APPENDIX L

Groundwater Study

WorleyParsons Komex

resources & energy

GROUNDWATER STUDY: PROPOSED NORTH FORK CASINO

MADERA COUNTY, CALIFORNIA

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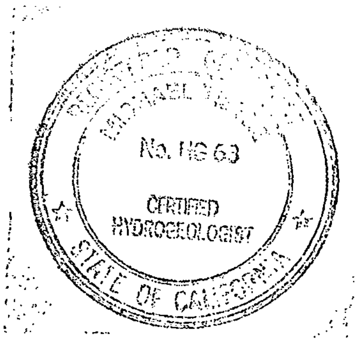

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EXECUTIVE SUMMARY

The North Fork Rancheria of Mono Indians has proposed to establish a casino and hotel development to the northwest of the City of Madera in Madera County, California ("the Madera Site"; **Figures 1, 2, and 3**). An alternative site near the town of North Fork in the same county is also being considered ("the North Fork Site"; **Figures 1 and 4**).

Four development alternatives are being considered, as follows:

A Development of the casino and hotel on the Madera Site;

B Reduced intensity casino development on the Madera Site;

C Alternative retail use for the Madera Site; and

D Development of a casino and hotel on the North Fork Site.

WorleyParsons Komex was contracted to undertake a study relating to the proposed use of groundwater to supply each of the proposed development alternatives. The objective of the study was to assess how this use of groundwater would affect local groundwater levels and wells. Water demand parameters for each development alternative were supplied by HydroScience, Inc.

The Madera Site comprises about 305 acres of land located northwest of the City of Madera. It lies at an elevation of approximately 250 feet above mean sea level and is currently used for growing non-irrigated crops. A residence and associated buildings are present in the southeastern corner. Seven disused agricultural wells were observed on the Site during a visit conducted on 14 April 2005.

The Madera Site lies within the Madera subbasin of the San Joaquin Valley Groundwater Basin (**Figure 1**). The most important aquifer in the area is the Older Alluvium, comprising intercalated lenses of clay, silt, sand, and some gravel. An important regional aquitard, the E-clay or Corcoran Clay, is not thought to be present beneath the Madera Site. Borehole logs for wells drilled near to the Madera Site indicate alternating "sandy" and "clayey" layers to at least 700 feet below ground surface (bgs), with the sandier horizons generally accounting for between 25% and 40% of the total thickness.

Groundwater elevation data were not available for the Madera Site, but DWR interpretations based on records for nearby wells exhibit an overall decline in groundwater levels of approximately 80 feet between 1958 and 2003, with the current groundwater level interpolated to be about 145 feet bgs. The dominant influence on groundwater flow direction in the area over the last 15 years appears to be a pumping depression located north of the City of Madera (**Figure 5**). Comparison of local well hydrographs, precipitation records and reservoir storage data shows short-term correlations between rainfall amount / storage and groundwater levels, but also a long-term decline in groundwater levels that is independent of climatic factors (**Figures 6, 7, and 8**).

The North Fork Site is located about 38 miles east-northeast of the City Of Madera and approximately 2 miles east-southeast of the town of North Fork. The Site occupies wooded, south-facing slopes of the Sierra foothills, ranging in elevation from approximately 2,920 feet amsl in the southeast, to approximately 3,480 feet amsl in the northeast. Two residences currently occupy the Site. The North Fork Site overlies granitic basement rocks, within which groundwater is present in fractures. There is little available information on groundwater occurrence, levels, flow, or storage, and even when available, such properties are usually site-specific and highly variable from one location to another. However, groundwater is widely used for domestic supply in the area. Todd Engineers obtained records for approximately 4,600 wells in eastern Madera County and reported a median yield of 8.5 gallons per minute (gpm) and an average yield of 22 gpm (Todd, 2002). Wells in the vicinity of the Site reportedly achieve yields ranging from less than 10 to 240 gpm (**Section 5.5**).

An analytical model was constructed to examine the effects of the three proposed development alternatives for the Madera Site on off-Site groundwater levels and wells. The average groundwater pumping rates with and without water recycling for Development Alternatives A, B, and C, as determined by HydroScience (2006), were used in the model. These rates were as follows:

Alternative A – 273,000 gallons per day (gpd) (190 gpm) with recycling and 400,000 gpd (278 gpm) without recycling;

Alternative B – 166,000 gpd (115 gpm) with recycling and 251,000 gpd (174 gpm) without recycling; and

Alternative C – 11,000 gpd (8 gpm) with recycling and 23,000 gpd (16 gpm) without recycling.

Based on the pumping well location provided by HydroScience, the model showed that at the property boundary, the predicted drawdown would be as follows:

Alternative A: 6.4 feet with recycling and 9.3 feet without recycling;

Alternative B: 3.8 feet with recycling and 5.8 feet without recycling; and

Alternative C: 0.3 feet with recycling and 0.5 feet without recycling.

The predicted drawdown decreases to approximately 1.5 feet at a distance of 2 miles for Alternative A without recycling (the worst case) and about 1 foot for Alternative A with recycling and Alternative B without recycling. Drawdown of less than 1.5 feet is probably not significant relative to seasonal or short term water level changes in this area.

Records for 259 water production wells within 2 miles of the Site were obtained from the California Department of Water Resources (DWR). All of these wells are expected to experience some amount of interference drawdown from the project, as follows:

Alternative A: 1.0 to 4.9 feet with recycling and 1.5 to 7.2 feet without recycling;

Alternative B: 0.5 to 3.0 feet with recycling and 0.9 to 4.5 feet without recycling; and

Alternative C: less than 0.3 feet with recycling and less than 0.5 feet without recycling.

A combination of interference drawdown from the project and the documented regional declining groundwater level of 1.85 feet per year may result in four different potential impacts to nearby wells. These are:

1. The well going dry;
2. The water level in the well falling so low that the well is no longer usable;
3. Impacts 1 or 2 occur, but the well pump intake can be lowered to extend the life of the well; and/or
4. Increased operational costs.

Impacts 1 and 2 were evaluated in terms of projects impact on the usable lifetime of nearby wells. Given current groundwater level trends, there are 68 wells less than 250 feet deep that are at risk for going dry or becoming unusable in the next 50 years without development of the project. Project pumping will shorten the remaining usable lifetimes of these wells by 1 to 3 years. Impacts on well life are not a significant concern for wells that are more than 250 feet deep.

Impact 3 must be evaluated based on well-specific information that is not generally available at this time. We recommend that this impact be evaluated on case-by-case basis during the mitigation phase of the project.

A reasonable range for increased operational costs (Impact 4) was evaluated by simulating several different well, pump, water level and interference drawdown configurations. In general, it was found that increased costs for residential well operators are not expected to be significant. Increased costs for agricultural, industrial or municipal well owners with annual pumping requirements in the range of hundreds to several thousand dollars may be expected to range from several hundred to several thousand dollars. (For the pumps modeled, the maximum cost increase represents an approximately 2 percent increase in the user's overall pumping costs.) The only City of Madera well that may be impacted by project pumping (Well No. 26) is designated for use as a standby well and for fire suppression. As such, significant increases in the electrical cost to operate this well are not anticipated.

On a regional basis, the project will contribute slightly (approximately 0.02 to 0.5 percent) to an existing imbalance between groundwater pumping and recharge (overdraft). Significant ground subsidence is not anticipated as a result of the project.

Implementation of a drawdown monitoring program is recommended to document actual drawdown from the project as well as regional water level trends and interference drawdown from other nearby groundwater pumping. Data from the program can be used to establish baseline conditions, evaluate the effectiveness of measures designed to mitigate drawdown, and to assess appropriate mitigation for nearby impacted well owners.

Drawdown and overdraft impacts can be mitigated to some extent by implementation of Best Management Practices (BMPs) in the proposed construction and infiltration from on-Site land application of treated wastewater from the development. The effectiveness of this mitigation measure was estimated for Alternative A to be a reduction in predicted drawdown of between 7 and 49 percent, depending on the extent to which spray field or leach field application is used for disposal. Based on the information provided, slightly greater mitigation efficiencies may be expected for Alternatives B and C and if groundwater recycling is not incorporated, because the relatively more treated wastewater is discharged compared to the projected groundwater extraction rates for those alternatives. In addition to the above, the tribe is considering participating in regional groundwater recharge projects in the Madera subbasin.

All the wells in the area will experience impacts from the prevailing regional decline in groundwater levels of 1.85 feet/year. The following alternatives for mitigation of significant project-related interference drawdown impacts are being considered, to the extent the impact is attributable to project pumping as distinguished from the regional trend:

- Impacts 1 and 2 : Reimbursement for well replacement, rehabilitation or deepening;
- Impact 3: Reimbursement for pump replacement or re-setting;
- Impact 4: Compensation for increased cost; and
- At the tribe's discretion, providing a connection to a local public or private water system, for any and/or all potential significant impacts.

The average daily groundwater pumping rate for the North Fork Alternative (Development Alternative D) would be about 27,000 gpd (19 gpm) without water recycling and 14,000 gpd (10 gpm) if recycling is incorporated. The proposed pumping rate of 9 to 17 gpm is comparable to or lower than the reported yields of existing wells in the area of the North Fork Site for which information was obtained (**Section 5.5**), but exceeds the median well yield reported for wells drilled in eastern Madera County (Todd, 2002). Therefore, it appears likely that the aquifer could produce water at the proposed rate if one or more wells were installed, as needed. However, the drawdown resulting from this pumping cannot be predicted at this time, due to the lack of available data on groundwater levels or aquifer parameters in the North Fork area. In addition, due to the nature of fractured granitic aquifers, such properties are usually site-specific and highly variable from one location to another.

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LIST OF ACRONYMS AND ABBREVIATIONS

amsl	above mean sea level
AES	Analytical Environmental Services
AF	acre-feet
AFY	acre-feet per year
bgs	below ground surface
DWR	California Department of Water Resources
EIS	Environmental Impact Statement
gpd	gallons per day
gpd/ft	gallons per day per foot
gpm	gallons per minute
HydroScience	HydroScience Engineers, Inc.
mg/L	milligrams per liter
MID	Madera Irrigation District
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
WRCC	Western Regional Climate Center

1 INTRODUCTION

1.1 PROJECT BACKGROUND

The North Fork Rancheria of Mono Indians has proposed to establish a casino and hotel development on a 305-acre area of land to the northwest of the City of Madera in Madera County, California ("the Madera Site"; **Figures 1, 2 and 3**). An alternative site near the town of North Fork in the same county is also being considered ("the North Fork Site"; **Figures 1 and 4**). An Environmental Impact Statement (EIS) is to be prepared by Analytical Environmental Services (AES) as required by the National Environmental Policy Act.

The EIS will evaluate four development alternatives, as follows:

A Development of the casino and hotel on the Madera Site;

B Reduced intensity casino development on the Madera Site;

C Alternative retail use for the Madera Site; and

D Development of a casino and hotel on the North Fork Site.

HydroScience Engineers, Inc. (HydroScience) performed a *Water and Wastewater Feasibility Study* for the proposed casino and hotel development (HydroScience, 2006). In the case of the Madera Site, the study considers two alternative strategies for water supply to the proposed development: an off-Site groundwater supply from the City of Madera; and an on-Site groundwater supply using two proposed wells. The North Fork Site development alternative would be supplied by on-Site groundwater wells (HydroScience, 2006).

1.2 PROJECT SCOPE

WorleyParsons Komex was contracted by AES to undertake a study relating to the proposed use of groundwater from on-Site wells to supply the proposed development alternatives described above. Consideration of the alternative water supply from the City of Madera was not part of the project scope. The objective of the study was to assess how the use of groundwater to supply the new development alternatives, as recommended in the *Water and Wastewater Feasibility Study*, would affect local groundwater levels and wells, the groundwater basin in which the Site is located, and the potential for ground subsidence to occur. Our assessment was performed using existing data and limited field observation. This report includes revisions made in response to comments received from the City of Madera, Madera Irrigation District, and the U.S. Environmental Protection Agency. Subsurface investigation and hydrogeologic testing were not included in our scope of services.

1.3 REPORT ORGANIZATION

This report is subdivided as follows:

Section 1: Introduction.

Section 2: Regional Hydrogeologic Setting. An overview of the topography, drainage, climate, geology and hydrogeology of the Madera County region.

Section 3: Previous Groundwater Use Studies. A review of relevant groundwater studies undertaken between the late 1950's and 2004, with particular emphasis on measured groundwater elevations and trends.

Section 4: Madera Site Evaluation. A summary of geologic and hydrogeologic conditions pertaining to the Madera Site, with discussion of historical groundwater levels.

Section 5: North Fork Site Evaluation. A summary of geologic and hydrogeologic conditions pertaining to the North Fork Site, with discussion of groundwater use in the vicinity.

Section 6: Potential Impacts of Using Groundwater as a Water Supply for the Madera Site Development Alternatives. An evaluation of the effects of the three proposed development alternatives of the Madera Site on groundwater levels and wells in the vicinity, the groundwater basin in which the Site is located, and on ground subsidence.

Section 7: Potential Impacts of Using Groundwater as a Water Supply for the North Fork Site Development Alternative. Discussion of the effects of the North Fork Site development alternative on groundwater levels and wells in the vicinity.

Section 8: Conclusions.

Section 9: Closure/Limitations.

Section 10: References.

2 REGIONAL HYDROGEOLOGIC SETTING

2.1 TOPOGRAPHY AND LAND USE

Ground surface elevations in Madera County range from less than 300 feet above mean sea level (amsl) in the west to over 13,000 feet amsl in the east. The western third of the county is occupied by part of the San Joaquin Valley; the eastern area by the foothills and mountains of the Sierra Nevada.

The San Joaquin Valley is a structural trough up to 200 miles long and 70 miles wide, bounded to the west by the Coast Ranges, to the south by the San Emigdio and Tehachapi Mountains, to the east by the Sierra Nevada, and to the north by the Sacramento-San Joaquin Delta and the Sacramento Valley.

The San Joaquin Valley provides flat to gently rolling farmland. The foothills region is used mainly for grazing, irrigated pasture, and animal husbandry. The predominant land uses in the mountain region (above about 3,500 feet amsl) are tourism, recreation, and forestry (Todd Engineers, 2002).

2.2 CLIMATE

The San Joaquin Valley has an arid to semi-arid climate characterized by hot summers and mild winters. Mean annual precipitation on the valley floor ranges from less than 5 inches in the south to 15 inches in the north. Average annual precipitation in the Sierra Nevada ranges from 20 inches in the lower foothills to more than 80 inches at some high altitude sites (Gronberg *et al.*, 1998).

2.3 DRAINAGE

More than 90% of surface runoff from Madera County is ultimately discharged via the San Joaquin River, which forms the western and most of the southern county boundary (Todd Engineers, 2002). The Fresno and Chowchilla Rivers, both tributary to the San Joaquin River, are the other major drainage courses in the county.

The area also contains thousands of miles of canals and ditches, originally built for agricultural irrigation or for gold mining operations. In the late 1940's, the Federal government became involved with irrigation, and was responsible for the construction of substantial storage, pumping and conveyance facilities (Gronberg *et al.*, 1998). The major rivers and several of the minor courses are dammed within the county: major reservoirs in the foothill area include Millerton Lake (formed by Friant Dam) on the San Joaquin River, Hensley Lake on the Fresno River, and Eastman Reservoir on the Chowchilla River. The Madera and Friant-Kern Canals were constructed to divert water respectively north and south from below Friant Dam (Gronberg *et al.*, 1998).

2.4 GEOLOGY AND HYDROGEOLOGY

The San Joaquin Valley structural trough is infilled with up to 32,000 feet of marine sediments (deposited during periodic inundation by the Pacific Ocean) and continental sediments (formed by erosion of the surrounding mountains) (California Department of Water Resources [DWR], 2004). The foothills and mountains of the Sierra Nevada to the east are made up of pre-Tertiary igneous and metamorphic basement rocks. The Madera Site lies in the San Joaquin Valley, whereas the North Fork Site lies in the foothills to the east. Therefore, the two Sites are characterized by very different geologic and hydrogeologic conditions (see **Sections 4 and 5**).

The following are brief descriptions of the main geologic and hydrostratigraphic units present in Madera County, from youngest to oldest.

Flood Basin Deposits: these Holocene age deposits underlie recently flooded areas in a narrow band parallel to the San Joaquin River. Their maximum thickness is about 50 feet (Mitten *et al.*, 1970).

Younger Alluvium: this is a thin (0 to 50 feet thick) deposit of interbedded clay, silt, and sand, that underlies the channels, flood plains and parts of the alluvial fans of the Chowchilla, Fresno, and San Joaquin Rivers (Mitten *et al.*, 1970).

Older Alluvium: this is the most important aquifer in the area (DWR, 2004). It consists mainly of intercalated lenses of clay, silt, sand, and some gravel. It includes lacustrine and marsh deposits, which contain the E-clay or Corcoran Clay (equivalent to the Diatomaceous Clay of Davis *et al.*, 1959), a regionally important hydrogeologic confining layer. The Older Alluvium is of Pleistocene and Holocene age, ranges in thickness from 0 to about 1,000 feet, and dips gently towards the southwest (Mitten *et al.*, 1970).

Tertiary and Quaternary Continental Deposits: these include interbedded, poorly sorted sand, silt, clay and conglomerate with layers of hardpan and traces of volcanic glass and tuff (Mitten *et al.*, 1970). DWR (2004) includes the Ione Formation in this category, although Mitten *et al.*

(1970) group the Ione conglomerates and sandstones with the underlying consolidated strata. The Tertiary and Quaternary Continental Deposits are between 1,000 and 2,200 feet thick in the Madera area (Mitten *et al.*, 1970).

Pre-Tertiary and Tertiary undifferentiated marine and continental sedimentary rocks: these sandstone, siltstone, claystone and shale rocks overlie the basement complex unconformably (Mitten *et al.*, 1970).

Basement complex: granitic and schistose basement rocks underlie the valley infill deposits, and outcrop in the foothills and mountains of eastern Madera County. The basement comprises sedimentary and volcanic strata that were folded, faulted, metamorphosed, and intruded by granitic batholiths during the Nevadan Orogeny, which began about 200 million years ago and resulted in the formation of the Sierra Nevada mountains (Todd Engineers, 2002).

2.5 GROUNDWATER OCCURRENCE AND FLOW

In the San Joaquin Valley of western Madera County, potable groundwater occurs mainly in the unconsolidated alluvial deposits of Pleistocene and Holocene age (DWR, 2004). In the foothills to the east, groundwater occurs predominantly in fractured bedrock (Todd Engineers, 2002) but also in gravel- and silt-filled stream courses and meadows (Madera County, 1995).

Overall, groundwater flow in Madera County is from the upland areas of the east towards the San Joaquin Valley in the west.

3 PREVIOUS GROUNDWATER USE STUDIES

This Section briefly summarizes important historical groundwater use studies that are relevant to the Madera and North Fork Sites.

3.1 EARLY STUDIES

The first report on groundwater occurrences in the San Joaquin valley was authored by W. C. Mendenhall and published by the United States Geological Survey (USGS) in 1916, and was based on fieldwork carried out between 1905 and 1910 (Davis *et al.*, 1959). At the time, groundwater supplied only a small proportion of the agricultural water demand in the San Joaquin Valley, on the order of about a quarter of a million acre-feet per year (AFY).

In 1934, the California Division of Water Resources (now the Department of Water Resources) published reports on the state water plan that included the San Joaquin Valley. In 1939, Piper and others described hydrogeologic conditions in the Mokelumne area (Mitten *et al.*, 1970).

By 1955, approximately 9 million AFY of groundwater were being pumped to supply just over half of the irrigated area in the San Joaquin Valley (Davis *et al.*, 1959).

