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**HYDROGEOLOGIC ASSESSMENT OF
BEDROCK WATER WELL SITES
WITHIN THE MONTECITO WATER DISTRICT**

**for
MONTECITO WATER DISTRICT
Santa Barbara, California**

August, 1984

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INTRODUCTION

General Statement

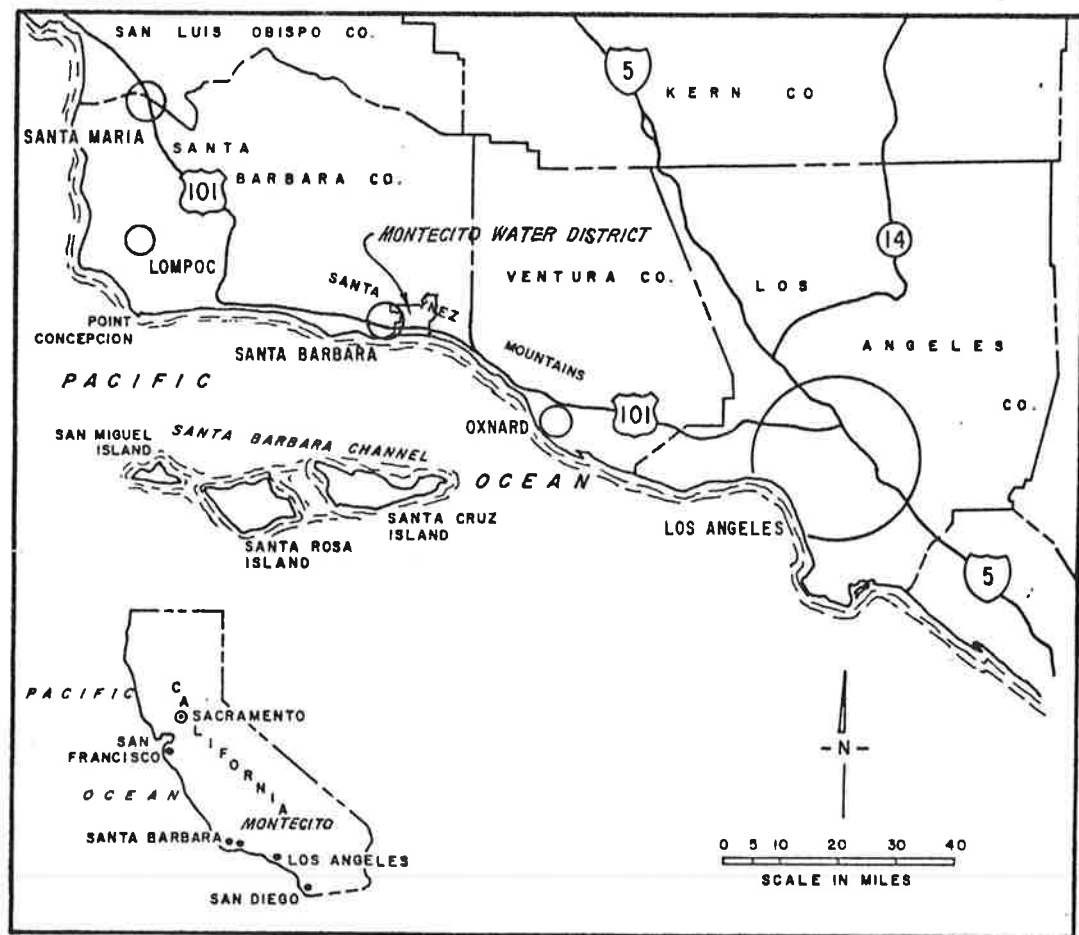
Presented in this report are the principal findings, conclusions, and recommendations developed as part of a hydrogeologic assessment of eight potential bedrock water well sites situated within the boundaries of the Montecito Water District (MWD). Each of the sites is located within the foothill margins of the Santa Ynez Mountains which flank the northerly boundaries of the service area of the District. The eight sites are informally designated as "bedrock" sites inasmuch as each is underlain by consolidated rock formations. Figure 1 - Location Map illustrates the location of the MWD service area.

Purpose And Scope

The purpose of this study was to assess the potential of constructing either a horizontally or vertically drilled water well at each of the sites. The eight properties are owned by MWD and were designated as sites to be evaluated for this study by the District. From east to west those MWD properties and their numerical designation include: Site No. 1 - Doulton, Site No. 2 - Picay, Site No. 3 - Bella Vista, Site No. 4 - Buena Vista, Site No. 5 - San Ysidro, Site No. 6 - Hot Springs, Site No. 7 - Cold Springs, and Site No. 8 - Terminal.

The District's criteria for considering a site as potentially favorable involves a well capable of an 80 percent production

Figure 1 - LOCATION MAP



rate at 50 gallons per minute (gpm). The 80 percent production rate is defined as the production of a well when pumped 80 percent of the year or 9.6 months out of the year. Thus, to satisfy these criteria for the District would require a yield of 64 acre feet per year per well per site.

