242	3.54	24,894	4.50	27,258	42,800	171,671	-85,793	653,473	4,888,634	12.54
MAY	31	682,000	91,183	1.51	10,632	5.27	31,922	42,800	177,393	-107,500	545,973	4,084,426	11.01
JUN	30	660,000	88,242	0.41	2,904	5.70	34,527	42,800	171,671	-115,051	430,922	3,223,728	9.23
JUL	31	682,000	91,183	0.07	467	5.89	35,678	42,800	177,393	-121,421	309,501	2,315,379	7.16
AUG	30	660,000	88,242	0.13	882	5.58	33,800	42,800	171,671	-116,347	193,154	1,444,987	4.89
SEP	30	660,000	88,242	0.58	4,045	4.50	27,258	42,800	171,671	-106,642	86,513	647,202	2.43
OCT	31	682,000	91,183	3.02	21,212	3.41	20,656	42,800	177,393	-85,653	859	6,428	0.00
	Totals:	**8,008,000**	**1,070,670**	**61.3**	**431,445**	**46.6**	**282,393**	**9,159,200**	**1,218,863**	**859**	**4,457,333**	**33,345,310**	

*WATER SURFACE AREA ASSUMED FOR EVAPORATION CALCULATIONS.
POND BOTTOM AREA, SQ FT 31400

WOODACRE FLATS WASTEWATER FEASIBILITY STUDY

POND CAPACITY ANALYSIS

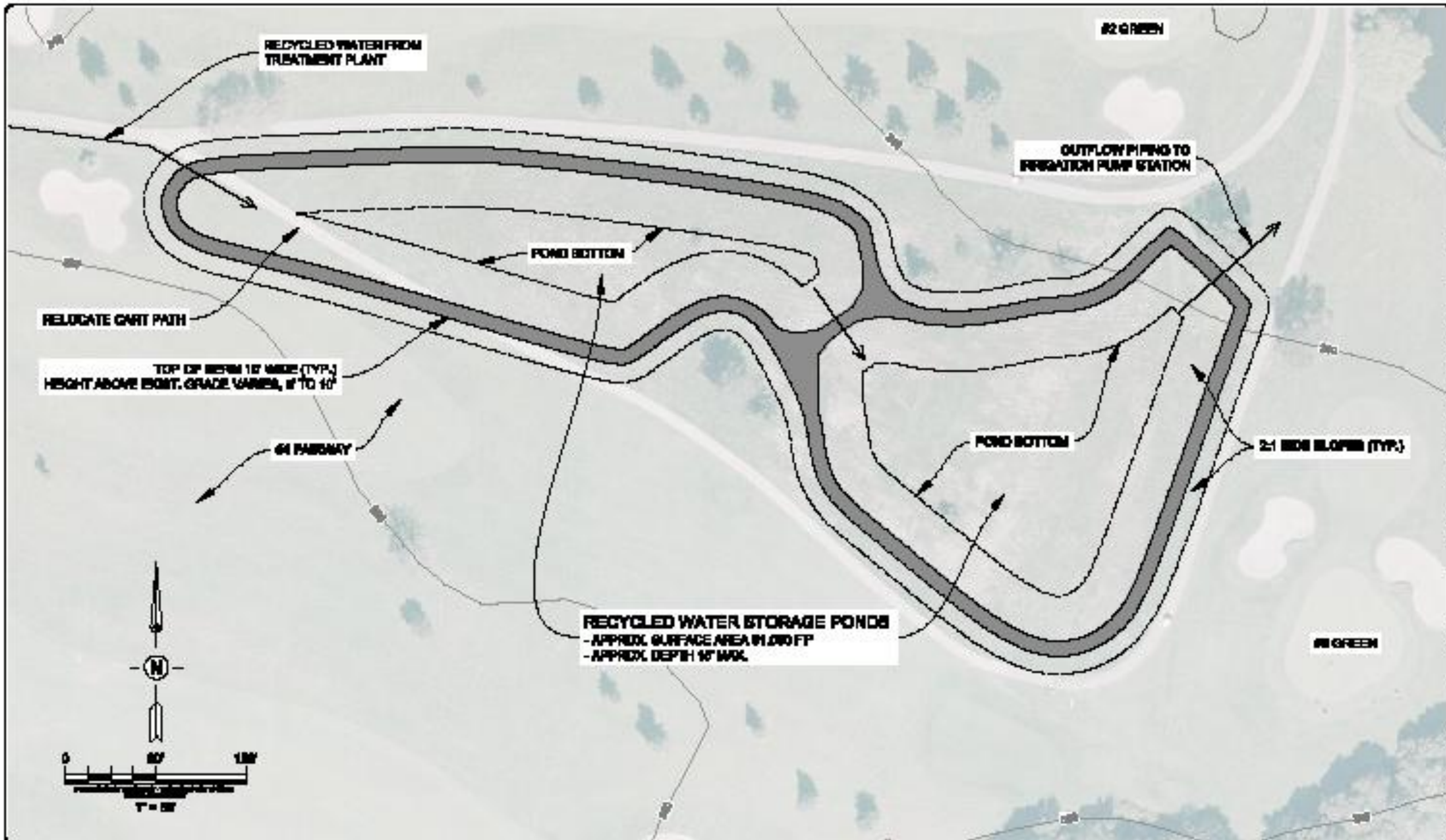
TOTOAL POND BOTTOM AREA, SQ FT: 31,400

WATER DEPTH (FT)	TOTAL POND WATER SURFACE AREA (SQ FT)	ELEVATION (FT)	WATER VOLUME (CU FT)	WATER VOLUME (1000 GAL)
0	31,400		0	0
2.0	34,700		66,100	494
3.0	38,000		104,100	779
4.0	41,300		145,400	1,088
5.0	44,600		190,000	1,421
6.0	47,900		237,900	1,780
7.0	51,200		289,100	2,163
8.0	54,500		343,600	2,570
9.0	57,800		401,400	3,003
10.0	61,100		462,500	3,460
11.0	64,400		526,900	3,942
12.0	67,700		594,600	4,448
13.0	71,000		665,600	4,979
14.0	74,300		739,900	5,535
15.0	77,600		817,500	6,116
15.0	81,000		843,000	6,306
16.0	84,400		926,400	6,930
Average	72,688			

Year	San Rafael	Kentfield	Average
1973	60.46	76.57	68.52
1996	53.45	70.94	62.20
1969	53.91	66.95	60.43
1995	59.67	61.07	60.37
1970	52.54	67.96	60.25
1998	52.23	65.30	58.77
1967	47.54	60.67	54.11
1979	44.45	56.24	50.35
1986	39.32	61.11	50.22
1968	42.63	52.31	47.47
1963	40.79	49.54	45.17
1966	37.87	50.80	44.34
2001	38.18	46.83	42.51
1992	35.52	45.46	40.49
1975	36.02	43.60	39.81
1972	31.65	44.16	37.91
2000	32.07	41.71	36.89
1974	29.83	43.64	36.74
2002	31.09	41.87	36.48
1965	32.49	39.20	35.85
1977	30.36	40.96	35.66
