FUGRO WEST, INC.

WATER RESOURCES ASSESSMENT
FOR THE
LOS ROBLES DEL MAR
SUPPLEMENTAL ENVIRONMENTAL IMPACT REPORT
FOR
DOUGLAS WOOD & ASSOCIATES, INC.

BY:

FUGRO WEST, INC.

MAY 2007

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Project No. 3202.0003

Douglas Wood & Associates, Inc.
1461 Higuera Street, Suite A
San Luis Obispo, California 93408

Attention: *Mr. Douglas Wood*

Water Resources Assessment
for the Los Robles Del Mar Supplemental Environmental Impact Report

Dear Mr. Wood:

Fugro West is pleased to submit this water resources assessment for the preparation of the Los Robles Del Mar Supplemental Environmental Impact Report (SEIR). The purpose of the report was to provide technical input to the SEIR on issues related to the proposed use of on-site water wells as a municipal water supply by the City of Pismo Beach, and assess the potential impacts of pumping these wells on nearby private water wells and other municipal (City of Arroyo Grande) water supply wells.

There are several issues related to this investigation, but the two primary concerns, and the ones most commonly expressed by homeowners in the vicinity of the proposed project, relate to (1) potential interference impacts and direct conflicts between the pumping of the deep aquifer project wells and the shallow aquifer private, domestic wells that most of the homeowners depend on, and (2) the yield of the deep aquifer that the project wells pump from and the ability of that aquifer to sustain the anticipated demand.

It has been concluded from this investigation that there is little to no hydraulic communication between the shallow and deep aquifers, thus there will be no significant impact on the private domestic wells from the pumping of the project wells. Also it has been calculated that the perennial yield of the deep aquifer is approximately 270 acre feet per year (afy). With current production from the deep aquifer at 90 afy and groundwater use by phreatophytes totaling 20 afy, an additional 160 afy could be extracted from the deep aquifer without placing the deep aquifer into an overdraft condition. Therefore the aquifer yield is sufficient to sustain current demand and the demand of the proposed project of 151 afy (or less depending upon the effectiveness of proposed water saving technologies).

The anticipated project demand of 151 afy was derived from earlier studies and has been used as a conservative estimate to assess the potential impact of pumping on the aquifer.

However, it is the plan of the City of Pismo Beach that the LRDM project demand will be met by municipal supply, which is derived from several sources. The project wells would be annexed into this municipal supply network. Subsequently the actual volume pumped from the project wells is likely to vary and be utilized on an "as necessary" basis.

Additionally the City of Arroyo Grande has installed a new well (AG #10) into the deep aquifer and has stated an intention to produce a significant volume of water from the aquifer for municipal use. The combined, cumulative impacts of current demand, anticipated project demand, and any future municipal use by the City of Arroyo Grande in excess of 270 afy will cause a potentially significant impact on the aquifer through aquifer overdraft. It is for this reason that one of the mitigation measures recommends that combined extraction from the deep aquifer should not exceed 270 afy, thereby protecting the aquifer from an overdraft condition.

This report documents the investigation and summarizes our findings, conclusions, and recommendations. If you have any questions, please feel free to contact me.

Sincerely,

FUGRO WEST, INC.

Paul A. Sorensen, PG, CHg
Principal Hydrogeologist
California Professional Geologist #5154
California Certified Hydrogeologist #154

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Project Hydrogeologist

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WATER RESOURCES ASSESSMENT FOR THE
LOS ROBLES DEL MAR SUPPLEMENTAL ENVIRONMENTAL IMPACT REPORT

1. INTRODUCTION AND SCOPE

The purpose of this report is to provide technical input to the Supplemental Environmental Impact Report (SEIR) of the proposed Los Robles Del Mar (LRDM) project on issues related to water supply. Specifically, the basic objective of the SEIR, as requested by the San Luis Obispo Local Agency Formation Commission (LAFCO), is to address the potential impacts associated with the proposed municipal use by the City of Pismo Beach of wells located on the LRDM site. As addressed in this study, the SEIR is intended to focus on the following objectives:

- Evaluate the City's plan to utilize the on-site water wells to augment the municipal water supply and assess the potential impacts of the use of the wells on nearby groundwater pumpers (private and public).
- Evaluate the cumulative impacts of the use of the on-site wells along with other nearby pumpers on the groundwater basin from which the wells extract groundwater.

The LRDM project area (Plate 1) consists of two separate parcels (Property A and Property B). Property A includes 154 acres and is planned for residential development while Property B is a 28-acre site planned for development of a private school. According to the LAFCO staff report dated March 16, 2006, the estimated water demand for the combined project development is 151 acre-feet per year (afy). However the City of Pismo Beach intends that the LRDM project demand will be met by municipal supply. The project wells would be annexed into the municipal supply network. Therefore the actual volume pumped from the project wells is likely to vary and be utilized on an "as necessary" basis. The exact volume of groundwater to be extracted is difficult to define, therefore the current study has been based upon removal of less than or equal to 151 afy as project demand from the deep aquifer. This is viewed as a conservative estimate as a revised estimate of the actual project demand of 105.6 afy has also been proposed RRM Design Group (July 2006). The lower project demand estimation incorporates the use of several water saving technologies to the project.

The project has been revised and evaluated many times, and has undergone several different CEQA assessments. The most recent environmental documentation prepared by the City of Pismo Beach addressed the various impacts of the project, with the exception of the use of the on-site wells and the potential impacts of pumping those wells on other wells in the area. As the concept developed to use the on-site wells as part of the City water supply to provide water to City (and project) residents, the need for additional environmental review emerged. Thus, the focus of this SEIR is on the City's plan to pump the LRDM on-site water wells and the impacts of pumping those wells on nearby groundwater users.

The SEIR also addresses the potential cumulative impacts on the groundwater basin due to the pumping of the on-site wells in combination with the private and municipal wells in the vicinity. This assessment is intended to accomplish the following objectives:

- Develop a conceptual model of the aquifer and calculate a water balance;
- Evaluate potential interference impacts;
- Estimate aquifer demand and assess potential impacts; and
- Propose mitigation measures, if appropriate.

The project site contains three wells, LRDM wells #1, #2 and #3, installed in 1986, 1990 and 2003, respectively. Pumping tests have been conducted on each of the wells at various times (LRDM well #1 in 1987, well #2 in 1990, and well #3 in 2003). Recent testing conducted by the property owner in 2006 and 2007 focused on the assessment of the impact of well interference caused by pumpage of the project wells.

Previous work conducted at the site or on projects nearby with relevance to the current study include:

- Cleath and Associates, 1990, Step and constant rate discharge testing on LRDM Well #2.
- Cleath and Associates, 1998, Water supply study for village green project.
- Cleath and Associates, 2003, Groundwater source assessment, LRDM.
- Cleath and Associates, 2004, Well yield and aquifer testing LRDM report (pump testing of LRDM Well #2, while observing AG Well #9 and LRDM Well #1).
- Cleath and Associates, 2005, Well installation and pump testing of LRDM Well #3 on Oak Park Road.
- Cleath and Associates, 2006, Recovery testing at LRDM Well #2.
- Cleath and Associates/City of Arroyo Grande, 2007, Deep aquifer testing by pumping Arroyo Grade Well #10.
- Cobalt Construction Company, 1987, Step and constant rate discharge testing on LRDM Well #1
- Fugro West Inc, 2003, Peer review of Cleath groundwater source assessment report, LRDM.
- Fugro West Inc, 2005, Evaluation of Meadow Creek wells and aquifer.
- HydroMetrics, 2006, review of LRDM hydrogeology.
- Impact Sciences, 2001, Draft supplement to the final environmental impact report, LRDM specific plan.

As part of this study Fugro has reviewed each of the above documents and where appropriate has provided assessment on the conclusions within this document. The pumping test data contained within several of the Cleath reports was also used to conduct a separate aquifer analysis, in order to verify previous conclusions. These analyses are presented within the following text, tables and in appendices B and C. Each of the background documents was found to be based on sound scientific interpretation. However, additional pumping tests and a more detailed geological and hydrological investigation has yielded a refinement in some of the conclusions as previously presented. The interpretations and conclusions as to the potential impact of the proposed project on the deep aquifer are detailed within this document.