The scope of work for this study was developed through meetings and discussions with Mr. C. Charles Evans, General Manager and Secretary of the Montecito Water District and was outlined in his letter dated May 15, 1984. Specific tasks involved the following:

1. Collection and review of previous studies and reports discussing the hydrogeology of the Montecito Groundwater Basin.
2. A site visit to each of the properties to assess geologic features, location with respect to the District service area, site access, tributary watershed size, and general topographic characteristics.
3. Review of geologic well log, water quality, water level and production characteristics data available from wells situated in the vicinity of each of the properties.
4. Hydrogeologic analyses of the above data, and
5. Preparation of this report presenting major conclusions and recommendations for further study, and preliminary cost estimates for test hole construction, if warranted.

For this report, several plates have been prepared to depict the location of the eight District properties, watershed/drainage areas tributary to each, geologic conditions, closely proximate wells, and other pertinent hydrogeologic data. A bibliography has been included at the end of this report.

FINDINGS

General Statement

Hydrogeologic features that characterize the Montecito area of Santa Barbara County have been discussed in several previous reports, notably that by the United States Geological Survey (1968), Geotechnical Consultants, Inc. (1974), and Michael F. Hoover (1980). All three reports generally delineated the hydrogeologic framework of the area and recognized the distinction between: unconsolidated deposits that form the topographically lower areas of the basin and which provide the majority of the higher capacity wells (i.e., those in excess of 25 gpm); and consolidated sedimentary rocks which are exposed throughout the topographically elevated bedrock areas to the north. Because more than one hundred water wells have been drilled within this latter area since the early-1970's, the area is recognized to display inherently low and variable water-yielding characteristics, based largely on that fact that water is stored and transmitted in fractures, joints, and along bedding planes in a complicated and poorly understood fashion.

General Hydrogeologic Features

As depicted on Plate 1 - Hydrogeology Map, the geologic formations in the region have been divided according to their relative water-bearing characteristics, that is, to their relative

ability to contain, transmit, and yield groundwater to wells. As such, two divisions are recognized: undifferentiated alluvial sediments and the consolidated rock group.

Historically, the alluvial-type sediments (map symbol, Qa1) have yielded the majority of groundwater extracted by wells in the Montecito area. For the most part, they are exposed throughout the gently seaward-dipping coastal plain which comprises the Montecito Water District, and as valley fill in the numerous creek channels in the region.

Underlying all undifferentiated alluvium in the coastal plain and in the canyons, and exposed at ground surface in the surrounding hills are geologically older consolidated rocks. Because of their lithified and/or cemented character, these rocks do not possess primary or interstitial porosity. Instead, they contain variable quantities (and qualities) of water along bedding planes, joints, shears and/or fractures. Based on work by others, including Lian (1954), these consolidated rocks underlying the District generally strike east-west and dip steeply to the north, typically greater than 60 degrees from the horizontal. Faults exist also, but as shown on Plate 1, none are known to occur near any of the eight prospective well sites in the northern portion of the District.

Consolidated rocks within the service area of MWD consist of the following (see Plate 1):

1. The Monterey, Rincon & Vaqueros formations of Miocene geologic age which are exposed in the Summerland area, and in and beyond the westerly boundary of the District. The shales of the Monterey and Rincon formations are nonwater-bearing, while rocks of the Vaqueros are known to produce moderate to large quantities of water to wells farther west in Santa Barbara County (no wells are known to produce from the Vaqueros in the Montecito area).
2. The alternating beds of vari-colored sandstone, siltstone and shale of the Sespe Formation of Oligocene age. Small quantities of water are occasionally extracted by wells in these rocks. Much of the northern portion of the District is underlain by Sespe rocks.
3. The massively-bedded, buff-colored sandstone of the Coldwater Formation of Eocene age. These rocks may yield small to moderate quantities of water to wells. These rocks lie in an east-west trending band roughly subparallel to the northern boundary of the District.
4. The shale and occasional sandstone interbeds of the Cozy Dell Shale of Eocene age are considered to be nonwater-bearing.
5. Interbedded, buff-colored sandstone and local shale interbeds comprise the Matilija Sandstone of Eocene age. These rocks may yield small to moderate amounts of water to wells and do provide natural inflow into portions of the unlined Doulton Tunnel. Except for the topographically rugged northerly half of prospective Site No. 1, these rocks are not exposed on any of the potential District properties.

A review of the location and production characteristics of wells drilled in the consolidated bedrock area does not suggest any obvious or systematic pattern of higher yielding wells relating to discrete hydrogeologic or geologic factors. If any generalizations can be made, wells which penetrate fractured sandstone units of the Coldwater Formation and wells situated in

the larger watersheds proximate to the drainage channels appear to display the more favorable water yielding characteristics. Furthermore, as discussed by Hoover (1980), bedrock wells within consolidated rock of the Sespe Formation display an inherently lower overall porosity and permeability as compared to the Coldwater Formation, and, hence, well yields from Sespe rocks tend to be more variable and groundwater is typically of a poorer quality.

