Water Quantity and Quality Impact Study
Bean Hollow Housing Project
Pescadero, California

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Prepared for:

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1.0 INTRODUCTION

The Bean Hollow Housing Project (BHHP) is proposed for development on land west of the town of Pescadero, California (Figure 1). The project will be located on what is presumed to be part of an aquifer recharge area. Two wells, the Pescadero Community Water System (PCWS) well and the nearby Warheit well (Figure 3), are completed in the underlying aquifer, and are the source of water for the newly completed Pescadero water system.

The purpose of this study is to investigate the potential impacts of the BHHP on groundwater in the underlying aquifer; both quantity and quality. The study objectives are to:

1. Review existing information about the physical setting and summarize,
2. Estimate the project consumptive use of water,
3. Evaluate the impact of project impermeable surfaces on the quantity of water recharging the underlying aquifer,
4. Investigate the potential impacts of wastewater disposal from the project on the water quality of the aquifer, and
5. Provide recommendations on the next step in planning the project.

Preliminary plans of the proposed project layout were obtained from the architect, David Baker and Associates (DBA). The proposed project layout envisions 30 housing units, parking areas, and lawns (Figure 2). DBA also tabulated the minimum and maximum numbers of occupants of the site, ranging from 96 to 182 persons (Table 1).

Table 1. BHHP Housing Tabulation

Type	Number	Bathrooms per Type	Fixtures per Type	Persons Minimum	Total Minimum	Persons Maximum	Total Maximum
1 Bdrm	4	1	14	1	4	3	12
2 BdRm	10	1	32	2	20	5	50
3 BdRm	12	2	74	4	48	7	84
4 BdRm	4	2	26	6	24	9	36
Total	30		145		96		182

2.0 PHYSICAL SETTING

The BHHP project will be located along Bean Hollow Road in rural San Mateo County, south of Pescadero Road, about one mile west of the town of Pescadero. One mile to the west of the site is Pescadero Point and the Pacific Ocean. The site is on the northern portion of a geographic feature called the Mesa (USGS, 1968), at an elevation of approximately 280 feet. East of the site and at lower elevation is Butano Creek, which flows to the north towards its junction with Pescadero Creek. Site vegetation consists of grasslands.

2.1 Climate

The precipitation records for Pescadero were obtained from the County of San Mateo (1994), covering approximately 25 years. The records are collected sporadically throughout the year, so the monthly distribution of precipitation at San Gregorio, the nearest California Department of Water Resources (DWR) weather station, were used to estimate the monthly average precipitation at Pescadero (Table 2). Average monthly reference evaporation was estimated from statewide data (DWR, 1987).

Table 2. Average Monthly Weather Data for Pescadero (inches)

Month	Precipitation	Reference ET	Potential ET	NAF
January	4.8	1.4	1.0	3.8
February	3.1	1.9	1.3	1.8
March	3.1	2.5	1.8	1.3
April	1.8	3.5	2.5	-0.7
May	0.3	4.1	2.9	-2.6
June	0.2	4.4	3.1	-2.9
July	0.2	4.5	3.2	-3.0
August	0.2	4.3	3.0	-2.8
September	0.2	3.9	2.7	-2.2
October	1.3	2.8	2.0	-0.7
November	3.3	1.5	1.1	2.2
December	3.7	1.1	0.8	2.9
TOTALS	**22.2**	**35.9**	---	---

Note: ET = Evapotranspiration NAF = Net Atmospheric Flux

Based on this data the climate is semi-arid, with precipitation exceeding evaporation in five months (November through March) of an average year.

2.2 Soils

The soils at the site are mapped as Elkhorn sandy loam (Eh) on the western portion and Colma sandy loam (Cm) on the eastern portion (Figure 3). According to the U.S. Soil Conservation Service (SCS, 1969) the Elkhorn sandy loam has a slow infiltration rate, but is suitable for septic system installation. The Colma sand loam is reported to have a moderate infiltration rate, with a severe restriction for septic fields.

2.3 Geology

The surficial geology of the Pescadero area has been mapped by the USGS (Akers, 1980). The geologic map (Figure 4) shows terrace deposits and the Pigeon Point Formation on the site. The Pigeon Point Formation is described as consisting of several hundred feet of generally well-consolidated and low permeability conglomerate, sandstone, siltstone, and mudstone.

A geologic map of unconsolidated and moderately consolidated deposits of San Mateo County (Lajoie, 1974) shows marine terrace deposits at the site. These deposits are described as consolidated, moderately weathered, well-sorted to poorly sorted sand and gravel that was deposited in shallow water on old wave cut marine terraces now elevated above sea level.

A cross-section sketch showing the relationship of geologic formations and land forms in the site vicinity is presented in Figure 5 (SCS, 1969). This figure clearly depicts the wavecut terrace deposits relative to the underlying Purisima Formation. Perry Wood (1982), a registered geologist who logged the drilling of a test boring at the Warheit well location, reported that the Pigeon Point Formation differed considerably from the description given by the USGS. He noted that beds of conglomerate and siltstone were conspicuously absent. Instead, Mr. Woods describes a sedimentary unit comprised of weathered, dark yellow brown to orange brown, sand and clayey sand to a depth of 110 feet. Between 110 and 240 feet a brown sand was encountered that was described as "...similar to an old beach or sand dune deposit...". Sieve analysis of a sample from a depth of 200 feet appears to show that about 80% of the soil particles by weight were the size of fine to medium sand. Groundwater was encountered at a depth of 205 feet in this sand unit.

Geoconsultants (1983) drilled and constructed the Warheit well, penetrating what they described as a sequence of locally clayey, tan to yellow-brown, fine to medium grained sand to total depth of about 270 feet. Some local areas were noted to be cemented. The well was screened across the interval from 207 to 247 feet deep (78 to 38 MSL).

Kennedy, Jenks, Chilton (KJC, 1987) described the site surface geology as comprised of terrace deposits of coarse-grained sand and gravel, light gray to tan in color with apparent mottled iron staining, attaining a maximum thickness of 40 feet. The Pigeon Point Formation is described as composed of rhythmically bedded marine sandstones, siltstones, and shales. The Pigeon Point Formation is estimated to be 8,500 feet thick based on cited references.

F. Beach Leighton and Associates (FBLA, 1972) conducted a geotechnical feasibility study of the neighboring parcel for a waste disposal site (landfill). Based on shallow borings, they described the Pigeon Point Formation as consisting of dark gray to red-brown, pebble to pebble conglomerate, medium to coarse-grained sandstone, siltstone, and shale. Terrace deposits were reported to range in thickness from 2 to 30 feet, consisting of firm to soft, yellow to red-brown gravel, sand and silt. In addition, an inactive fault was mapped in the nearby quarry.

2.4 Surface Water Hydrology

Surface water drainage features in the site vicinity generally flow towards the north, as evidenced by Butano Creek just east of the site on the USGS (1968) topographic map (Figure 1). Surface water drains from the site either to the east into the nearby quarry sediment pond eventually reaching Butano Creek, or to the north through an ephemeral drainage directly into the Pescadero marsh.

In addition to the watercourses there are ponds, reservoirs, and seeps shown on the soils map of the site vicinity (Figure 3). The presence of these ponds and seeps suggest that vertical leakage of water through the shallow soils is restricted by underlying low permeability sediments. Seeps usually occur where permeable, water-bearing sediments, underlain by impermeable sediments, intercept the ground surface. Thus, the presence of the seeps suggests that very little recharge is occurring from the ground surface to the deeper sediments at the site.

2.5 Groundwater Hydrology

FBLA (1972), investigating the neighboring property for a landfill, stated that the Pigeon Point Formation acts as a barrier to downward percolation of groundwater, creating perched water in the overlying terrace materials. FBLA cited the presence of a spring along Bean Hollow Road and perched groundwater in trench excavations as evidence of the low permeability of the Pigeon Point formation. FBLA stated that following heavy rainfall "...the surficial materials (terrace and colluvium) were found to be essentially saturated to the ground surface whenever bedrock was within approximately 20 feet of the ground surface." FBLA completed several shallow wells at the site which contain perched groundwater at a depth of 10 feet (about 250 MSL). As a result, the landfill Solid Waste Facility Permit (1978) does not allow liquid waste disposal at the site.

This apparent lack of recharge due to the low permeability of the Pigeon Point formation is supported by the observations of previous investigators. Akers (1980) suggested that the location of most of the seeps at higher elevation suggests that not much water moves downward into the Pigeon Point Formation.

In contrast, KJC (1987) suggested that the primary source of recharge to the deeper water table (Warheit aquifer) at a depth of 170 feet (110 MSL) is most likely relatively rapid infiltration of precipitation through the terrace deposits, as there is little evidence of any significant strata of low permeability that would restrict the amount of deep percolation.

The lateral extent of the groundwater resource in the site vicinity is unknown. Geologist Perry Wood (1982) who drilled the Warheit well test boring hypothesized that the deeper groundwater was "... an elongate lens of fresh water between Butano Creek Valley and the Pacific Ocean." In contrast, KJC (1987) formulated a conceptual model of the regional groundwater flow in the site vicinity based with hydrologic boundaries defined at Butano Creek, Arroyo de Las Frijoles, the Pacific Ocean, and the interface between the Purisima and Pigeon Point formations to the southeast. Based on the water surface elevation in the Warheit well (117 MSL), KJC postulated that groundwater may discharge into Butano Creek and/or the Arroyo or into the ocean, but based on available data the direction of flow could not be determined.

Geoconsultants (1983) stated that the water-bearing strata appeared capable of supporting additional wells provided land was available and that a regional water balance demonstrated additional yield was possible without mining groundwater. More specifically, Todd (Winzler & Kelly, 1989) estimated the sustainable yield (average annual recharge) to the aquifer was between 25 and 50 AF/yr. In addition, the volume of water in aquifer storage was estimated at 2,400 AF, with the caution that the actual amount that could be withdrawn would be less because some moisture is retained in the soil pores.

2.6 Groundwater Quality

The geophysical logs of the Warheit well show an increase in TDS below a depth of 260 feet (approximately 25 MSL), suggesting the influence of the saline ocean water. Depth to water in the Warheit well was measured at about 170 feet below ground surface, indicating approximately 90 feet of potentially good quality water. The Warheit well was screened between depths of 207 and 247 feet (78 and 38 MSL).

An analysis of major cation and anion ratios by Todd showed that the water from the Warheit well is chemically similar to shallow wells near the town of Pescadero which have exhibited high salinity, indicating that both aquifers are supplied from the same source. Thus, Todd reasoned that the Warheit well has the potential to exhibit the same water quality problems that presently exist in shallow wells near Pescadero, an increase in salinity with time due to saltwater intrusion of underlying ocean waters, if the aquifer is pumped beyond its safe yield.