3.2 USGS WATER-SUPPLY PAPER 1469, 1959

The study undertaken by Davis *et al.* (1959) and published as Water-Supply Paper 1469 was the first on groundwater conditions in the San Joaquin Valley since Mendenhall's publication of 1916. The study was designed to provide a reconnaissance appraisal of groundwater conditions and quality.

For the purposes of the study, the San Joaquin Valley was divided into several smaller units. The Madera Site is located within the San Joaquin River unit. In this unit, groundwater recharge occurs chiefly along the San Joaquin and Fresno Rivers, the Berenda Slough, and several lesser streams. Flow in these streams is augmented by deliveries from the Madera Canal to the Madera Irrigation District (MID), which in 1951 totaled 37,727 acre-feet (AF).

Irrigation in the unit was largely accomplished by groundwater extraction. Thus, well hydrographs commonly showed a general rise of water levels in late autumn and winter, when groundwater pumping was small and recharge comparatively large, and a decline in late spring and summer, when pumping increased and recharge was smaller.

3.3 DWR BULLETIN 135, 1966

DWR Bulletin 135 (DWR, 1966) was intended to provide a comprehensive report on water resources in Madera County and the drainage basins of the Chowchilla and Fresno Rivers. The study was undertaken at the request of the Madera County Water Commission, which had been tasked with addressing water "problems" in the county.

The report concluded that existing and authorized water supply projects were insufficient to meet the projected demands in the area. The report highlighted proposed projects that could meet the anticipated demand, both in the valley area and in the foothills of the eastern county. Off the valley floor, the report noted that water was supplied almost entirely from limited groundwater resources which were "... inadequate to cope with increasing requirements."

3.4 USGS OPEN FILE REPORT 70-228, 1970

The USGS, in cooperation with DWR, began studying areas within the San Joaquin Valley in 1948. In 1970, their report on the Madera area (including the area of the Madera Site) was published (Mitten *et al.*, 1970). The purposes of the study were to detail the geology and hydrogeology of the area, to describe groundwater storage, and to relate conditions to those in adjacent areas. The work was carried out between 1964 and 1968.

The report gives a detailed account of geology, hydrogeology, and water quality in the area. It describes the three groundwater bodies present: the confined water body (which underlies the E-clay in the western area); the unconfined water body (which overlies the E-clay, where present, and supplies most of the groundwater pumped in the area); and the shallow water body (which is only locally present).

Analysis of hydrographs revealed a general long-term decline of the groundwater surface in the unconfined water body in the area. Between 1906 and 1965, water levels declined between 40 and 55 feet in some areas.

The potentiometric surface of the confined water body also showed a long-term declining trend due to increased pumping. In the western part of the area, the potentiometric surface was above ground level in 1905; in 1965 it was between 60 and 100 feet below ground surface (bgs). This was mainly attributed to pumping to the west of the Madera area.

Most of the fresh groundwater in the area is a bicarbonate type that generally contains less than 500 milligrams per liter (mg/L) dissolved solids, although this increases to in excess of 2,000 mg/L below 800 feet depth.

3.5 USGS PROFESSIONAL PAPER 1401, 1984-1991

This study, published in four parts between 1984 and 1991, sought to describe major aspects of the geology, hydrology, and geochemistry of the Central Valley aquifer system (Bertoldi *et al.*, 1991).

The report notes the difference between the "traditional" view of the San Joaquin Valley as containing two aquifers (unconfined and confined) separated by a regional confining unit (the Corcoran or E-clay), and a more recent interpretation which envisages a single heterogeneous aquifer containing many isolated lenses of sand, silt, and clay. Under the latter interpretation, although the Corcoran Clay is present as a distinct, comparatively thick, low permeability layer, its significance in controlling vertical groundwater flow is less than that of the combined effect of the many other fine-grained lenses present in the stratigraphic sequence.

The report notes that groundwater flow in the Central Valley has been greatly altered by large-scale groundwater development and very large diversions and redistribution of surface water. Heavy pumping from wells, averaging 11.5 million AF annually during the 1960's and 1970's (peaking at 15 million AF in the drought year of 1977), combined with increased recharge due to irrigation, caused changes in groundwater levels throughout the area. Groundwater flow was now primarily towards pumping centers rather than towards pre-existing natural discharge areas.

Increased pumping of groundwater has also caused land surface subsidence over a large area.

3.6 DWR SAN JOAQUIN DISTRICT STUDY, 1992

DWR (1992) provided an analysis of groundwater level trends between 1970 and 1991 in the San Joaquin Valley. The report notes that other DWR publications describe the Valley's groundwater basin as being in overdraft, based on long-term average conditions. As defined by DWR, overdraft is a long-term deficiency in water supplies – and specifically the portion of water demand that exceeds long-term supplies. This overdraft was estimated as about 10% of the Valley's average, long-term, sustainable supply.

Groundwater levels beneath the San Joaquin Valley were described as "high" in 1970. Decreasing precipitation, culminating in the 1976-77 drought, led to increased groundwater pumping and declining groundwater surface levels. However, by the early 1980's increased precipitation had allowed groundwater levels to rebound to or exceed 1970 elevations. After 1987, another downward trend began.

Annual changes in groundwater storage were computed for each county in the study area for the years 1970 to 1991. For Madera County, the cumulative change in storage was calculated as a decrease of 2,091,600 AF. This was reflected in an average groundwater level decline of 38.8 feet, which represented a larger decline than observed in many other counties; this was attributed to the "inadequacy of surface water supplies" to supplement groundwater in Madera County.

3.7 MADERA COUNTY GENERAL PLAN, 1995

The background report to Madera County's General Plan (Madera County, 1995) lists the four irrigation districts that manage surface water delivery in the county, and states that groundwater wells for municipal use are managed by local governments. There are eleven large and about 44 small community water systems in operation in the county, the vast majority of which use groundwater as the primary source.

Groundwater resources in western Madera County are described as adequate, with residential wells generally pumping from between 150 and 300 feet deep, and commercial and agricultural wells being deeper. However, the report states that "the average amount of [annual] groundwater recharge is far less than the average annual use. The result of this trend is increasing depth to groundwater".

In the eastern mountainous area of the county, reliable sources of groundwater are more difficult to find, with fracture systems, gravel- and silt-filled stream courses, and meadows presenting the best opportunities for water supply development.

The report draws attention to the Central Valley Project Improvement Act, signed into law by Congress in 1992, which, according to the report, could result in increased costs and reduced supplies of surface water to agricultural users in Madera County, and in turn could increase pressure on groundwater supplies. The report considers that this act alone has the potential to drastically affect the agricultural community, and that its combined effect with existing legislation that reserves more water for environmental purposes and future droughts could have "even greater severity."

The following extract from the report summarizes concerns over water supply in the county:

> "Madera County faces two key issues in regard to groundwater supply. First, continued agricultural production will continue to lower the water table. Reduced surface supplies during dry years and the potential ability to sell water outside the county will exacerbate this situation. Secondly, groundwater in the foothills and mountains is very limited, and is not adequate to serve significant future growth. Water supply is therefore one of the most critical issues facing Madera County."

3.8 MADERA IRRIGATION DISTRICT GROUNDWATER MANAGEMENT PLAN, 1999

In 1999, MID described its intention to produce a groundwater management plan, designed to define its role in managing local groundwater resources in order to maximize supply and protect quality (Boyle Engineering, 1999). The Madera Site lies within the MID service area.

MID measures spring and fall depths to groundwater in wells throughout its service area. These measurements have recorded an average groundwater level decline of about 1.25 feet per year. In an effort to replenish the groundwater supply, MID operates eight recharge basins and unlined canals that contribute to recharge. These recharge basins and canals are all located in the Madera subbasin. The Madera subbasin is defined as lands overlying the alluvium in Madera County (DWR, 2004). The location of the Madera subbasin and the recharge basins are shown on **Figure 1**.

The report compares hydrographs of wells in and near the City of Madera with those of wells near the Fresno and San Joaquin Rivers. The hydrographs show that water levels are generally in decline near the City of Madera, whereas near the rivers they vary with annual precipitation. The report concludes that "it is apparent that the basin underlying the city [of Madera] is in a much more serious state of overdraft." This is a primary concern for the MID, because groundwater is the primary source of water for municipal and agricultural users in the basin.

3.9 MADERA COUNTY AB3030 GROUNDWATER MANAGEMENT PLAN

A groundwater management plan for the groundwater basins in the western third of Madera County was prepared by Todd Engineers (2001). Included were parts of the Madera, Chowchilla, and Delta-Mendota subbasins that were not already subject to existing management plans prepared by others. The Madera Site is covered by the MID's groundwater management plan (**Section 3.8**) because it is located in the MID service area. Madera County's groundwater management plan is limited to portions of Madera County that are not covered by existing groundwater management plans and, therefore, does not strictly apply to the Madera Site. However, the information contained within Madera County's plan is relevant to the general Madera Site area.

The plan notes that DWR classified the Madera and Chowchilla subbasins as being in a state of "critical overdraft" in 1980, although this terminology is no longer used by DWR. A long-term declining trend in groundwater elevations was observed from well hydrographs. Overall declines ranged from less than 10 feet in wells located near the San Joaquin River, to more than 150 feet in northwestern Madera County.

A correlation between precipitation, availability of surface water deliveries, and water elevations was noted, with water levels rising during wet periods and falling during periods of drought. However, following a drought in the mid- to late-1980's, groundwater levels did not recover significantly, despite the drought being followed by several of the wettest years on record. This was attributed to increased pumping over time, and possibly also the effect of decreasing specific yields in deeper saturated sediments.

Todd Engineers (2001) estimated the change in groundwater storage from the drought conditions of the early 1990's to the wet conditions of the late 1990's as -68,338 AFY on average. This corresponded to an average annual decline in groundwater levels of 1.5 feet. Todd Engineers noted that three separate calculations of change in groundwater storage (two by DWR and one by Todd Engineers) resulted in similar quantification of overdraft conditions in the Madera County groundwater subbasins from 1952 to 1998. Todd Engineers made the following comments:

> "These data indicate that no measures to date have arrested the overdraft condition of the groundwater basin, despite recent record wet years. Without mitigation, water levels are expected to continue to decline into the future with the rate of decline controlled by precipitation and pumping patterns. As water levels reach all-time lows, damage to the groundwater basin may be occurring."

Four strategies to address the declining water levels and achieve a sustainable water supply were discussed:

1. Maximize groundwater recharge. Maximizing natural streamflow recharge could partially mitigate groundwater overdraft. The purchase of additional water could also be considered.

2. Preclude export of water out of the County.

3. Agricultural land conversion. Agricultural pumping is estimated to account for more than 95% of groundwater pumping in the County. Conversion of the land to urban usage could reduce groundwater use. However, if agricultural land currently irrigated with surface water is converted to urban use – with total reliance on groundwater for potable uses – then groundwater demand would increase and surface water return flows would be lost.

4. Develop standards for urban development. Regional overdraft conditions and water balance should be taken into consideration when demonstrating a sufficient water supply for any new development.

3.10 TODD ENGINEERS REPORT – EASTERN MADERA COUNTY, 2002

Madera County contracted Todd Engineers to undertake a study of groundwater conditions in the eastern part of the county, in the foothill and mountain regions not covered by the AB3030 plan (See **Section 3.9**). The North Fork Site lies within this area. The objectives of the study were to compile, summarize, and analyze existing data on groundwater conditions, and to provide recommendations for further work and on groundwater management issues.

Data were generally not available on groundwater occurrence, levels, flow, or storage. However, groundwater is the main source of water supply in eastern Madera County, with surface water from streams and reservoirs supplementing in some areas. Approximately 45 county- and community-operated water systems, and 69 non-community water systems are active in the area, and there are records for about 4,500 private wells.

Todd Engineers carried out a preliminary watershed water balance for the foothill region. The total groundwater recharge was estimated at 107,000 AFY, compared to an annual water demand of 5,803 AFY. Thus, water demand was estimated to be only about 5% of recharge. However, it was cautioned that most groundwater recharge occurs in portions of the county where groundwater is not used. In developed areas, the water demand is likely a much higher percentage of the local recharge.

The study concluded that on a regional basis, sufficient groundwater is available to meet demand. However, development is typically concentrated (*e.g.*, in small towns), which causes water demand to be a significant proportion of local recharge. Well yields are typically less than 50 gallons per minute (gpm), with a median reported yield of 8.5 gpm and an average reported yield of 22 gpm. In some cases, it may be necessary to drill several wells until one with sufficient yield is found.

Note that the conclusions of this study are seemingly in contradiction to the conclusions of the study performed in support of the Madera County General Plan (**Section 3.7**), which stated that "groundwater in the foothills and mountains is very limited, and is not adequate to serve significant future growth".

3.11 MILLERTON AREA WATERSHED ASSESSMENT, 2003

The Millerton Area watershed lies west of the town of North Fork and, although the area covered by the Millerton Area Watershed Assessment does not include the North Fork Site, the assessment provides insights into water supply issues in the foothills of Madera County.

Because of a general lack of information on groundwater resources (the most extensive study undertaken had been the Todd Engineers project – see **Section 3.10**), discussions were undertaken with local well drillers and geologists. Details of these discussions are included in Appendix 3 to the draft watershed assessment (Millerton Area Watershed Coalition, 2003). Some of the comments made include the following:

- Typical domestic water well production is in the 5 to 7 gpm range.
- Well depths are generally between 400 and 700 feet bgs. The deepest wells are about 1,500 feet deep. Deep fractures remain open because they contain weathered rock particles.
- Water levels are falling in some areas. Current well "re-drills" due to declining groundwater levels are generally in excess of 700 feet bgs, with most around 900 feet bgs.
- DWR does not keep records of well water levels in the foothill area.
- "You don't really know [if sufficient groundwater is present] until you drill a well and test what you have."

3.12 DWR BULLETIN 118 UPDATE, 2003-2004

DWR maintains online descriptions of California's groundwater basins, including the Madera subbasin of the San Joaquin Valley Groundwater Basin (DWR, 2004).

The Madera subbasin is defined as lands overlying the alluvium in Madera County. The subbasin is bounded to the south by the San Joaquin River, to the west by the eastern boundary of the Columbia Canal service area, to the north by the southern boundary of the Chowchilla subbasin, and to the east by the crystalline bedrock of the Sierra Nevada foothills.

On average, water levels in the subbasin declined nearly 40 feet from 1970 through 2000:

- Approximately 30 feet of decline occurred from 1970 to 1978;
- Stabilization and rebound of about 25 feet occurred from 1978 to 1987;
- Steep declines to about 45 feet below the 1970 level occurred from 1987 to 1996; and,
- A rise of about 8 feet occurred from 1996 to 2000.

The estimated average specific yield of the Madera subbasin is 10.4%. The storage capacity of the subbasin above a depth of 300 feet bgs was estimated to be 18,500,000 AF, and the storage capacity to the base of fresh groundwater was estimated to be 40,900,000 AF. DWR (2004) gives two estimates of the actual groundwater stored:

- 24,000,000 AF to a depth of about 1,000 feet bgs in 1961; and,
- 12,600,000 AF to a depth of 300 feet bgs in 1995.

DWR (2004) reported a partially complete groundwater budget for the Madera subbasin in 1990 as follows:

- Applied water recharge: 404,000 AF;
- Natural recharge: 21,000 AF;
- Agricultural extraction: 551,000 AF; and,
- Urban extraction: 15,000 AF.

Artificial recharge, subsurface inflow and outflow, and the change in groundwater storage were not determined. The net effect of these undetermined components is equivalent to a groundwater inflow of 141,000 AF. Komex anticipates that the undetermined inflow consists mainly of groundwater withdrawn from storage in the aquifer, because the other three undetermined components are expected to be relatively small in comparison to withdrawal from storage.

3.13 DRAFT EIR FOR THE MADERA IRRIGATION DISTRICT WATER SUPPLY ENHANCEMENT PROJECT, 2005

As an outgrowth of its AB 3030 Groundwater Management Plan, MID proposed the Water Supply Enhancement Project to increase its storage capacity and supply reliability for its customers. The project consists of aquifer storage of surface water entitlements that typically cannot be delivered to MID customers due to the timing and/or duration of their availability. As conceived, up to 55,000 AFY will be diverted to the Madera Ranch, located approximately 8 miles southwest of the Site in the Madera subbasin (**Figure 1**), where it will be infiltrated by applying it to swale recharge areas and recharge basins. The infiltrated water will be stored in the aquifer for future extraction. The total storage capacity of the project is estimated to be 250,000 AF. The water will be extracted by pumping it from up to 15 existing and 49 proposed new wells and pumped back into MID and surrounding areas for agricultural use when needed. Only up to 90 percent of the water that is infiltrated will be recovered, leaving the remaining 10% to help offset the current overdraft condition in the basin. Exportation of water outside of Madera County will not be permitted. Shallow groundwater levels will be monitored around the perimeter of the recharge area, and recharge will be managed such that groundwater levels do not rise higher than 20 feet bgs.

Under current conditions, MID diverts an average of 3,080 AFY of surface water to the eight recharge basins located within its jurisdiction in the Madera subbasin (**Figure 1**). The amount of water sent to the basins has varied since measurements began in 1993. Water was diverted to these basins during 10 of the 12 years from 1993 through 2004, and during three of the years, less than 1,000 AF was sent to the basins. The maximum amount of water sent to the basins was 8,091 AF in 2000.

The Draft Environmental Impact Report (DEIR) for the project states that the Madera Subbasin is in overdraft by an estimated average of 100,000 AFY. As a result, groundwater levels declined an average of 67 feet since 1945 and 30 feet since 1980. The amount of groundwater pumped varies from year to year, depending upon the availability of surface water, precipitation and temperature. Groundwater pumping during critically dry years can be more than twice as high as pumping during wet years.

4 MADERA SITE EVALUATION

4.1 SITE LOCATION AND DESCRIPTION

The Madera Site comprises about 305 acres of land located northwest of the City of Madera. It is bounded by Golden State Boulevard and Highway 99 to the northeast, Avenue 18 to the north, Road 23 to the west, and residential and agricultural land to the south (**Figures 2** and **3**).

The Madera Site is currently used for growing non-irrigated crops. A residence and associated buildings are present in the southeastern corner. Seven agricultural wells were observed on the Site during a visit conducted on 14 April 2005 (**Figure 3**). These wells appear to have been disused for some time.

4.2 TOPOGRAPHY, CLIMATE AND DRAINAGE

The Madera Site lies at an elevation of approximately 250 feet amsl and occupies essentially flat-lying agricultural land.

The following references for average annual rainfall in the vicinity of the Madera Site were found during Komex's literature review:

- 11 inches in the majority of the Madera subbasin (DWR, 2004);
- 10.3 inches in the MID area (Boyle Engineering, 1999); and,
- 11.22 inches at Madera station (period of record 1 July 1948 to 31 December 2004; Western Regional Climate Center [WRCC], 2005a).

In the Madera area, only 1 to 2% of the precipitation falls in summer, and 70 to 75% falls in winter (Mitten *et al.*, 1970).

The Madera Site lies approximately 2.25 miles north of the Fresno River, and less than 0.25 mile south of Dry Creek. The USGS topographic map (**Figure 3**) shows Schmidt Creek, an ephemeral stream, flowing onto the Site along its eastern boundary. This stream is now channelized across the Site as indicated in Figure 1-2 of HydroScience (2005). Airport Ditch, a canal operated by MID (AES, 2004), runs along the western Site boundary.

4.3 GEOLOGY AND HYDROGEOLOGY

The Madera Site lies within the Madera subbasin of the San Joaquin Valley Groundwater Basin. Water-bearing units in the Madera subbasin comprise unconsolidated deposits of Pleistocene and Holocene age (DWR, 2004).

The most important aquifer in the area is the Older Alluvium, comprising intercalated lenses of clay, silt, sand, and some gravel (see **Section 2.4**). The E-clay or Corcoran Clay is not thought to be present beneath the Madera Site; its eastern boundary lies about 4 miles to the southwest (Figure 5 of Mitten *et al.*, 1970; see **Figure 2**).