A general review of well yields for wells drilled in the Sespe and Coldwater formations reveals sustained, reliable yields commonly on the order of 5 to 10 gpm. Many of the data on file with the District must be accepted with considerable caution inasmuch as many "reported" well yields were not developed through sustained long-term tests but rather through short-term, tests, typically on the order of several hours of air-lifting or blow testing performed by the well drilling contractor. Many of these short-term tests are considered misleading, inaccurate, and confusing. Moreover, Hoover (1980) reported numerous dry holes in the Sespe and even some of the successful wells often dewatered after prolonged pumping, which implies these rocks have limited storage capabilities.

Based on the above, the following site specific assessments are provided for each of the eight District properties.

Site Hydrogeologic Characteristics

Site No. 1 - Doulton. This site, referred to as the Doulton site due to its location with respect to the south portal of the Doulton Tunnel, is located within the easterly Toro Canyon drainage area of the MWD and includes a property of approximately 40 acres (see drainage conditions on Plate 2 - Watershed Map). Elevations at the site are on the order of 1900 to 1950 feet although a maximum elevation of 2500 feet occurs at the northern edge of the property. The majority of the property is inaccessible due to steep terrain. Because of the topographic conditions, the only flat and accessible area on the property occurs at and in the immediate vicinity of the existing water storage tank.

Rock units at the site consist of: a steeply north-dipping sequence of massive to thinly bedded, but well-bedded and well fractured/jointed sandstone assigned to the Matilija Formation in the steep, northerly half of the property; and dark-colored silty shale and occasional sandstone interbeds of the Cozy Dell Shale in the southern half of the site (see Plate 1). Structurally, bedding is overturned to the north.

The watershed size above the most southerly site area, i.e., at the chlorination tank, is on the order of 130 acres and consists of a steeply south-sloping, bowl-shaped type catchment area. At the time of my site visit on June 1, 1984, the creek was dry, suggesting no upstream baseflow or springs. One spring

is known to occur in the watershed to the east as shown on Plate 2.

Data on file with MWD indicates two water wells/test holes have been constructed within 1500 feet of the property, both drilled within shale and sandstone of the Cozy Dell Shale. These borings, including others drilled proximate to the remaining seven District sites, are illustrated on Plate 3 - Well Location and Water Sampling Map. The 2 holes near Site No. 1 include well No. 70E and well No. 70G. It should be noted that all well number designations and locations used in this report are those provided directly by MWD except for a few holes near Site No. 4 which were obtained from independent sources.

MWD data show that well NO. 70E was drilled in 1976 into blue sandstone to a depth of 158 feet, and was completed with 5-inch diameter PVC pipe having perforations from 98 to 150 feet. No pump test or water quality data are available, suggesting the hole may be dry. Well No. 70G lies southeast of the site and was drilled in 1976 to a depth of 210 feet; it was completed with 5-inch diameter PVC pipe with perforations from 110 to 210 feet. No pump test or water quality data are available although the driller reported a static water level of 10 feet (prior to completion) at the time of drilling. The static level likely represents the depth at which water, likely in the form of

seepage, was first encountered. Limited water quality data suggest a calcium bicarbonate character and a total dissolved solids concentration (TDS) of 500 mg/l or less. Groundwater infiltration into Doulton Tunnel has a calcium bicarbonate character also and a TDS less than 400 mg/l.

Using a 130-acre watershed size, an average annual precipitation of 26 inches (SBFC & WCD, 1975), and an assumed groundwater recharge factor of 5 percent, the total potential recharge to an onsite, vertical bedrock well would be on the order of 14-acre feet per year (acft/yr). Well yields would likely be about 5 gpm. Bedrock dips steeply to the north, thereby minimizing an effective recharge mechanism.

Horizontal wells driven at shallow inclinations to the north from the site could be expected to be of limited value due to local presence of the unlined Doulton Tunnel. Being unlined, this tunnel is known to intercept a few hundred acft/yr of groundwater from the region; reportedly, most of these inflows into the tunnel occur northeasterly of a point a few thousand feet from the South Portal at the site.

For these reasons, the site is considered a poor prospect for groundwater development for the District.

Site No. 2 - Picay. The Picay site is located approximately 1500 feet northeast of the intersection of Ladera Lane and Bella Vista Drive and falls within the west branch of the Toro Canyon

Creek drainage area. The property is provided with only limited access and has a level pad area of only approximately 200 by 40 feet; the entire property encompasses perhaps 2 to 3 acres. The west branch of Toro Canyon Creek flows immediately east of the site at an elevation roughly 50 feet below the pad elevation which is approximately 1250 to 1300 feet. Steep and rugged topography occurs on all sides of the pad.

Thickly-bedded to massive, hard sandstone of the Coldwater Formation is exposed on the site; bedding dips at angles greater than 45° to the north (see Plate 1).

As shown on Plate 2, the watershed tributary to the Picay site is roughly square-shaped and encompasses approximately 325 acres. The upper reaches of this drainage area occur along the crestal elevations of about 3000 feet at the major divide with the watershed to the north.