Two shallow monitor wells and a leachate collection system were installed at the nearby landfill to monitor groundwater conditions. Sampling reports (Sequoia, 1992) for the monitor wells indicate that groundwater is present at a depth of about 10 feet in the wells and that the water contains high readings of coliform bacteria, indicating the landfill has impacted the perched groundwater quality.

2.7 Summary of Groundwater Conditions

Based on an examination of the above-references and a site visit, ASE believes that a permeability contrast between the upper terrace formation and the lower Pigeon Point formation does exist, and that this permeability contrast retards infiltration of precipitation, leading to numerous seeps along the upper elevations (Figure 3). During a site visit, ASE noticed a distinct change in vegetation along a visually continuous elevation, suggesting the accumulation of moisture in the shallow terrace deposits. In addition, perched groundwater has been shown to be present at a depth of less than 10 feet in the monitor wells at the nearby Pescadero landfill. A conceptual diagram of the site groundwater conditions is shown in Figure 6.

However, based on the descriptions of the Pigeon Point Formation as a sand deposit, ASE believes there may be a significant component of vertical flow of this moisture into the underlying Pigeon Point formation over the long term. There is no other satisfactory explanation for the presence of groundwater at an elevation above nearby Butano Creek and Arroyo de Los Frijoles. In addition, precipitation accumulating in the nearby quarry sediment pond may provide a measure of recharge through the porous sandstones that are exposed in the quarry.

ASE also suspects that the aquifer may extend beneath the Mesa to the south and perhaps to the west. ASE noted two wells to the south of the site, across Bean Hollow Road (Figure 3). One well is on property owned by Bay City Flowers. The second well is in an artichoke field across from Bay City Flowers. The presence of these wells suggest that the aquifer may extend to the south throughout the Mesa. Another well located to the north of the site at the California Department of Forestry (CDF) is reported to be low yield (Figure 3).

With respect to water quality, ASE believes that there is a long-term potential for degradation of aquifer water quality from saltwater intrusion if the aquifer is overpumped. This is a common problem throughout coastal California where wells are located in close proximity of the ocean. Ocean saltwater is denser than freshwater, and therefore is found beneath the lighter "fresh" groundwater that percolates from rainfall. When pumping exceeds the natural aquifer recharge, saltwater intrusion will occur, requiring installation of treatment systems to remove salts or the importation of drinking water.

3.0 POTENTIAL IMPACTS ON WATER QUANTITY

ASE used a water balance approach to analyze the potential water quantity impacts on the underlying aquifer. Inputs to the water balance are the water supply requirement from the well (domestic + irrigation demand) and direct precipitation. Run-on to the project site from neighboring properties does not occur at its location on top of the knoll. Outputs from the site are percolation of rainfall, irrigation, and wastewater. Additional outputs are run-off, evaporation from standing water, evapotranspiration by plants (ET), and surface run-off. A schematic of the water balance is shown in Figure 6. The water balance can be expressed as the equation:

$$\textbf{project consumptive use} = \textbf{domestic use} + \textbf{landscape use} + \textbf{precipitation} - \textbf{evaporation} + \textbf{evapotranspiration} + \textbf{runoff} + \textbf{percolation}$$

Consumptive use is the actual quantity of water that is used by the project and that is lost from the hydrologic system. The quantity of water that must be supplied by the well is the sum of domestic and irrigation water use.

Because percolation could not be quantified, the water balance was simplified to consider only the changes in water use that will be a result from construction of the BHHP project; domestic water use, landscape evapotranspiration, and increased runoff due to increased impermeable surfaces. Consumptive use was then estimated based on published data. The other inputs and outputs to the water balance will not be significantly affected by the BHHP project.

The results of the water use analysis are summarized in Table 3.

Table 3. BHHP Water Use Summary (AF/yr)

Use	Project Use	Consumptive Use
Domestic	10	0.5
Landscape	3.6	3.6
Runoff	1.5	1.5
TOTAL	**15.1**	**5.6**

Note that most of the domestic demand is not consumed, but rather it could be returned to the hydrologic system as percolation of wastewater for reuse. Of the total estimated project use by BHHP approximately 63%, about 9.5 AF/yr, could end up as recharge to the aquifer, if recharge is possible.

ASE also considered measures for mitigating potential impacts on water quantity. These mitigation measures are discussed and quantified in the following sections describing the water uses. Estimated savings that will be realized by adoption of the mitigation measures are shown in Table 4.

Table 4. Water Savings Estimates

Mitigation Measure	Estimated Water Savings (AF/yr)
Water Conservation Devices	0.3
Modern Irrigation	0.7
Run-off Reduction	1.5

The effect of the water savings mitigation measures on BHHP water use are summarized in Table 5.

Table 5. BHHP Water Use Summary (AF/yr)

Use	Project Use	Mitigated Project Use	Consumptive Use	Mitigated Consumptive Use
Domestic	10	9.7	0.5	0.5
Landscape	3.6	3.6	3.6	3.6
Runoff	1.5	0.0	1.5	0.0
TOTAL	**15.1**	**13.3**	**5.6**	**4.1**

A comparison of the quantities of water use calculated for BHHP is presented in Table 6 along with the PCWS water use, estimated aquifer recharge, and estimated aquifer storage.

Table 6. Water Quantity Comparison

Demand/Resource	Flow (AF/yr)	Volume (AF)
BHHP-Total	15.1	--
BHHP-Mitigated Total	13.3	--
BHHP-Consumption	5.6	--
BHHP-Mitigated Consumption	4.1	--
Pescadero CWS-Total	50	--
Est. Aquifer Recharge	25 - 50	--
Est. Aquifer Storage	--	3,400

If recharge is possible, then the consumptive use, estimated at between 4.1 and 5.6 AF/yr, is a more accurate measure of the impact of the project on water quantity in the aquifer. The BHHP consumptive use is equivalent to between 8% and 11% of the estimated maximum annual recharge to the aquifer and the PCWS demand (50 AF/yr). It is also equal to less than 0.2% per year of the estimated total volume of water in storage in the aquifer.

3.1 Domestic Water Supply

The water balance assumes that water for the project is withdrawn from the underlying aquifer, either from the PCWS well or another well in the site vicinity. Water is used by the project for drinking, bathing, kitchen, and landscaping. The demand for in-house water supply was estimated using the domestic demand cited in calculations for the Pescadero system of 300 gallons per day per residence (Winzler and Kelly, 1989). This demand is equivalent to 9,000 gallons per day (gpd) or 10 acre feet per year (AF/yr) for the 30 residences at BHHP (Table 3). This demand assumes that the units are metered and on septic systems, both of which encourage conservation of water.

In reality, the water use by the project may be lower. A typical rate of water use by an apartment unit is between 80 and 130 gpd (Tchobanoglaus, 1979). In addition, newly mandated construction standards in California require the inclusion of low flow toilets intended to reduce water usage. However, the water balance uses the estimate of 300 gpd per residence developed for the Pescadero water system.

Mitigation Measures

Domestic water use demand can be partially mitigated by incorporating water conservation design features into construction of the project. A metered water supply is assumed above, as meters provide an economic incentive for water conservation by billing the user according to the quantity used. Also envisioned for the project are low flow toilets and fixtures. Presently, low flush toilets are required in all new buildings in California (DHCD, 1992). This measure will result in a flow reduction of between 6% and 10% for this device (EPA, 1990). Similarly, low flow shower heads are becoming common in new construction, leading to an additional potential water savings. Based on the 6% to 10% reduction cited by the EPA, installation of low flow toilets will lead to a water savings of between approximately 0.2 and 0.4 AF/yr, or about 0.3 AF/yr.

3.2 Landscape Water Use

Water use outdoors was estimated assuming that only the lawns will require irrigation. Thus, the proposed windscreen plantings (Figure 2) are assumed to be composed of plants that do not require irrigation. Any water consumption by these plants is from direct precipitation, and is not included in the water balance because it is balanced by the decrease in run-off provided by the vegetation.

The total area of the lawns proposed for the site was calculated from the scale drawing (Figure 2) at approximately 1.47 acres. Then, the precipitation records for Pescadero (County of San Mateo, 1994) were used to estimate the monthly average precipitation at Pescadero (Table 2). Average monthly reference evaporation was estimated from statewide published data (DWR, 1987). Then, the potential ET was estimated assuming a pan coefficient of 0.70. Finally the net atmospheric flux (NAF), which is the difference between precipitation and potential ET, was calculated (Table 2). This yielded an annual irrigation requirement during the seven dry months (April through October) of 14.9 inches of water, or 1.83 AF/yr. Assuming that an automated irrigation system is installed and operated by facility management at an irrigation efficiency of 50%, this is equivalent to a demand of about 3.6 AF/yr.

Mitigation Measures

The landscape water use mitigation measures proposed are already incorporated into the water use calculation: native plants in landscaping, and modern irrigation systems. Only the lawn areas will not be native plants, but this area will be irrigated using modern water -saving techniques (automatic timers, soil moisture sensors, rain sensors,and drip systems) which increase the efficiency of water application can be implemented to lower the irrigation demand. The result will be less run-off and percolation, with a savings of 20% of the applied water (Klack,1977).

Another possible mitigation measure for landscape water is installation of a system which utilizes the nearby quarry pond for irrigation. It may be possible to store winter rains in the pond for use in summer. Implementation of this measure would require construction of a separate non-potable water system at additional cost, reducing the water quantity impact on the underlying aquifer. However, the relationship of the quarry pond to the aquifer is unknown, and the pond may be a source of recharge to the aquifer, so the quantity of water saved by implementation of this measure cannot be quantified.

3.3 Effect of Impermeable Surfaces

Another potential impact of the project on water quantity is the result of construction of impermeable surfaces (roads, walkways, roofs). The quantity of precipitation recharging the aquifer will be reduced due to the increase in the area of impermeable surfaces at the site. Impermeable surfaces do not allow water to infiltrate into the soil, particularly in comparison to the natural grassland soils that now cover the site. The rational formula is commonly used to estimate run-off flows from small watersheds:

$$Q = CiA$$

where:
Q = volumetric flowrate
C = run-off coefficient
i = rainfall intensity
A = drainage area

The run-off coefficient varies to reflect changes in land use and/or ground surface from a value of 0.20 for natural ground to 0.85 for roofs and paving (Hjemfelt, 1975). Based on the site layout drawing (Figure 2), the total area of impermeable surfaces (roofs and parking) created by the project excluding the driveway is estimated at about 1.25 acres. Thus, in an average year of 22.2 inches of precipitation the amount of run-off will increase due to the increase in impervious surfaces from a pre-development flow of about 0.46 AF/yr (C = 0.20) to a post-development flow of about 1.97 AF/yr (C = 0.85). Assuming that this increased run-off does not infiltrate when it reaches nearby permeable land, the impact of the acre of impermeable surfaces will be to increase run-off and reduce aquifer recharge by about 1.5 AF/yr.