Borehole logs for wells drilled near to the Madera Site, obtained from DWR, are consistent with the above description of the Older Alluvium. The geologic descriptions on the logs are generally very basic (often limited to one word, *e.g.*, "sand" or "clay"), but the logs do serve to give a qualitative indication of geologic conditions. The logs indicate alternating "sandy" and "clayey" layers to at least 700 feet bgs in the vicinity of the Madera Site, with the sandier horizons generally accounting for between 25% and 40% of the total thickness.

4.4 GROUNDWATER LEVELS

4.4.1 SITE-SPECIFIC MEASUREMENTS

Komex attempted to measure the depth to groundwater in the on-Site agricultural wells during a Site visit carried out on 14 April 2005. Efforts were made to lower a measuring tape into the wells, but on each occasion an obstruction was met before groundwater was reached. No measurements of depth to groundwater could therefore be obtained from the on-Site wells.

4.4.2 DWR INTERPRETATIONS OF HISTORICAL GROUNDWATER LEVELS

Maps produced by DWR show lines of equal groundwater elevation in the Madera subbasin (DWR, 2005a), as interpreted from spring measurements in designated wells. These maps are included as **Appendix A**. The following table provides the approximate groundwater elevation beneath the Madera Site for each mapped year, together with the general horizontal groundwater flow direction as interpreted from the maps. Note that due to the map scale, the interpolated elevations must be regarded as very approximate; the figures serve to illustrate the general change in groundwater elevations over time. The depth to groundwater given is based on an approximate Site elevation of 250 feet amsl.

Year	Approximate Groundwater Elevation (feet amsl)	Approximate Depth to Groundwater (feet bgs)	Groundwater Flow Direction
1958	180	70	West
1962	170	80	West
1969	165	85	West
1970	170	80	West
1976	165	85	West
1984	170	80	West
1989	135	115	Northwest
1990	135	115	West to Northwest
1991	120	130	Northwest
1992	115	135	Northwest
1993	115	135	Northwest
1994	110	140	North
1995	110	140	West-northwest
1996	115	135	West to Northwest
1997	115	135	Northwest
1998	115	135	West-northwest
1999	110	140	Northwest
2000	110	140	West-northwest
2001	110	140	West-northwest
2001	105	145	West-northwest
2003	100	150	Northwest
2004	105	145	Northwest

The final, 2004 entry in the above table is based on DWR's interpretation of groundwater contours in the San Joaquin Valley in Spring 2004 (DWR, 2005b), as shown on **Figure 5**.

The maps in **Appendix A** indicate an approximate decline in the groundwater surface of 80 feet between 1958 and 2003 in the vicinity of the Madera Site.

The sequence of groundwater elevation contour maps shows the development of an apparent pumping depression northwest of the Madera Site, beneath an area approximately half way between the Cities of Madera and Chowchilla. The beginnings of this depression are evident on the earliest map (1958), and the later maps show the depression continuing to deepen, causing the initial westerly groundwater flow direction in the Madera Site vicinity to migrate towards the northwest. By 1991 this depression had effectively merged with a second depression that had initially developed west of Chowchilla. According to the DWR interpretation, this depression has been the dominant influence on groundwater flow direction in the vicinity of the Madera Site for the last 15 to 20 years.

Beginning in 1969, there has also been a groundwater table depression southwest of the Madera Site, between it and the San Joaquin River. The 2002 map shows this depression in the groundwater surface as being as much as 50 feet lower than the groundwater elevation near the River.

4.4.3 SITE VICINITY HYDROGRAPHS

Groundwater elevation data for wells located on the Madera Site were not available from the sources reviewed. The DWR's online database was reviewed (DWR, 2005c), and three wells which are located in the vicinity of the Madera Site and have relatively complete records over a long time period, were selected for analysis. These key wells are designated as State Wells 10S/17E-34A2, 11S/17E-6J1, and 11S/17E-4R1. The key well locations are indicated on **Figure 2**, and hydrographs showing spring groundwater elevations for the three wells are plotted on **Figure 6**. Well 11S/17E-4R1 is the nearest of the three wells to the Madera Site.

The well-documented declining groundwater elevation trend in the area (see **Section 3** and **Section 4.4.2**) is clearly evident in the three hydrographs. Overall, the trends shown by the wells are roughly parallel before 1984. After 1984, the groundwater elevations in wells 10S/17E-34A2 and 11S/17E-6J1 began to decline at a faster rate. The trend of the other well, 11S/17E-4R1, is a more consistent decline over the entire period of record from 1961 to 2003; however, it does show a steeper decline during 1985 through 1991.

Before 1984, groundwater elevations in well 10S/17E-34A2 were higher than in the other two wells, reflecting the westerly groundwater flow direction that prevailed at the time. In 1985, the groundwater elevation in well 10S/17E-34A2 dropped below that in well 11S/17E-4R1, and then in 1992 it dropped below that in well 11S/17E-6J1. This reflected the change to a more northwesterly flow direction (see **Section 4.4.2**).

Precipitation records were examined to determine whether groundwater levels and precipitation amount can be correlated. Because the precipitation record for the nearest measuring station at Madera is incomplete, data from the Fresno station were used (WRCC, 2005b). The average annual (water year) precipitation for the period 1954 through 2003 was calculated, and for each water year the departure from that average (positive or negative) was computed. The cumulative departure from average precipitation, and the prevailing climate (wet or dry), are shown on **Figure 7**. Hydrographs for the three wells described above are shown for comparison. All three hydrographs show short-term correlations with annual precipitation:

- The years 1970 through 1977 were marked by below-average precipitation (except 1973) and the hydrographs show a generally declining groundwater surface.
- Between 1978 and 1983, rainfall was above-average, and groundwater elevations stabilized or rose slightly. The wettest year in the period of record was 1983.
- 1984 to 1991 were below-average rainfall years (except 1986), and were marked by declining groundwater levels. The cumulative departure from average precipitation during this period declined at a similar rate as was seen during 1970 to 1977, but groundwater elevations declined much faster than they had during 1970 to 1977. This is likely a consequence of increasing groundwater pumping in the area.
- From 1992 to 2000, rainfall was markedly above-average with occasional below-average years (1994 and 1999). In two of the wells, groundwater elevations still declined overall, but at a slower rate than during 1984 to 1992. However, the groundwater elevation in well 10S/17E-34A2 continued to decline at a similar rate to the previous period.
- From 2001 through 2003, rainfall was below average and groundwater levels in the three wells showed an overall decline at about the same rate as in the previous period (note: water level data were not available for 2002).

Groundwater levels can be expected to decline during dry periods, and this is clearly demonstrated in **Figure 7**. However, data for the wet period of 1992 through 2000 demonstrate there is a long-term declining trend in groundwater levels that is influenced by factors other than climate. The most likely cause of this decline is groundwater pumping leading to overdraft conditions.

An additional, short-term influence on groundwater levels is produced by Hensley Reservoir. Hensley Reservoir is located on the Fresno River, about 14 miles upstream of the Madera Site (**Figure 1**). The reservoir stores runoff during the wet season and releases stored water during the dry season. Reservoir storage in May (*i.e.*, at the end of the wet season) is plotted along with the hydrographs for the three wells near to the Madera Site in **Figure 8** (United States Bureau of Reclamation [USBR], 2005).

Following a period of two or more dry years, storage in the reservoir is typically depleted. Runoff from the next wet year is then used to refill the reservoir and is held in storage. As a result, the groundwater system does not receive the amount of recharge that would be expected during that wet year. This in turn produces a steeper decline in groundwater levels during that wet year than would otherwise be expected. **Figure 8** shows that sharp declines in groundwater levels occurred in the wet years 1978, 1982, 1986, and 1993, when reservoir storage increased sharply.

The opposite phenomenon can occur following a period of two or more wet years, when the reservoir is typically near-full. During the next dry year, stored water is released in relatively large volumes. As a result, the groundwater system receives more recharge than would be expected during that dry year. This produces a rise in groundwater levels, or less of a decline than would otherwise be expected. **Figure 8** shows that groundwater-levels rose during the dry years 1984 and 1987, when reservoir storage decreased sharply.

In summary, the groundwater elevation in well 11S/17E-4R1, nearest to the Site, declined 55 feet between 1968 and 2003. Over the same period, the elevation in well 11S/17E-6J1 declined 68.2 feet, and the elevation in 10S/17E-34A2 declined 131.4 feet. The larger decline in 10S/17E-34A2, which is located just over 1.5 miles northeast of the Madera Site, could reflect influence of the pumping depression that appears to exist between the cities of Madera and Chowchilla (see **Section 4.4.2**). Similarly, the 68.2 feet decline in well 11S/17E-6J1, located about 1.25 miles west of the Madera Site, could be related to the depression that formed west of the Madera Site, between it and the San Joaquin River. Well 11S/17E-4R1, located about 1/4 mile southeast of the Site, appears less influenced by these pumping centers.

5 NORTH FORK SITE EVALUATION

5.1 SITE LOCATION AND DESCRIPTION

The North Fork Site is located about 38 miles east-northeast of the City Of Madera and approximately 2 miles east-southeast of the town of North Fork (**Figures 1 and 4**). The Site occupies wooded, south-facing slopes of the Sierra foothills. Two residences are currently present on the property.

5.2 TOPOGRAPHY, CLIMATE AND DRAINAGE

The North Fork Site ranges in elevation from approximately 2,920 feet amsl in the southeast, to approximately 3,480 feet amsl in the northeast (**Figure 4**).

At the nearby town of North Fork, average annual precipitation is 33.2 inches, with more than 87% falling between November and April (Todd Engineers, 2002).

A tributary stream to Whisky Creek flows across the eastern part of the North Fork Site. Another stream, tributary to Willow Creek, originates near the southwestern corner of the Site.

5.3 GEOLOGY AND HYDROGEOLOGY

The North Fork Site lies on an outcrop of the early Cretaceous Bass Lake Tonalite, described as an equigranular, typically medium gray, medium-grained, hornblende-biotite tonalite (Bateman, 1992). This is part of the granitic basement complex described generally in **Section 2.4**.

Groundwater in the North Fork area is available primarily from fractures within the bedrock. Fractures and joints are likely to be more extensive and interconnected within the upper few hundred feet bgs, and tend to decrease in number and size with depth. The depth of weathering and decomposition of granitic rocks varies from none to approximately 100 feet bgs (Todd Engineers, 2002). Each fracture intercepted by a pumping well is usually connected only to a limited number of additional fractures. This effect tends to limit the area from which the well can receive recharge, thus limiting the well's potential yield.

5.4 GROUNDWATER LEVELS

The DWR website does not include information on groundwater levels in the North Fork area. In their study of groundwater conditions in eastern Madera County, Todd Engineers reported that data were generally not available on groundwater occurrence, levels, flow, or storage. However, it was noted that groundwater is the main source of water supply in the area. Groundwater was measured at a depth of 60 feet bgs in a domestic well located on the North Fork Site during a Site visit on 13 April 2005 (see below). HydroScience (2006) reports the depth to water (presumably at the time of well installation) in 43 wells installed in the North Fork Site vicinity between 1959 and 2002 as ranging from 18 to 575 feet.

5.5 GROUNDWATER PUMPING

Groundwater is widely used for domestic supply in the area. Todd Engineers obtained records for approximately 4,600 wells in eastern Madera County and reported a median yield of 8.5 gallons per minute (gpm) and an average yield of 22 gpm (Todd, 2002). As noted below, wells in the vicinity of the North Fork Site reportedly achieve yields ranging from less than 10 to 240 gpm.

North Fork Maintenance District supplies water to the town of North Fork, about 5 miles west of the North Fork Site. It has one, 520-feet deep groundwater well, with a pumping capacity of 240 gpm (Todd Engineers, 2002). An additional well operated by the district is currently inactive but available for future use (HydroScience, 2006). At the time of Todd Engineers' report (2002), water shortages had not been an issue for this district.

Cascadel Water Company supplies a community located about 4,000 feet northeast of the North Fork Site. Water has been supplied from a spring and three wells. Wells 1 (500 feet deep) and 1A produce 57 gpm combined, and Well 2 (550 feet deep) produces 25 gpm (Todd Engineers, 2002).

HydroScience obtained well completion records for 43 wells installed in the North Fork Site vicinity between 1959 and 2002. The locations of 33 of these wells and the well completion details for all of the wells are summarized in **Appendix B**. The depths of the wells reportedly range from 60 to 1,075 feet bgs and the reported well yields range from 1 to 171 gpm. Several of the plotted wells are located on the land allotments northwest of the North Fork Site, but no wells were identified on the Site itself. The records indicate that several of the wells have been deepened over time.

The two residences located on the North Fork Site have wells for domestic water supply. The water level in one of these wells was measured at approximately 60 feet bgs on 13 April 2005. The depth of the well was not determined. The yield of the well was estimated to be less than 10 gpm. The well serving the other residence was not easily accessible at the time of the Site visit; however, the residents reported that the well was tested to yield approximately 55 gpm. Several springs were reportedly located near this residence and had historically been developed for water supply. The capacities of these springs are not known.

Anecdotal evidence from current North Fork Site occupants and other local residents indicates there are a number of springs and wells on land allotments adjacent to the North Fork Site. One of these wells was reportedly drilled to 400 feet bgs, and yielded 55 gpm at the time of installation. Another well reportedly tested at 100 gpm, with little or no measurable drawdown. Other wells are reported to have been drilled to at least 700 feet bgs.

Mr. Galen Lee (one of the residents living on the land allotments) indicated that approximately 10 domestic wells are currently in use on the land allotments (personal communication, February 2006). Of these, seven wells were installed between 1974 and 1976. These wells had to be deepened in 1982/83 because the original installations were too shallow and water levels declined during the drought of the late 1970s. New wells installed on the land allotments in subsequent years were drilled to greater depths. Mr. Lee indicated that the well on his property has experienced decreased yield over the last 10 years, which he attributed to development of the community water supply at Cascadel and a productive domestic well installed south of the North Fork Site.

6 POTENTIAL IMPACTS OF USING GROUNDWATER TO SUPPLY THE MADERA SITE DEVELOPMENT ALTERNATIVES

6.1 MADERA SITE DEVELOPMENT ALTERNATIVES AND WATER SUPPLY REQUIREMENTS

AES has provided details of three development alternatives for the Madera Site:

Alternative A – Development of a casino and hotel;

Alternative B – Reduced intensity casino development; and

Alternative C – Alternative retail use.

HydroScience produced a *Water and Wastewater Feasibility Study* for the development alternatives, including recommendations for the number, depth, and capacities of new on-Site wells needed for water supply (HydroScience, 2006).

The proposed casino and hotel development at the Madera Site (Development Alternative A) has a projected average water demand of 400,000 gallons per day (gpd). Assuming recommended water recycling is undertaken, the recommended groundwater pumping capacity for the wells is 320 gpm (HydroScience, 2006). Note that the recommended pumping capacity is designed to allow the water supply system to handle peak demand with an appropriate safety factor, and average pumping rates are expected to be lower. The average projected water demand and long term pumping rate for each alternative, with and without water recycling, may be summarized as follows (HydroScience, 2006):

Alternative A – 273,000 gpd (190 gpm) with recycling and 400,000 gpd (278 gpm) without recycling;

Alternative B – 166,000 gpd (115 gpm) with recycling and 251,000 gpd (174 gpm) without recycling; and

Alternative C – 11,000 gpd (8 gpm) with recycling and 23,000 gpd (16 gpm) without recycling.

HydroScience recommends that groundwater be supplied by two new production wells drilled to at least 600 feet bgs (HydroScience, 2006). (WorleyParsons Komex anticipates that Development Alternative C could be supplied by a single well.) The proposed wells would likely be drilled near the water treatment plant for the proposed development, in the approximate Site area shown on **Figures 9 and 10**.

6.2 DEVELOPMENT OF DRAWDOWN MODEL

An analytical drawdown model was developed for predicting water-level impacts due to proposed pumping at the Madera Site. The purpose of the model is to assess potential impacts from the proposed pumping associated with each of the three development alternatives on groundwater levels and wells in the Site vicinity. Existing or future impacts due to groundwater pumping from off-Site wells in the area are not predicted by the analytical model, but are included in our discussion of cumulative impacts in **Section 6.7**.

The analytical model uses the Theis non-equilibrium equation (Driscoll, 1986) for describing drawdown from a pumping well. Parameters for the analytical model were derived from a historical pumping test carried out in the vicinity and data obtained from other sources cited in this report (see **Section 6.2.1**).

Although HydroScience has recommended that groundwater be supplied by two new production wells (HydroScience, 2006), the analytical model described in this Section simulates the project's average pumping rates assuming a single pumping well. Simulating a single well to represent two closely spaced wells with the same total pumping rate generally gives a small overestimate in the predicted off-Site drawdown. Other conservative assumptions intended to compensate for uncertainties in the model data and assumptions are described in **Sections 6.2.1 through 6.2.3**.

6.2.1 HYDROGEOLOGIC DATA USED IN MODEL DEVELOPMENT

The average specific yield of the strata between 10 and 200 feet deep in the San Joaquin River unit, within which the Madera Site lies, was estimated to be 11.9% by Davis *et al.* (1959). Estimates were given for each township subunit; for Township 11S, Range 17E, in which the Madera Site is situated, the average estimated specific yield was 11.6%. More recently, DWR (2004) estimated the average specific yield of the Madera subbasin to be 10.4%.

Mitten *et al.* (1970) reported six estimates of transmissivity obtained from a total of four aquifer tests in the Madera area. Well 10S/16E-24H1 is the nearest of the four tested wells to the

Madera Site and is located about 3 miles to the northwest (**Figure 2**). Well 10S/16E-24H1 is screened in the Older Alluvium between 136 and 172 feet bgs. The aquifer test on this well resulted in a transmissivity estimate of 18,000 gallons per day per foot, measured from a 240 feet-deep observation well (10S/16E-24J1). The estimate of 18,000 gallons per day per foot was the lowest of the six transmissivity estimates derived from well tests in the area; the highest was 99,000 gallons per day per foot (Mitten *et al.*, 1970).

The following caveats apply to the transmissivity value obtained from the aquifer test at well 10S/16E-24H1:

a. Well 10S/16E-24H1 is 183 feet deep (and is screened from 136 to 172 feet bgs), whereas the proposed wells at the Site would be 600 feet deep (HydroScience, 2006). However, the E-clay is not present in the area of this test well or the proposed wells at the Site, so they would produce water from the same aquifer. Komex assumes that the proposed supply wells will intercept a greater saturated thickness of aquifer than the test well because the proposed wells are deeper (600 feet versus 180 feet). The smaller aquifer thickness of the test well as compared to the proposed supply wells implies that the transmissivity estimated from the aquifer test is conservative (smaller) with respect to the proposed wells. The smaller transmissivity of the test well will cause the drawdown of the proposed wells to be overestimated.

b. The observation well used for the aquifer test (10S/16E-24J1) is 240 feet deep as compared to 183 feet for the pumping well (10S/16E-24H1). Due to this difference in depth, the screened interval of the observation well potentially may not overlap the screened interval of the pumping well. This condition may have caused over-estimation of aquifer transmissivity during interpretation of the test data. However, since the E-clay is not present in the area of these wells, both wells are likely screened in the same aquifer, thus minimizing the amount of overestimation due to this effect. In addition, the transmissivity at 10S/16E-24H1 is the lowest of the six values reported by Mitten *et al.* (1970).

An aquifer test could be performed with the proposed pumping well(s) to confirm that the aquifer parameters (transmissivity and storativity) used in the model are applicable to the proposed wells, and that the model is not overly conservative. An existing inactive well near the test well should be used as an observation well for the test. If a suitable existing well is not available, then a monitoring well should to drilled near the test well to the same depth as the test well.

The aquifer parameters used in the analytical model are summarized in the table below.