2. INVESTIGATIVE METHODOLOGY

To evaluate the geologic and hydrologic conditions of the basin from which the LRDM project is proposing to extract groundwater and to assess the relative impact on groundwater conditions should project demand be extracted, the following work was conducted:

- Geologic and hydrogeologic reports and maps, both published and unpublished were reviewed;
- The geological interpretation of the basin was refined by the collection and digitization of available borehole logs, field reconnaissance and review of available literature. This interpretation has included the construction of geological cross-sections, as displayed in Plates 2 to 6;
- Aquifer testing data in previous reports was reviewed and reanalyzed where monitoring data was available. These separate analyses are presented within the following text, tables and in appendices B and C;
- The ability of the LRDM project wells (LRDM #1, #2 and #3) to extract a volume of water equivalent to the project demand was assessed. To achieve this previous and recent well test data were analyzed;
- The impact of pumping the deep aquifer on wells screened in a shallow aquifer in the basin (well interference) was assessed. Additional pump testing of LRDM Well #2, in February 2007, was specifically conducted for this purpose. The results of this test and previous aquifer testing were analyzed;
- Hydraulic parameters for the deep aquifer were calculated using the results of previous and recent aquifer testing. These values were compared to that derived by previous work to test their validity and consistency between reports;
- Local precipitation data was obtained to enable the calculation of recharge to the deep aquifer by percolation (Appendix D). Additionally outcrop of the deep aquifer was calculated from the geological interpretation (as above and Plate 1);
- Recharge to the aquifer via stream bed was assessed by identifying streams that crossed the deep aquifer and incorporating known hydraulic parameters for the deep and aquifer and alluvium. The area of contact between alluvium was determined from map interpretation, borehole logs and field reconnaissance. Seasonal alluvial sub flow was assessed from local stream flow and precipitation trends;

- An aerial photograph review was performed to identify domestic parcels located on, or in the vicinity of, the outcrop of the deep aquifer. This was required for interpretation of domestic groundwater pumpage and waste water recharge;

- Groundwater storage capacity of the deep aquifer was calculated using the outcrop and cross section maps to determine aquifer available volume and then combined with groundwater level data to determine the saturated volume; and

- A water balance for the deep aquifer was calculated, incorporating functions of input (e.g. precipitation recharge) and removal (e.g. domestic pumpage) from the deep aquifer. This has enabled an assessment of the impact of withdrawal of additional water from the aquifer for use by the City of Pismo Beach.

- Groundwater quality data was collected, assessed and compared with trends observed in the region.

3. ENVIRONMENTAL SETTING

3.1 GEOLOGIC AND HYDROGEOLOGIC SETTING

The following discussion is based on previous available work describing the geology of the area (DWR, 1970; Hall, 1973: CDM, 1977; Cleath, 2003), as well as our interpretation of water well and oil exploration borehole logs conducted as part of this investigation.

The generalized geology is shown on Plate 2, which also gives the location of cross sections, depicted as Plates 3 to 6. Principally outcropping in the areas are the Pliocene beds of the Pismo Formation, composed primarily of sand interbedded with clay and silt layers. In areas where drainage channels are present a variable thickness of Quaternary-age sediments overlie the Pismo Formation. These sediments are composed of sand, silt, and gravel interbedded with clay layers, and are of greatest thickness in the center of the drainage channels.

The Pismo Formation is underlain by Miocene marine sediments of the Monterey Formation, comprised primarily of shale, diatomite, and fine-grained siltstone, which typically form the basement rock for the aquifer. The Monterey Formation is a local source of gas and oil, with oil sands being encountered around 3,000 to 4,000 feet below ground surface. Beneath the Monterey Formation are sediments and volcanics of the Point Sal and Obispo formations.

Hall (1973) shows the Pismo syncline bisecting the study area and trending northwest to southeast, as shown on Plate 2. Cleath (2003) described the syncline as plunging towards the center of the basin from Price Canyon and Arroyo Grande Creek Valley. The synclinal structure forms a sedimentary basin in which groundwater is contained within permeable (typically sand rich) layers, forming aquifers separated by relatively impermeable clay-rich beds.

An extensive review of available borehole logs, both water well and oil well, indicates the existence of a dual aquifer system in the basin, here referred to as the “shallow” and “deep” aquifers, which are separated by a thick clay-rich aquitard. The areal extent of these aquifers and zone of outcrop for each aquifer is shown on Plate 1. This relationship, and the implications of the hydrogeologic structure of the area, will be discussed in detail in the following sections.

It should be noted that many individual sand and clay layers can be identified from the borehole logs throughout the Pismo Formation. Each of sand layers will likely act as a sub aquifer and the clay layers as an aquitard between the sand rich layers. This is particularly true of the shallow aquifer unit. However, between the shallow and deep aquifer zones is a thick aquitard consisting of clay-rich sediments.

The Shallow Aquifer

The shallow aquifer is composed of sand, clay, clayey sand and sandy clay layers, with occasional gravels. This aquifer reaches its greatest depth at the center of the synclinal structure, corresponding to a thickness of 750 feet as shown on Plate 5. Most of the private domestic supply wells are screened in the shallow aquifer, as shown on Plates 3, 4 and 5. Water levels within the shallow aquifer are quite variable, ranging from 20 to 180 feet below ground surface, depending on the stratigraphic layers that the well screen intersects.

The Deep Aquifer

The deep aquifer is composed of fine sand, silty sands, and clays, with occasional gravels. The sands and clays are typically of greenish-gray to blue-green coloration. The aquifer thickness was determined based upon data from water and oil well logs and is of 250 to 350 feet in thickness, reaching a depth of more than 1,400 feet below sea level at the center of the basin (Plates 3 and 5). The aquifer outcrop or subcrop pattern, where the surface expression of the sediments that comprise the deep aquifer reach the ground surface, is shown on Plate 1. The outcrop pattern of the deep aquifer as shown on Plate 1 is reasonably well constrained to the north, west, and south, but is not well defined to the east, which is well outside the extent of the study area.

Water levels in wells that penetrate the deep aquifer at depth are clearly under hydraulic pressure. In wells with screened intervals several hundred feet below ground surface, water levels are near ground surface, such as LRDM wells #1, #2, and #3 and the City of Arroyo Grande well #10, in which water levels range from 5 feet to 55 feet below ground surface (Plates 3, 4 and 6).

The Aquitard

The lithology of the clay-rich aquitard. unit between the shallow and deep aquifers is that of sandy clay or green sand and clay. Where sand is present in boreholes that penetrate the clay-rich zone, the sand is generally described as very fine to fine-grained. One such sand-rich layer appears to be present across throughout the aquitard (Plates 3 to 6). Several wells penetrate this thin sandy layer, but are characterized by relatively poor production capability and water levels that are typically deeper than water levels in wells that penetrate either the shallow or deep aquifers.

The aquitard is 400 to 700 feet in thickness. The thickness of the unit and abundance of clay-rich horizons within the unit prevents significantly or retards hydraulic communication between the shallow and deep aquifers. Wells that have been screened in this unit typically appear to exhibit lower water levels than that of the shallow and deep aquifer, as shown by wells 015 and 004 on cross section B-B’ (Plate 4) and wells 015 and 030 on cross section C-C’ (Plate 5).

Groundwater Occurrence and Movement

Groundwater data for the Oak Park area was typically limited to water levels measured during the installation of wells. This means that the data have been collected at variable times by various recorders, and therefore should only be considered as a general indication of flow direction when combined to gain a regional interpretation.

The shallow aquifer typically shows groundwater movement from the northwest to the southeast, with water level elevations ranging from approximately 300 feet above mean sea level (AMSL) in the northwest to 100 feet AMSL to the southeast, which generally corresponds to a drop in topography from approximately 500 feet AMSL in the northwest portion of the area to approximately 200 feet AMSL in the southwest. Water level elevations at the LRDM site are typically on the order of 150 to 200 feet AMSL.