Mitigation Measures

This impact can be partially offset by modifying construction to maximize and/or promote infiltration of water. For example, construction of gravel driving and parking areas (Figure 7) can be used to reduce the impermeable area. In addition, it may be possible to mitigate the potential impacts of both roofs and parking areas by constructing rainwater collection systems that promote infiltration of precipitation. Rainwater can be collected by grading the site to promote ponding, leading to infiltrations of water and eventual percolation to groundwater (Figures 8 and 9). This measure could result in a saving of as much as the entire 1.9 AF/yr of increased runoff. Implementation of this measure would require periodic maintenance of any enhanced infiltration systems (e.g. infiltration trenches) to rehabilitate any clogged soil pores.

3.4 Water Consumption

The total use of the BHHP project is the sum of domestic demand, landscape irrigation demand, and increased run-off, or about 15.1 AF/yr (Table 3). However, only a portion of the domestic demand will actually be consumed and lost to the hydrologic system. The remainder will become wastewater that will be re-introduced into the hydrologic system after treatment as recharge to the groundwater. In house consumption of water is limited to about 5% of the total (Flack, 1977), about 0.5 AF/yr at this site.

In addition, if the potential impact of impermeable surfaces is totally mitigated an additional 1.5 AF/yr will be saved. Then, the total consumptive use of the project is estimated at 4.1 AF/yr. Because the project overlies the aquifer, the remaining 11 AF/yr may recharge the aquifer either as percolation from the wastewater disposal system or as induced percolation of run-off from impermeable surfaces.

Therefore, the impact of the project on the quantity of water in the aquifer in an average year is withdrawal from storage of between 4.1 AF/yr and 15.1 AF/yr, depending on whether treated wastewater and run-off reach the aquifer as recharge. This is equivalent to a well operating continuously at a flow rate of between 2.5 and 10 gpm.

3.5 Fire Demand

The fire protection requirement is not included in the water balance analysis because the fire demand should not have a significant long term impact on the quantity of water in the aquifer. Fires should be extremely rare occurrences.

Nevertheless, preliminary estimates of the required flows were obtained for use in project planning. According to Mr. Les Parr of the California Division of Forestry (1992) a fire flow of 500 gpm for a period of 2 hours at a minimum pressure of 20 psi should be provided for planning purposes. This is equivalent to a volume of water of 60,000 gallons. In addition, the 500 gpm flow must be provided on top of the maximum daily flow for domestic use. Winzler and Kelly (1989) indicate that to obtain maximum benefits from insurance rates a fire flow of 1,000 gpm is required for single-family residential units built at a density greater than three per acre.

One potential source of fire demand is the existing quarry pond, located at lower elevation but relatively close to the project site, discussed above as a potential source of water to mitigate the irrigation demand. The pond appears to be large enough to satisfy the fire requirement of 60,000 gallons. The areal extent of the pond was determined from scaled drawings (Carpenter, 1991) to be 37,000 square feet. If the pond is only one foot deep then the total volume of storage is greater than 270,000 gallons. If half of this volume were available for fire demand and the necessary plumbing were in place, the existing quarry pond could supply the required 500 gpm for 540 minutes, or about 9 hours. Thus, a water system for fire suppression utilizing the pond may be feasible if the pond volume is sufficiently large. In addition, the fire water system could be constructed with a provision for also supplying the irrigation requirements of the project.

Another possible source of water to supply fire demand is the nearby storage tank that is part of the Pescadero Water System. The tank holds approximately 135,000 gallons, about twice the estimated fire demand volume. Use of the tank would require construction of a pumping system. Since fires are not common, use of the tank for fire control should not have a significant impact on the Pescadero Water System.

4.0 POTENTIAL IMPACTS ON WATER QUALITY

ASE investigated the potential impacts of the proposed development on the water quality of the underlying aquifer, identifying three potential routes, surface water run-off, wastewater disposal, and saltwater intrusion. The constituents of concern are oil and grease in surface water run-off from automobile parking areas, nitrate from the wastewater disposal system, and mineral salts from saltwater intrusion.

ASE also considered measures for mitigating potential impacts on water quality. These mitigation measures are discussed in following the description of the potential impacts.

4.1 Surface Water Run-off

Surface water run-off from parking areas is known to contain hydrocarbons associated with automobile parking areas (Stenstrom, 1984), principally oil and grease. Potentially, these hydrocarbons could be washed off the parking surfaces, carried by surface water to bare ground, and then infiltrate into the ground, eventually percolating to the underlying groundwater.

Considering that there will be only approximately 0.55 acres of asphalted parking area, and that the aquifer is approximately 170 feet beneath the ground surface in the existing wells, there does not appear to be any significant threat of hydrocarbons reaching the groundwater from this source. The oil and grease will likely run-off from the paving, become adsorbed to soil particles, and undergo biodegradation by soil microorganisms.

Mitigation Measures

Porous pavements that allow infiltration and subsequent biodegradation have been proposed as a control measure for reducing oil and grease concentrations in urban run-off (Silverman, 1988). As such, a potential mitigation measure is construction of pervious parking surfaces such as gravel to reduce the potential impacts of oil and grease in surface water run-off from parking areas. Pervious parking surfaces will allow precipitation falling on the parking area to infiltrate, with oil and grease from automobiles carried into the shallow soil where biodegradation will decompose the constituents (Silverman, 1988). Implementation of this measure would require periodic maintenance of the pavement comprised of rehabilitation of any clogged pavement pores.

4.2 Wastewater Disposal

MPHC has reportedly completed a few preliminary percolation tests at the site with results indicating that a conventional septic system (tank and leach fields) appears feasible. This method of wastewater treatment and disposal could potentially impact the water quality of the underlying aquifer. Wastewater discharged into the soil through the leach lines could potentially percolate downward and reach groundwater, carrying coliform bacteria, viruses, biochemical oxygen demand (BOD), nitrate, and phosphorous.

The EPA (1980) recommends a minimum distance of 4 feet between the bottom of the leach field and the water table or creviced rock to prevent waterlogging. This condition is met at the site with respect to the water supply aquifer which occurs at a depth of 170 feet. Therefore, a conventional septic system designed according to EPA guidelines should perform at this site without affecting the underlying groundwater aquifer, except possibly for nitrate.

A conventional septic system is comprised of a septic tank and leach lines for treatment and disposal of both gray (bathing, kitchen, etc.) and black (toilet) water. The septic tank performs primary treatment of the wastewater, removing nearly all of the settleable solids, floatable grease, and scum, leaving a relatively clear liquid for discharge to the leach field. Further treatment and disposal of the wastewater occurs at the soil water interface in the leach field trenches. Bacteria are strained or filtered out of the wastewater by the soil particles (Gerba, 1975). Viruses are removed by adsorption on the soil particles (Gerba, 1975). Biochemical oxygen demand (BOD) is reduced by adsorption and subsequent biodegradation (Pound, 1978). Phosphorous, from synthetic detergents, is removed in the soil, primarily by chemical precipitation with metal ions commonly present (Winneberger, 1974). Winneberger (1974) states that "....where the soil is suitably pervious, normal bacterial activities are capable of reducing the biochemical oxygen demand to the tertiary level, while at the same time, nutrients found in detergents are degraded almost 100%."

The remaining constituent of concern for the wastewater disposal is nitrogen. About 90% of the nitrogen in wastewater is from toilet wastes (Winneberger, 1974). Nitrogen is present in septic tank effluent in the form of organic nitrogen and ammonia. The usual reductions in nitrogen across the septic tank are approximately between 20% to 40%. Adsorption of nitrogen occurs in the soil, along with biodegradation, leading to a total removal efficiency of nitrogen from the septic tank/leach field system of about 40% to 72% (Winneberger, 1974). The remaining nitrogen is relatively mobile in the hydrologic system. In theory, the nitrogen could potentially percolate to groundwater, impacting water quality. However, the depth to the water supply aquifer is so large (150 feet) at this site that a water quality impact is unlikely.

Consider that a typical domestic wastewater contains about 40 mg/L of nitrogen after primary treatment in the septic tank (Pound, 1978). Additional reduction in nitrogen can be expected in the leach field as noted by Winneberger (1974). Then, the effluent will percolate through the underlying sandy soils to the water table, providing additional nitrogen reduction through nitrification, adsorption on soil, and denitrification by soil microorganisms. Data collected at a rapid infiltration site processing primary treated wastewater in Hollister, California after 30 years of operation indicates that a 93% reduction in total nitrogen was achieved as wastewater passed from the surface to the shallow water table at a depth of less than 42 feet (Pound, 1978). Assuming this treatment efficiency applies to the BHHP site, where the depth to the water supply aquifer is at least 170 feet, results in a nitrogen concentration of about 3 mg/L at the water surface. Including the effect of dilution of the percolating wastewater with aquifer waters will further reduce the nitrogen concentration to about 1 mg/L. These calculated concentrations are below the EPA primary drinking water standard of 10 mg/L, suggesting that no significant impact on water quality will occur from a properly designed and operated septic system.

The above analysis considers the potential impact of nitrogen on the water supply aquifer. However, at this site there is the possibility of a perched groundwater zone at shallow depth that could be significantly impacted by wastewater disposal. FBLA (1972) reported the depth to the top of the fractured bedrock (Pigeon Point formation) on the neighboring site was between 4 and 30 feet. In addition, the perched water table could rise during the winter precipitation, leading to waterlogging of the disposal trench. These conditions would probably lead to elevated concentrations of nitrates in the shallow, perched groundwater, but would not impact any known water supply. The reports of a perched water table calls into question the technical feasibility of using septic systems for wastewater treatment at the site.

Volume of Wastewater

Estimates of the quantity of wastewater that will be generated by the project were developed based on published data. Winneberger (1974) estimated that about 255 gpd of wastewater is generated by an average household. Of this amount it is estimated that 100 gpd is generated by the toilet (black water) with the remaining 155 gpd generated from bathing, kitchen washing, laundry, bathroom sinks, and utility sinks (gray water). Similarly, the EPA (1980) estimates the average daily wastewater flow from a typical residential dwelling unit at approximately 45 gpd per person (Table 6) with flows typically no greater than 60 gpcd.

Table 6. Domestic Wastewater by Use

Use	AMOUNT (gpcd)
Toilet	16.2
Bathing	9.2
Clotheswashing	10.0
Dishwashing	3.2
Garbage Grinding	1.2
Miscellaneous	6.6
TOTAL	**45.6**

Thus, for the maximum average project household of 6 persons (180 occupants in 30 units) the average wastewater flow is 250 gpd per unit with a maximum of 360 gpd per unit. For the purposes of consistency, a wastewater flow of 285 gpd per unit was used, equivalent to 95% of the 300 gpd per unit demand.

Preliminary Estimate of Septic Tank Size

Preliminary sizing of the required septic tank size was calculated using the EPA (1980) guidelines for multi-unit housing without garbage disposals. Assuming a population of 180 people in 30 units, the wastewater flow of 285 gpd per unit is equivalent to 47.5 gallons of wastewater per person per day. Thus, the total project wastewater flow is 8,550 gpd. Applying the following EPA equation for housing clusters:

$$V = 1{,}125 + 0.75\,Q$$

where: V = net volume of septic tank in gallons
Q = daily wastewater flow in gallons

According to this guideline a septic tank capable of holding 7,500 gallons will be required. In addition, EPA recommends that a two compartment tank be installed to improve treatment results.