Surface flow in the creek to the east was noted on June 1, 1984 and estimated to be 20 to 25 gpm. Water quality measurements at a point approximately 2000 feet south of the property indicated an electrical conductivity value of EC=1150 umhos/cm, a pH of 7.8, and a slight hydrogen sulfide odor. Flow at this point (shown on Plate 3) was approximately 10 gpm.

Two test holes/water wells have been drilled within 1000 feet of the property in what would be considered similar consolidated rock units; neither well lies in the same watershed of the Picay site however. Well No. 70B, located approximately 700

feet to the east and along the margin of the local drainage divide was drilled in 1977 to a depth of 207 feet into yellow and blue sandstone; perforations are from 107 to 207 feet. The static water level at that time, i.e., after well completion, was measured at 100 feet below ground surface; a discharge of 5 gpm was recorded although the length of the test and test procedure were not recorded.

Well No. 70A, located approximately 700 feet southwest of the property and immediately adjacent to Toro Creek, was drilled in 1977 (drought period) to a depth of 200 feet and was completed with 5-inch diameter steel casing having perforations from 70 to 190 feet; materials penetrated included blue and yellow sandstone of the Coldwater Formation. The static water level after completion was given as 28 feet below ground surface; a well yield of 50 gpm was recorded after 5 hours of testing. Neither the method of testing nor the associated drawdown was reported.

Review of Plate 3 suggests that Well No. 70A is located within an upstream drainage area of some ± 400 acres, and, perhaps more importantly, may be situated ideally at a topographically-low canyon mouth and resulting point for ground-water discharge. Comparison to the MWD-owned Picay site reveals similar geologic materials, i.e., sandstone of the Coldwater Formation and a similar disposition with respect to drainage area discharge and creek recharge.

A discrepancy is noted between the date of drilling indicated on the State well log filed by the driller (Alexander Brothers) given as May of 1978 and that reported on the work sheet completed by the MWD, listed as May of 1977. The former date is likely correct on the basis of sequential numbering provided on the DWR well log filed by the contractor (and has been corroborated by personal communication with MWD on August 28, 1984). The date is important inasmuch as the relatively high well yield, if recorded during 1977 (i.e., near the end of a two-year drought in the southern California area), would be considered as a very favorable well yield. The heavy rains in early-1978 reversed the drought cycle and may partially explain the relative success of this well at that time. Nonetheless, the favorable well yield suggests a comparable well yield could be achieved at the MWD Picay property.

Using a 325-acre watershed size, average annual watershed precipitation of 28 inches, and an estimated recharge capability of 5 percent, the total potential recharge to the site would be the order of 40 acft/yr. The fact that surface flows of 25 gpm were still occurring in the adjoining creek in June 1984, which was preceded by a below-normal rainfall year, suggests that this site has potential for a future test hole. Limited downstream surface quality is demerited slightly by the presence of hydrogen sulfide, but the source of the H_2S is not known at this time. No quality is available for the two proximate wells. Because of the limited pad size, it would not be possible to construct several

wells on this site; mutual well drawdown interference would likely be high in this event. Hopefully, one well would produce the required supply.

Site No. 3 - Bella Vista. This site consists of about 50 acres and is located immediately north of the intersection of Ladera Lane and Bella Vista Drive (refer to Plate 1). Onsite elevations from south to north range from 750 feet to about 1600 feet, although the pad elevation is near 1050 feet. An existing concrete water storage reservoir owned by MWD exists at the site and was constructed in the mid-1970's. The topography at the reservoir site is gentle but becomes rugged, steep, and inaccessible to the north. Potential well sites would be limited to the area immediately adjacent to the existing reservoir.

The geology of the site is described in a report prepared by Geotechnical Consultants, Inc. (1973) and consists of massively bedded, north-dipping, well-jointed sandstone of the Coldwater Formation (Plate 1). Of importance is that the site is situated in a topographically elevated area closely proximate to the crest of the local drainage divide. Hence, recharge is likely limited and groundwater likely flows away from the site. Total local watershed size is less than 60 acres (see Plate 2).

Several water wells or test holes have been drilled within 1000 feet of the site (refer to Plate 3), all of which have been completed within strata of the Coldwater Formation; a few (namely

70D and 70J) may actually have begun drilling in the Sespe Formation (refer to Plate 1). Well 70D, located approximately 200 feet south of the property was drilled in 1981 to a depth of 330 feet with perforations from 60 to 330 feet. Materials encountered included gray and yellow sandstone of the Coldwater Formation. The static water level at the time of drilling was recorded at a depth of 50 feet, and a well yield of 25 gpm was recorded after a 24-hour pump test. A drawdown of 97 feet was measured, resulting in a specific capacity of 0.25 gpm per foot of drawdown. The yield of this well appears anomalously high considering the size and location of the well relative to the watershed. The well is located immediately downgradient of the MWD-owned Bella Vista Reservoir.