Seasonal fluctuations in water levels in the shallow aquifer are on the order of 23 feet (Cleath, 2003). Over the past 40 to 50 years, water levels in the aquifer have shown an overall decline of 10 to 15 feet (Cleath, 2003).

Only limited water level information is available, with little historic data, for the deep aquifer. Generally, water levels in the range of 80 and 170 feet AMSL have been noted from driller's logs and pumping test data. Minor seasonal fluctuations in water levels of 10 feet or less have been noted.

Until 2005, only minor pumpage had occurred from the deep aquifer. Recent (2006) pumpage of approximately 130 acre-feet (af) from LRDM well #2, along with approximately 90 af pumped from AG well #9 has not impacted water levels in the aquifer.

Water level records from wells designed to withdraw water from the aquitard were highly variable. Water levels in wells were noted from 20 to 140 feet AMSL, which are typically lower than both the shallow and deep aquifers and likely reflects that these wells tap thinner minor sand layers with lower transmissivity.

Aquifer Parameters

The deep aquifer, which is the source of groundwater to the LRDM wells, is approximately 300 feet in thickness (Plates 3, 4 and 5). A summary of the deep aquifer parameter data is given in Table 1. A review of all the available pumping test data for wells LRDM well #1, #2, and #3 compare closely with the values derived for transmissivity, hydraulic conductivity, and storativity reported by Cleath (2003).

The three LRDM wells were found to have a range of transmissivity values from 710 to 1300 gallons per day per foot of aquifer (gpd/ft) and hydraulic conductivity of 2.4 to 4.3 feet per day (ft/d) for the deep aquifer, assuming an aquifer thickness of 300 feet. Cleath (2003) had previously reported an approximate transmissivity of 1000 gpd/ft and hydraulic conductivity of

3.3 ft/d for this aquifer, based on an analysis of the LRDM wells as well as AG well #9 and the Deer Trail test well.

The storativity values shown on Table 1 were derived primarily from observation well data obtained during the 2007 well interference pumping tests. Some of the values suggest that the deep aquifer acts as a semi-confined aquifer (Table 1 and Appendix C), however the results of single well tests analyzed by the Cooper-Jacob analysis method indicates an aquifer in which confined conditions predominate.

Table 1: Deep Aquifer Parameter Summary

Well	Date	Drawdown (s) in feet	Pump Rate (Q) in gpm	Specific Capacity (Q/s) in gpm/ft	Transmissivity in gpd/ft (Appendix B and D)	Storativity (Appendix C)	Hydraulic Conductivity (K) in ft/d	Source
LRDM Well #1	2/6/1987	59, 96, 154, 203	75, 125, 175, 225	1.2	990 to 1,300	-	3.3 to 4.3	Fugro Analysis
*LRDM #1 Obs Well	2/5/2007	-	125 in LRDM #2	-	970	7.6×10^{-3}	-	Fugro Analysis
LRDM Well #1	9/12/1987	-	-	-	1240	-	4.1	Cleath 1998
LRDM Well #2	5/29/1990	102, 159, 214	100, 150, 195	0.9	980 to 990	-	3.3	Fugro Analysis
LRDM Well #2	2/5/2007	-	125	-	825	-	2.8	Fugro Analysis
LRDM Well #2	6/2/1990	-	-	-	900	-	3.0	Cleath 1998
LRDM Well #3	10/31/2005	132, 177, 267	60, 120, 180	0.4	710 to 790	-	2.4 to 2.6	Fugro Analysis
*Arroyo Grande #9 Obs Well	2/5/2007	-	125 in LRDM #2	-	2060	3.9×10^{-3}	6.9	Fugro Analysis
Arroyo Grande #9	6/29/1990	-	-	-	2350	-	7.8	Cleath 1998
Arroyo Grande #10	1/25/2007	-	120	0.33	630	1.0×10^{-3}	-	Cleath 2007

*As observation wells while pumping LRDM Well #2.

3.2 PROJECT WATER SUPPLY

The LRDM project water supply will be delivered from the municipal water system of the City of Pismo Beach. The City of Pismo Beach is in turn served by State Water, Lopez Water and groundwater wells. Upon annexation of the LRDM project, the on site water wells would be transferred to the City of Pismo Beach, which intends to include them in its municipal supply network. Each of the LRDM wells penetrates the deep aquifer (Plate 4) and is described in detail, below.

LRDM #1

LRDM well #1 was drilled in 1986 by Floyd V. Wells Inc., to a depth of 604 feet and cased with 8-inch diameter PVC casing to a depth of 525 feet. The screened interval, with 0.040-inch slots, is from 225 feet to 525 feet. A sanitary seal was installed from ground surface to 50 feet below ground surface (bgs) to meet state and local well construction standards. A copy of the driller's Well Completion Report is provided in Appendix A.

Pumping tests conducted in 1987 resulted in the conclusion that the well is capable of producing 100 gallons per minute (gpm) on a reliable, operational basis (Cleath, 2004). Cleath's (2004) analysis and conclusions appear reasonable, based on a review of the data and additional analysis (Appendix B).

LRDM #2

LRDM well #2 was drilled in 1990 by Arroyo Water Well Supply and cased with 8-inch diameter PVC casing to a depth of 620 feet. The screened interval, with 0.040-inch slots, was placed from 300 feet to 620 feet bgs. A copy of the driller's Water Well Completion Report is provided in Appendix A.

The results of pumping tests conducted in 1990 were similar to the results of the LRDM well #1 tests (Cleath, 2004). Cleath (2004) concluded that the well is capable of producing 100 gpm on a consistent operational basis. Cleath's (2004) analysis and conclusions appear reasonable, based on a review of the data and additional analysis (Appendix B).

LRDM #3

LRDM well #3 was drilled in 2003 by Filipponi and Thompson Drilling Company, Inc. to a depth of 980 feet, and cased with 8-inch diameter PVC casing. The was constructed with multiple screened intervals, as described on the driller's Water Well Completion Report provided in Appendix A. As shown on the Report, the top of the uppermost perforations is 230 feet bgs.

Pumping tests conducted in 2005 resulted in the conclusion that the well is capable of producing 40 gpm on a consistent, operational basis (Cleath, 2005). Cleath's (2005) analysis and conclusions appear reasonable, based on a review of the data and additional analysis (Appendix B).

Water Supply Summary

The water supply for the LRDM project would be derived from the City of Pismo Beach municipal water system. Upon annexation of the LRDM project, the on site water wells (LRDM #1, #2 and #3) would be transferred to the City of Pismo Beach, which intends to include them in its municipal supply network. Each of these wells penetrates the deep aquifer (Plate 4, section B-B') as described earlier. A summary of step-drawdown testing performed on the wells is presented in Table 2. Full analyses are presented in Appendix B.

Table 2: Summary of Step-Drawdown Testing of LRDM Wells #1, #2 and #3

Well Name/Number	Date	Drawdown (s) in feet	Pump Rate (Q) in gpm	Specific Capacity (Q/s) in gpm/ft	Expected Long-Term Production Capacity (gpm)
LRDM Well #1	2/6/1987	59, 96, 154, 203	75, 125, 175, 225	1.0	100
LRDM Well #2	5/29/1990	102, 159, 214	100, 150, 195	0.9	100
LRDM Well #3	10/31/2005	132, 177, 267	60, 120, 180	0.4	40

Constant discharge rate pumping tests were conducted on each of the project wells and are summarized in Table 3.

Table 3: Summary of Constant Discharge Rate Tests of LRDM wells #1, #2 and #3

Well	Pumping rate	Screen interval (ft bgs)	Expected Long-Term Production Capacity (gpm)
LRDM Well #1	150	225 to 525	100
LRDM Well #2	150	300 to 600	100
LRDM Well #3	75	230 to 250; 350 to 370; 470 to 490; 590 to 610; 710 to 730; 830 to 970	40

The results of the pumping tests indicate that LRDM wells #1 and #2 each have the capacity to produce in excess of 100 gpm, and LRDM well #3 in excess of 40 gpm. However, because of the proximity of wells #1 and #2 and resulting interference impacts, wells #1 and #2 will likely not be capable of being pumped at the same time.