Preliminary Estimate of Leach Field Size

A preliminary estimate of the leach field size was calculated from assumed percolation rates based on the reported soil texture. For a fine, sandy loam the percolation rate is reported at between 6 and 15 minutes per inch (EPA, 1980). A wastewater application rate of 0.8 gallons per day per foot squared (gpd/sf) of infiltrative surface is recommended. Thus, for the projected BHHP wastewater flow of 8,550 gpd this is equivalent to an infiltrative surface of 10,125 sf. Assuming that a trench can be constructed above the water table or creviced rock to a depth of 5 feet, providing an infiltrative surface of 5 feet (2 sidewalls @ 2.5 feet), this is equivalent to 2,000 feet of trench. In addition, EPA recommends construction of a three-field system incorporating an additional 50% of the required infiltrative surface to allow for alternate use of fields, yielding a total leach field requirement of 3,000 feet for the depths assumed above. The final design of the leach field should be based on depth to bedrock and/or water table and percolation testing in the field.

Mitigation Measures

EPA (1980) promotes the use of water saving devices such as low flow toilets to reduce the volume of wastewater generated. Construction with water saving devices will theoretically reduce the quantity of wastewater used (although the concentrations will increase), leading to a smaller volume of wastewater requiring treatment. For example, a system that recycles "gray" wastewater from the bath and laundry for reuse in a toilet flush will significantly reduce the volume of wastewater produced.

Another mitigation measure to reduce water quality impacts of the wastewater is pollutant mass reduction (EPA, 1980). EPA states that the pollutant mass in the wastewater can be reduced by not allowing the installation of garbage disposals. The material normally deposited in a garbage disposal can be treated as solid waste and not as part of the wastewater flow, thereby reducing the BOD and suspended solids load. Implementation of the mitigation measure was assumed in the preliminary sizing of the septic tank presented above.

A final mitigation measure is provision of additional wastewater treatment method beyond the conventional septic system. An additional treatment stage can provide additional cleansing prior to disposal of wastewater to the ground through the septic trenches. For example, a three stage septic system can be used to reduce nitrate loads in the wastewater. The three stage system utilizes a conventional septic tank, followed by an aerobic trickling filter that nitrifies the organic nitrogen and ammonia. Then, organics are added to the waste stream prior to removal of the nitrates in an upward flow anaerobic filter by microorganisms. The requirement for additional organic matter can be met either actively by manual addition of organic matter (e.g. methanol) by an operator, or passively by reintroduction of gray water that has previously been separated from the black water in a parallel grey water system. If necessary, chlorination can also be added to reduce the amount of bacteria and viruses prior to discharge of the treated wastewater into the ground.

4.3 Saltwater Intrusion

As in all coastal California, there is the potential for saltwater to intrude into the aquifer, either from a greater depth or from the ocean, as a result of increased pumping to meet the BHHP demand (domestic + landscape). Increased pumping will lower the water level in the well and aquifer, causing fluids to flow towards the well from greater lateral and vertical distances. Since saline waters are located at a depth of 260 feet (15 MSL) in the Warheit well (Geoconsultants, 1983), and the ocean is one mile west of the site, there is the potential for an increase in salt concentrations in the aquifer over the long term.

Assuming no recharge of treated wastewater, the quantity of water required to supply the total use of the project was previously estimated at approximately 15.4 AF/yr, equivalent to a flow of about 10 gpm from a continuously operating well. The average annual PCWS demand was estimated at 50 AF/yr (Winzler & Kelly, 1989), equivalent to a flow of 30 gpm from a continuously operating well. Pumping tests conducted at the PCWS well show that the water level is lowered in the well by about 13 feet at a flow of 50 gpm for 330 minutes. An analysis of the step drawdown test conducted at the Warheit well suggests that the specific drawdown of the well is about 0.26 feet per gpm (KJC, 1987). Based on this value the drawdown in the well at a flow of 30 gpm after 330 minutes is estimated to be 7.8 feet. Similarly, at a flow of 40 gpm the drawdown is estimated at 10.4 feet. The results of this test indicate that the additional 10 gpm required for the BHHP supply will result in a decrease in the well water level well of about 2.6 feet, a relatively small distance when compared to the thickness of useable water of at least 50 feet. Thus, for short term pumping there does not appear to be a significant potential that saline waters will be drawn into the well.

Over the long term Todd (Winzler & Kelly, 1989) estimated the average annual recharge to the aquifer at between 25 and 50 AF/yr, with a total volume of water presently in storage of 2,400 AF. Thus, the BHHP total use of 15.1 AF/yr is between 30% and 60% of the average annual recharge, and 0.5% of the total volume of water in aquifer storage in the site vicinity. Winzler & Kelly (1989) conducted an analysis of the aquifer adequacy using a value of 1,300 AF for aquifer storage, the lower annual recharge estimate of 25 AF/yr, and a factor of safety of 2, with results showing that the aquifer is projected to be viable for about 27 years. If the BHHP total use of 15.1 AF/yr is included in this analysis the projected life of the aquifer is reduced by approximately 8 years, to 19 years. Alternatively, if only the BHHP mitigated consumptive use of 4.1 AF/yr is included in calculation, then the aquifer life is reduced by only about 4 years, to 23 years.

Mitigation Measures

Potential water quality degradation from saltwater intrusion as a result of increased pumping may be mitigated by investigation of the extent of the groundwater resources penetrated by the Warheit and PCWS wells, provided that the investigation shows that the aquifer is more extensive than presently thought. A more extensive aquifer will mean that the projected aquifer recharge, storage volume, and life are greater than previously calculated, and thus that the additional pumping will not be as significant. ASE noted additional wells to the south of the site which could be further researched (e.g. boring logs, pumping rates, water chemistry) in an effort to determine whether they penetrate the same aquifer. Finally, if no well data is available a test boring could be drilled to determine the extent of the aquifer to the west.

5.O SUMMARY AND CONCLUSIONS

5.1 Physical Setting

ASE reviewed the available information on the physical setting of the site including climate, soils, geology, surface water hydrology, groundwater hydrology, and groundwater quality. Based on this review and a site visit, ASE concluded that a permeability contrast between the upper terrace formation and the lower Pigeon Point formation exists which retards infiltration of precipitation, reducing groundwater recharge. However, based on the descriptions of the Pigeon Point Formation as a sand deposit, ASE concluded that there is a significant component of vertical flow of this moisture into the underlying Pigeon Point formation over the long term. ASE also suspects that the aquifer may be more extensive than previously estimated based on the presence of two wells to the south of the site, across Bean Hollow Road. With respect to water quality, ASE concludes that there is a long-term potential for degradation from saltwater intrusion if the aquifer is overpumped.

5.2 Water Quantity

The project water use by the maximum population at BHHP was estimated at 15.1 AF/yr including domestic use, landscape use, and increased run-off due to increase in impermeable surfaces. Of this total use it is estimated that as much as 11.0 AF/yr (approximately 73%) could end up as recharge to the aquifer, either through percolation of treated wastewater or induced infiltration of run-off. If recharge is possible, then the consumptive demand of the project is estimated at between 4.1 and 5.6 AF/yr, depending on the mitigation measures adopted. This is equivalent to between 8% and 22% of the estimated annual recharge to the aquifer, and less than 0.2% per year of the estimated total volume in storage. If water from the BHHP will recharge the aquifer, then water quantity impacts appear insignificant, because water is essentially recycled through the project back into the aquifer.

A preliminary estimate of the fire demand was developed. For planning purposes an existing quarry pond was considered as a possible source of water to meet the fire demand. Based on limited data about the size and depth of the pond, it appears that the existing quarry pond could be used for fire demand after construction of necessary plumbing. However, further study of the pond characteristics (e.g. seasonal variation in the volume of water) would be necessary.

ASE developed a variety of alternative measures to mitigate the potential impacts of the project on water quantity. To mitigate this potential reduction in water quantity ASE envisions the use of:

1. water conservation devices in the design of the project structures,
2. modern irrigation equipment and native plantings,
3. run-off reduction measures with induced infiltration incorporated into the site grading.

Incorporation of modern irrigation equipment and native plants was assumed in the water use analysis. Total savings from implementation of the other two measures is estimated at 1.8 AF/yr.

5.3 Water Quality

ASE investigated the potential impacts of the proposed development on the water quality of the underlying aquifer, identifying three potential routes, surface water run-off, wastewater disposal, and saltwater intrusion. The constituents of concern in surface water run-off are oil and grease from automobile parking areas. Considering the size of the parking area and the depth to the aquifer there does not appear to be any significant threat of oil and grease reaching the groundwater from surface water run-off.

The constituent of concern from the wastewater disposal (septic system) is nitrate. Assuming that a conventional septic system is technically feasible at the site, its potential impact on water quality was evaluated, with results suggesting that the effect of dilution of the percolating wastewater in aquifer waters will reduce the nitrogen concentration to about 1 mg/L, below the EPA primary drinking water standard of 10 mg/L. If this water does not recharge the aquifer, then the potential water quality impacts are insignificant.

Wastewater flows, septic tank size, and leach line lengths were estimated for planning purposes. The volume of wastewater was estimated at 8,550 gpd. Using an EPA formula for housing clusters a preliminary septic tank size of 7,500 gallons was calculated. Assuming a percolation rate for a fine, sandy loam and a trench with 2.5 feet per side of infiltrative surface yields a preliminary estimate of 3,000 feet of leach field lines. However, reports of perched groundwater in the site vicinity makes the technical feasibility of septic systems questionable.

Finally, the potential water quality impact of saline intrusion as a result of additional withdrawal of water from the aquifer was considered. Short term impacts are apparently insignificant. Long term impacts reduce the estimated 27 year life of the aquifer by between 4 to 8 years, depending on whether wastewater can reach the aquifer as recharge. If water from the BHHP will recharge the aquifer, then the water quality impact appear insignificant, because the aquifer will probably not be overpumped.

ASE proposed measures for mitigating these potential impacts on water quality. The impacts of surface water run-off can be mitigated by using porous pavements on parking areas. Potential impacts of the wastewater disposal system can be mitigated by the use of water saving devices such as low flow toilets to reduce the volume of wastewater generated, pollutant mass reduction by eliminating the use of garbage disposals, and addition of an additional wastewater treatment method such as a three stage septic system or chlorination. The potential water quality impact of saltwater intrusion as a result of increased pumping may be mitigated by investigating the extent of the groundwater resources penetrated by the Warheit and PCWS wells.