An additional well, No. 70F, is located about 600 feet west of the Bella Vista site and was drilled in 1976 to a depth of 130 feet, with perforations from 50 to 130 feet. The well was bailed at 15 gpm but was not tested by a pump. Water quality, which is likely representative of the general area, is calcium-sodium bicarbonate in character, with total dissolved solids concentration in the range of 425 mg /l. An additional test hole, No. 70H, is located approximately 1200 feet west of the property and was drilled in 1977 to a depth of 570 feet, but was recorded as a dry hole.

Using a 60-acre watershed area, an average annual rainfall of 23 inches, and an estimated recharge to the site of 5 percent, the total potential recharge to the property would be on the order of 10 acft/yr or less. For these reasons, the site is considered a poor prospect for groundwater development for the District.

Site No. 4 - Buena Vista. The Buena Vista site consists of approximately 2 to 3 acres of generally rugged and steep terrain. The site is presently occupied by a MWD-owned concrete reservoir, but access to the remainder of the site is severely restricted. Pad grade for the reservoir is near elevation 725 feet; total relief on the property is about 100 to 150 feet. Though a paved road leads to the pad area, there is no vehicular access at all to the remainder of the property.

The geology of the site consists of massively bedded hard sandstone assigned to the Coldwater Formation. Bedding is overturned to the north, with dips of greater than 65° from the horizontal (see Plate 1).

As depicted on Plate 2, the property occupies a ridge immediately east of Buena Vista and on the margin of a tributary watershed comprising about 375 acres. The adjoining creek channel was moist on June 1, 1984, but there was inadequate free water to sample in order to identify water quality parameters.

In the creek channel offsite to the southeast, a creek flow of 1 gpm was noted, together with the following quality parameters: EC = 1244 umhos/cm, pH = 8.05, and no H₂S odor.

Within the area as many as ten water wells/test holes have been drilled and for which data are on file with the MWD. Three wells, those listed as Nos. 66A, 66B, and 64A are located approximately 500 to 750 feet south west of the property, and all contain perforations in and produce water from the Coldwater Formation. Characteristics of these wells are summarized on Table 1-Data for Wells Near Buena Vista Site. Of these wells, only the Pfau well is located in the watershed that is tributary to the Buena Vista property.

The data on Table 1 appear to imply that the watershed/property provide limited recharge potential and/or that the local porosity/permeability characteristics of the Coldwater Formation are not as high relative to the adjacent areas. Also, it is reported that a horizontal well was drilled some time in the 1920's by the Buena Vista Water Company within Buena Vista Creek approximately 1000 feet north of the property. Yields from this tunnel/horizontal well were reportedly as high as 10 acre-feet per month; flow from this well is presently about 14 gpm. Diversion of this water may also partially explain the somewhat lower well yields displayed by the adjacent Park Lane Hills wells.

TABLE 1 - DATA FOR WELLS NEAR BUENA VISTA SITE

Well No.	Date Drilled	Depth (feet)	Perforations (feet)	Yield (gpm)	Type of Test
66A (a)	9-78	175	n.a.	7 @ 150 ft.	24-hour
66B (a)	7-78	215	n.a.	30	long-term
64A (a)	1-80	440	50-400 (?)	40	blow test
Park Lane 1(b)	11-81	420	140-400	20 @ 87 ft.	24-hour
Park Lane 2 (b)	3-82	380	50-200	15 @ 105 ft.	24-hour
67A(c)	6-78	420	n.a.	40	long-term (1)
67B (c)	3-77	340	100-340	30 @ 300 ft.	blow test
67C (c)	10-77	360	100-320	20+	blow test
67D (c)	3-77	300	140-300	30 @ 280 t.	blow test
67E (c)	3-77	380	180-380	30 @ 375 ft.	blow test
67F (c)	10-77	320	80-310	15+ (2)	blow test
Pfau (d)	n.a.	250	n.a.	8	n.a.

* n.a. - not available

(1) Test pump data reportedly on file with MWD.

(2) Reported high iron and manganese ion concentrations.

(a) Located in San Ysidro Creek watershed with tributary drainage of 2000+ acres.

(b) Located in Buena Vista Creek watershed with tributary drainage of 500+ acres. Data not on file with MWD.

(c) Located in East Fork Buena Visa Creek watershed with tributary drainage of 500+ acrs.

(d) Located 200 feet west of the property. Data not on file with MWD.

Relatively high yields are consistently reported by wells further to the east as shown on Table 1 (see data for wells 67A through 67F). However, none of these wells lie within the Site 4 watershed, although they would be extracting from similar rocks of the Coldwater Formation. Based on limited data, groundwater appears to be of calcium sulfate-bicarbonate character, with TDS on the order of 80 to 1000 mg/l, and with iron and manganese at or near State limits.

Based on a 375-acre watershed, an average annual rainfall of 23 inches, and an assumed recharge to the site of 5 percent, the total potential recharge to the property would be on the order of 35 acft/yr. Because of this and the upstream diversions, and due to the ridge-top locations of the pad in the watershed, drilling of a test hole/water well at this site is considered marginal.