3.3 PROJECT WATER DEMAND

The proposed project plan is to use water derived from the City of Pismo Beach municipal water system to meet project demand. Upon annexation of the LRDM project, the on site water wells (LRDM #1, #2 and #3) would be transferred to the City of Pismo Beach, which intends to include them in its municipal supply network. The City will then use the wells as is necessary.

In this study it has been assumed that the City will pump the wells at a volume equal to or less than the project demand, which was estimated by RRM Design Group to be 151 acre feet per year (afy; Cleath, 2003; LAFCO, 2006, Hydrometrics, 2006). The relevant data sets used for these analyses are presented in Appendix B. A revised estimate of the actual project demand was made by RRM Design Group (July 2006) of 105.6 afy, based upon implementation of water saving technologies (RRM, 2006). However, this study has used a project demand of 151 acre feet as it is seen as being a conservative estimate, should the water saving technologies not be as effective as envisaged.

Based on the results of previous pumping tests, the three on-site wells are capable of providing the project demand of 151 afy. The pumping of wells #1 or #2, in conjunction with well #3, will supply a sufficient volume to the City of Pismo Beach to meet the project demand, and allow for flexibility to meet peak daily seasonal demands, if required.

Recent pumping by the applicant provides some precedence for these conclusions, as well. In the one-year period from August 2005 through August 2006, the applicant pumped approximately 135 af from LRDM Well #2 for irrigation purposes. This volume is slightly less than the anticipated project requirement, and suggests that the well (and well field) is capable of providing the project demand. Furthermore, during the period when LRDM well #2 was pumping 134 af for agricultural irrigation, AG well #9 pumped approximately 70 af (Hydrometrics, 2006), suggesting that any well interference impacts that may exist between AG #9 and the LRDM wells are not sufficient enough so as to limit the ability of the wells to supply the project demand.

3.4 WELL INTERFERENCE

One of the primary concerns expressed by local homeowners in the vicinity of the proposed project is the relationship, or degree of hydraulic communication, between the pumping of the project wells and the private, domestic wells that many of the homeowners depend on. As shown on Plates 1 and 3-6, most of the private domestic water supply wells are relatively shallow and withdraw groundwater from the shallow aquifer. As such, understanding the degree of hydraulic communication between the shallow aquifer and the deep aquifer is a key issue.

The extensive geologic review and evaluation of numerous water well and oil logs described in earlier sections allowed for the preparation of the geologic cross sections shown on

Plates 3-6. Based on that review, it appears that there is little to no hydraulic communication between the shallow and deep aquifers. To test that conclusion, several pumping tests were conducted to monitor the potential impacts on the shallow aquifer from extracting groundwater from the deep aquifer.

In conducting the well interference tests, large diameter wells (LRDM #2 and separately AG#10) were pumped for extended periods (one week) to induce a cone of depression (decreased water level) in the deep aquifer. At the same time water levels were monitored in wells screened within the shallow aquifer. A reduction of water levels within the shallow wells during the test would indicate a connection between the wells and allow an assessment of the degree of well interference.

As described in the following section that reviews the results of those pumping tests, there is no evidence of measurable hydraulic communication between the two aquifers. On the basis of this review, it is concluded that there is no significant impact on the shallow aquifer from pumping the deep aquifer. The pumping tests that were conducted that lead to this conclusion are described in more detail, below.

Long-Term Agricultural Pumping and Recovery Monitoring of LRDM Well #2 September 2006

During the approximately one year period from August 2005 through August 2006, the applicant pumped water from LRDM well #2 to provide on-site irrigation water. No monitoring was conducted and no records were recorded on the pumping well, except for a totalizing meter that recorded the cumulative volume of produced water. Reportedly, at the end of the roughly one year period of intermittent pumping, approximately 135 AF of water had been produced.

Table 4: Well Recovery During LRDM Well #2 Shutdown Testing, 2006

Well Location	Distance from LRDM Well #2	Water Level at End of 1-Year of Pumping (ft bgs)	Water Level (ft bgs) 23 hours after shutting off pump	Water Level (ft bgs) Two weeks after shutting off pump
LRDM Well #1	100	95.0	78.4	65.7
LRDM Well #2	0	249.8 (pumping water level)	96.7	81.5
LRDM Well #3	2100	13.7	13.6	13.5
AG Well #10	2200	3.6	--	3.6

At the end of the pumping period, the pump was shut off and water levels were recorded to monitor the recovery of the well and aquifer (Cleath 2006). The recovery response was recorded in the pumping well and several observation wells, the results of which are summarized in Table 4.

The results of the recovery test show normal recovery trends in the pumping well (well #2), with somewhat less recorded drawdown (interference) in LRDM well #3 and AG well #10 than was anticipated (Cleath 2006). Overall, the test suggests that the one year of pumping of well #2 did not result in aquifer depletion or mining, and the potential interference impacts of the pumping on nearby wells completed in the deep aquifer was slightly less than anticipated.

Pumping Test of Arroyo Grande Well #10
January 2007

Pumping tests of the City of Arroyo Grande well #10 were conducted in January 2007 by the City to test the production capability of the new well (Cleath 2007). As noted earlier, AG 310 is completed in the deep aquifer, similar to the LRDM wells. Throughout the test, water levels were measured not only in the pumping well, but also in AG well #9, LRDM wells #1, #2, and #3 (all completed in the deep aquifer). Water levels were also monitored in two nearby, shallow domestic wells in an attempt to analyze whether any impacts could be observed on the shallow aquifer from pumping of the deep aquifer (Cleath 2007).

The constant discharge rate testing of AG #10 was conducted at 120 gpm for 64 hours, after which the flow rate was adjusted to 100 gpm for the remainder of the 72-hour test.

During the test, no drawdown interference was observed in the shallow aquifer, in response to pumping the deep aquifer (Cleath 2007).

The results of the pumping test of AG well #10 demonstrates a hydraulic connection between AG well #10 and the LRDM wells, all completed in the deep aquifer. However, a hydraulic connection between the deep and shallow aquifers was not observed. This conclusion is based on the fact that the private domestic wells screened in the shallow aquifer did not display changes in water level in response to pumping AG#10 screened in the deep aquifer.

Pumping Test of LRDM Well #2
February 2007

A long-term (one month) pumping test of LRDM well #2 was conducted in February 2007 for the purpose of assessing the potential interference impacts between the shallow and deep aquifers. Initially, the test started as a constant discharge rate test at a rate of 125 gpm for seven days. At the end of the seven-day period, the pumping rate of the well was adjusted to 100 gpm on an intermittent schedule. This pumping schedule, which continued for 21 additional days, approximately represented an agricultural irrigation schedule. The results of the pumping test are presented in Table 5 and Appendix C. Wells for inclusion in testing were chosen by Cleath and Associates and Fugro, being selected as the best available locations to assess a hydraulic connection between the shallow and deep aquifers. Field testing was primarily conducted by Cleath and Associates, with Fugro observing field operations and monitoring on two separate occasions.

Throughout the one-month long test, several wells were monitored for changes in water level, including all three LRDM wells; AG well #9, and AG well #10, all of which are screened in the deep aquifer. Additionally, seven private domestic wells that are completed in the shallow aquifer and/or the aquitard were monitored for potential impacts (wells 002, 032, 044, 045, 046, 047, and 048 on Plate 1).

After the initial seven days of continuous pumping, only two wells, both screened in the deep aquifer, displayed drawdown in response to the pumping of LRDM #2, including LRDM well #1 (drawdown of 48.2 feet) and AG #9 (18.7 feet of drawdown). LRDM well #3 and AG well #10, the other wells screened in the deep aquifer, did not display a drawdown response to the pumping of LRDM well #2. Furthermore, no drawdown was observed in the private domestic wells screened in the shallow aquifer or aquitard.