Aquifer Parameter	Parameter Value	Units	Source
Transmissivity	18,000	gpd/ft	Mitten *et al.* (1970)
Storativity	0.104	NA	DWR (2004)
Pumping Rate+ Alternative A	278 (190 with recycling)	gpm	HydroScience (2006)
Pumping Rate+ Alternative B	174 (115 with recycling)	gpm	HydroScience (2006)
Pumping Rate+ Alternative C	16 (8 with recycling)	gpm	HydroScience (2006)
Pumping Time++	10	years	WorleyParsons Komex

+ Rate is time-constant in the model and represents the Average Day Flow with recycling operations.
++ Methodology for selecting pumping time is described in **Section 6.3**.
gpd/ft = gallons per day per foot

6.2.2 MODEL ASSUMPTIONS

The Theis non-equilibrium well equation incorporates the following standard assumptions:

1. The aquifer being pumped is homogeneous and isotropic.
2. The aquifer is uniform in thickness and infinite in areal extent.
3. The aquifer receives no recharge, thus all flow produced from the pumping well comes from aquifer storage.
4. The pumping well is screened in, and receives water from, the full thickness of the aquifer.
5. Water is released from aquifer storage instantaneously when the water level is lowered.
6. The pumping well is 100 percent efficient.

7. Laminar flow exists throughout the well and aquifer.
8. The water table or potentiometric surface has no slope.

The drawdown predictions developed for this report assume that water levels near the Madera Site will adjust to the proposed pumping, and that a period of about ten years can be used to compute drawdown representative of long-term conditions, as described in **Section 6.3**.

The model assumes that the proposed wells will pump at a constant rate (*i.e.*, without seasonal or weekly variations). This assumption is suitable for making long-term predictions of drawdown, such as the drawdown after ten years.

6.2.3 MODEL LIMITATIONS

The analytical model used for this report was developed to predict drawdown using available hydrogeologic data as input. Thus the lack of Site-specific data for transmissivity, storativity, and pumping time has been compensated by using data from surrounding areas (*e.g.*, well 10S/16E-24H1) to make reasonable to conservative estimates of Site conditions. The Theis equation is based on the eight assumptions listed above in **Section 6.2.2**. The Theis equation is accurate when each of these assumptions is met. Most of the assumptions are considered reasonable for the Madera subbasin aquifer. To the extent that these assumptions are realistic, the analytical model remains accurate.

6.3 GROUNDWATER-LEVEL IMPACTS IN THE SITE VICINITY FROM THE PROPOSED PUMPING WELLS

The analytical drawdown model was used to predict drawdown impacts in the vicinity of the Madera Site, from pumping the proposed 600 feet-deep wells. The Theis equation assumes that the aquifer is infinite, and as a result, the predicted drawdown (water-level decline in feet) increases roughly in proportion to the logarithm of the pumping time. For example, the increase in drawdown during the time period from 10 days to 100 days after the start of pumping would be about the same as the increase in drawdown from 100 days to 1,000 days after the start of pumping. Thus drawdown increases very slowly after long periods of pumping, giving the impression that drawdown has stopped increasing. In practice, a finite time period must be used to predict drawdown with the Theis equation. Although the selection of this time period may seem arbitrary, the use of a long time period ensures that drawdown would be increasing very slowly at the end of the selected period. For purposes of this report, a time period of 10 years was selected for predicting drawdown effects from the proposed pumping wells, based on the considerations described above. In addition, the limitations of the available data (**Section 6.2.1**) suggest that the analytical model should not be used to make predictions over exceedingly long periods of time (*e.g.*, greater than 10 years).

Figure 11 is a distance-drawdown graph showing the model's predicted drawdown for Development Alternatives A, B and C with and without water recycling. (Note that the effects of mitigation measures discussed in **Section 6.7** are not reflected in the drawdown predictions shown on **Figure 11.**) **Figure 11** indicates the predicted drawdown as a function of distance between the proposed pumping well and the point of drawdown measurement. For example, the distance could represent the interval between the proposed pumping well and an off-Site well. **Figure 11** can be applied to any potential pumping well location on the Site.

A vertical, blue, dashed line on **Figure 11** indicates the approximate distance from the center of the area for siting the production well(s) to the nearest point on the Site boundary (see **Figures 9** and **10**). This distance is approximately 1,000 feet. Drawdown occurring beyond the Site boundary (*i.e.*, to the right of the 1,000-foot line) can potentially impact existing off-Site water levels and wells. **Figure 11** shows the following predicted drawdown at the property boundary:

Alternative A: 6.4 feet with recycling and 9.3 feet without recycling;

Alternative B: 3.8 feet with recycling and 5.8 feet without recycling; and

Alternative C: 0.3 feet with recycling and 0.5 feet without recycling.

Figure 11 illustrates that the magnitude of drawdown decreases with distance from the pumping well and extends for a finite distance from the Site. That is, the greatest amount of drawdown occurs near the Site and the amount of drawdown decreases rapidly with increasing distance. Farther from the Site, the magnitude of drawdown is smaller and the rate at which the drawdown decreases with distance is also less. As a result, the difference in drawdown effects between the various alternatives also decreases with distance At a distance of approximately 2 miles, the estimated drawdown for Alternative A without recycling (the worst case in terms of drawdown) is 1.5 feet, which is only 0.5 foot more than the estimated drawdown for Alternative A with recycling and Alternative B without recycling (both about 1 foot). Based upon examination of the hydrographs for wells in the Site vicinity, drawdowns of this magnitude are probably insignificant in relation to seasonal and short term natural variations in groundwater levels, and the difference in drawdown between the alternatives also appears insignificant.

6.4 INTERFERENCE DRAWDOWN IMPACTS IN OFF-SITE WELLS

6.4.1 TYPES OF IMPACTS AND EVALUATION APPROACH

The project-related drawdown at any affected well (interference drawdown) will result in a decreased saturated thickness available to be pumped at that well. In the most extreme case, this could result in drawdown of the water level in a well to a depth below the screen of the well (*i.e.*, the affected well goes dry as a result of project pumping). At the other extreme, the effect of project pumping may be so small that the project-related drawdown is insignificant relative to short term or seasonal fluctuations, or the drawdown could represent an insignificant impact to the well user. The following possible significant impacts could occur:

1. The interference drawdown results in the water level in the aquifer being drawn down below the screen of the well (*i.e.*, the well goes dry as discussed above).

2. The interference drawdown results in the water level in the aquifer being drawn down to a point where the remaining saturated thickness is too small for the affected well to provide an adequate water supply for the intended use, or the pumping water level is too close the intake level of the pump, exposing it to potential damage.

3. The interference drawdown results in the water level in the well during pumping (the well's pumping water level) being drawn near the intake of the pump, requiring lowering of the pump intake in order for the well to remain operational. This is essentially a variation of case 2, but there is space below the pump allowing an adequate flow rate to be restored by lowering the pump. Energy costs would be expected to increase after the pump is lowered.

4. The interference drawdown results in a decrease in saturated thickness such that the well and pump can continue to operate and produce the required amount of water, but pumping must occur at either greater frequency/duration and must lift water for a greater height, using more energy, therefore resulting in greater operational and maintenance costs. This is a condition that can develop prior to the onset of case 1, 2 or 3.

The hydrogeologic factors that dictate which of the above impacts will occur are the saturated thickness of the well before interference drawdown and the amount of interference drawdown that is applied (which varies with the distance of the impacted well from the project well). The impact from interference drawdown has the potential to be more severe if it represents a higher percentage of the well's initial saturated thickness prior to the onset of interference drawdown. For example, a 10-foot drop in water level has a greater potential to cause Impacts 1 or 2 in a shallower well; whereas, the same drop in water level in a deeper well might result in less serious, but potentially still significant, impacts such as 3 or 4. In general, small variations in saturated thickness are not considered significant when assessing transmissivity values from the interpretation of aquifer test drawdown data (Jacob, 1950). However, in assessing the impacts of interference drawdown to neighboring pumping wells, a small change in saturated thickness (*e.g.*, 2 feet or more) could still cause a significant increase in electrical costs or could shorten the life of a well. These cases are discussed in additional detail in the subsequent sections.

The impacts resulting from interference drawdown are also dependant on several factors that may vary from well to well, even if the wells have the same saturated thickness and applied interference drawdown. These well-specific factors include the following:

- Local variations in the transmissivity of the saturated sediments in which the well is completed (*i.e.*, their ability to yield water to the well with a given amount of drawdown in the aquifer);
- The condition and efficiency of the well (*i.e.*, the water level in the well bore compared to the water level in the aquifer just outside the well, which can be significantly lower if the well is in poor condition or poorly designed);
- The well's pump specifications, including its rating curve, the depth at which the pump intake is set, and the resulting pumping water level in the well during operation;
- The well's screened interval, which usually, but not always, extends to the bottom of a well; and
- The minimum required water production rate of the well.

The factors listed above affect the amount of water a well can produce, the amount of drawdown in the aquifer needed to produce that water, and the pumping water level inside the well while it is operating, which may be lower than the water level in the aquifer. As such, information regarding these factors is important when assessing impacts to individual wells; however, it is not readily available for the Site. For this reason, our present evaluation uses saturated thickness and interference drawdown, which can be determined by applying our analytical drawdown model to available information regarding nearby wells, to assess the range of potential impacts that may reasonably be expected. Well-specific impacts are more appropriately evaluated and addressed during the mitigation phase of the project (**Section 6.7**).

Our evaluation of interference drawdown related impacts to nearby wells will be based on the following specific data:

- The distance from the proposed pumping wells to the off-Site well in question;
- The predicted drawdown in the aquifer at the location of the off-Site well;
- The depth of the off-Site well; and
- The static depth to groundwater in the off-Site well.

For the purposes of this analysis, Impacts 1 and 2 may be grouped together since they both result in a well's being rendered unusable. In addition, the concept of a "usable well lifetime" is a useful and appropriate approach to evaluating these impacts as further discussed in **Section 6.4.3**. As stated above, Impact 3 is best evaluated on a case by case basis during the mitigation phase (**Section 6.7**), but a limited discussion is included in **Section 6.4.4**. Impact 4 can occur in shallow or deeper wells that may or may not be at risk of the first three impacts. It is further discussed in **Section 6.4.4**.

6.4.2 PREDICTED INTERFERENCE DRAWDOWN IN WELLS WITHIN A 2-MILE RADIUS

Data regarding potential wells which might be affected by the project was obtained for wells within a 2-mile radius of the Site. As stated above, drawdown impacts at greater distance from the Site are probably insignificant compared to seasonal and short term natural fluctuations in groundwater levels that all wells experience. Information regarding the location, construction and use of 259 wells within approximately 2 miles of the area proposed for installation of the project well(s) was obtained by WorleyParsons Komex from the DWR. (Note that our records search identified only one of the seven disused existing wells observed on the Madera Site. This raises the possibility that there could be other wells in the Site vicinity, used or disused, for which DWR has no records. In addition, it was not possible to correlate several wells for which hydrograph information is available on the DWR website with the wells for which construction records were provided.) Because shallow wells are more susceptible to the more potentially serious impacts, data are summarized separately for "Shallow" wells (i.e., wells that are less than 250 feet deep) and "Deeper" wells (i.e., wells that are 250 feet or deeper) in **Tables 1** and **2**, respectively. (The 250-foot depth cutoff was selected to correspond with an approximate usable well life of 50 years if groundwater levels in the area continue to drop at their present rate, as further discussed in **Section 6.4.3.**) The locations of the Shallow and Deeper wells are shown on **Figures 9** and **10**, respectively.

Tables 1 and **2** also present the existing saturated thickness of the wells and the predicted drawdowns for Alternatives A and B with and without recycling. The predicted drawdowns for Alternative C were not included because they are less than 0.4 foot for each well, which is not considered significant. The cumulative frequency distribution for interference drawdown for Alternatives A and B with and without recycling is also shown graphically in **Figure 12**. The predicted interference drawdown to nearby wells resulting from Development Alternatives A and B may be summarized as follows. (Note that the effects of mitigation measures discussed in **Section 6.7** are not reflected in these drawdown predictions.)

Alternative A (without recycling) – The predicted drawdown in nearby wells ranges from 1.5 to 7.2 feet. 100 wells are predicted to experience interference drawdown equal or greater than approximately 2.5 feet, and 10 wells are predicted to experience interference drawdown equal to or greater than approximately 5.5 feet.

Alternative A (with recycling) – The predicted drawdown in nearby wells ranges from 1.0 to 4.9 feet. 100 wells are predicted to experience interference drawdown equal or greater than approximately 1.7 feet, and 10 wells are predicted to experience interference drawdown equal to or greater than approximately 3.8 feet.

Alternative B (without recycling) – The predicted drawdown in nearby wells ranges from 0.9 to 4.5 feet. 100 wells are predicted to experience interference drawdown equal or greater than approximately 1.5 feet, and 10 wells are predicted to experience interference drawdown equal to or greater than approximately 3.4 feet.

Alternative B (with recycling) – The predicted drawdown in nearby wells ranges from 0.6 to 3.0 feet. 100 wells are predicted to experience interference drawdown equal or greater than approximately 1.0 foot, and 10 wells are predicted to experience interference drawdown equal to or greater than approximately 2.3 feet.

6.4.3 IMPACTS ON "USABLE LIFETIMES" OF NEARBY SHALLOW WELLS (IMPACTS 1 AND 2)

The total interference drawdown experienced by existing wells near the Madera Site will be the sum of drawdown caused by pumping at the Madera Site and drawdown caused by pumping other wells in the Madera subbasin. Thus, interference drawdown caused by pumping at the

Madera Site would be superimposed on the well-documented, historical and apparently continuing regional decline in groundwater elevations. DWR (1992) reported an average decline in the groundwater surface in Madera County of 38.8 feet between 1970 and 1991 (**Section 3.6**). This equates to an annual average decline of about 1.85 feet. In the absence of information to the contrary, it is reasonable to assume that average groundwater levels in wells in the Site vicinity will continue to decline at about 1.85 feet per year. Drawdown effects from the proposed pumping wells would be added to this regional decline.

The relationship between the regional water level trend and the types of impacts that may be expected to nearby wells from pumping at the Site is illustrated in **Figure 13**, which shows the three well hydrographs discussed in **Section 4.4.3**, representing the effects of regional declining groundwater level trends, and the well depth ranges in which the different kinds of well impacts may occur. The hydrographs and color bands shown on **Figure 13** indicate that wells less than 250 feet deep are threatened with going dry or being rendered otherwise unusable if regional groundwater level declines continue for a few more decades. The impact of pumping at the Site would be to accelerate this effect. These wells are represented by the uppermost color band. The shallowest well in the Site vicinity, represented by the upper edge of the uppermost color band, is 120 feet deep. This well is denoted number 71 in **Table 1**. As can be seen, this well is shallower than recent groundwater levels in the Madera Site vicinity, as indicated by the three hydrographs. Therefore, this well is almost certainly already dry. Well 56 (**Table 1** and **Figure 9**) is also probably already dry. Wells 12 and 137 are somewhat deeper and appear to extend below the projected depth of the water table, but have saturated intervals less than 10 feet. With such small saturated intervals, it is questionable whether these wells can currently yield enough water to serve their intended use.

A typical well that may be at risk of going dry or being rendered unusable in the future is well number 64 (**Table 1**). This well is 202 feet deep and located approximately 4,600 feet northwest of the center of the proposed area for siting the project production wells (**Figure 9**). The current groundwater elevation at this location is expected to be about 100 feet amsl (**Figure 5**), which equates to a depth to groundwater of about 150 feet bgs. The well is 202 feet deep, but its screened interval extends to only 188 feet bgs. The effective saturated thickness of the well is therefore likely to be around 38 feet, and the expected usable lifetime of the well is 15 years. From **Table 1**, it can also be seen that the predicted drawdown for this well under Development Alternative A without water recycling (the "worst case" alternative in terms of drawdown) would be about 4.0 feet. This predicted drawdown is equivalent to about 2 years of regional groundwater level decline at the 1.85 feet-per-year rate reported by DWR (1992). In other words, this well would go dry or be rendered unusable in 13 years, about 2 years sooner, due to the combined effects of regional water level decline and Development Alternative A.

Most of the Shallow wells in the Site vicinity are domestic wells that probably can continue to operate with a saturated thickness of as little as 10 feet. For the purposes of this report, it is assumed that if a well's non-pumping saturated thickness drops below 10 feet, then the well can no longer produce useable quantities of groundwater and thus may be considered "dry." Assuming well number 64 currently has a saturated thickness of 38 feet; that it will be considered "dry" when its saturated thickness reaches 10 feet; and that the groundwater level will continue to decline at 1.85 feet per year, then the usable life of the well is another 15 years. If the Madera Site Development Alternative A goes ahead, with its predicted interference drawdown effect of 4.0 feet, the well's life would be shortened by 2 years to about 13 years.

Table 1 shows well-life predictions undertaken for Shallow wells within 2 miles of the proposed project well location. This table indicates that the remaining lifetime of the Shallow wells may be reduced by approximately 2 to 10 percent under the worst case drawdown predictions (Alternative A without water recycling). A smaller reduction in the remaining lifetime of these wells would be expected under the other development scenarios. As the saturated thickness of a well increases, the effect of the Madera Site pumping becomes less significant compared to the regional groundwater decline. In addition, the assumption that historical groundwater level trends can be projected into the future becomes increasingly uncertain over longer periods of time, and is probably not meaningful beyond several decades. For these reasons, this study has adopted a threshold of significance for impacts to well life based on well depth (250 feet) and usable life expectancy (50 years). Wells deeper than 250 feet or with usable life expectancies exceeding 50 years are not further evaluated for impacts to usable well life, but may be subject to impacts that require lowering of their pump intakes (**Section 6.4.4**) or that result in increased operational cost (**Section 6.4.5**).

As indicated in **Section 3.13**, regional groundwater pumping during critically dry years can be more than twice as high as the average rate, resulting in a more rapid decline in groundwater levels. In the recent past, this appears to have occurred during a dry period between 1987 and 1990, when water levels in the key wells monitored by DWR near the Site declined at a rate of 5.8 to 9.4 feet/year, or three to five times the long-term average rate for the area (**Figure 7**). During such an extended dry period, wells with small remaining saturated thicknesses (less than about 30 to 50 feet) are vulnerable to going dry or being rendered unusable. Wells with longer remaining saturated thicknesses would likely outlive the dry period and experience long-term water level declines at the regional average rate.

Interference drawdown resulting from the project would remain the same whether it occurs during wet or dry periods; however, during dry periods it could contribute to the early demise of a well with a small remaining saturated interval. The percentage of time by which the well life would be shortened would remain constant however. Using well number 64 as an example again, with a remaining saturated thickness of 38 feet, this well would be rendered unusable within 3 to 5 years if a critically dry period were to ensue and water levels were to drop at the rate observed in the nearby key wells between 1987 and 1990. The predicted worst case interference drawdown (4.0 feet) would further shorten the expected well life by approximately 5 to 8 months. This equates to a reduction in the usable well life by about 14%, which is the same as the percent reduction in well life under long term average conditions.

It should be cautioned that the potential threat of a specific off-Site well going dry cannot be gauged solely from the well's depth, but is influenced by the well-specific factors discussed in **Section 6.4.1**. The well life calculations presented in **Table 1** and discussed in this section are presented for perspective to gauge the range of impacts that may reasonably be expected.

6.4.4 IMPACTS REQUIRING PUMP INTAKES TO BE RESET TO GREATER DEPTH (IMPACT 3)

A reduction in the saturated thickness above the well's pump intake can result in a decrease in the amount of water the well can produce. In extreme cases, the pumping water level inside the well can fall below the pump intake, potentially damaging the pump if the pump controls are not equipped to sense this condition and shut the pump down. In cases where the pump intake is set near the bottom of a well and cannot be lowered, this impact is essentially synonymous with Impacts 1 or 2, discussed in **Section 6.4.3**. In other cases, it may be possible to lower the pump intake and continue use of the well.