1964	29.88	41.18	35.53
1997	30.18	37.42	33.80
2009	27.36	37.93	32.65
2008	26.20	34.44	30.32
1988	16.95	33.63	25.29
1980	10.19	37.91	24.05
1971	17.51	29.51	23.51
2007	16.86	28.09	22.48
1990	13.40	27.18	20.29
1976	15.12	20.61	17.87
	35.02	46.93	40.98
	1.54	1.43	1.47

Average 10 year = 63.71
Total Average = 40.98
Factor = 1.55

10.53	8.24	9.39
8.42	6.63	7.53
6.19	4.38	5.29
2.79	2.01	2.40
1.31	0.74	1.03
0.34	0.22	0.28
0.05	0.04	0.05
0.09	0.08	0.09
0.47	0.31	0.39
2.42	1.67	2.05
5.85	4.40	5.13
8.94	7.07	8.01



WOODACRE FLATS
WASTEWATER FEASIBILITY STUDY

QUESTA ENGINEERING CORP.

RECYCLED WATER STORAGE
POND LAYOUT - CONCEPTUAL

G-1

Appendix H

Cost Estimates for Golf Course Water Recycling Alternatives 4

- Construction Costs
- Annual O&M Costs

Construction Cost Estimates

Preliminary Construction Cost Estimate
Alternative 4 - Golf Course Water Recycling System
Treatment and Recycle

100% Service Connections - 150 Parcels				
Item	**Units**	**No. of Units**	**Cost per Unit ($)**	**Total Cost ($)**
Title 22 Tertiary Treatment Plant				
Influent EQ Tank and Pumps	LS	1	$50,000	$50,000
1-day Emergency Storage Tank	LS	1	$125,000	$125,000
35,000 gpd MBR Treatment Plant	LS	1	$540,000	$540,000
Disinfection System	LS	1	$25,000	$25,000
Odor Control	LS	1	$30,000	$30,000
Sludge Storage	Gal	5,000	$4.00	$20,000
Effluent Pump Station	LS	1	$20,000	$20,000
Elecrtrical Service and Wiring	LS	1	$40,000	$40,000
Standby Emergency Generator	LS	1	$50,000	$50,000
Control Building/Office, Laboratory, Equip/Mtls Storage	SF	500	$150	$75,000
Grading & Site Improvements	LS	1	$60,000	$60,000
Golf Maintenance Yard Restoration	LS	1	$15,000	$15,000
Treatment Subtotal				**$1,050,000**
Recycled Water Transmission & Storage				
Transmission Line to Storage Pond	LF	1,500	$40	$60,000
Storage Pond Earthwork	CY	15,000	$30	$450,000
Storage Pond Liner	SF	100,000	$1	$100,000
Piping, valves & appurtenances	LF	300	$60	$18,000
Relocate Existing Irrigation Lines	LF	500	$40	$20,000
Irrigation Pump	LS	1	$30,000	$30,000
Disposal Subtotal				**$678,000**
			Total	**$1,728,000**