For the following 21 days, when LRDM well #2 was pumped on a daily intermittent schedule, similar observation well trends as were seen in the first seven days were noted in all the wells, with only LRDM well #1 and AG well #9 continuing to display interference impacts. No drawdown was observed in the other wells screened in the deep aquifer (LRDM well #3 and AG well #10), and no drawdown was observed in the wells screened in the aquitard or shallow aquifer. The observation well drawdown results of the wells in the deep aquifer are provided in Table 5; all of the collected data for the test, including water levels from all observation wells, is provided in Appendix C.

Table 5: Well Interference During LRDM Well #2 Pump Testing, 2007

Well Location	Distance from LRDM Well #2	Water Interference (ft drawdown) after 7 days (125 gpm)	Water Interference (ft drawdown) after 14 days (100 gpm)
LRDM Well #1	100	48.2	51.4
LRDM Well #3	2300	0	0
AG Well #9	400	18.7	17.0
AG Well #10	2200	0	0

Time-drawdown plots of the pumping and observation wells generally show straight lines without gradually flattening slopes that would be indicative of a recharge boundary such as leakage from the overlying aquifer (Appendix C; pumping and observation wells). The time-drawdown curves match type curves from the Cooper-Jacob method of analysis, thereby indicating an aquifer in which confined conditions predominate without showing evidence of a leaky condition whereby water flows vertically downward through the aquitard to recharge the deep aquifer.

Summary of Well Interference Testing

Drawdown and recovery testing to evaluate potential well interference was conducted through a series of pumping tests on deep aquifer wells. The results showed that the pumping of LRDM well #2 causes interference drawdown in LRDM well #1 and AG well #9, and minor to no drawdown in LRDM well #3.

Pumping tests of AG well #10 showed potential interference impacts on LRDM well #3, only. No measurable interference that could be attributed to the pumping of well #10 was seen in LRDM well 32 or in AG well #9.

No interference impacts or drawdown was observed in any of the shallow private domestic wells from pumping of the deep aquifer wells.

From data generated by the pumping test of LRDM well #2, an interpretation of the potential for drawdown interference can be gained by analysis of the time-drawdown plots for wells screened in the deep aquifer. These time-drawdown plots typically match the Cooper-Jacob analysis method, thereby suggesting that the deep aquifer is an aquifer in which confined conditions predominate. Characteristics of vertical leakage or recharge from the shallow aquifer or the aquitard, such as gradual flattening of the drawdown curves, were not observed. Therefore, based on this and the lack of drawdown interference evidence, it is concluded that the shallow domestic wells pump water from an aquifer that is hydraulically separate from the deep aquifer from which the LRDM wells extract groundwater.

3.5 WATER BALANCE, AQUIFER YIELD, AND AQUIFER DEMAND

A water balance equation for the deep aquifer accounts for the inflow and outflow components of the aquifer, plus or minus the change in groundwater in storage. A summary of the water balance equation is defined as follows:

Aquifer Inflow = Aquifer Outflow

$$P + (S_l - RR) + WW = Q + QM + EP + Sb_o \pm \Delta S$$

where:
- P = Percolation of Precipitation
- S_l = Streambed Percolation
- RR = Rejected Recharge
- WW = Percolation of Wastewater Discharge
- Q = Domestic Groundwater Pumpage
- QM = Municipal Groundwater Pumpage
- EP = Extraction by Phreatophytes

Sb_o = Alluvial Outflow

ΔS = Change in Groundwater Storage

Each of these components of inflow and outflow will be considered, below. It should be noted that each of the estimated volumes for the components of inflow and outflow, with the exception of the metered municipal groundwater pumpage, is extremely rough. Assumptions have been made for each component, which typically could only be refined with significant monitoring effort over long time periods.

- **Percolation of precipitation (P = 60 acre feet per year)**: Percolation of precipitation is assumed to occur only in areas of surface outcrop of the deep aquifer, which constitutes an area of approximately 435 acres (Plate 1). Several studies have assessed the amount of percolation of precipitation as a percentage of total rainfall, and have concluded that effective percolation can be assumed to be more or less equal to 10% of rainfall. With an outcrop area of 435 acres, average annual rainfall of 16.7 inches (Appendix D), and an assumed effective percolation rate of 10% of precipitation, then the amount of recharge to the deep aquifer from rainfall is estimated to be approximately 60.5 afy, rounded to 60 afy.

- **Streambed Percolation (SI - RR = 200 - 85 = 115 acre feet per year):** Percolation of stream flow into the aquifer occurs only after the surficial recent alluvium in the stream channel is saturated, followed by recharge of the deep aquifer subcrop where the saturated river alluvium and aquifer subcrop are in contact. Absent monitoring data that measures stream flow up and downstream of the aquifer outcrop, it is likely that stream seepage is limited to not more than two or three months of the year during periods of greatest rainfall, where the alluvium is fully or nearly fully saturated. During this period, the limiting factor for stream flow recharge is the percolation rate or relationship between the alluvium and deep aquifer subcrop. Inspection of the streams and channels that cross the aquifer outcrop indicates approximately 1,700 feet of major drainage channels (about 100 feet alluvial channel width), and 2,880 feet of minor drainage channels (about 40 feet alluvial channel width) pass across the subcrop of the deep aquifer. This equates to contact areas of 3.9 acres and 2.6 acres for the major and minor channels, respectively. Assuming an overall hydraulic conductivity of 2.5 to 3.0 gallons per day per foot squared (0.35 to 0.4 feet per day), the potential recharge is about 2.3 to 2.6 acre-feet per day. If this condition is met for 2 to 3 months of the year (say 75 to 90 days) then approximately 170 to 230 afy of recharge could enter the deep aquifer (average 200 afy). However, water levels in the deep aquifer are currently high enough to restrict a significant portion of this infiltration from occurring, due to being essentially full. The available recharge water that flows across the subcrop and does not recharge the aquifer is defined as "Rejected Recharge" (RR). This component is directly related to the amount of discharge from the aquifer, where additional water extracted from the aquifer will result in an equivalent decrease in rejected recharge thereby increasing streambed percolation. It should be noted that without further investigation of the stream channels the approximations in this variable of the water balance have a high degree of potential error due to the number of assumptions and the complexity of the mechanism of stream-aquifer interaction.

- **Percolation of Wastewater Discharge (WW = 10 acre feet per year):** Percolation of wastewater was assumed to occur only in areas where residences are located on the outcrop of the deep aquifer. Residences overlying the surface expression of the deep aquifer were located through aerial photo review. A total of 21 residences were identified. Most of these parcels are more or less one acre in size, and a water use duty factor of approximately one afy of water demand per residence was assumed. Of this pumped volume, it was estimated that 50% of the water use is returned to the aquifer through landscape irrigation return flow and percolation of the on-site wastewater treatment system (septic tank and leach fields), and is therefore returned to the groundwater as recharge. Based on these assumptions, the amount recharge to the aquifer through wastewater discharge is approximately 10.5 afy, rounded to 10 afy.

- **Domestic Groundwater Pumpage (Q = 20 acre feet per year):** Extraction of domestic groundwater pumpage from the deep aquifer is assumed to occur only in areas where residences contain wells that are screened in the deep aquifer. The number of residences overlying the deep aquifer was located through an aerial photo review, and typically occupies parcels of 1 acre or more. A duty factor of 1.0 afy was applied to water usage for parcels of this size. As described above, a total of 21 residences were identified, resulting in an estimated 21 afy, rounded to 20 afy, of groundwater use extracted by domestic users directly from the deep aquifer.

- **Municipal Groundwater Pumpage (QM = 70 acre feet per year):** The City of Arroyo Grande has been extracting approximately 70 afy of groundwater from the AG well #9, which pumps from the deep aquifer. (Note that pumpage in 2005-06 from LRDM well #2 for irrigation is not included in this component).