Site No. 5 - San Ysidro. The San Ysidro property occupies an approximate one-acre parcel north of Mountain Drive along San Ysidro Lane. The property is situated along the eastern boundary of the Oak Creek drainage. Pad grade for the existing San Ysidro reservoir is about 670 feet. Site geology consists of interbedded and thinly bedded sandstone and shale of both the Coldwater and Sespe formations. Bedding dips to the north at 40 to 60 degree angles.

Plate 2 reveals the property falls within but near the upper, northeasterly margin of the Oak Creek drainage area. The

watershed tributary to the site is very small, only about 10 acres.

One water well, that listed as 64C by the MWD, is located just south of the site. Well No. 64C was drilled in July, 1978 to a depth of 300 feet and was completed with 5-inch PVC having perforations from 200 to 300 feet. The static water level after completion was recorded at a depth of 200 feet. On the basis of a short-term "blow test", the yield of this well was recorded at 65+ gpm. No other data regarding this well are available. Several other wells reportedly are located further to the north, although no data exist for these wells in MWD files; these other wells are not shown on Plate 3.

Groundwater data from well 64C was obtained during the field reconnaissance on June 1, 1984 and included: EC = 2810 umhos/cm, pH = 7.93, T = 23.9°C, and a moderate H₂S odor. The well was being airlifted at a rate of 20 gpm at the time of the site visit. It likely produces from the Sespe Formation.

Based on the very small watershed area, the lack of adjoining stream canyons, poor logistics for site drilling, no potential for horizontal drilling due to lack of topographic relief, and the local presence of shale, this site is not considered amenable to future groundwater development.

Site No. 6 - Hot Springs. The Hot Springs site is situated immediately east of Hot Springs Creek and about 30 to 35 feet

above the adjacent creek bottom elevation. This site occupies a relatively flat pad which supports the Hot Springs reservoir. The reservoir encompasses nearly the entire site, with the small remainder of the property descending steeply into the creek channel to the west. Pad grade is near elevation 775 feet. Equipment access on the pad is limited strictly to the easterly side of the reservoir.

Site geology consists of a thin cap of fanglomerate/terrace deposits likely less than 50 feet in thickness as indicated on drillers' logs (viz. well No. 75A), which are in turn underlain by sandstone of the Coldwater and then the Sespe formations. These units are overturned and dip steeply to the north (see Plate 1).

As shown on Plate 2, as many as five water wells have been drilled within several hundred feet of the property. Pertinent data from each are summarized on Table 2 - Data for Wells Near Hot Springs Site. As indicated, well depths are in excess of 300 feet, and yield is quite variable, i.e., from dry to as much as 40 gpm (see note for well 75B). From Plate 1, it is probable that wells 62C, 75A and 75B produce from the Coldwater Formation, while wells 63C and 63D produce from Sespe rocks. In addition, the three former wells lie within the same tributary watershed as that of the proposed property, while the latter 2 wells are situated in a lower drainage area (see Plate 2).

Table 2 - Data for Wells Near Hot Springs Site

Well No.	Date Drilled	Depth (feet)	Perforations (feet)	Yield (gpm)	Type of Test
62C (1)	7-78	300	140-290	15	n.a
75A (2)	6-77 (3)	460	200-460	35+	6-hour pump
75B (a)	5-78	340	50-340	150 (4)	blow test
63C	10-77	380	120-280	20+	blow test
63D	10-77	340	100-300	dry	-

* n.a. - not available

- (1) Well treated by Culligan softener for high manganese ion concentration.
- (2) Within 200 feet of property.
- (3) During drought.
- (4) Subsequent long-term pump test for this well indicated a yield of 40 gpm.

Tributary to Site No. 6 is a watershed occupying approximately 450 acres in the upper and middle reaches of Hot Springs Creek (refer to Plate 2). Springs are known to exist in the canyon further north of the property. Reportedly, the Montecito Creek Water Company diverts water from these springs. Observation of the creek bottom on June 1, 1984 noted the alluviated channel was damp only; no live flow existed.

Available quality data reveal: well 62B has a TDS = 624 mg/l, and some color and turbidity problems; well 62C has high

manganese levels; well 75A has very high iron concentrations, a sodium bicarbonate character and a TDS = 350 mg/l.

Based on a 450-acre watershed, an average annual rainfall of 21 inches, and an assumed groundwater recharge of 5 percent, the total potential recharge to the property would be on the order of 40 acft/yr. However, the site has a good location within the watershed.

Based on the above information, the Hot Springs site appears amenable for potential test hole drilling. Future construction should note any differences in water quality between the Coldwater and underlying Sespe formation rocks at this site.

Site No. 7 - Cold Springs Site. The Cold Springs property consists of an approximate two-acre site located 600 feet east of Chelham Creek. Cold Springs Reservoir occupies the pad near elevation 860 feet. Topographically, the property has relatively gentle relief, a reflection of the poor resistance to weathering of the underlying Sespe formation rocks. Shale predominates on the property, though sandstone interbeds are present. Beds are overturned and dip at 70 to 80 degree angles to the north (see Plate 1).

Plate 2 reveals that the property lies within a small sub-watershed of the Chelham Creek watershed. East of the watershed divide of the site is the separate watershed of Cold Springs Creek (this creek is about 1500 feet from the property).