Because interference drawdown from project pumping is superimposed on a regional declining groundwater level trend, the concept of usable well life can also be applied to Impact 3. In this instance, the usable well lifetime would be the number of years until the regional water level decline plus the project-induced interference drawdown cause the impacted well to become unusable through decreased yield or the pump to be in danger of damage. At that point, the pump intake would need to be lowered to extend the well's usable lifetime.

In shallow or domestic wells, the pump intake is often set near the bottom of the well and evaluation of this impact is synonymous with Impacts 1 and 2, as noted above. Pump intakes for deeper wells and high capacity wells (e.g., municipal wells) are commonly set above the bottom of the well.

The City of Madera provided information regarding the completion and operation of the wells within their municipal water system, including Well No. 26, located approximately 6,200 feet south of the proposed project well location. This well is designated well number 142 in **Table 1** and is 600 feet deep. It is presently used for standby and fire water only. Information provided by the City of Madera indicates the well's pump intake level (bowl) is set at 220 feet bgs, and that the pumping water level is 201 feet bgs, or 19 feet above the pump intake. The well is currently capable of producing water at a rate of 1,374 gpm. Under current conditions, we expect that the City would want to lower the pump intake in this well in the relatively near future, but certainly by the time the pumping water level is 5 feet above the pump intake (a reasonable minimum factor of safety). The remaining time, in the absence of the casino development, before the pump intake must be lowered can be estimated by dividing the saturated thickness (14 feet) by the rate of regional water level decline (1.85 feet/year). The remaining time before it would become necessary to lower the pump intake is therefore approximately 8 years. The predicted worst case interference drawdown from the project wells is 3.1 feet (Alternative A without recycling, see **Table 2**), and would therefore decrease the time before the pump intake needs to be lowered by 2 years, from 8 years to 6 years. Under the other development alternatives, the time would be decreased by closer to 1 year, from 8 years to 7 years.

6.4.5 IMPACTS ON OPERATING COST OF NEARBY SHALLOW AND DEEPER WELLS (IMPACT 4)

Interference drawdown changes the operational characteristics of the pump operating within an existing water well. The additional interference drawdown effectively results in an increase in pump head (the distance the pump must lift the water), which in turn decreases the pump discharge rate, and changes the pump power requirements. The well will have to be pumped for a longer time each day as a result. Thus, more power will be required to pump the same total volume of water. The extent to which a well might be impacted by increased electrical costs may be dependant upon several factors, including the following:

- Distance from the proposed pumping wells to the off-site well of concern (*i.e.*, the amount of interference drawdown;
- Aquifer characteristics;
- Depth of the off-site well;
- Pumping water level in the well prior to the onset of interference drawdown;
- Pump specifications;

- Well condition and efficiency; and
- Nature of pumping (rate and duration/frequency).

Because information regarding the well-specific factors above (except well depth) is not readily available for wells near the Site, several operational scenarios and their associated changes in pumping power requirements were examined in order to add perspective on the range of impacts that might be anticipated. These included:

- A range of interference drawdown to represent varying distance between the pumping wells at the Site and the off-site well;
- Three pumping rates (15, 500 and 1,500 gpm) to generally represent well uses for residential, irrigation and municipal/industrial purposes;
- A range of well depths (pump depths) to represent typical well depths in the area; and
- A range of pumping water levels based on conditions at the Madera Site and the addition of potential interference drawdown.
- The assumption of appropriate pumps installed in the wells to produce the designated flow rates under the assumed conditions;

For each scenario, our engineer selected a pump that would be appropriate to supply water at the approximate rate specified given the well depth and water level. Thus, for purposes of this analysis, wells with different pumping water levels were assumed to contain different pumps, in order to maintain a reasonable match in each case between the well's pump, water level, and flow rate. The changes in electrical consumption to pump 1 AF of water were then evaluated for that pump when the different levels of interference drawdown were applied. Additional details regarding our methodology are presented in **Appendix C**.

By attempting to model a range of conditions, we hoped to bracket the real world pumps and ensure that their operating conditions lie within the feasible space of this analysis. While this analysis is not exact and may not be representative of all actual installed pump types and conditions, it does offer some insight as to how much additional power might be required to pump 1 acre-foot of water if additional water table drawdown occurs. If site-specific information regarding water wells and pumps becomes available in the future, this analysis could be adapted to examine power requirement impacts for those specific pumps during the mitigation phase of the project.

Twelve distinct evaluations, representing six different well and pump configurations under two different interference drawdown conditions, were made based upon the following ranges of values and boundary conditions:

- Three pumping rates: 15 gpm, 500 gpm, and 1,500 gpm;
- For the 15 gpm pumping rates: two different pump configurations with intake depths at 200 and 400 feet bgs, and two associated pumping water levels, 160 and 300 feet bgs, respectively;
- For the 500 and 1,500 gpm pumping rates: two different pump configurations with intake depths at 350[1] and 500 feet bgs, and two associated pumping water levels, 200 and 400 feet bgs, respectively;
- Two interference drawdown depths: 2.0 feet, and 6.0 feet.

The 12 evaluations were combined to produce the following matrix with 12 cells for which the additional incremental power (in kilowatt-hours [kW-hours]) required to pump 1 AF of water was evaluated per the procedures outlined in **Appendix C**.

[1] Note that the pump intake depth of City of Madera Well No. 26, the closest municipal supply well to the Site, is reportedly 220 feet bgs; however, the average pump intake depth of municipal supply wells in Madera is 300 feet bgs, and pump intake depths range from 220 to 400 feet bgs. In addition, Well No. 26 is used for standby and fire water only. Pump intake depths of 300 and 500 feet bgs were therefore selected to evaluate larger capacity wells.

Additional Power Consumption Caused by Interference Drawdown Under Representative Well Configurations for the Madera Site Vicinity

Pump Discharge Rate (gpm)		15	
Pump Installation Depth (feet bgs)		200	400
Pumping Water Level (feet bgs)		160	300
	Interference Drawdown (feet)	Additional Power Consumption (kW-hours/acre-foot)	
	2.0	0.4	4.8
	6.0	29.4	33.5
Pump Discharge Rate (gpm)		500	
Pump Installation Depth (feet bgs)		350	500
Pumping Water Level (feet bgs)		200	400
	Interference Drawdown (feet)	Additional Power Consumption (kW-hours/acre-foot)	
	2.0	0.1	1.9
	6.0	4.6	7.9
Pump Discharge Rate (gpm)		1,500	
Pump Installation Depth (feet bgs)		350	500
Pumping Water Level (feet bgs)		200	400
	Interference Drawdown (feet)	Additional Power Consumption (kW-hours/acre-foot)	
	2.0	2.0	5.5
	6.0	5.0	20.1

The results of our evaluation are discussed below. Additional details are presented in the graphs and charts included in **Appendix C**.

For the pumping case of 15 gpm, and 2.0 feet of interference drawdown, the additional power required varied from a low of approximately 0.4 kW-hours to a high of approximately 4.8 kW-hours per acre-foot of water. For 6.0 feet of interference drawdown, the additional power required varied from a low of approximately 29.4 kW-hours to a high of approximately 33.5 kW-hours per acre-foot of water. The average additional power required was 2.6 kW-hours and 31.5 kW-hours, for 2.0 feet and 6.0 feet of interference drawdown, respectively.

For the pumping case of 500 gpm, and 2.0 feet of interference drawdown, the additional power required varied from a low of approximately 0.1 kW-hours to a high of approximately 1.9 kW-hours per acre-foot of water. For 6.0 feet of interference drawdown, the additional power required varied from a low of approximately 4.6 kW-hours to a high of approximately 7.9 kW-hours per acre-foot of water. The average additional power required was 1.0 kW-hours and 6.3 kW-hours, for 2.0 feet and 6.0 feet of interference drawdown, respectively.

For the pumping case of 1,500 gpm, and 2.0 feet of additional drawdown, the additional power required varied from a low of approximately 2.0 kW-hours to a high of approximately 5.5 kW-hours per acre-foot of water. For 6.0 feet of interference drawdown, the additional power required varied from a low of approximately 5.0 kW-hours to a high of approximately 20.1 kW-hours per acre-foot of water. The average additional power required was 3.8 kW-hours and 12.6 kW-hours, for 2.0 feet and 6.0 feet of interference drawdown, respectively.

Considering all pumping rates, for 2.0 feet of interference drawdown, the additional power requirements ranged between a low of approximately 0.1 kW-hours to a high of approximately 5.5 kW-hours per acre foot. For 6.0 feet of interference drawdown, the additional power requirements ranged between a low of approximately 4.6 kW-hours to a high of approximately 33.5 kW-hours.

The following conclusions may be drawn from the above results:

- As interference drawdown increases, the additional power required to pump 1 AF of water also increases.
- As the depth to the pumping water level increases, the additional power required to pump 1 AF of water when interference drawdown is applied also increases.
- Wells operated at lower flow rates (15 gpm) may experience a greater increase in the power required to pump an acre-foot of water than higher capacity wells when interference drawdown increases from 2 feet to 6 feet. Conversely, at higher flow rates (500 and 1,500 gpm), interference drawdown causes less of an increase in power to pump 1 AF of water than for the 15 gpm flow rate.
- Notwithstanding the increase in unit power consumption rates, the actual cost increase resulting from interference drawdown will be greater for higher capacity wells (500 and 1,500 gpm) than for lower capacity wells (15 gpm). This is because lower capacity wells are typically associated with residential use, and the annual water volume pumped by a residential user is comparatively small. According to

the American Water Works Association (AWWA), the average household in the United Stated uses approximately 1/3 AF of water per year, so the net cost increase to a domestic user will probably not be significant (*i.e.*, only a few dollars per year). Conversely, water wells pumping at higher rates are typically associated with agricultural, industrial or municipal users, with water requirements in the hundreds or thousands of acre feet per year. Even though less additional power is generally required per acre-foot of water when interference drawdown occurs in higher capacity wells, the need to pump many acre-feet of water per year results in a larger overall annual cost increase. For perspective, if a municipal water user pumps a well with a capacity of 1,500 gpm to produce 1,900 AF of water in a year, the additional annual power requirement with 6 feet of interference drawdown will be approximately 24,000 kW-hours of electricity. At $0.15 per kW-hour, the additional cost impact to that user would be approximately $3,600 per year. (It should be noted that for the pump modeled, this represents an approximately 2 percent increase in the user's overall pumping cost.) Similarly, the additional annual cost resulting from 2 feet of interference drawdown would be about $1,100.

- The difference between the upper and lower bound power consumption increase for a 1,500 gpm pump subject to 6 feet of interference drawdown is relatively high, especially when considering the potential cost differential to a higher capacity water user. This illustrates the importance of using well- and pump-specific information in assessing impacts to wells during the mitigation phase of the project.

6.4.6 IMPACTS ON CITY OF MADERA MUNICIPAL WELLS

The closest well to the Site in the City of Madera's water supply system is Well No. 26, located approximately 6,200 feet from the proposed pumping well location south of the Site at the municipal airport. This well is used for standby and fire protection purposes. Other wells in the City of Madera's water supply system are located more than 2 miles from the Site and are not expected to experience significant drawdown-related impacts. Well No. 26 is estimated to experience drawdowns of up to approximately 1.9 to 3.1 feet, depending upon the development alternative, and could be subject to increased electrical costs during operation. However, based on the analysis presented in Section 6.4.5 and the current status of the well, it is unlikely that the additional costs would amount to more than $100 per year and, as such, these impacts may be considered insignificant. This well is not likely to experience other interference drawdown-related impacts.

Based on discussions with the City of Madera (Mr. Marvin Ward and Mr. David Merchen, personal communication), we understand that there are presently no plans to expand the City's water supply system by installing additional wells near the Site or reinstating Well No. 26 for ongoing production.

6.5 POTENTIAL FOR DRAWDOWN-INDUCED GROUND SUBSIDENCE

Ground subsidence can occur as a result of water level decline in aquifer systems. When the fluid pressure in an aquifer is reduced as a result of changes in the groundwater level, a shift in the balance of support for the overlying materials causes the "skeleton" of the aquifer system to deform slightly (Galloway, et al., 1999). Reversible deformation occurs in all aquifer systems as a result of the cyclical rise and fall of groundwater levels associated with short and longer term climatic cycles. Permanent ground subsidence can occur when pore water pressures in the aquifer fall below their lowest historical point, and the particles in the aquifer skeleton are permanently rearranged and compressed. This type of deformation is most prevalent when confined alluvial aquifer systems are overdrafted. Confined aquifer systems ("pressure aquifer systems") undergo much larger changes in porewater pressure during groundwater withdrawal than unconfined systems ("water table aquifer systems"). In addition, alluvial aquifer systems often include aquitards with a high clay content. When water pressures in the confined aquifer fall, water drains from the aquitards and the relatively open and weak pore structure in the clay strata undergoes a permanent collapse and compression.

In the San Joaquin Valley, an area of approximately 5,200 square miles has experienced ground subsidence in excess of 1 foot (Ireland, 1986). The greatest amount of subsidence, over 29 feet, occurred in the western part of the valley southwest of the town of Mendota. Most of the subsidence occurred during periods of increasing groundwater demand and decreasing groundwater levels (pressures) in the confined aquifer system from the 1920s to the 1970s. In the western portion of the San Joaquin Valley, where the greatest subsidence was recorded, groundwater levels in the deep confined aquifer system dropped by over 400 feet during this period, and were declining at a rate of about 10 feet per year in some areas as of 1960 (Galloway, et al., 1999). Since the 1970s, ground subsidence has continued at a much slower rate in some locations, but has generally stopped due to increased surface water deliveries and recovering groundwater levels. Most of the area in which subsidence occurred is underlain by the Corcoran Clay, which is the major regional aquitard that separates the San Joaquin Valley's confined and unconfined aquifer systems (**Sections 2.4** and **3.4**).

Based on discussions with the City of Madera (Mr. Marvin Ward and Mr. David Merchen, personal communication), we understand that there are presently no plans to expand the City's water supply system by installing additional wells near the Site or reinstating Well No. 26 for ongoing production.

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Ground subsidence of up to approximately 1 foot has been documented west of the City of Madera, in the vicinity of Madera Ranch, despite the fact that the area has been subject to extensive groundwater pumping from both above and below the Corcoran Clay over the last 100 years (Jones & Stokes, 2005). Jones & Stokes therefore concluded that significant ground subsidence was not likely to be associated with MID's Water Supply Enhancement Project (**Section 3.13**). The eastern boundary of the subsidence-affected area coincides approximately with the eastern extent of the Corcoran Clay (Ireland, 1986) and does not extend beneath the Site, despite the fact that significant groundwater pumping has also occurred in the Site vicinity. In conclusion, significant ground subsidence is not expected to be associated with the proposed casino project because subsidence has not been a significant problem in the Madera area despite significant historical pumping, the area that has been impacted does not extend beneath the Site, and the Site is underlain by an unconfined aquifer system, which is less susceptible to pumping induced subsidence.

6.6 POTENTIAL FOR SURFACE WATER IMPACTS

Groundwater occurs at a depth of approximately 140 feet below the ground surface near the Site and surrounding are is generally level. There is no known hydrologic connection between groundwater and surface water in this area and impacts to surface water resources are not likely to occur as a result of project groundwater pumping.

6.7 CUMULATIVE IMPACTS

Future trends in groundwater levels near the Site would be determined by a combination of the drawdown effects caused by pumping at the Site, the existing regional declining trend in groundwater elevations, interference drawdown from other groundwater pumpers (e.g., the City of Madera), and changes in water levels due to other causes (*e.g.*, artificial groundwater recharge or climatic trends). A regional declining trend has been documented at approximately 1.85 feet per year in the Madera subbasin in the vicinity of the Site. This trend appears to be corroborated near the Site by long-term well hydrographs (**Figures 6, 7 and 8**). The effect of groundwater pumping at the Site will be a small amount of additional drawdown in a finite area around the Site.

The Madera subbasin has been determined to be in a state of overdraft (**Sections 3.6, 3.7. 3.8, 3.9** and **3.13**); that is, the groundwater removed by pumping exceeds recharge, and as a result basin storage and groundwater levels are both declining with undesirable side effects. The basin overdraft has been estimated to be approximately 100,000 AFY (Jones & Stokes, 2005). The project pumping of approximately 8 to 278 gpm (18 to 450 AFY) would cause a very small increase in the basin overdraft of approximately 0.02 to 0.5 percent. Note that this estimate does not consider any of the mitigation measures described in the following section.

6.8 POTENTIAL MITIGATION MEASURES

6.8.1 GROUNDWATER LEVEL MONITORING

The actual drawdown impacts from using groundwater to supply the proposed projects can only be accurately assessed with the implementation of a properly designed monitoring program. Such a program would allow documentation of the actual distance-drawdown relationship in the vicinity of the Site, local ambient groundwater level trends and the potential influence of interference drawdown from other water users in the area. This information in turn can be used to evaluate the effectiveness of the hydrogeological mitigation measures that are being considered as part of the project, and can form the basis for assessment of impacts to well owners in the Site Vicinity.

A groundwater level monitoring program could include existing wells and/or new wells installed for the project. We recommend that a monitoring program be designed based on an evaluation of completion data and lithologic logs for existing wells that may be available for that purpose. The monitoring program should include at least two wells completed at depths shallower than 250 feet and two wells completed at depths between 300 and 600 feet. Ideally, one shallow and one deep monitoring well should be located within ½ mile of the proposed project pumping well(s) to evaluate near-Site drawdown associated with the project. The other shallow and deep monitoring wells should be located between 1 and 2 miles from the pumping well(s), near the estimated lateral limit of significant drawdown associated with the project. If existing wells are used, they should not be used for water production within one month of being measured. Also, the monitoring wells should not be located near wells that are being actively pumped. We recommend that water level measurements begin at least one year prior to project development to develop sufficient baseline data, and that both spring and fall measurements be taken.

Data from groundwater level monitoring that is conducted by DWR can be used to assess the ongoing regional groundwater level trend in the Madera subbasin and establish a regional baseline.

6.8.2 ON-SITE HYDROGEOLOGIC MITIGATION MEASURES CONSIDERED AS PART OF SITE DEVELOPMENT

Several mitigation measures are included as part of the proposed project, which will reduce the drawdown impact of on-Site pumping for water supply. Key measures that are planned include Best Management Practices (BMPs) that promote infiltration of storm water runoff from developed portions of the Site, and on-Site disposal of treated wastewater. BMPs for enhancing infiltration of storm water runoff have the potential to increase the rate of natural recharge at the Site, while on-Site disposal of treated wastewater will return groundwater originating from the casino wells back to the aquifer. As discussed below, the effectiveness of these measures to reduce drawdown impacts is directly proportional to the rate of new recharge compared with the pumping rate.

Since buildings and pavements are relatively impermeable to storm water, such "hardscape" development increases runoff and decreases recharge to groundwater relative to pre-development conditions. The primary function of storm water BMPs is usually to decrease the amount or rate of runoff entering waterways from impermeable hardscape development. However, an important secondary function is to recapture as recharge some of the storm water that would otherwise flow from the Site as runoff. Storm water BMPs that are planned for the project include routing of storm water runoff to landscaped areas where feasible, conveying storm water via vegetated swales instead of concrete-lined V-ditches, and constructing a storm water detention basin to retain a portion of the storm water at the Site, where it will evaporate or percolate into the subsurface while detained in the basin. The effectiveness of these BMPs in promoting recharge depends on soil and climatic conditions, available space, Site layout and BMP design. Typically, site or development constraints are such that only some of the pre-development recharge is recovered, but if enough space is available and soil conditions are favorable, a storm water detention basin can be designed to percolate several times the amount of pre-development recharge.