- **Extraction by Riparian Phreatophytes (EP= 20 acre feet per year):** Phreatophyte evapotranspiration occurs in stream channels, where riparian vegetation consumes shallow groundwater. It is assumed that the dense stands of shallow vegetation in the area extracts three afy of water. The area of phreatophytes in stream channels overlying the deep aquifer is estimated at 7.2 acres, resulting in an estimated groundwater demand of approximately 23 afy, rounded to 20 afy.

- **Alluvial Outflow (Sbo = 75 acre feet per year):** Alluvial outflow occurs at the downstream edge of the aquifer via the Meadow Creek alluvial channel and related sub-channels. Subsurface alluvial outflow occurs when the aquifer is full and water levels are high, and is expressed as stream flow in the Meadow Creek drainage network, saturated underflow in the alluvium, and spring flow in the lower hillsides and drainages.

This volume can be approximately calculated through stream flow analysis of the alluvial channels. Currently, year round underflow occurs in Meadow Creek. Three sub-watersheds feed the Meadow Creek alluvium and the total alluvial outflow can be approximated from the cumulative total. Assuming a combined alluvial outflow width of about 400 feet and a saturated thickness of 35 feet, the saturated cross-sectional area of the alluvium equals 14,000 square feet. With an average hydraulic gradient of 0.016 feet per foot and hydraulic conductivity of 40 feet per day (300 gallons per day per foot squared) for loose, alluvial sands, the resulting average annual alluvial outflow through the Meadow Creek alluvium is approximately 75 afy.

A summary of the water balance components can be summarized as follows:

$$P + (S_l - RR^*) + WW = Q + QM + EP + Sbo \pm \Delta S$$

$$60 + (200 - 85) + 10 = 20 + 70 + 20 + 75 \pm \Delta S$$

$$185 \text{ afy} = 185 \text{ afy} \pm \Delta S$$

Aquifer Change in Storage = 0 afy

*As pumpage increases rejected recharge (RR) will decrease until reaching zero, at which point streambed percolation recharge will have reached a maximum capacity of 200 afy.

Estimation of the water balance equation suggests that the deep aquifer is currently full, and receives a greater volume of inflow than what is extracted through pumpage and evapotranspiration. A full aquifer necessarily means that the net change in groundwater in storage is zero. This assumption is consistent with observations by Cleath (2003) that commented that water levels in wells screened in the deep aquifer appear to have consistent and stable water levels.

Perennial Yield

The perennial yield of an aquifer may be defined as the rate at which groundwater can be pumped from wells year after year without decreasing the groundwater in storage. In the case of water balance shown above, it would also result in maximum utilization of potential recharge, that is, no rejected recharge. A perennial yield estimate of an aquifer is not an exact calculation. The difficulty in calculating an exact perennial yield figure relates to the inherent uncertainties in the estimates of recharge and discharge. Also contributing to the difficulty is the lack of historical and current data on change of groundwater in storage. Despite these limitations, reasonable estimations can still be made.

This first approach is that the perennial yield is equal to the long-term recharge less the net change in groundwater in storage. There are considerable assumptions used in the methodology used to estimate each component in the hydrologic equation, and it is exceedingly difficult to calculate some of the components when the aquifer is full as is the case with the deep aquifer. However, the data suggest a perennial yield of the deep aquifer of approximately 270 afy. With a full aquifer and zero net change in storage, subsurface outflow is potentially significant. Likewise, rejected recharge is also likely significant in these conditions, which may more or less balance out if aquifer discharge through pumpage increases.

Thus, a water balance equation describing a situation where there is no rejected recharge and subsurface outflow is minimized would be as follows:

$$P + S_I + WW = Q + QM\ Qf + EP + Sbo \pm \Delta S$$

$$60 + 200 + 10 = 20 + 70 + 160 + 20 + 0 \pm \Delta S$$

$$270 \text{ afy} = 270 \text{ afy} \pm \Delta S$$

Aquifer Change in Storage = 0 afy and where Qf = future pumpage = 160 afy

A second method to estimate the perennial yield of the aquifer is to compute the average annual total net discharge over a period when the net change of groundwater in storage was zero and when recharge is about equal to the long-term average. This method, the so-called "practical rate of withdrawal" is a useful method so long as the coefficient of correlation between annual pumpage and storage changes is sufficiently robust and the calculated inflow and outflow values are relatively accurate. Unfortunately, these conditions are not particularly well met for this analysis, despite the relatively high degree of accuracy in the estimates of annual groundwater extractions. Given the recognition of the inherent difficulties with this method, inspection of the water balance equation still suggests a “practical rate of withdrawal” in the range of 250 to 300 afy.

Based on these results, a perennial yield value of 250 afy to 300 afy for the deep aquifer is appropriate. Selecting the value near the mid range is warranted because of the inherent uncertainty in calculating some of the components, and the lack of historical data upon which to base the assumptions.

As noted, calculation of a water balance equation for a small aquifer such as this one, with very little historical data, requires a significant number of gross assumptions. Varying the values of hydraulic conductivity, stream width, water duty factors, etc. will result in changes in each of the inflow/outflow components and changes in the equation. Thus, the values expressed here are rough estimates, only, based on available data, the best available evidence, and our experience with similar water balance equations for other basins.

Groundwater Storage

Groundwater in storage in the deep aquifer is calculated using the outcrop and cross section maps (Plates 1, and 3 to 6), assuming an average aquifer thickness of 300 feet and average specific yield of 8%. On the basis of these assumptions, total groundwater in storage is estimated at 60,000 af for the deep aquifer. This value is consistent with the volume of groundwater in storage previously been estimated by Cleath (2003) of 50,000 af.

Current Aquifer Demand, Future Aquifer Demand, and Aquifer Yield

Current aquifer demand from extraction of groundwater by the City of Arroyo Grande (through AG well #9) and the approximately 21 private residences withdrawing water from the deep aquifer is about 90 afy. Assuming the need to maintain phreatophyte (riparian) vegetation in the downstream channels, the aquifer is currently in surplus of about 160 afy.

Solution of the water balance suggests that 75 afy is discharged as alluvial outflow from the deep aquifer. An additional 85 afy of potential recharge is rejected because the aquifer is full. The combined total of alluvial outflow and rejected recharge (160 afy) is available for extraction from the deep aquifer without causing the deep aquifer to enter an overdraft condition (aquifer outflow > inflow).

Additional groundwater removed by pumping would initially decrease rejected recharge, until this factor became zero. After this occurred, further extraction would result in a reduction of alluvial outflow by the volume extracted, until this factor also became zero. Any subsequent extraction would then result in an overdraft condition.

Extraction of the proposed project demand of 151 afy would not place the deep aquifer into an overdraft condition, given current aquifer demand and pumping conditions. The ability of the deep aquifer to produce enough water to supply the project without creating deleterious effects has been tentatively confirmed over the past year. During a one-year period, 135 af was pumped from LRDM well #2, in addition to ongoing pumping of AG well #9 (70 af) and domestic pumpage (20 acre feet). Over this period, water levels in the aquifer remained stable. However, the effect on alluvial discharge during this period was not monitored and is unknown.

Given a perennial yield of 270 afy, current aquifer demand of 90 afy, and projected LRDM demand of 151 afy, the aquifer would still be in surplus of approximately 10 afy (if the project demand of 151 afy were extracted by the City of Pismo Beach). It should be noted that although a project demand of 151 afy has been assumed by this study, the City of Pismo Beach would intend to pump the wells on an “as needed” basis following annexation. Therefore the volume to be pumped might be significantly different. Under present conditions and extraction the LRDM Wells could theoretically extract a maximum of 160 afy, before placing the aquifer in a condition of overdraft.

Additionally, the City of Arroyo Grande has also publicly stated their intention to produce water from AG well #10. Reports of future production from AG well #10 have ranged from 100 afy to “as much as we can.” A scenario where future combined pumpage from the LRDM project wells and AG well #10 exceeded 160 afy would result in a likely condition of aquifer overdraft.

Subsurface Aquifer Outflow and Meadow Creek Alluvial Flow

Increased aquifer pumpage will potentially decrease alluvial outflow to the Meadow Creek alluvial drainages and therefore decrease drainage underflow. The proportion of this underflow has been estimated by considering the drainage channel watersheds that supply runoff recharge to the alluvium.