6.0 RECOMMENDATIONS

6.1 Incorporate Water Conservation Design Features

ASE recommends design and construction of the project to incorporate water conservation design features such as low flow fixtures (toilets and showers), individual water meters, native landscaping, and modern irrigation systems. These design features will lower the overall water demand of the project and the wastewater generated at a relatively small cost. Included in this recommendation is the absence of garbage disposals to reduce both water use and pollutant mass loading. Because many of these features were assumed to be present in developing the water demand, implementation of this measure will lead to a water saving of only about 0.3 AF/yr.

6.2 Incorporated Run-off Reduction Measures

ASE recommends incorporation of the run-off reduction measures consisting of pervious (gravel) parking areas and contouring of the land for rainwater collection and eventual percolation. An added benefit of this measure is that it also mitigates the potential impacts of parking area surface water run-off water quality. This measure will effectively eliminate any increase in run-off due to asphalted surfaces, leading to a water savings estimated at 1.5 AF/yr. As part of this measure ASE recommends that an effort be made to retain the quarry sediment pond for potential use in rainwater collection and recharge. Grading of the project site to drain into the quarry pond may be possible. A site visit by ASE in October 1992 suggests that the pond retains water year-round, and may be a significant source of recharge to the aquifer.

6.3 Investigate Use of the Existing Quarry Pond for Fire Demand

In order to determine the viability of the pond to meet the fire demand it is recommended that the depth of the pond be determined and that water levels be measured throughout the course of a year, particularly at the end of the dry summer months, to establish the pattern in storage volume.

6.4 Investigate Percolation/Recharge

If water will not recharge the aquifer, then the potential water quality impacts from the wastewater system are insignificant because the wastewater will not reach the groundwater. Water quantity impacts and their mitigation will be of primary concern. If water will recharge the aquifer, then water quantity impacts appear insignificant, because water is essentially recycled through the project. In addition, there will be less potential for saline intrusion because lower volumes of water will be withdrawn from the aquifer. Water quality impacts from the wastewater disposal system and their mitigation will become the primary concern.

Because of the importance of wastewater recharge in evaluation of potential project impacts, ASE recommends investigation of the feasibility of conventional septic systems at the site. In addition, ASE recommends investigation of the amount of recharge that occurs to the aquifer through the shallow soils. This investigation should include percolation testing to determine the adsorption capacity of the terrace deposits, drilling of borings to ascertain the character of the any permeability contrast between shallow soils and the Pigeon Point formation, construction of a shallow well to monitor the perched water table level, and percolation testing of the upper strata of the Pigeon Point Formation. ASE recommends that the septic system feasibility investigation focus on the Elkhorn soils at the site, based on the SCS (1961) evaluation that it is more suitable for septic systems than the Colma soils. The underlying Pigeon Point formation should be tested for percolation, in case deep leach field trenches which penetrate the Pigeon Point formation are necessary to promote recharge into the underlying aquifer.

6.5 Investigate Extent of Water Supply Aquifer

ASE observed water wells on agricultural property south of the site, reinforcing the thought that the resources penetrated by the existing wells may be more extensive than estimated by Todd (Winzler & Kelly, 1989). Todd's estimate appears to have limited the PCWS recharge area to the equivalent of a circle with a diameter of approximately 2,400 feet. In contrast, Geoconsultants (1983) and KJC (1987) both concluded that the water-bearing strata in the vicinity of the existing wells appeared capable of providing additional water supply pending a regional water balance.

Thus, additional investigation of the extent of the groundwater resources in the site vicinity is warranted. This information will also be useful to PCWS in evaluating the life of their groundwater resources. As a first step ASE recommends investigating the characteristics of existing wells (boring logs, flowrates, water chemistry) in the site vicinity. If well characteristics are unattainable, a test boring may be required to determine the extent of the aquifer, particularly to the west towards the ocean, preferably at a distance of greater than 1,200 feet from the PCWS and Warheit wells.

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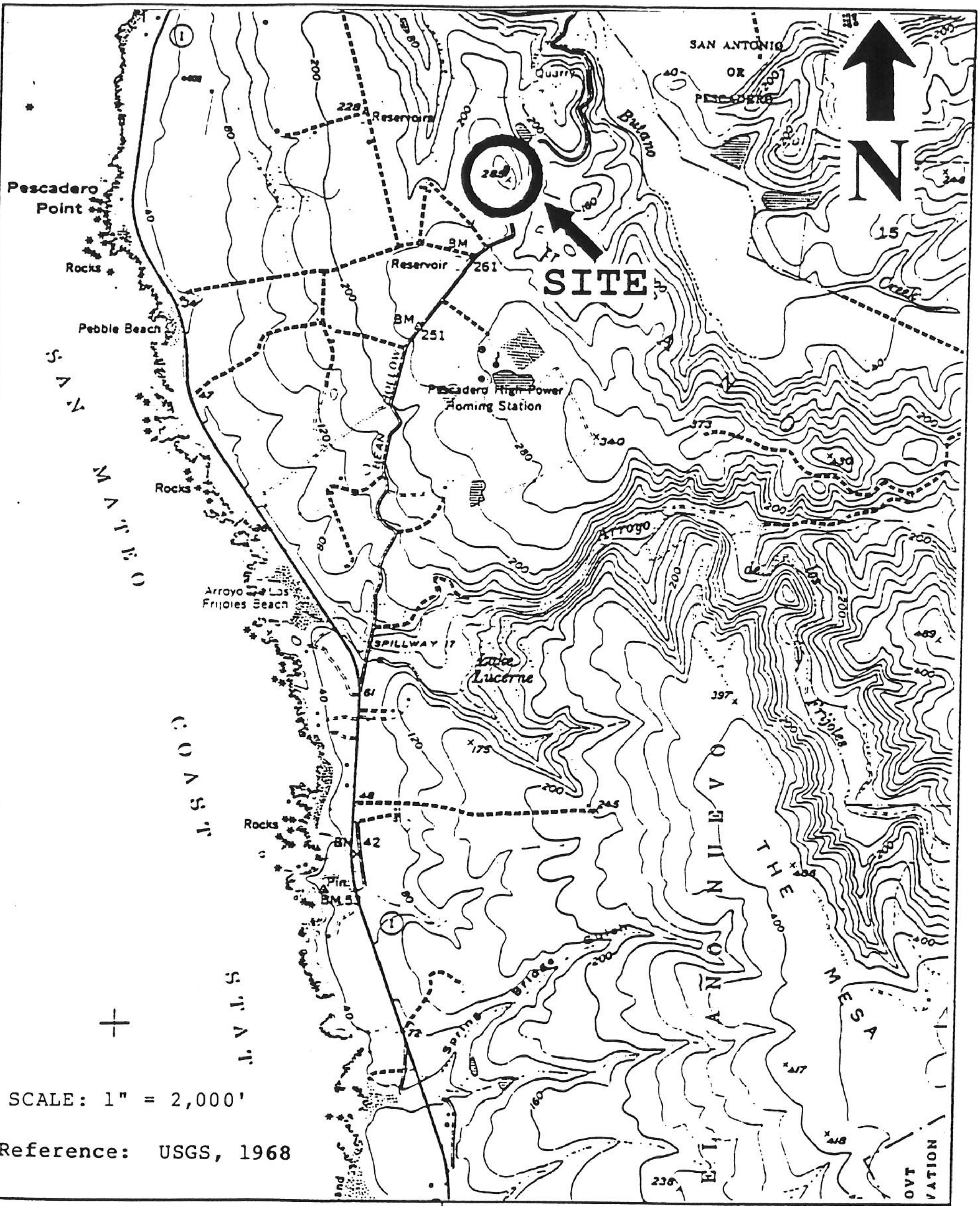

SCALE: 1" = 2,000'

Reference: USGS, 1968

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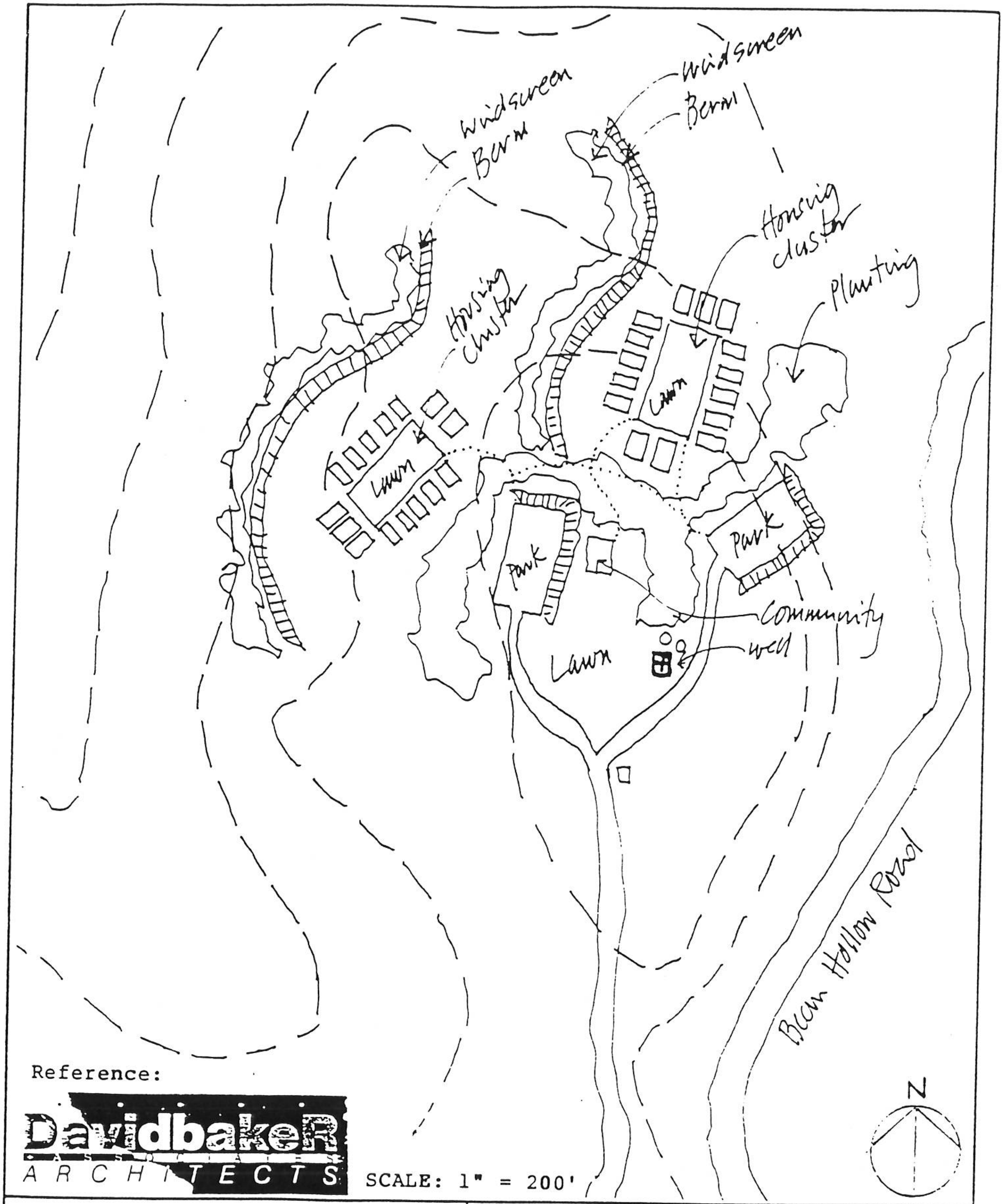
Figure 1. Site Location Map
Bean Hollow Housing Project
Pescadero, California