To add perspective on the potential effectiveness of storm water BMPs to mitigate drawdown from the development of on on-Site groundwater supply, we have compared the potential rate of recharge from implementation of these BMPs to the projected rate of groundwater pumping. (The effect on drawdown will be proportionally the same as the rate of additional recharge divided by the pumping rate.) The area of the Site that will be developed with buildings and pavements encompasses approximately 40 acres. Given that the annual precipitation in the Site area is just under 12 inches and that a reasonable pre-development percolation rate from precipitation in a semi-arid environment is about 12 percent, the annual pre-development recharge in portions of the Site proposed for hardscape development (approximately 40 acres) is approximately 1.6 million gallons. This recharge rate is equivalent to approximately 3 gpm, or about 1.6 percent of the projected groundwater pumping rate at the Site under Alternative A with recycling (190 gpm). Thus, if the recharge in developed area were increased by an additional 3 gpm (or 100 percent over pre-development conditions, a reasonable gain if BMPs are constructed in a way that promotes infiltration), the projected drawdown would be decreased by only 1.6 percent. In conclusion, the planned BMPs are expected to be effective in reducing or controlling runoff, but are likely to have only a limited benefit in terms of reducing the drawdown impacts of pumping.

Recharge from on-Site disposal of treated wastewater is likely to have a more significant mitigating effect because the recharge rate is much greater than that generated by implementation of storm water BMPs. Wastewater from the casino development will be treated in an on-Site wastewater treatment plant to a level meeting or exceeding tertiary treatment standards. The treated wastewater will then be either: (1) disposed at the Site in a leach field, (2) disposed at the Site in a spray field, (3) a combination of these two on-Site disposal alternatives, (4) disposed off-Site via surface water discharge or (5) discharge to the local sewer system. If wastewater recycling is implemented, the demand for pumped groundwater will be reduced and a portion of the recycled water will be used for landscape irrigation. Wastewater recycling will be conducted unless the Site is connected to the local sewer system. **Figure 14** presents a diagram showing the anticipated water and wastewater balance for Alternative A with water recycling using information provided in the *Water and Wastewater Feasibility Study* report by HydroScience (HydroScience, 2006).

As shown on **Figure 14**, under Alternative A with water recycling, approximately 270,000 gallons per day of wastewater will be treated by the wastewater treatment plant. Approximately 107,000 gpd of this amount will be reused by the development in recycled water applications. Of the remaining 163,000 gpd, approximately 20,000 gpd will be applied to landscaped areas as irrigation water and 143,000 will be disposed via land application using a spray field, a leach field, or a combination of the two. Reasonable percolation rates were estimated for each of these treated wastewater streams using professional judgment.

Figure 14 shows estimated recharge rates for disposal of 143,000 gpd of treated wastewater assuming either spray disposal (resulting in an estimated recharge rate of 10 gpm) or leach field disposal (resulting in an estimated recharge rate of 89 gpm). The spray and leach field disposal alternatives shown on **Figure 14** are assumed to be combined with landscape irrigation disposal of 20,000 gpd (for which the estimated recharge rate is 3.5 gpm). Based on this analysis, we estimate that the range of recharge that may be expected from the on-Site application and disposal of treated wastewater (under Alternative A with water recycling) will range from approximately 13.5 to 92.5 gpm. This rate of additional recharge will reduce the drawdown impact from using an on-Site groundwater source by an amount proportional to the groundwater pumping rate, or between approximately 7 to 49 percent under Alternative A.

The additional recharge that may be induced by on-Site disposal of wastewater and implementation of storm water BMPs under Alternatives A, B and C with wastewater recycling is summarized in the table below.

Development Alternative	Pumping Rate	Additional Recharge Rate (gpm) [1]				
		Leachfield Disposal	Sprayfield Disposal	Irrigation	Stormwater BMPs	Total Range (% of Pumping Rate)
A + Recycling	190 gpm	89	10	3.5	3	9% to 50%
B + Recycling	110 gpm	59	7	3.5	2	11% to 64%
C + Recycling	12 gpm	6	1	1	1	25% to 67%

Notes:
1. For the purposes of this analysis, we have assumed that no groundwater recharge would be derived if treated wastewater is discharged to off-Site surface water; however, some water of the discharged water would be expected to percolate through off-Site stream beds.

As shown above, the percent reduction in drawdown impact would be slightly greater under Alternatives B and C with water recycling, because the wastewater disposal rate is greater relative to the rate at which groundwater is extracted. Under each alternative, if treated wastewater is disposed via a leach field, the recharge rate is expected to be in the upper end of the range; whereas, if the treated wastewater is disposed in a spray field, the recharge rate is expected to be in the lower end of the range. In actual practice, a combination between landscape, spray field and leach field application for wastewater disposal may be selected.

6.8.3 OFF-SITE HYDROGEOLOGIC MITIGATION MEASURES CONSIDERED AS PART OF THE PROJECT

In addition to mitigation measures that are being considered as part of Site development, participation on off-Site artificial recharge projects is currently being considered. This could be accomplished by purchasing water to participate in MID's Water Supply Enhancement Project at Madera Ranch, or purchasing water for recharge at MID's existing recharge basins in the Madera subbasin (**Figure 1**). In addition, we understand that MID is considering potential development of additional parcels in the area as recharge basins. The Tribe could assist in the development of these basins, or could provide water to be recharged there.

6.8.4 POTENTIAL MITIGATION MEASURES FOR IMPACTS TO NEARBY WELLS

Impacts to nearby wells will result from a combination of the documented regional declining trend in groundwater levels of approximately 1.85 feet/year and the added affect of interference drawdown from groundwater pumping associated with the proposed project. The amount of project-related interference drawdown that may be expected has been predicted as a function of distance (**Figure 11**) and at the known off-Site well locations (**Tables 1 and 2**). The actual amount of interference drawdown associated with the project and the future rate of regional groundwater level decline will be estimated from the proposed groundwater level monitoring program (**Section 6.7.1**). We recommend that these data be used in the proposed mitigation program to distinguish the portion of impacts to nearby wells that is project related vs. the portion that is attributable to regional declining groundwater level trend. At least one year of baseline data and one year of data after project pumping begins should be collected prior to implementation of the mitigation/cost reimbursement program outlined below.

The following mitigation measures for impacts to nearby wells are proposed:

- Reduction in usable well life (Impacts 1 and 2) – Based on the available data, we estimate the lives of existing wells in the Site vicinity that are less than 250 feet deep may be shortened by 1 to 3 years due to project pumping (**Table 1**). The average lifespan of these wells without the casino project is estimated to be about 34 years, so the project's impact on well lifespan is generally well under 10 percent. The tribe would reimburse the owners of wells that become unusable within 30 years of the onset of project pumping for a portion of the prevailing, customary cost for well replacement, rehabilitation or deepening. The percentage of the cost reimbursed by the tribe would depend upon the degree to which the well's usable life is shortened: 5 % for one year, 10% for two years and 15 % for three years. In order to be eligible, the well owner would need to provide the tribe with documentation of the well location and completion data, and that the well was constructed and usable before project pumping was initiated.

- Groundwater level falling near or below pump intake (Impact 3) – The concept of usable well life can also be applied to this impact, except that the well's usable life is extended by lowering the pump intake. The time period until a pump intake requires lowering depends on a number of well-specific factors that are not known at this time and can be less than or greater than the range of remaining well lifetimes listed in **Table 1.** However, the impact of project pumping on shortening this time period would be similar to the impact on shortening well life, and can be determined by dividing the amount of interference drawdown at the off-Site well by the regional rate of groundwater decline. The tribe would reimburse the owners of wells with pumps that require lowering within 30 years of the onset of project pumping for a portion of the prevailing, customary cost for this service. The percentage of the cost reimbursed by the tribe would depend upon the degree to which the time period until a well's pump intakes require lowering is shortened, at a rate of 10% for each year (*i.e.*, 10% for one year, 20% for two years, 30% for three years, etc.). In order to be eligible, the well owner would need to provide the tribe with documentation of the well location and completion data, including pump intake depth, and that the well was constructed and usable before project pumping was initiated. The tribe must be made aware of the cost reimbursement claim prior to lowering of the pump intake, so that the need for possible well deepening, replacement or rehabilitation can be assessed. At the tribe's discretion, compensation may be paid toward well deepening, replacement or rehabilitation in lieu of toward lowering the pump intake.

- Increased Electrical and Maintenance Cost (Impact 4) – Based on our analysis, operators of wells utilized for domestic purposes and limited agricultural or industrial pumpers are not expected to experience significant increases in their electrical costs. The tribe would reimburse well owners pumping more than 100 AF/year for their additional annual electrical costs at the prevailing electrical rate based on the following formula[2]:

$$\text{KWhr/year} = \frac{\text{(gallons Pumped/year) x (feet of interference drawdown)}}{1621629}$$

[2] This formula is derived from combining the following two formulas:

KW input = ([Pump brake horsepower] x 0.7457) / (motor efficiency)

Pump brake horsepower = ([gpm] x [feet of water] x [specific gravity]) / (3960 x [pump efficiency])

Where:
specific gravity = 1;
typical motor efficiency = 85%; and
typical pump efficiency = 60%

In order to qualify for reimbursement, the well owner must provide proof of the actual annual volume of water pumped. As an alternative to annual payments, a one-time lump sum payment of a mutually agreeable amount could be made.

- No reimbursement would be made available for wells installed after operation of the project wells commences.

- For any of the above impacts, the tribe may choose at its discretion to provide the well owner with a connection to a local public or private water supply system in lieu of the above mitigation measures, at reduced cost in proportion to the extent the impact was caused by project pumping.

The known owners of identified wells within 2 miles of the proposed project pumping well would be notified of the mitigation program outlined above before project pumping begins. We recommend that the tribe contract with a third party such as the County of Madera to oversee this mitigation program.

7 POTENTIAL IMPACTS OF THE NORTH FORK SITE DEVELOPMENT ALTERNATIVE ON OFF-SITE GROUNDWATER LEVELS AND WELLS

The average daily groundwater pumping rate for the North Fork Alternative (Development Alternative D) would be about 27,000 gpd (17 gpm) without water recycling and 14,000 gpd (10 gpm) with water recycling (HydroScience, 2006). We understand that Alternative D would be supplied by installing one or two new pumping wells near the center of the North Fork Site, drilled to at least 500 feet bgs, or by using the existing water supply well currently at that location (Chad Broussard, AES, personal communication, February 2006).

The proposed pumping rate of 10 to 19 gpm is comparable to or lower than the reported yields of existing wells in the area of the North Fork Site for which information was obtained (**Section 5.5**), but exceeds the median well yield reported for wells drilled in eastern Madera County (Todd, 2002). Therefore, it appears likely that the aquifer could produce water at the proposed rate if one or more wells were installed, as needed. However, the drawdown resulting from this pumping cannot be predicted at this time, due to the lack of available data on groundwater levels or aquifer parameters in the North Fork area. In addition, due to the nature of fractured granitic aquifers, such properties are usually site-specific and highly variable from one location to another.

Possible effects on nearby wells could range from no impact at all to a well going dry or its pumping capacity being significantly reduced. A new pumping well could also cause a similar range of effects on existing springs. Drawdown effects from the new well could be felt at a considerable distance if the well is screened in a long fracture system. Mitigation measures similar to those described in **Section 6.7** would be available to counter impacts from the proposed pumping.

8 CONCLUSIONS

8.1 THE MADERA SITE

- The Madera Site lies within the San Joaquin Valley and is underlain by at least 700 feet of unconsolidated Pleistocene and Holocene age deposits, including groundwater-bearing sands, gravels and silts. The E-clay or Corcoran Clay, generally regarded as a significant aquitard, is not believed to be present beneath the Madera Site.

- Groundwater elevation data were not available for the Madera Site, but DWR interpretations based on records for nearby wells exhibit an overall decline in groundwater levels of approximately 80 feet between 1958 and 2003, with the current groundwater level interpolated as being about 145 feet bgs. The dominant influence on groundwater flow in the area over the last 15 years appears to be a pumping depression located between the cities of Madera and Chowchilla.

- Comparison of local well hydrographs and precipitation records shows short-term correlations between rainfall amount and groundwater levels, but also a long-term decline in groundwater levels that is independent of climatic factors.

- An analytical model was prepared to examine the effects on off-Site groundwater levels and wells of the three proposed Development Alternatives with and without water recycling incorporated. The average groundwater pumping rates considered are as follows:

  Alternative A – 273,000 gallons per day (gpd) (190 gpm) with recycling and 400,000 gpd (278 gpm) without recycling;

  Alternative B – 166,000 gpd (115 gpm) with recycling and 251,000 gpd (174 gpm) without recycling; and

  Alternative C – 11,000 gpd (8 gpm) with recycling and 23,000 gpd (16 gpm) without recycling.

- Based on the model, the predicted drawdown at the Madera Site boundary would be as follows:

  Alternative A: 6.4 feet with recycling and 9.3 feet without recycling;

Alternative B: 3.8 feet with recycling and 5.8 feet without recycling; and

Alternative C: 0.3 feet with recycling and 0.5 feet without recycling.

The predicted drawdown decreases to approximately 1.5 feet at a distance of 2 miles for Alternative A without recycling (the worst case) and about 1 foot for Alternative A with recycling and Alternative B without recycling. Drawdown of less than 1.5 feet is probably not significant relative to seasonal or short term water level changes in this area.

- Records for 259 water production wells within 2 miles of the Site were obtained from the California Department of Water Resources (DWR). All of these wells are expected to experience some amount of interference drawdown from the project, as follows:

  Alternative A: 1.0 to 4.9 feet with recycling and 1.5 to 7.2 feet without recycling;

  Alternative B: 0.5 to 3.0 feet with recycling and 0.9 to 4.5 feet without recycling; and

  Alternative C: less than 0.3 feet with recycling and less than 0.5 feet without recycling.

- A combination of interference drawdown from the project and the documented regional declining groundwater level of 1.85 feet per year may result in four different potential impacts to nearby wells. These are:

  1. The well going dry;
  2. The water level in the well falling so low that the well is no longer usable;
  3. Impacts 1 or 2 occur, but the well pump intake can be lowered to extend the life of the well; and/or
  4. Increased operational costs.

- Impacts 1 and 2 were evaluated in terms of projects impact on the usable lifetime of nearby wells. Given current groundwater level trends, there are 68 wells less than 250 feet deep that are at risk for going dry or becoming unusable in the next 50 years without development of the project. Project pumping will shorten the remaining usable lifetimes of these wells by 1 to 3 years. Impacts on well life are not a significant concern for wells that are more than 250 feet deep.

- Impact 3 can only be evaluated based on well-specific information that is not generally available at this time. We recommend that this impact be evaluated on case-by-case basis during the mitigation phase of the project.

- A reasonable range for increased operational costs (Impact 4) was evaluated by simulating several different well, pump, water level and interference drawdown configurations. In general, it was found that increased costs for residential well operators are not expected to be significant. Increased costs for agricultural, industrial or municipal well owners with annual pumping requirements in the range of hundreds to several thousand dollars may be expected to range from several hundred to several thousand dollars. (For the pumps modeled, the maximum cost increase represents an approximately 2 percent increase in the user's overall pumping costs.) The only City of Madera well close enough to the site to experience these types of impacts is currently used only for standby and fire suppression purposes, so significant cost impacts are not expected.

- On a regional basis, the project will contribute slightly (approximately 0.02 to 0.5 percent) to an existing imbalance between groundwater pumping and recharge (overdraft). Significant ground subsidence is not anticipated as a result of the project.

- Implementation of a drawdown monitoring program is recommended to document actual drawdown from the project as well as regional water level trends and interference drawdown from other nearby groundwater pumping. Data from the program can be used to establish baseline conditions, evaluate the effectiveness of measures designed to mitigate drawdown, and to assess appropriate mitigation for nearby impacted well owners.

- Drawdown and overdraft impacts can be mitigated to some extent by implementation of Best Management Practices (BMPs) in the proposed construction and infiltration from on-Site land application of treated wastewater from the development. The effectiveness of these mitigation measures was estimated to be 9 to 50 percent for Alternative A, 11 to 64 percent for Alternative B, and 25 to 67 percent for Alternative C, depending on the extent to which spray field or leach field application is used for disposal. In addition to the above, the tribe is considering participating in regional groundwater recharge projects in the Madera subbasin.

- All the wells in the area will experience impacts from the prevailing regional decline in groundwater levels of 1.85 feet/year. The following alternatives for mitigation of significant project-related interference drawdown impacts are being considered, to the extent the impact is attributable to project pumping as distinguished from the regional trend:

> Impacts 1 and 2 : Reimbursement for well replacement, rehabilitation or deepening;
>
> Impact 3: Reimbursement for pump replacement or re-setting;
>
> Impact 4: Compensation for increased cost;
>
> At the tribe's discretion, providing a connection to a local public or private water system, for any and/or all potential significant impacts.

8.2 THE NORTH FORK SITE

- The North Fork Site overlies granitic basement rocks, within which groundwater is present in fractures. There is little available information on groundwater occurrence, levels, flow, or storage, and such information is usually very Site-specific in such a setting. However, groundwater is widely used for domestic supply in the area, with wells reportedly achieving yields of between 10 and 240 gpm.

- The average day groundwater pumping rate for the North Fork Alternative (Development Alternative D) would be about 27,000 gpd (19 gpm) without water recycling and 14,000 gpd (10 gpm) if recycling is incorporated. We understand that Alternative D would be supplied by installing one or two new pumping wells near the center of the North Fork Site, drilled to at least 500 feet bgs, or by using the existing water supply well currently at that location.

- The proposed pumping rate of 10 to 19 gpm is comparable to the reported yields of existing wells in the area of the North Fork Site for which information was obtained (**Section 5.5**), but exceeds the median well yield reported for wells drilled in eastern Madera County (Todd, 2002). Therefore, it appears likely that the aquifer could produce water at the proposed rate if one or more wells were installed, as needed. However, the drawdown resulting from this pumping cannot be predicted at this time, due to the lack of available data on groundwater levels or aquifer parameters in the North Fork area, and the general uncertainty in estimating aquifer parameters in fractured granitic aquifers without site-specific data.

9 CLOSURE/LIMITATIONS

This report has been prepared for the exclusive use of Analytical Environmental Services, Inc. as it pertains to the assessment of the effects of the use of groundwater to supply the proposed North Fork Casino development near Madera and North Fork, Madera County, California. Our services have been performed using that degree of care and skill ordinarily exercised under similar circumstances by reputable, qualified environmental consultants practicing in this or similar locations. No other warranty, either express or implied, is made as to the professional advice included in this report. These services were performed consistent with our agreement with our client.

Opinions and recommendations contained in this report apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We do not warrant the accuracy of information supplied by others or the use of segregated portions of this report.