The Meadow Creek watershed drains an area of approximately 2,500 acres, which equates to approximately 3,500 afy of precipitation falling on the watershed. If the perennial yield of the deep aquifer is fully utilized through pumpage, and aquifer storage is maintained at zero change, then subsurface outflow will be reduced by approximately 75 afy. To evaluate the potential impact of this subsurface outflow reduction on the Meadow Creek drainage, it is necessary to quantify the underflow and streamflow of the creek. Because no gauging data for Meadow Creek exists, the gauging data for nearby Wittenberg Creek was reviewed. Wittenberg Creek, located approximately 10 miles east-northeast of the project, has a watershed of approximately 2,000 acres at an average elevation of 800 feet. Average flow data for Wittenberg Creek is shown in Table 6.

Application of the Wittenberg Creek flow data to Meadow Creek, coupled with an anticipated reduction of subsurface outflow of 75 afy, would result in an approximate 2% reduction in annualized surface flow. Because streamflow is seasonal, this impact will be also affect the Meadow Creek seasonally, ranging from undetectable impact most months of the year, to potentially significant temporary impacts during the driest months of the year. The potential impacts of this reduction subsurface outflow may reduce spring flow on the lower hillsides and slightly diminished underflow during the dry periods of the year. There will be no significant impacts on Pismo Lake.

Table 6: Wittenberg Creek Gauging Station Flow Data 1967-1971

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Flow (cfs)	4.8	3.6	2.9	0.78	0.35	0.19	0.11	0.06	0.04	0.03	0.14	0.47
% Flow	35.6	26.7	21.5	5.8	2.6	1.4	0.8	0.4	0.3	0.2	1.0	3.5

3.6 WATER QUALITY

Groundwater quality of the LRDM wells is typically within regulated concentrations for chemical constituents, as shown in Table 7, with the exception of slightly high iron content in wells #2 and #3. Reports indicate that hydrogen sulfide odor is present in (at least) well #2 (Cleath 2004). The presence of hydrogen sulfide at elevated concentrations is primarily a secondary issue that results in unpleasant odors and complaints from the end customer.

Hydrogen sulfide at lower concentrations can be treated with charcoal filters and other wellhead strategies.

Table 7: Groundwater Quality of the LRDM Wells

Constituent	Unit	MCL	Well #1 2/12/1987	Well #2 6/2/1990	Well #2 5/17/2004	Well #2 6/2/2004	Well #3 11/3/2005
Calcium	Mg/l	-	11	7	72	22	12
Magnesium	Mg/l	-	4.7	2.0	30	9.0	4.0
Sodium	Mg/l	-	95	160	150	170	57
Alkalinity ($CaCO_3$)	Mg/l	-	150	220	170	200	80
Chloride	Mg/l	250	65	72	190	100	50
Sulfate	Mg/l	500	20	28	200	66	13
Conductance	Umhos/cm	1600	550	700	1300	880	360
TDS	Mg/l	1000	320	-	810	520	240
Total Hardness	Mg/l	-	50	30	300	92	-
Color	Units	15	<15		200	20	-
Odor	Units	3	2		1.0	8.4	ND
pH	Units	6.5 to 8.5	7.8		7.8	8.4	7.1
Nitrate (N)	Mg/l	10	<0.1		ND	-	ND
Fluoride	Mg/l	2	<0.19		0.4	-	0.8
Iron	Mg/l	0.3	0.16		5.8	2.6	0.4
Manganese	Mg/l	0.05	<0.02		0.42	0.08	0.47
Arsenic	Mg/l	0.01	<0.05		ND	ND	0.001

4. REGULATORY SETTING

4.1 WATER RESOURCES

There are no regulations that would restrict the use of underlying groundwater by overlying landowners, as long as the aquifer is not in a state of overdraft. The State Water Resources Control Board regulates the use of surface water and its underflow, but not groundwater as defined in California water law. The groundwater proposed for use by this project is defined as percolating groundwater, thus is not regulated except as to the rights of overlying landowners. If the aquifer were to go into a state of overdraft and an action was brought against the cities of Pismo Beach and Arroyo Grande (as users of the aquifer) by overlying property owners, then precedence has been set that would establish the cities to be junior appropriators to the senior rights of the property owners, and a court-ordered solution would be required.

4.2 WATER QUALITY

Groundwater extracted from the LRDM project will be pumped into the City of Pismo Beach water system. The groundwater will be blended and/or treated prior to distribution. The City of Pismo Beach water system falls under the jurisdiction of the California State Department of Health Services.

5. THRESHOLD OF SIGNIFICANCE

A "threshold of significance" is defined by Section 15382 of the CEQA Guidelines as simply that level at which the Lead Agency finds the effects of a given environmental effect within the project significant. Thresholds of significance can be defined as a quantitative or qualitative standard, or set of criteria pursuant to which the significance of a given environmental effect may be determined.

5.1 WATER RESOURCES

The State of California or the County of San Luis Obispo has not established specific thresholds of significance for the consumption of water resources. In general, an increase in groundwater consumption is regarded to be significant where an overdraft condition exists within the basin being analyzed, or where the use of the project water resource creates a deleterious condition for existing nearby water users. If a groundwater basin or aquifer were not in a state of overdraft, then the additional demand on the resource would not be a significant impact unless it would result in the basin or aquifer being in a state of overdraft. In addition, no specific guidelines are established to determine the level of significance of an increased water demand if the basin goes into an overdraft condition. Additionally, impacts to water quality are determined to be significant if project implementation would not comply with standards and objectives established by the State Department of Health Services.

The threshold of significance for groundwater use is the point at which a project's estimated contribution to the overuse of groundwater is considered significantly adverse. For purposes of this analysis, and without specific guidelines indicating otherwise, the threshold of significance for this analysis is considered the amount of new pumpage that would result in a cumulative local or regional deleterious impact, which could be defined in terms of depletion of aquifer storage, decline in water levels in neighboring well, or degradation of water quality.

5.2 WATER QUALITY

Under the authority of the California Safe Drinking Water Act, standards have been set for more than 90 contaminants in drinking water. For each of these contaminants, a legal limit, called a maximum contaminant level (MCL), is established. Concentrations of the contaminants in the water above the MCL requires treatment or blending with better quality water so that the delivered water meets standards. Even when a drinking water meets these standards, however, consumers may object to the taste, hardness, color, or appearance of the water. Thus, secondary standards are set based on these aesthetic characteristics (not health effects).

6. PROJECT SPECIFIC IMPACT ANALYSIS

Potential project specific impacts include the ability of the LRDM project wells to provide water to the City of Pismo Beach in a volume at least equal to the project demand, potential interference impacts from the project wells on neighboring wells, and potential impacts on the perennial yield of the aquifer. The impact on neighboring wells is considered "significant" if extraction of groundwater from the project well would substantially impair the ability of the nearby well to pump at rates at which the well has historically been used or if the use of the well would substantially deplete aquifer storage such that the groundwater resource would not be available during drought times.

6.1 WATER DEMAND

Ability of Project Wells to Supply Water to the LRDM Project

The proposed water supply source for the LRDM project would involve the pumping of three wells (LRDM wells #1, #2 and #3). Each of these wells penetrates the deep aquifer (Plate 4, section B-B') as described in the earlier geological section of this report. Likely, only one of LRDM wells #1 or #2 will be used at any one time in addition to LRDM well #3, because of the close proximity of wells #1 and #2 and the mutual interference impacts on each other. The project requirement has been calculated to be approximately 151 afy (IIPCC, 1996, LAFCO, 2006).

It should be noted that the LRDM project demand will actually be met by municipal supply, which is subsequently derived from several sources. The project wells would be annexed into the municipal supply network. Therefore the actual volume pumped from the project wells is likely to vary and be utilized on an "as necessary" basis. With this exact volume difficult to define, the current study was based upon removal of 151 afy as project demand from the deep aquifer.