MWD data reveal that one well, 73A was drilled proximate to the site (Plate 3). This well was drilled in April 1978 to a depth of 215 feet, and was completed with 5-inch diameter casing having perforations from 95 to 215 feet. Well yield was listed as 13 gpm. No nearby groundwater quality data were encountered. The nearest surface water information is from the adjoining Cold Springs Creek watershed where, on June 1, 1984, the following were noted (see Plate 3): flow of 75 gpm, EC = 742 umhos/cm, pH = 8.02, T = 17.8°, and no H₂S odor.

Using a tributary watershed area of 20 acres, an average annual rainfall of 22 inches, and an assumed groundwater recharge of 5 percent, the total potential recharge to the property would be on the order of 2 acft/yr.

Based on the above information, further consideration of the Cold Springs site for groundwater extractions in the future required volumes does not appear to be warranted.

Site No. 8 - Terminal. This property consists of approximately 4 to 5 acres of relatively flat to gently sloping land situated north of Mountain Drive in the northwestern corner of the MWD service area. Occupying the cut pad on the site is the MWD Terminal Reservoir, near elevation 860 feet. Site relief is on the order of 150 feet.

Site geology consists of the fanglomerate deposits underlain by steeply north-dipping interbedded shales and siltstone of the

Sespe Formation. Bedding continues to be overturned, and dips on the order of 70 to 80 degrees to the north predominate as illustrated on Plate 1.

Plate 2 information indicates the terminal site lies west of Chelham Creek but still within its drainage area. The watershed of Chelham Creek that is tributary to this site comprises about 150 acres. The channel of Chelham Creek adjoining the site lies 15 to 20 feet below pad elevation and was noted to be dry on June 1, 1984.

Data are available from one well, that listed as well No. 72B, located approximately 500 feet west of the site (see Plate 3). The well was drilled in December, 1979 and would appear to be a dry hole. Several other wells located further west and at comparable elevations, notably well Nos. 72A and 65A, reportedly yielded from 5 to 10 gpm. No quality data are available for this well or the nearby Chelham Creek.

Based on the 150-acre tributary watershed, 22 inches of annual rainfall, and an assumed groundwater recharge factor of 5 percent, there would be on the order of 14 acft of potential recharge to the site each year.

Based on the above factors, this site does not appear to possess the potential to produce groundwater of adequate volumes to meet District needs.

CONCLUSIONS AND RECOMMENDATIONS

1.0 General Statement

Based on the above findings, it appears to be hydrogeologically feasible for the Montecito Water District to drill vertical exploratory borings on at least two of the eight District properties evaluated during this assessment. The properties displaying the best potential for groundwater development include the Picay and Hot Springs sites.

The purpose of these exploratory holes will be to validate the capability of a future well of providing the appropriate quality and requisite supply of a 50 gpm well at an 80 percent production rate, even during a two-to-three-year drought. Projections of groundwater supply to these wells beyond a 2- or 3-year drought are not readily feasible with available data.

2.0 Site Priorities

The following table (Table 3-Site Prioritization) qualitatively summarizes, from a hydrogeologic perspective, the potential priority of the eight sites.

Table 3 - Site Prioritization

<u>Site No.</u>	<u>Remarks</u>	<u>Potential Priority</u>
1	- Small watershed, potential low yields, proximate interception of water by tunnel	No
2	- Relatively large watershed, creek flow nearby, favorable yields in proximate wells, bedrock ok	Yes
3	- Small watershed, poor location in watershed, marginal yields in proximate wells	No
4	- Large watershed but poor location in this watershed, some upstream diversions, bedrock ok	Marginal
5	- Very small watershed, potential poor bedrock, poor nearby water quality	No
6	- Very large watershed, favorable yields in proximate wells, some upstream diversions, verify quality	Yes
7	- Very small watershed, no nearby creeks, poor geology, poor yields in nearby wells	No
8	- Small watershed, dry nearby creek, marginal yields in nearby wells	No

2.1 Key Sites.

As indicated, both Site Nos. 2 and 6 display a favorable potential for developing a groundwater supply. Both have relatively large tributary watersheds (325 acres-Site 2, and 450 acres-Site 6), both are in favorable locations in their respective watersheds, both are located adjacent to or proximate with other properties having favorable well yields, and both contain

Coldwater sandstone (although deep drilling at Site No. 6 may encounter the Sespe Formation because bedding in the rocks is overturned).

At these two sites, it is recommended that at least one test hole be drilled, geologically logged, electric logged, (caliper and sonic logs), and then tested for long-term yield, quality, and drawdown. If the results are favorable, a production well can then be designed and completed. Cost estimates and drilling guidelines are presented in Section 3.0.

Besides well yields, water quality remains a major unknown. It is recommended that quality be tested while the exploratory borings are being pump tested. Hydrogen sulfide is known to occur, but its presence is spotty in bedrock wells; high iron and manganese concentrations occur also but such data are particularly meager.