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(http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?cafres+nca)

APPENDIX A

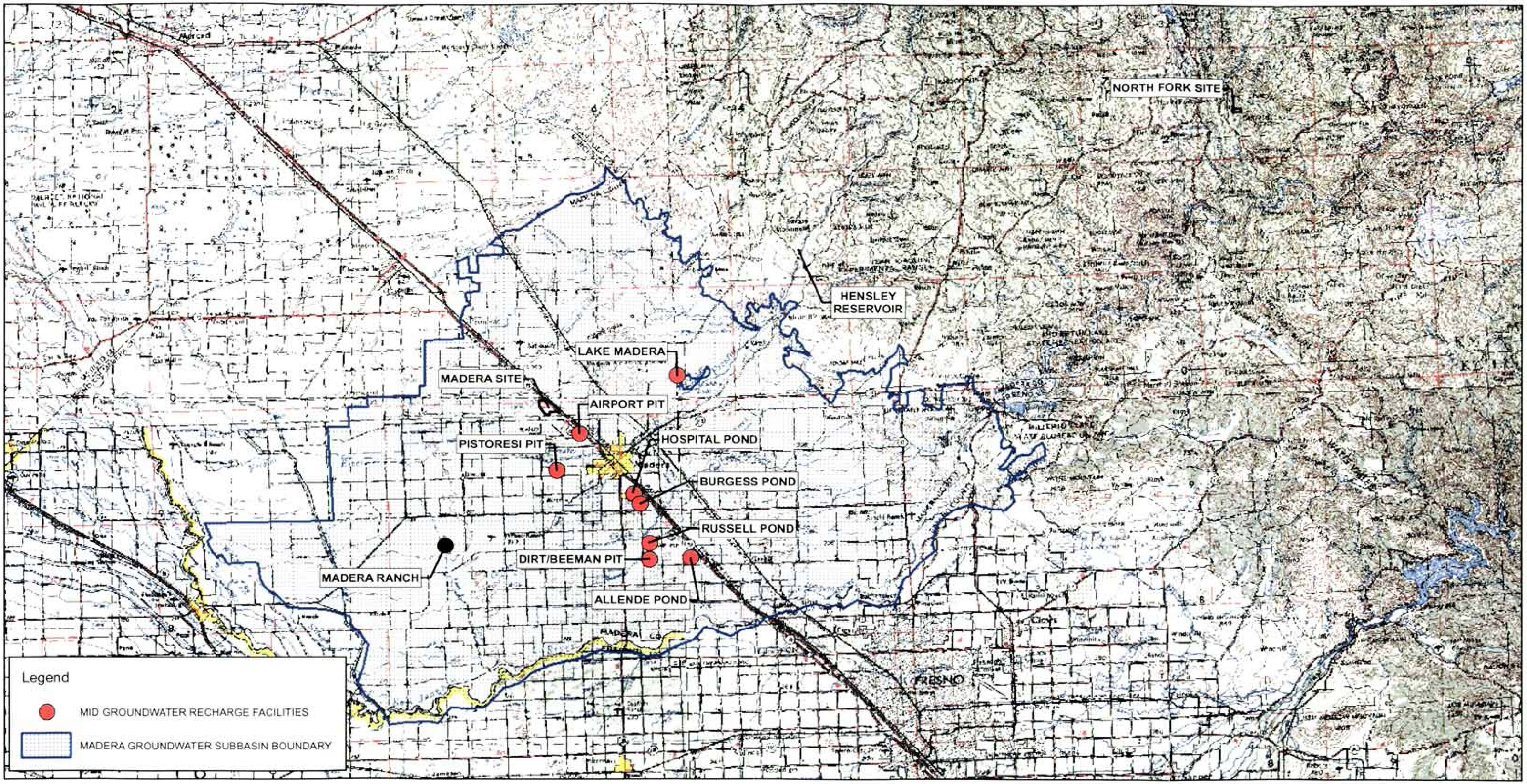
DWR INTERPRETATIONS OF GROUNDWATER ELEVATION IN THE MADERA SUBBASIN

APPENDIX B

DATA REGARDING WELLS NEAR THE NORTH FORK SITE

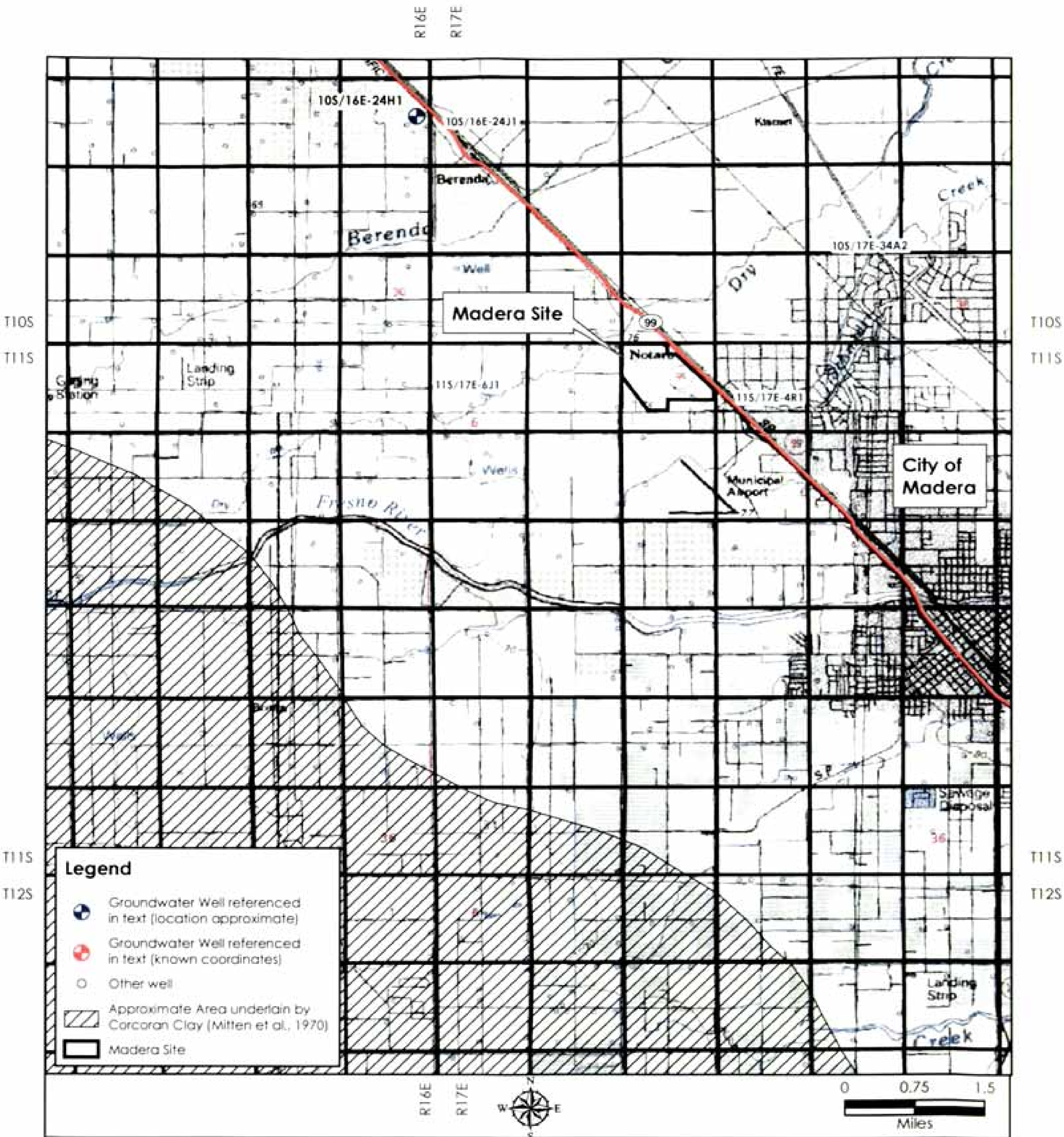
APPENDIX C

EVALUATION OF WELL PUMP ELECTRICAL CONSUMPTION

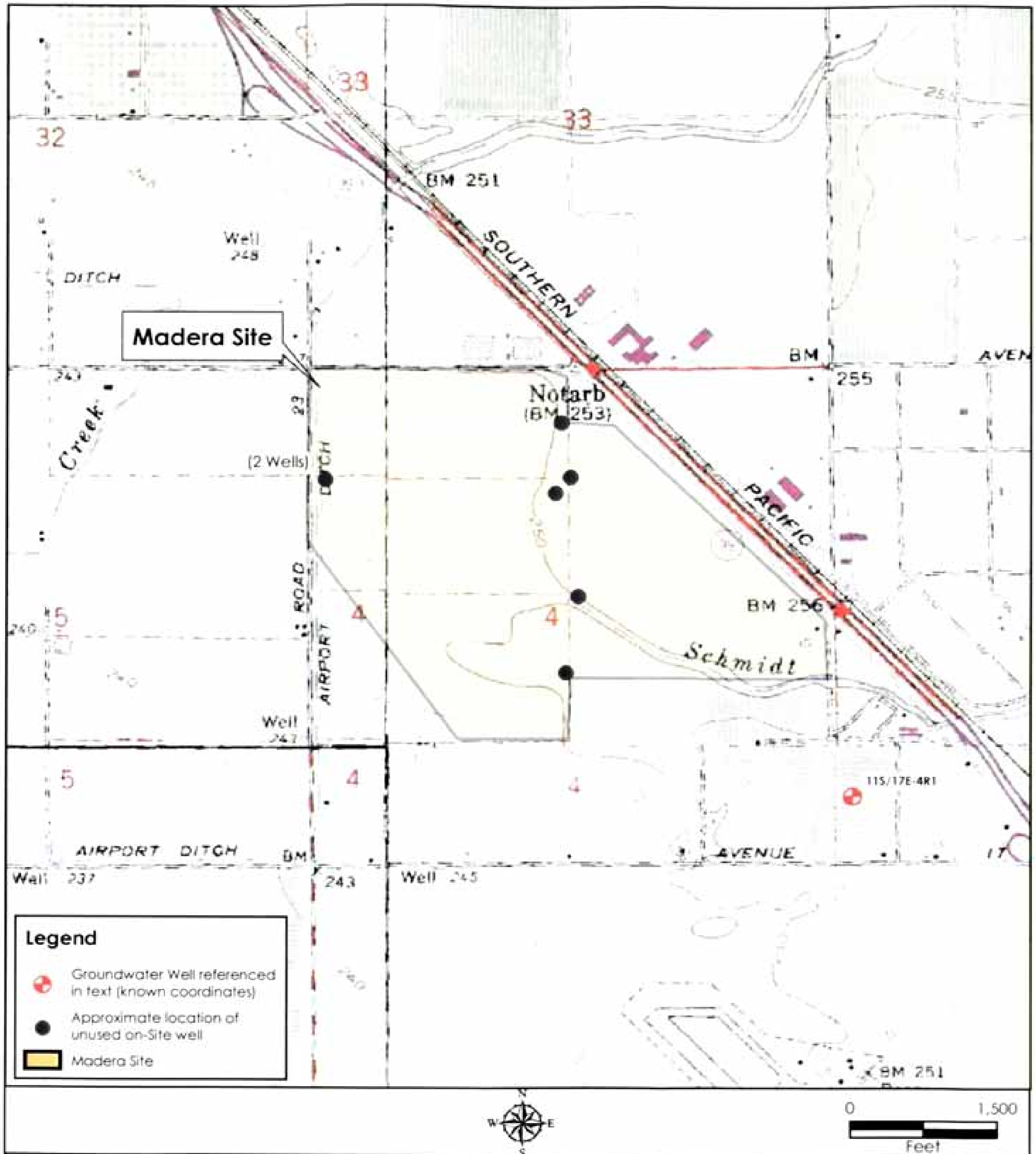


NOTE; Groundwater recharge facilities approximated from "Groundwater Recharge Facilities" Figure 1-1 BOYLE ENGINEERING CORP.
All locations approximate

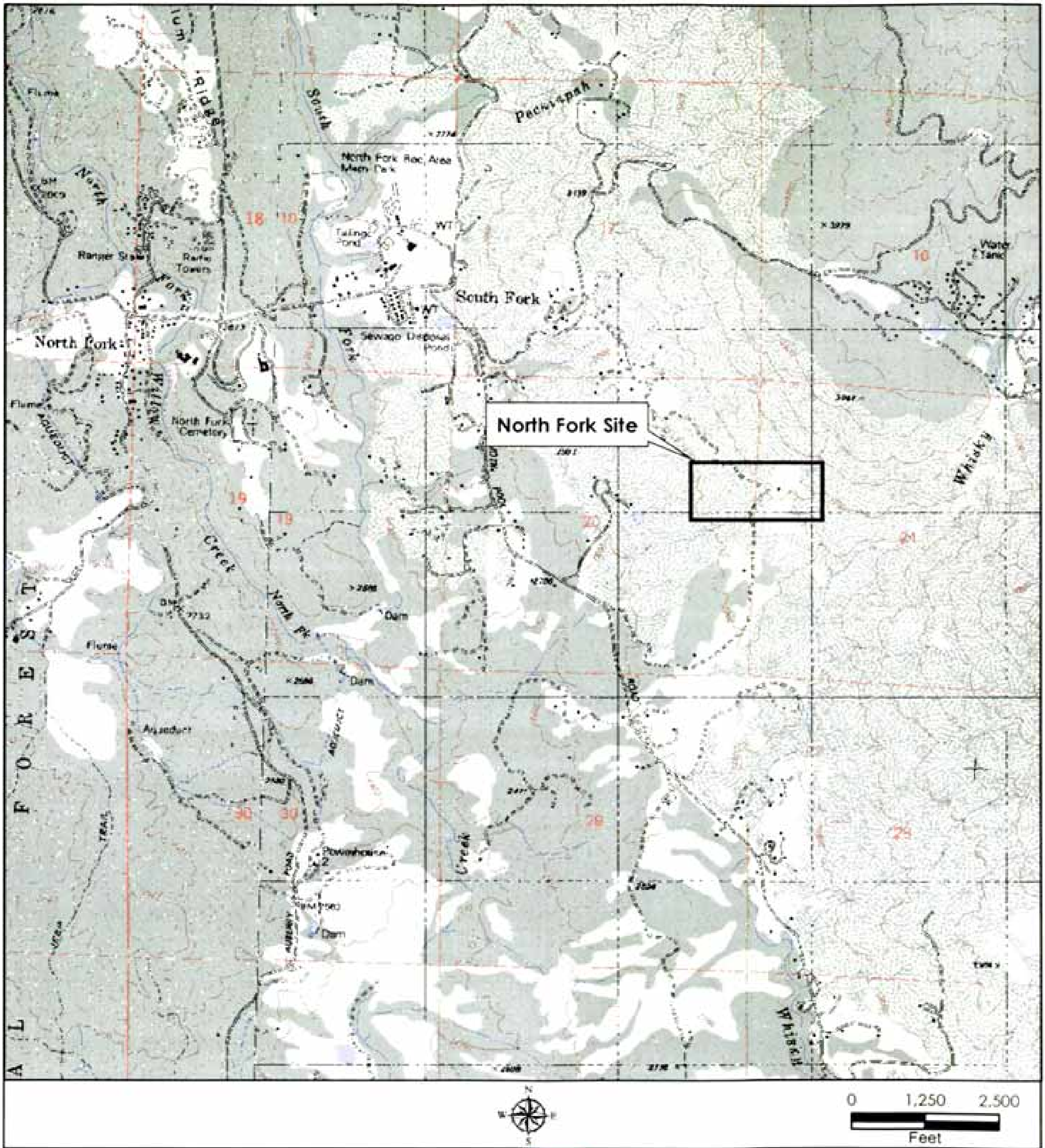
PROPOSED NORTH FORK CASINO	WorleyParsons Komex resources & energy		
REGIONAL MAP	SWL	MT	11/2006
	N0492	1	



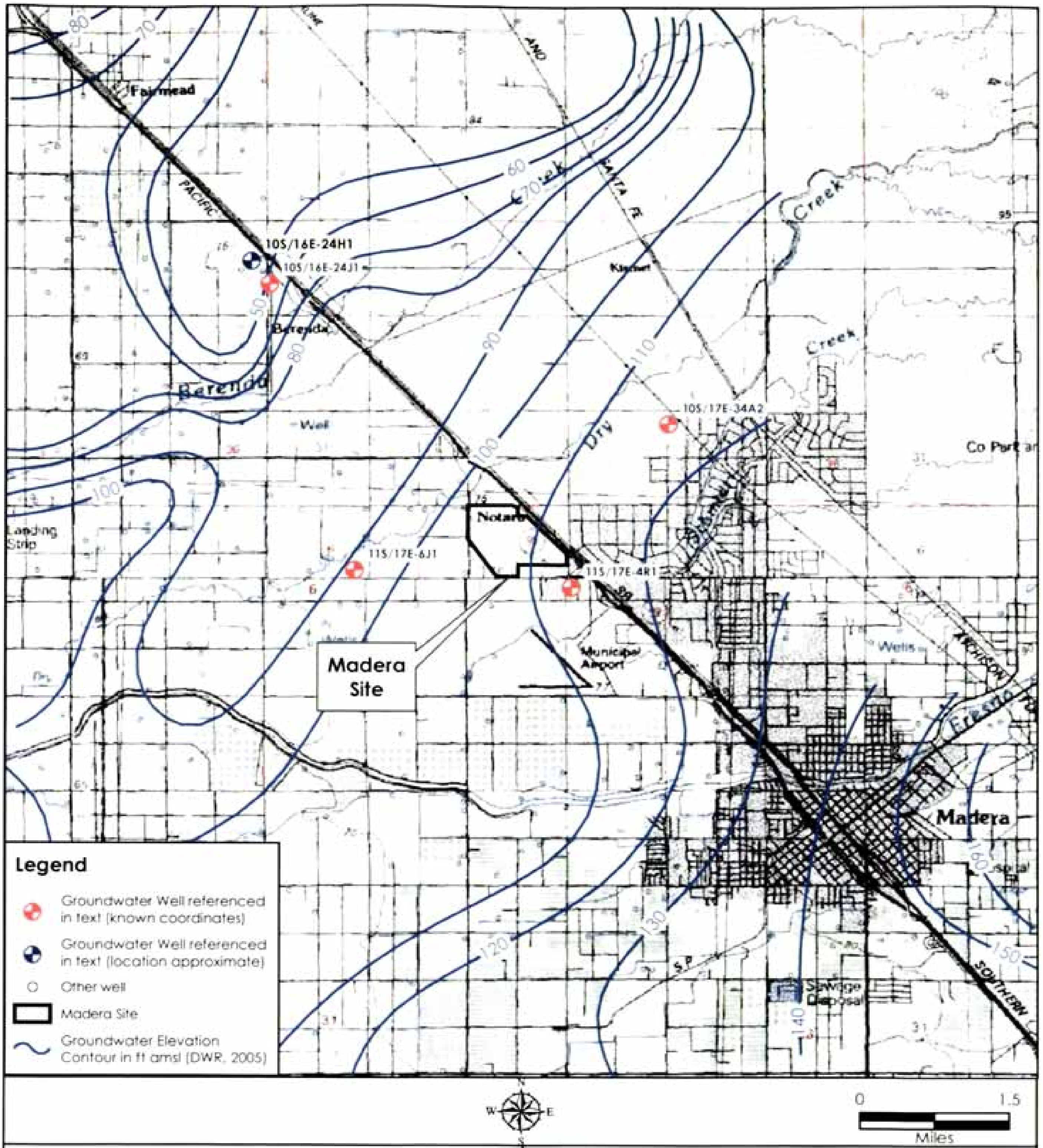
PROPOSED NORTH FORK CASINO	WorleyParsons Komex resources & energy			
MADERA SITE VICINITY	SWL	MT	05/2005	
	N0492		2	



PROPOSED NORTH FORK CASINO		WorleyParsons Komex resources & energy	
MADERA SITE VICINITY	SWL	MT	05/2005
	N0492	**3**	



PROPOSED NORTH FORK CASINO	WorleyParsons Komex resources & energy		
NORTH FORK SITE	SWL	MT	05/2005
	N0492		**4**