Preliminary Construction Cost Estimate
Alternative 4 - Golf Course Water Recycling System
Treatment and Recycle

75% Service Connections - 112 Parcels				
Item	**Units**	**No. of Units**	**Cost per Unit ($)**	**Total Cost ($)**
Title 22 Tertiary Treatment Plant				
Influent EQ Tank and Pumps	LS	1	$50,000	$50,000
1-day Emergency Storage Tank	LS	1	$100,000	$100,000
35,000 gpd MBR Treatment Plant	LS	1	$540,000	$540,000
Disinfection System	LS	1	$25,000	$25,000
Odor Control	LS	1	$30,000	$30,000
Sludge Storage	Gal	5,000	$4.00	$20,000
Effluent Pump Station	LS	1	$20,000	$20,000
Elecrtrical Service and Wiring	LS	1	$40,000	$40,000
Standby Emergency Generator	LS	1	$50,000	$50,000
Control Building/Office, Laboratory, Equip/Mtls Storage	SF	500	$150	$75,000
Grading & Site Improvements	LS	1	$60,000	$60,000
Golf Course Maintenance Restoration	LS	1	$15,000	$15,000
Treatment Subtotal				**$1,025,000**
Recycled Water Transmission & Storage				
Transmission Line to Storage Pond	LF	1,500	$40	$60,000
Storage Pond Earthwork	CY	12,000	$30	$360,000
Storage Pond Liner	SF	75,000	$1	$75,000
Piping, valves & appurtenances	LF	300	$60	$18,000
Relocate Exist Irrigation Lines	LF	500	$40	$20,000
Irrigation Pump	LS	1	$30,000	$30,000
Disposal Subtotal				**$563,000**
			Total	**$1,588,000**

Annual O&M Cost Estimates

Annual O&M Cost Estimate
Alternative 4 - Golf Coures Water Recycling System

100% Service Connections - 150 Parcels				
Item	**Units**	**No. of Units**	**Unit Cost**	**Cost ($)**
District/Program Administration				
Insurance, legal, financial	Months	12	$1,000	$12,000
RWQCB Permit	LS	1	$4,500	$4,500
MBR Treatment Plant & Lift Station Operations				
Systems Control Technician	Hours	80	$90	$7,200
Grade III Operator (1/8th time)	Hours	260	$80	$20,800
Grade I Operator (1/4th time)	Hours	520	$60	$31,200
Field Technician	Hours	260	$50	$13,000
Engineering Consultation	Hours	24	$150	$3,600
On-call Monitoring & Response Allowance	Months	12	$500	$6,000
Solids Disposal	Months	12	$400	$4,800
Sewer Maintenance Cleaning	LS	1	$2,000	$2,000
Equip, Supplies, Maintenance & Replacement	Months	12	$1,500	$18,000
Expenses				
Laboratory	Months	12	$1,200	$14,400
Chemicals	Months	12	$250	$3,000
Electrical				
Collection System	kWhr	5,000	$0.14	$700
Treatment Plant	kWhr	75,000	$0.14	$10,500
Storage and Irrigation - by Golf Course	0	0	$0	$0
			Sub-total	$151,700
			10% Contingency	$15,170
			Estimated Total Annual Cost	$166,870
			Estimated Annual Cost per Connection	**$1,112**

Annual O&M Cost Estimate
Alternative 4 - Golf Course Water Recycyling System

75% Service Connections - 112 Parcels				
Item	**Units**	**No. of Units**	**Unit Cost**	**Cost ($)**
District/Program Administration				
Insurance, legal, financial	Months	12	$750	$9,000
RWQCB Permit	LS	1	$4,500	$4,500
MBR Treatment Plant & Lift Station Operations				
Systems Control Technician	Hours	60	$90	$5,400
Grade III Operator	Hours	200	$80	$16,000
Grade I Operator	Hours	400	$60	$24,000
Field Technician	Hours	200	$50	$10,000
Engineering Consultation	Hours	20	$150	$3,000
On-call Monitoring & Response Allowance	Months	12	$500	$6,000
Solids Disposal	Month	12	$300	$3,600
Sewer Maintenance Cleaning	LS	1	$2,000	$2,000
Equip, Supplies, Maintenance & Replacement	Months	12	$1,200	$14,400
Expenses				
Laboratory	Months	12	$1,200	$14,400
Chemicals	Months	12	$200	$2,400
Electrical				
Collection System	kWhr	4,000	$0.14	$560
Treatment Plant	kWhr	56,000	$0.14	$7,840
Storage and Irrigation - by Golf Course	-	0	$0	0
			Sub-total	$123,100
			10% Contingency	$12,310
			Estimated Total Annual Cost	$135,410
			Estimated Annual Cost per Connection	**$1,209**