Aquifer testing has been conducted in excess of the amount required for the project supply. In each case, testing has indicated that the project wells will be capable of supplying the required project demand. To further illustrate this conclusion, LRDM Well #2 was pumped for irrigation purposes for one year (2005-2006) and produced 135 acre feet without resulting in water level decline, aquifer mining, or apparent interference effects on neighboring wells. Thus, impacts of supplying water to the proposed LRDM project relative to the water supply resource are **insignificant**.

Aquifer Demand from Increased Pumping by the Project

Recharge to the deep aquifer has been estimated at 270 afy (precipitation, maximum potential alluvial percolation and waste water infiltration). Of this volume, 20 acre feet is consumed by phreatophytes in the riparian zone, and current pumpage amounts to about 90 acre feet per year, split between domestic pumpage (20 acre feet per year) and the City of Arroyo Grande pumpage at well #9 (70 acre feet per year). Additional outflow from the deep aquifer occurs as discharge to alluvium in Meadow Creek (75 acre feet). An estimated 85 afy is potential recharge that is rejected because the aquifer is full.

Up to 160 acre feet of additional water could be pumped from the deep aquifer without placing the aquifer in overdraft. Extraction of the project demand (151 afy) would not place the deep aquifer into overdraft. Therefore, the impact of extracting the project demand on the deep aquifer, in combination with current demand (90 acre feet per year) is considered **insignificant**.

Aquifer Demand from Increased Pumping by the Project and Other Potential Deep Aquifer Users

The cumulative use of current demand and project demand results in an aquifer surplus of 10 afy before creating a condition of overdraft. Other potential users of groundwater from the deep aquifer are the City of Pismo Beach (if they pump additional groundwater from the LRDM wells beyond that required to supply the proposed project), the City of Arroyo Grande (AG well #10) and/or other domestic users that could potentially drill domestic wells into the deep aquifer. If additional pumping by these potential users exceeds 10 afy, then the combined impact of all future users on the aquifer would be **significant**.

Meadow Creek Drainage

Full utilization of the perennial yield of the deep aquifer will reduce subsurface outflow and reduce the current discharge volume to Meadow Creek alluvial drainages. This is expected to reduce underflow by an annualized volume of about 2%, which is considered **insignificant**. There will be no significant impacts on Pismo Lake.

6.2 WELL INTERFERENCE

Mutual Interference Impacts in the Deep Aquifer

Pumping tests conducted on LRDM well #2 shows that there is direct hydraulic communication between well #2 and AG well #9, located approximately 400 feet away. A two-week test of well #2 resulted in an observed drawdown in AG well #9 of 15 to 20 feet. Likewise, drawdown in LRDM well #1 and #2 has been observed at different times when AG #9 is pumping.

The one-month long testing of LRDM well #2 resulted in minor drawdown in LRDM well #3. Similarly, the long-term pumping test conducted on AG well #10 also had a minor effect on LRDM well #3. Thus, it appears that although there is hydraulic communication between all the deep wells that penetrate and extract water from the deep aquifer, the amount of interference will not significantly hinder the ability of any of the wells to produce groundwater. Therefore, the potential mutual interference among deep wells extracting water from the deep aquifer is considered **insignificant**.

Impacts of Pumping the Deep Aquifer on Wells Producing from the Shallow Aquifer

Throughout the extent of the recent one-month long pumping test of LRDM well #2, water levels in wells screened in the shallow aquifer and in the intermediate aquitard did not show a drawdown response (Appendix C). The clay-rich nature of the aquitard, interpreted from inspection of more than 25 water well logs, the thickness of the aquitard, and the lateral extent of the aquitard across the entire width and breadth of the aquifer, indicates that the aquitard is an effective hydraulic barrier between the shallow and deep aquifers.

Interpretation of the drawdown response of wells in the deep aquifer shows that the semi-log time-drawdown plots match a typical Cooper-Jacob analysis for a confined aquifer. Typical characteristics of leakage into the producing aquifer, such as a gradual flattening of the semi-log time-drawdown plots, were not apparent, and leakage between the shallow and deep aquifers was not apparent from pumping test data. Therefore, it is unlikely that well drawdown interference between pumping wells in the deep aquifer and those in the shallow aquifer will occur, and the potential impacts of interference between wells pumping from the deep aquifer and the shallow wells is **insignificant**.

Impacts of Pumping the Deep Aquifer on Private Wells Also Producing from the Deep Aquifer

Interference testing of the deep wells in the deep aquifer shows that mutual interference impacts are expected to be minor to nil. Likewise, the interference impacts on the few private residences that produce from the deep aquifer (currently estimated to be 21 residences) will also be **insignificant**.

The water balance equation that indicates that future extraction from the deep aquifer can increase as much as 160 afy above current pumpage is based on maintaining the condition of zero change in groundwater in storage. That is to say, if total extraction does not exceed 270 afy, then the aquifer will not be in overdraft, there will be no change or decline in groundwater in storage, and the impacts on the private wells that also pump from the deep aquifer will be **insignificant**.

6.3 WATER QUALITY

The produced water quality of the LRDM wells is currently acceptable for domestic use, with the exception of iron and manganese. The slightly elevated iron and manganese levels can be treated at the well head, and/or blended into the City of Pismo Beach water distribution system before delivery, thus the water quality impacts of the project are considered **insignificant**.

7. CUMULATIVE IMPACT ANALYSIS

7.1 WATER RESOURCES

The deep aquifer has the ability to supply the project water demand (151 acre feet per year) without going into overdraft, assuming current pumping conditions. Pumping the project demand, coupled with current demand (AG well #9 and private domestic pumping) would amount to 261 afy. Any amount of pumping above this amount that totals more than nine (9) afy will result in condition where discharge from the deep aquifer exceeds recharge. With the City of Pismo Beach and/or the City of Arroyo Grande's (AG well #10) apparent intention to pump significant volumes of groundwater, the potential cumulative impact of both LRDM and AG well #10 coming on-line is **potentially significant**.

8. RECOMMENDATIONS FOR MITIGATION MEASURES

8.1 AQUIFER DEMAND

Mitigation Measures

The on-site LRDM water wells appear capable of producing sufficient groundwater to serve the project demand, therefore the potential impacts of the proposed project on the ability of the proposed source of water supply to supply the project are **insignificant**. Based on an estimated aquifer yield of 270 afy, the impact of pumping the project demand of 151 afy as well as current demand (90 acre feet per year) is considered **insignificant**. Full utilization of the perennial yield of the deep aquifer will reduce subsurface outflow and reduce the current discharge volume to Meadow Creek alluvial drainages. This is expected to reduce underflow to the drainages by a minor volume, which is considered **insignificant**. There will be no significant impacts on Pismo Lake. No mitigation measures are necessary for insignificant impacts.

If aquifer pumpers, including the City of Pismo Beach and/or the City of Arroyo Grande, increase pumping by any amount greater than nine (9) afy, then the combined impact of all future users on the aquifer would be **potentially significant**. Several measures are recommended to protect the water resource as the project proceeds. As the major users, and as the junior appropriators, the cities of Pismo Beach and Arroyo Grande should be responsible for mitigation monitoring. The relatively few private domestic users that utilize the deep aquifer have senior rights, as overlying landowners, and should not bear the responsibility of mitigation monitoring. These measures could include:

1) Regular monitoring of water level, pumping water level, and total production from wells extracting water from the deep aquifer (LRDM wells, AG wells #9 and #10). Total production from all LRDM wells and City of Arroyo Grande wells should not exceed 250 afy (coupled with the current private demand of 20 afy).

2) If long-term monitoring of water levels and production capability of deep aquifer wells shows no decline in groundwater in storage, then pumping can be gradually increased to test the estimated perennial yield.

3) Total extraction from the deep aquifer by the City of Pismo Beach (LRDM project after annexation) should be restricted to the safe yield of the deep aquifer. This would help prevent the aquifer from entering an overdraft condition.

4) Water saving measures as specified by RRM (2006) for the LRDM project should be implemented.

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