Other recommendations include: determine the surface water quality (including H_2S) in the creek directly adjoining Site No. 2-Picay; consider obtaining rights-of-way to drill a test hole on the private property just north of Site No. 6-Hot Springs because access to the Picay property for a drill rig is strictly limited to the east side of the reservoir.

2.2 Marginal Site.

According to Table 3, the Buena Vista Site (No. 4), has a marginal potential priority. This property has a large tributary watershed (375 acres) but may not be as ideally located in its watershed as the other sites are in theirs.

An immediately adjacent well, that owned by Pfau, displayed a yield of about 8 gpm although the drawdown and method of testing are unknown. Adjacent wells, notably those drilled for Park Lane Hills, displayed yields of between 15 and 20 gpm with specific capacities on the order of 0.4 to 0.6 gpm/ft of drawdown after 24-hour continuous tests. Yields of 40 gpm for Park Lane well No. 1, however, displayed a drawdown of 220 feet which did not stabilize after 24 hours of test pumping (unpublished report prepared by Mike Hoover). Such data suggest a 50 gpm well at the Buena Vista site is marginal and possibly could not likely maintain a sustained yield greater than 20 gpm on a 80 percent operational basis. It is, however, interesting that relatively larger diversions are available from an upstream horizontal well.

3.0 Specifications and Costs

Well specifications for either the Picay or Hot Springs sites should be approached strictly on a test hole basis utilizing the air rotary/air percussion method. Drilling muds should not be used, as they tend to plug off rock fractures.

Test holes into the Coldwater Formation should be of 6 inches in diameter and extend to approximate depths of 500 feet.

The test hole should be electric logged and water quantity/quality preliminarily evaluated through pumping for a minimum of twelve hours with the pump intake set at variable depths to assess drawdown characteristics. Test hole drilling by the air rotary method is presently costing on the order of eight to ten dollars per foot. Hence, construction of a 500-foot hole, including mobilization, would likely cost on the order of \$5,000 to \$5,500, plus an additional \$1,700 for the geophysical logs (electric, sonic and caliper logs), and approximately \$2,500 for mobilizing and operating a test pump for test hole development and groundwater monitoring purposes.

Once the test hole is evaluated as to potential yield, further assessment as to the desirability of well completion should be based on static water levels, estimated pumping levels, and the ability of the well to meet the 80 percent productivity level, both seasonally and under drought conditions. The District should also assess the cost/benefit of mechanical, electrical, and conveyance costs, relative to reliable well yield.

The quality of the groundwater test pumped at various depths during the test hole evaluation project will be necessary to: provide site specific quality; determine whether or not quality changes with pumping depth; define whether or not the quality meets State standards for domestic usage; and to define the types of water treatment, if necessary.

Assuming all conditions are acceptable, it should be feasible to re-mobilize the drill rig and ream each test hole to

the appropriate depth. Casing, perforation sizes and depths, and gravel pack can then be emplaced.

The completed well should utilize 6-to 8-inch diameter PVC pipe with machine-cut horizontal perforations. A slot opening of 0.125 inch with an appropriately sized gravel pack should be used. Perforation intervals will depend on location of fractures and joints, and on the static and pumping levels monitored during the field tests. Completed well costs are likely on the order of \$10,000 each, exclusive of mechanical, electrical, pipeline, and engineering costs.

4.0 "Safe Yield" Considerations

Review of the report by Hoover (1980) implies that the bedrock/sandstone formations flanking the alluvial basin do not recharge the basin and, therefore, are not part of the currently postulated "safe yield" of the basin. This assertion may, in large part, derive from the difficulties in assessing the magnitude of recharge that occurs in the bedrock areas and the amount of groundwater that eventually becomes available for extraction by wells.

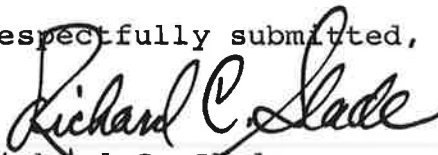
The number of bedrock wells that either have been located or have data on file with the MWD currently numbers roughly between 100 and 125. Additional, undocumented, wells undoubtedly exist and may number an additional 25 to 50 wells. Assuming each of

these wells extracts a minimum of one to two acre-feet per year, their cumulative annual pumpage may be on the order of 200 to 300 acre-feet, or more. It would be advisable for the District to obtain better definition of: the number and location of such active, privately-owned wells; the general quality of such wells (such information as conductivity, hydrogen sulfide presence or not, etc.); and the total annual production of these wells.

Such data would not only serve to document future appropriate and inappropriate places to site future homes and/or wells, but would aid in defining the overall basin "safe yield".

The attachments which complete this report are listed in the Table of Contents.

Respectfully submitted,

A handwritten signature in dark ink, reading "Richard C. Slade". The signature is fluid and cursive, with the first letters of the first and last names being capitalized and prominent.

Richard C. Slade
Certified Engineering Geologist No. 929

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Plate 1 - Hydrogeology Map - too big to scan

Plate 2 - Watershed Map - too big to scan

Plate 3 - Well Location and Water Sampling Map - too big to scan