Reference:

DavidbakeR ASSOCIATES ARCHITECTS

SCALE: 1" = 200'

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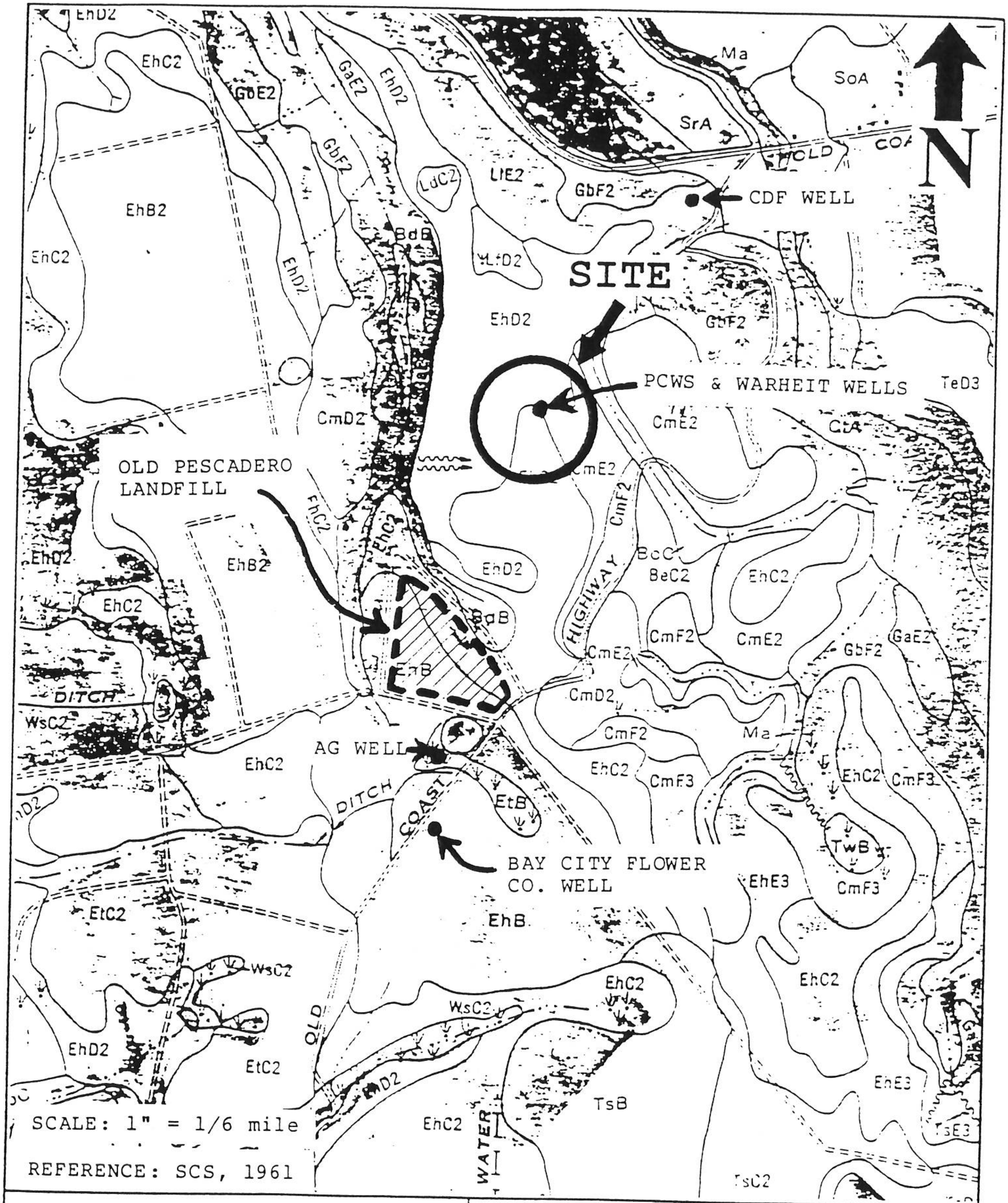
Figure 2. Preliminary Site Layout
Bean Hollow Housing Project
Pescadero, California



SCALE: 1" = 1/6 mile

REFERENCE: SCS, 1961

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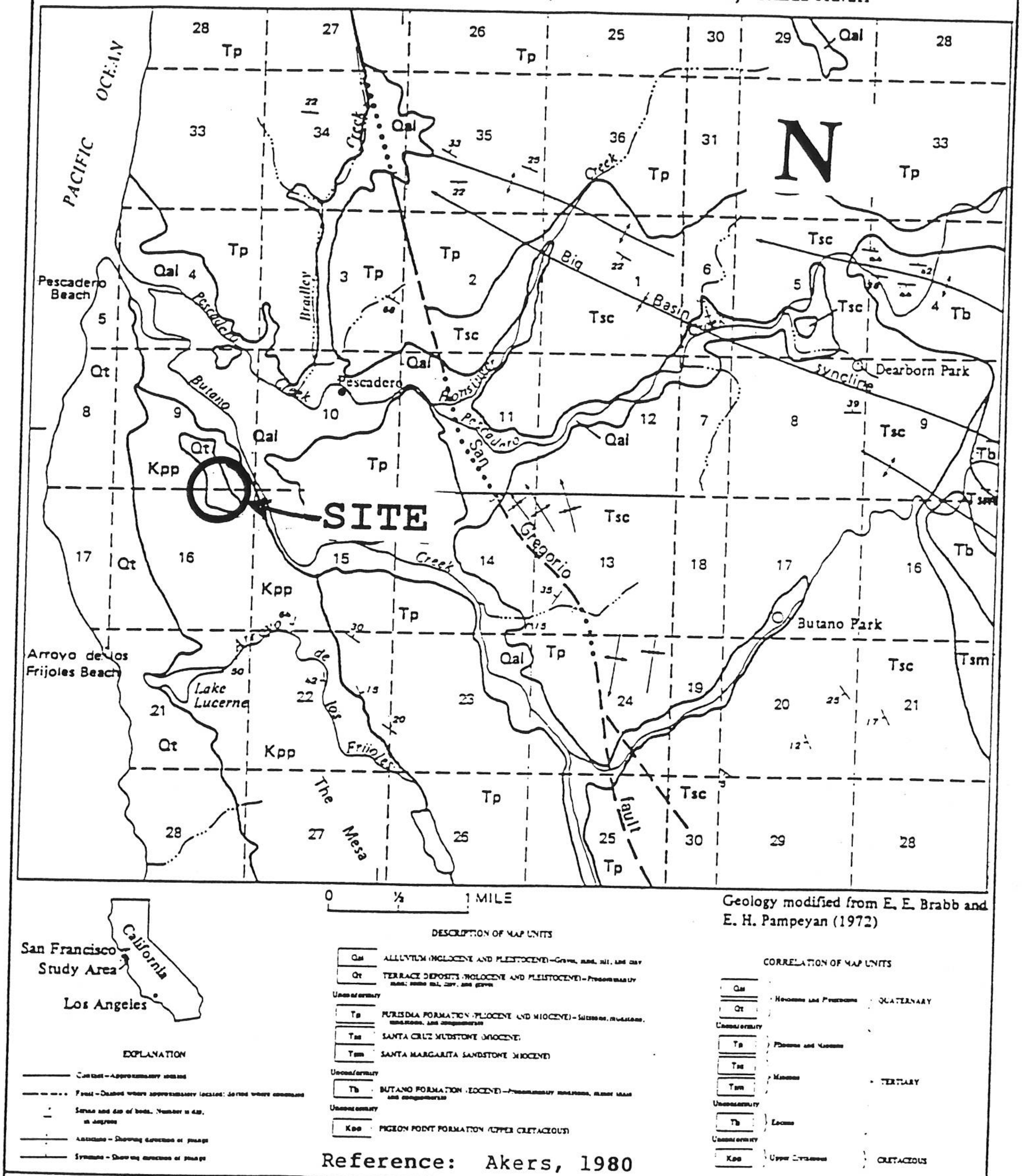
Figure 3. Soil Map
Bean Hollow Housing Project
Pescadero, California

2 POTENTIAL FOR GROUND-WATER SUPPLIES, PESCADERO AREA, CALIFORNIA



Geology modified from E. E. Brabb and E. H. Pampeyan (1972)

Reference: Akers, 1980

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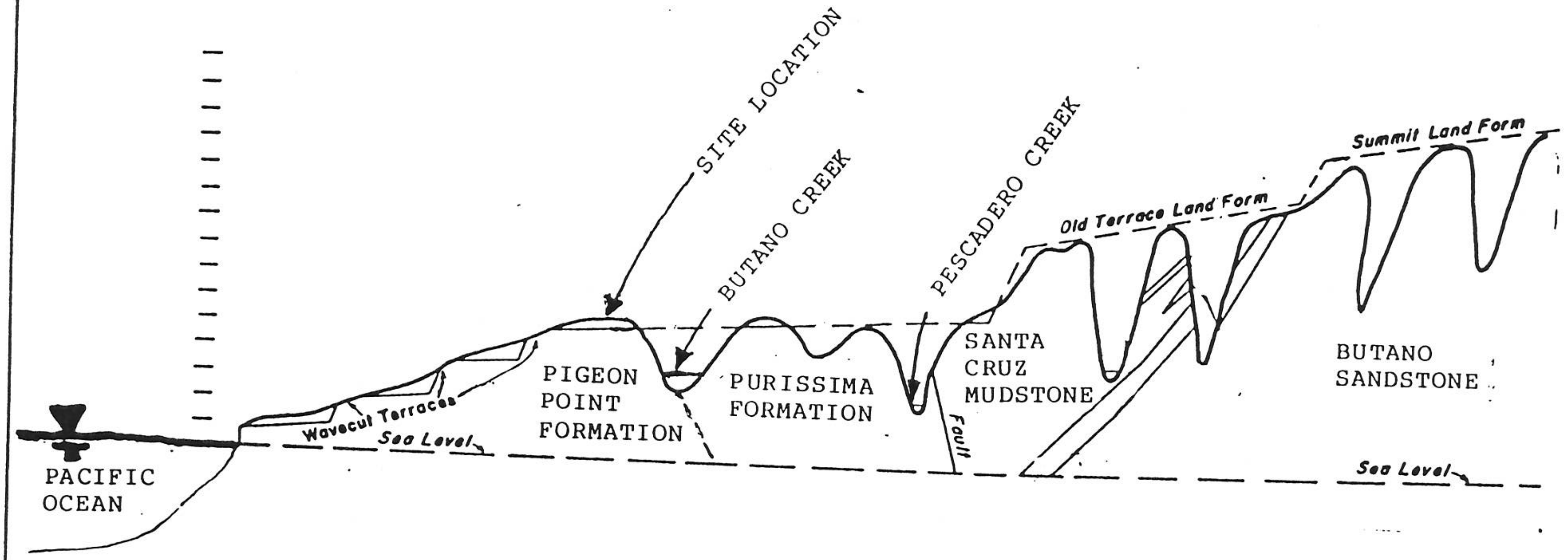
Figure 4. Surface Geology
Bean Hollow Housing Project
Pescadero, California