Capital Cost Summary - Alternative 4 - Route A

Woodacre Flats Wastewater Feasibility Study

Alternative 4 - Tertiary Treatment w/Irrigation Reuse @ San Geronimo Golf Club						
Cost Item	100% Service Connections (150 parcels)			75% Service Connections (112parcels)		
	Gravity Sewer	Pressure Sewer	Effluent Sewer	Gravity Sewer	Pressure Sewer	Effluent Sewer
Collection System (Route A)	$2,541,800	$2,858,550	$2,695,900	$2,282,050	$2,079,650	$2,278,650
Tertiary Treatment Plant	$1,050,000	$1,050,000	$1,050,000	$1,025,000	$1,025,000	$1,025,000
Recycled Water Storage & Transmission	$678,000	$678,000	$678,000	$563,000	$563,000	$563,000
Land/Easement Costs	$0	$0	$0	$0	$0	$0
Mobilization/Demobilization	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Permit Fees & Encroachment Fees	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Sub-total	**$4,389,800**	**$4,706,550**	**$4,543,900**	**$3,990,050**	**$3,787,650**	**$3,986,650**
Contingency @ 20%	$877,960	$941,310	$908,780	$798,010	$757,530	$797,330
Sub-total	**$5,267,760**	**$5,647,860**	**$5,452,680**	**$4,788,060**	**$4,545,180**	**$4,783,980**
Engr & Environ Studies @ 15%	$790,164	$847,179	$817,902	$718,209	$681,777	$717,597
Contruction Management @ 10%	$526,776	$564,786	$545,268	$478,806	$454,518	$478,398
Admin, Dist Formation, Financing @ 5%	$263,388	$239,199	$272,634	$239,403	$227,259	$239,199
Total Estimated Cost	**$6,848,088**	**$7,299,024**	**$7,088,484**	**$6,224,478**	**$5,908,734**	**$6,219,174**
Estimated Cost Per Connection	**$45,654**	**$48,660**	**$47,257**	**$55,576**	**$52,757**	**$55,528**

Capital Cost Summary - Alternative 4 - Route B

Woodacre Flats Wastewater Feasibility Study

Alternative 4 - Tertiary Treatment w/Irrigation Reuse @ San Geronimo Golf Club						
Cost Item	100% Service Connections (150 parcels)			75% Service Connections (112 parcels)		
	Gravity Sewer	Pressure Sewer	Effluent Sewer	Gravity Sewer	Pressure Sewer	Effluent Sewer
Collection System (Route B)	$2,488,750	$2,829,150	$2,642,850	$2,229,000	$2,050,250	$2,225,600
Tertiary Treatment Plant	$1,050,000	$1,050,000	$1,050,000	$1,025,000	$1,025,000	$1,025,000
Recycled Water Storage & Transmission	$678,000	$678,000	$678,000	$563,000	$563,000	$563,000
Land/Easement Costs	$0	$0	$0	$0	$0	$0
Mobilization/Demobilization	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Permit Fees & Encroachment Fees	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Sub-total	**$4,336,750**	**$4,677,150**	**$4,490,850**	**$3,937,000**	**$3,758,250**	**$3,933,600**
Contingency @ 20%	$867,350	$935,430	$898,170	$787,400	$751,650	$786,720
Sub-total	**$5,204,100**	**$5,612,580**	**$5,389,020**	**$4,724,400**	**$4,509,900**	**$4,720,320**
Engr & Environ Studies @ 15%	$780,615	$841,887	$808,353	$708,660	$676,485	$708,048
Contruction Management @ 10%	$520,410	$561,258	$538,902	$472,440	$450,990	$472,032
Admin, Dist Formation, Financing @ 5%	$260,205	$236,016	$269,451	$236,220	$225,495	$236,016
Total Estimated Cost	**$6,765,330**	**$7,251,741**	**$7,005,726**	**$6,141,720**	**$5,862,870**	**$6,136,416**
Estimated Cost Per Connection	**$45,102**	**$48,345**	**$46,705**	**$54,837**	**$52,347**	**$54,789**