Modified From SCS, 1961

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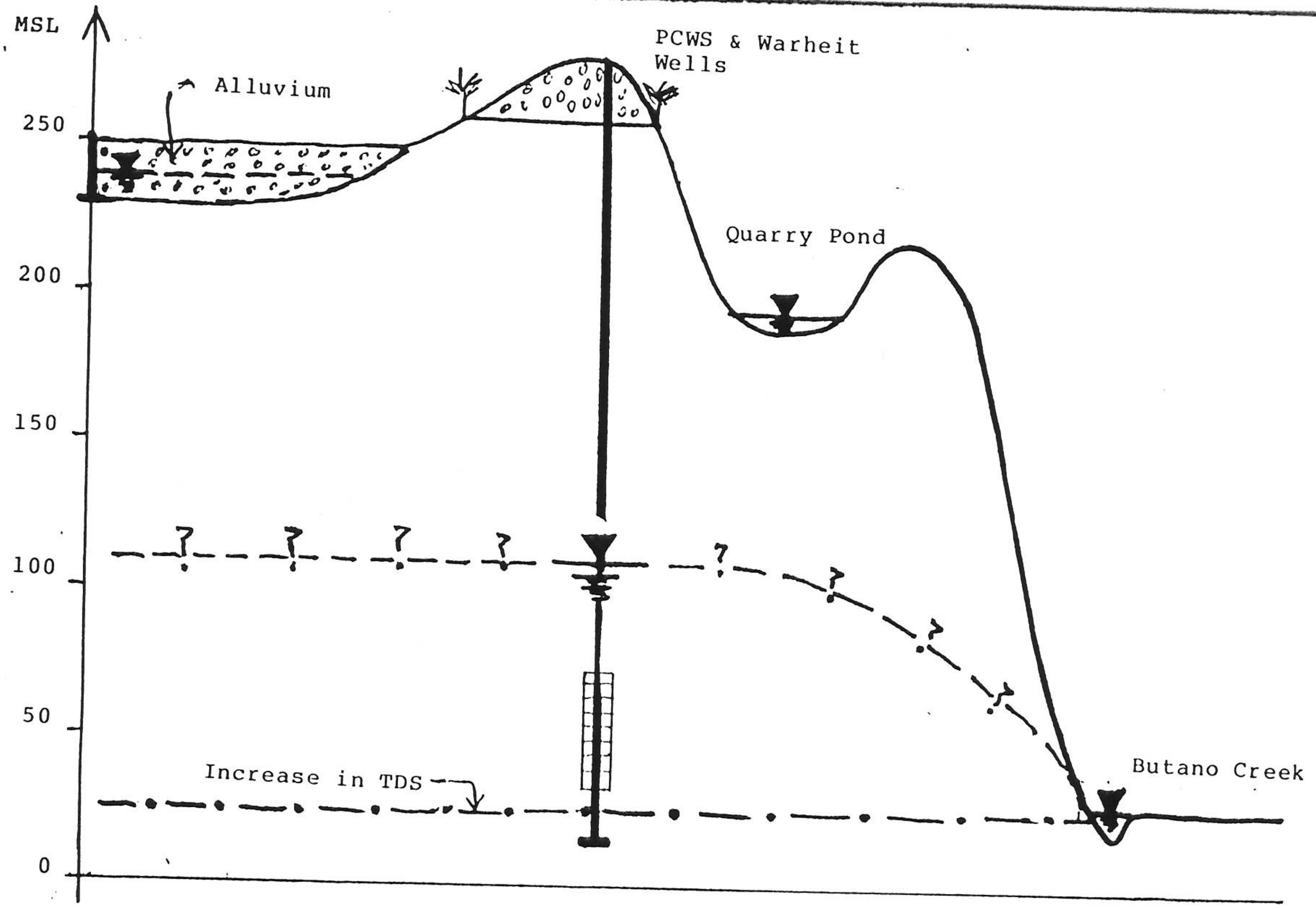
NO SCALE

Figure 5. Generalized Landforms in Site Vicinity
Bean Hollow Housing Project
Pescadero, California



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Horizontal Scale: 1" = 500'

Figure 6. Conceptual Diagram of Groundwater at Site BHHP
Pescadero, California

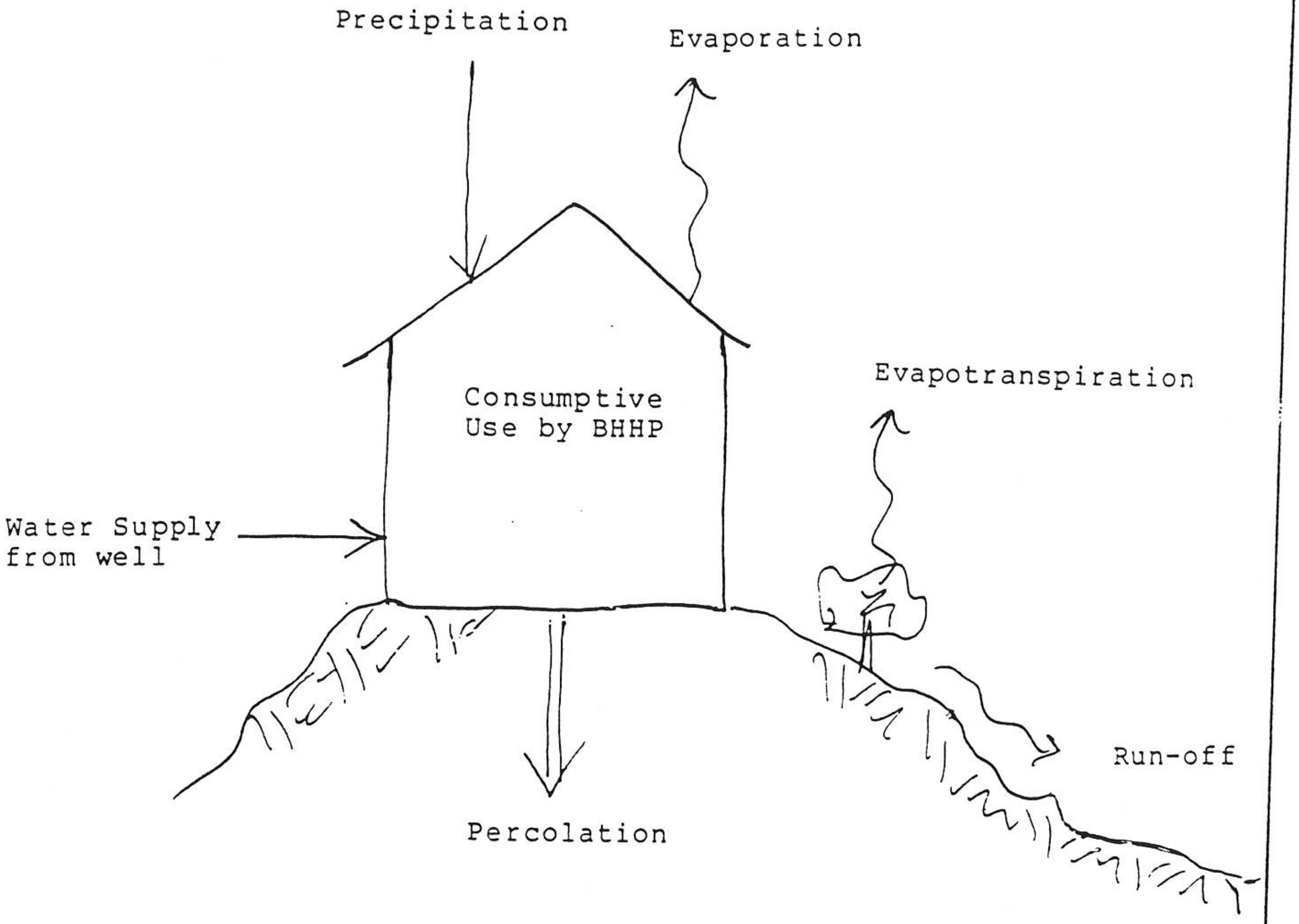

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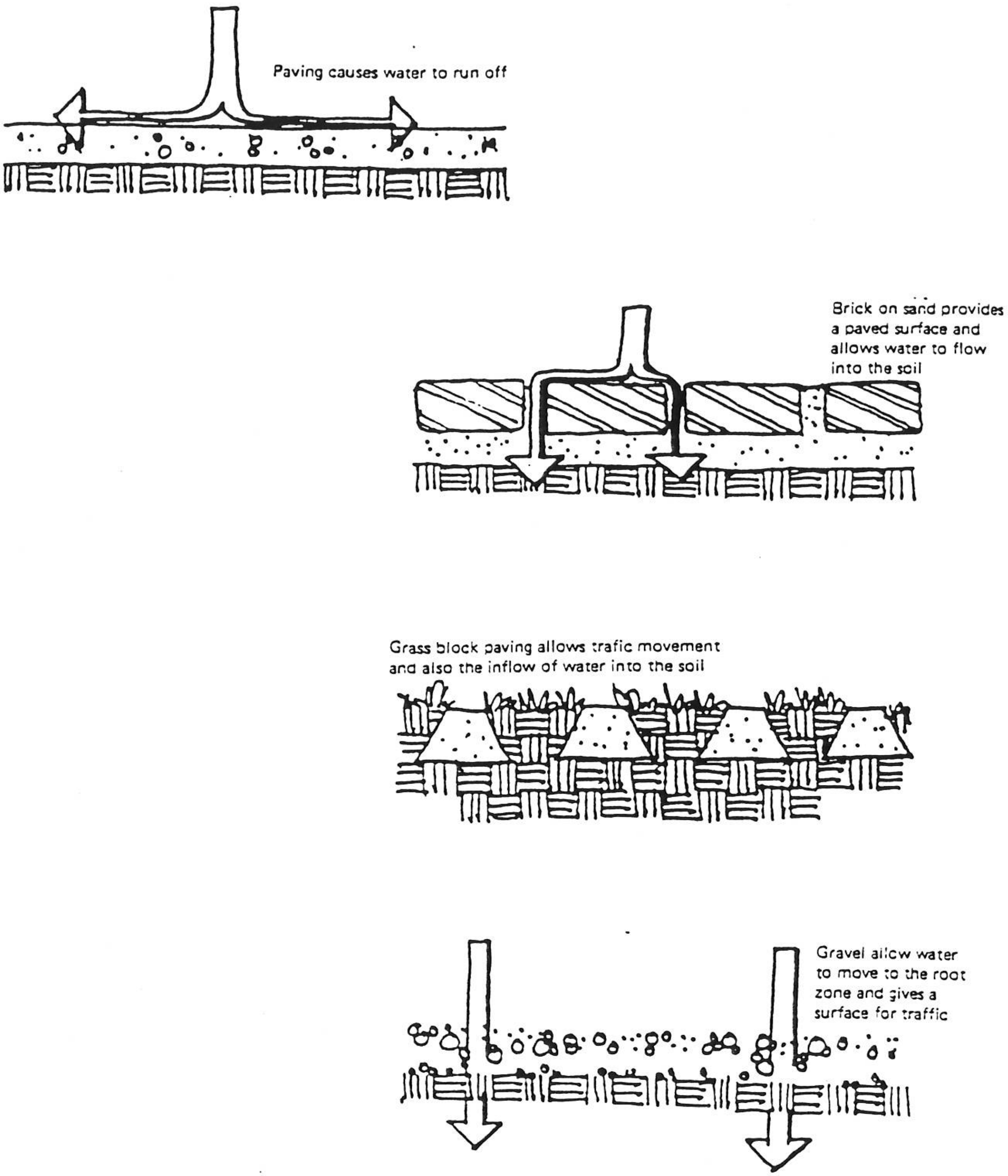
Figure 7. Water Balance Schematic
Bean Hollow Housing Project
Pescadero, California



Reference: Robinette, 1984

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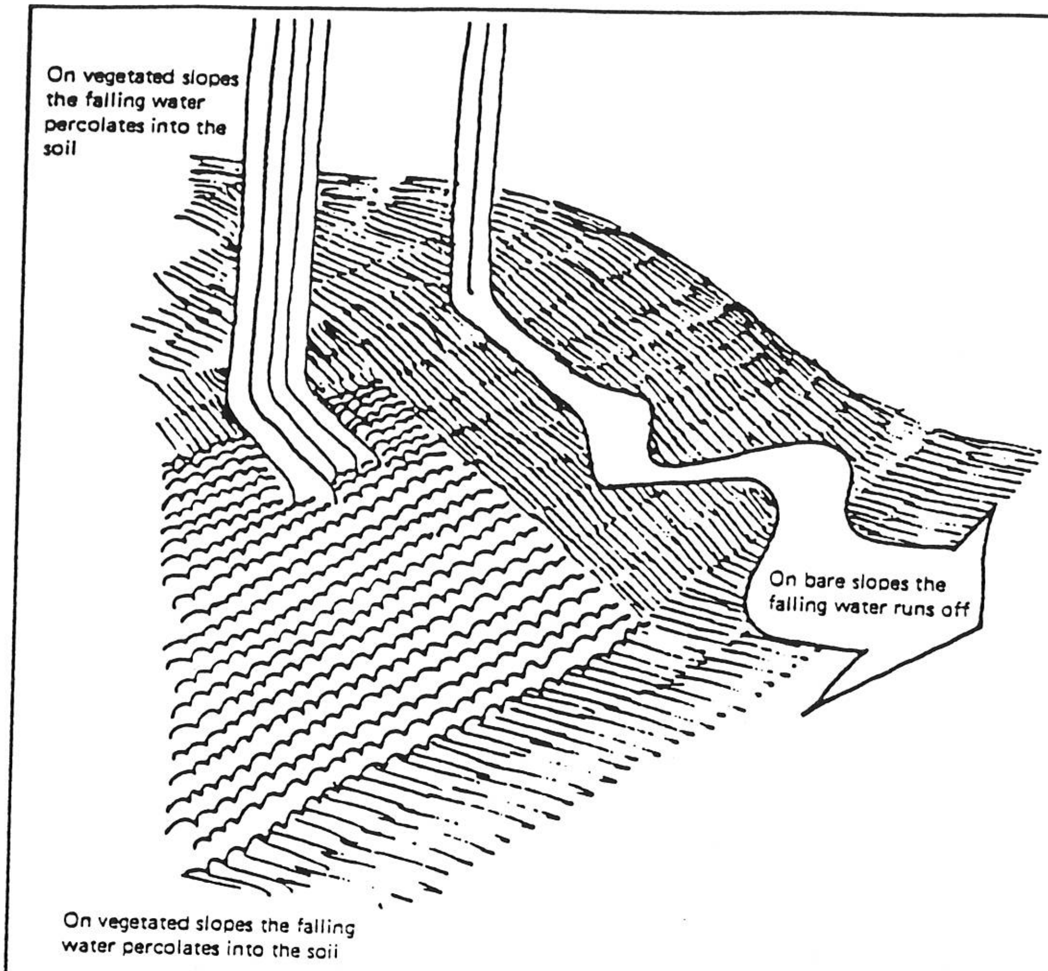
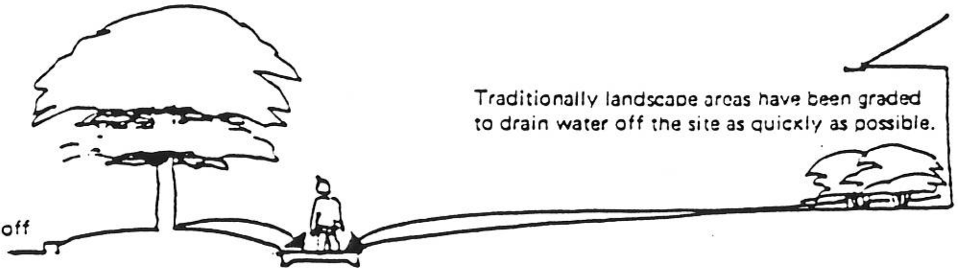
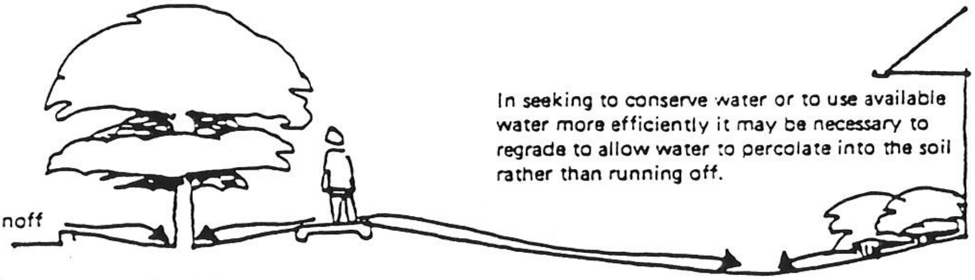
Figure 8. Pervious Parking Areas
Bean Hollow Housing Project
Pescadero, California







Reference: Robinette, 1984

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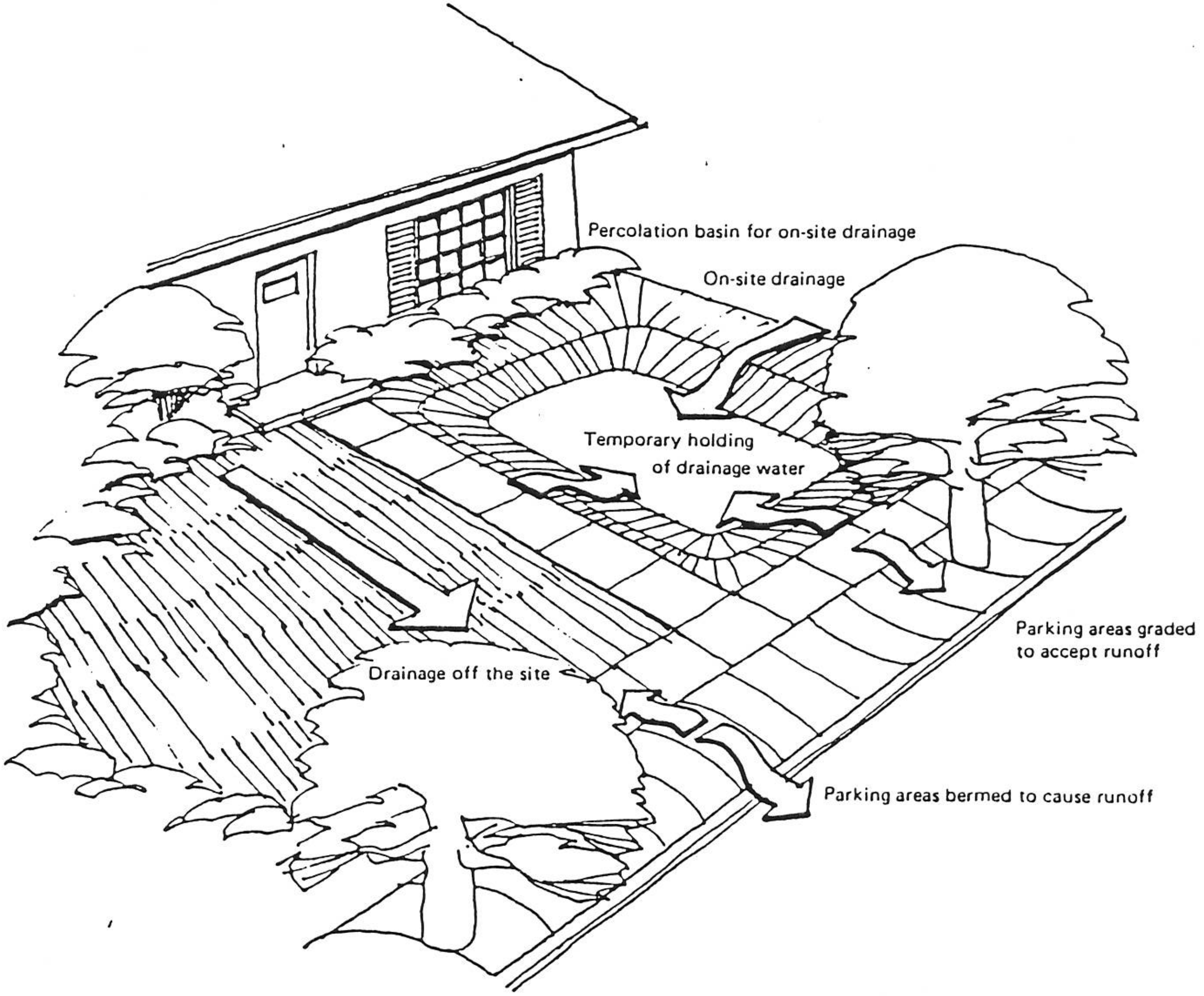
Figure 9. Run-off Reduction Concepts
Bean Hollow Housing Project
Pescadero, California



Reference: Robinette, 1984

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Figure 10. Rainwater Collection System
Bean Hollow Housing Project
Pescadero, California