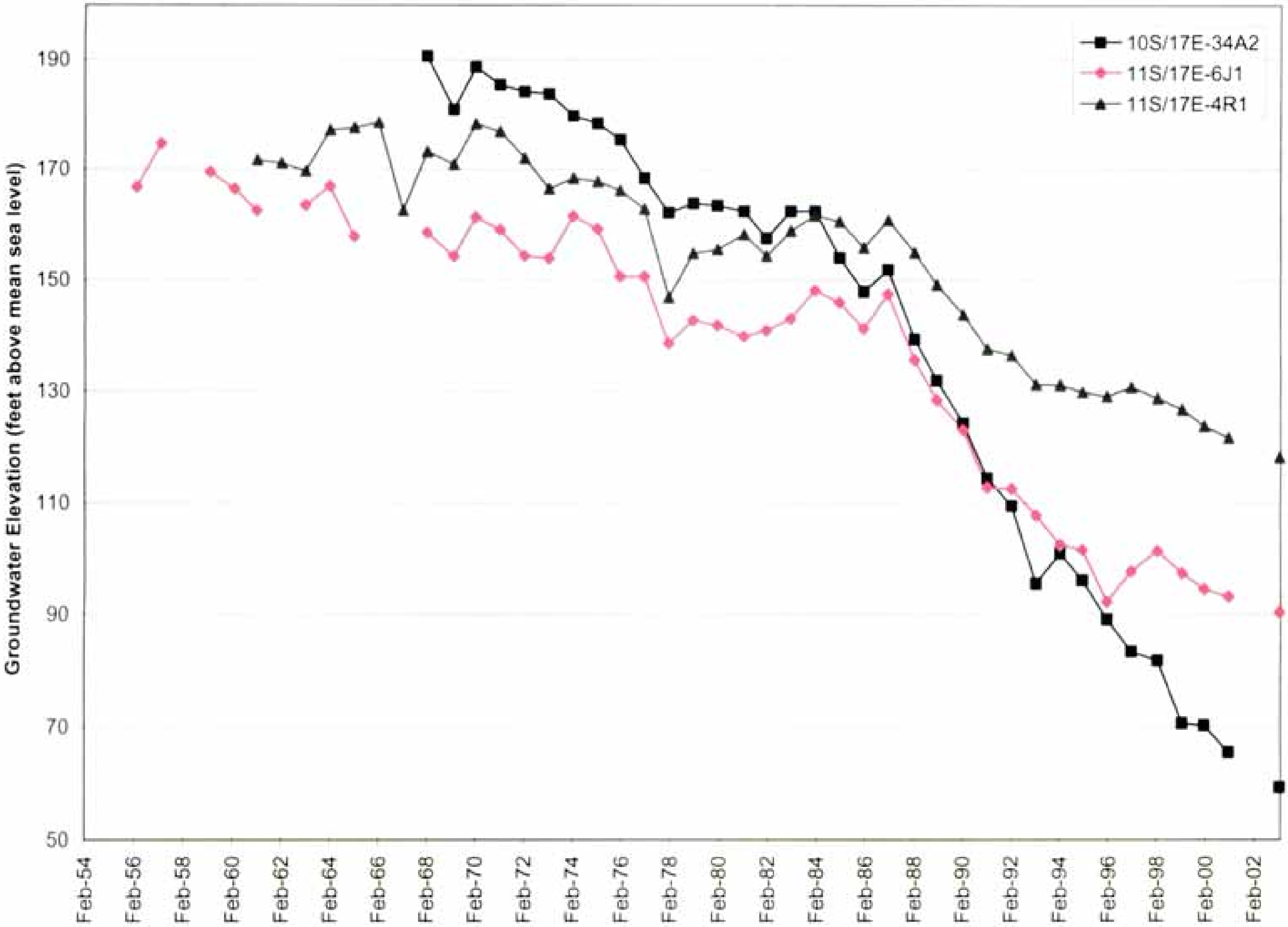
PROPOSED NORTH FORK CASINO

WorleyParsons Komex

resources & energy

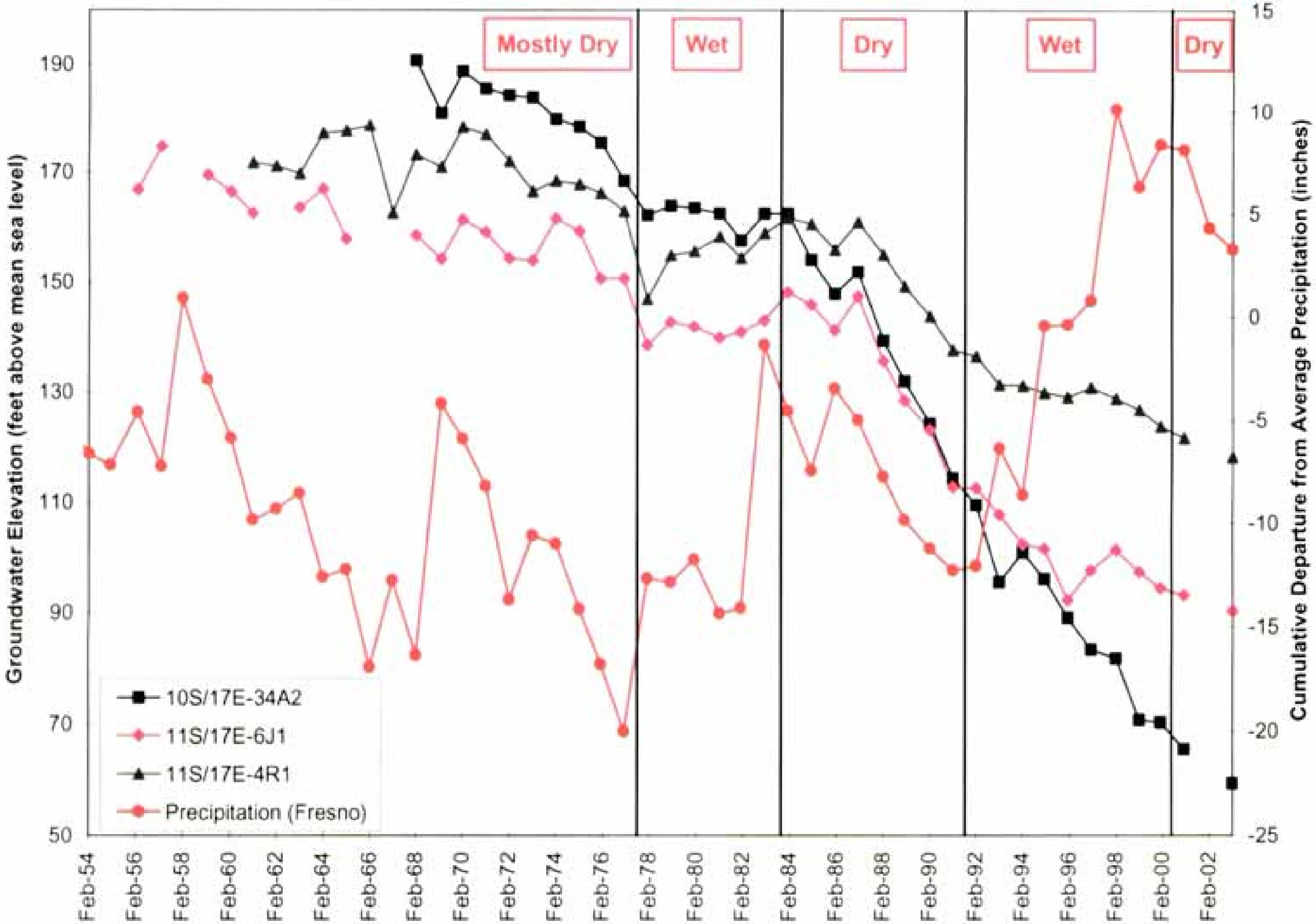
SPRING 2004 GROUNDWATER ELEVATIONS IN THE MADERA SITE VICINITY

SWL	MT	05/2005
N0492		**5**



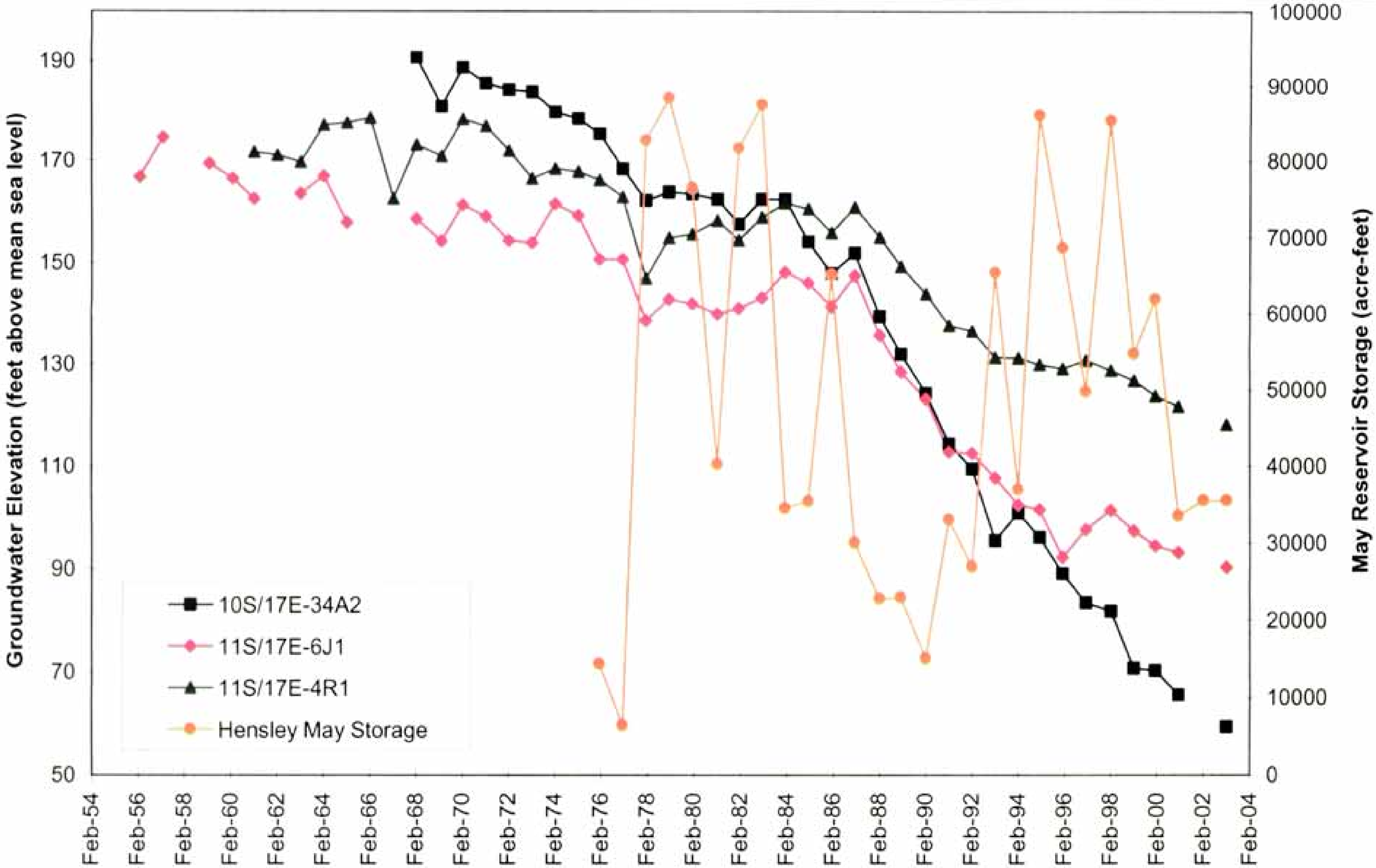
Note: Spring groundwater elevations are shown. Source: DWR (2005c)

PROPOSED NORTH FORK CASINO	WorleyParsons Komex resources & energy			
MADERA SITE VICINITY WELL HYDROGRAPHS	SWL	MT	09/2006	
	N0492A	6		



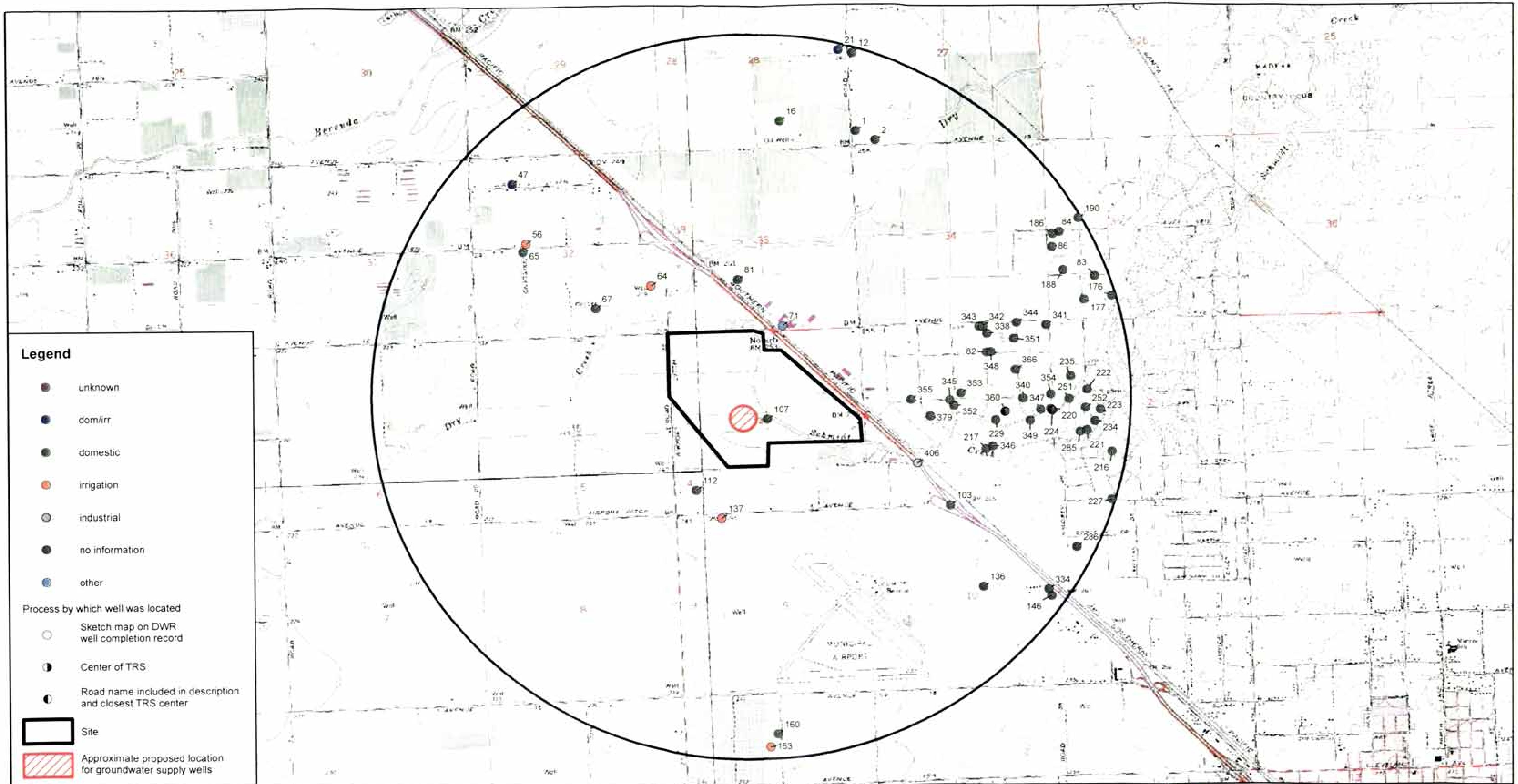
Note: Spring groundwater elevations are shown. Source: DWR (2005c) and WRCC (2005b)

PROPOSED NORTH FORK CASINO	WorleyParsons Komex resources & energy			
MADERA SITE VICINITY WELL HYDROGRAPHS COMPARED TO CUMULATIVE DEPARTURE FROM AVERAGE PRECIPITATION	SWL	MT	09/2006	
	N0492A	7		



Note: Spring groundwater elevations are shown. Source: DWR (2005c) and USBR (2005b)

PROPOSED NORTH FORK CASINO	WorleyParsons Komex resources & energy			
MADERA SITE VICINITY WELL HYDROGRAPHS COMPARED TO STORAGE IN HENSLEY RESERVOIR	SWL	MT	09/2006	
	N0492A	8		



All well locations are approximate, based on the methods used and were not field verified.
Locations of monitoring wells and test wells were not plotted.
See Table 1 for well completion details.
TRS = Township-Range-Section

N S E W

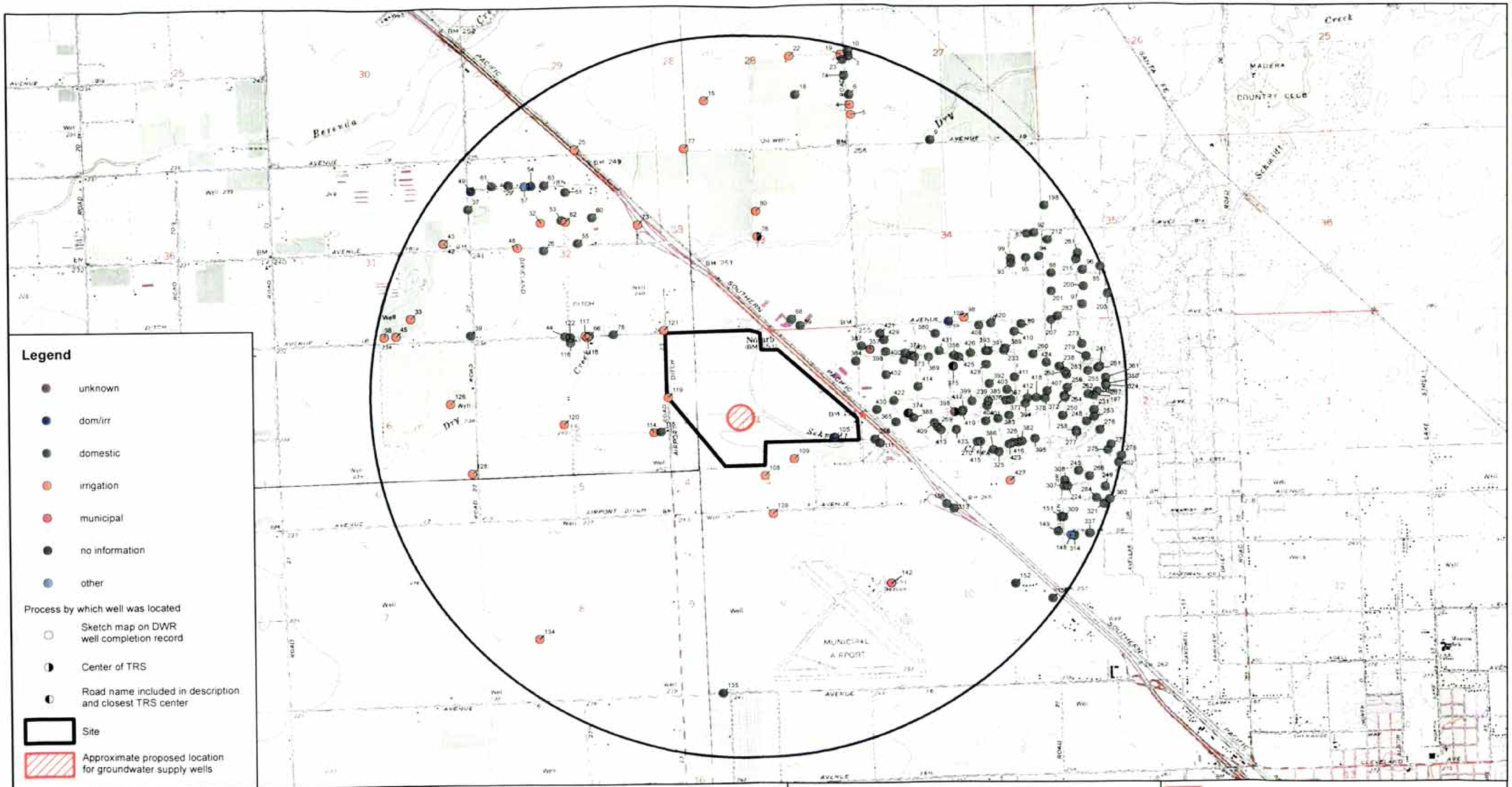
0 0.5
Miles

PROPOSED NORTHFORK CASINO

WorleyParsons Komex
resources & energy

APPROXIMATE LOCATION OF SHALLOW WELLS

SWL	MT	9/2006
N0492	9	



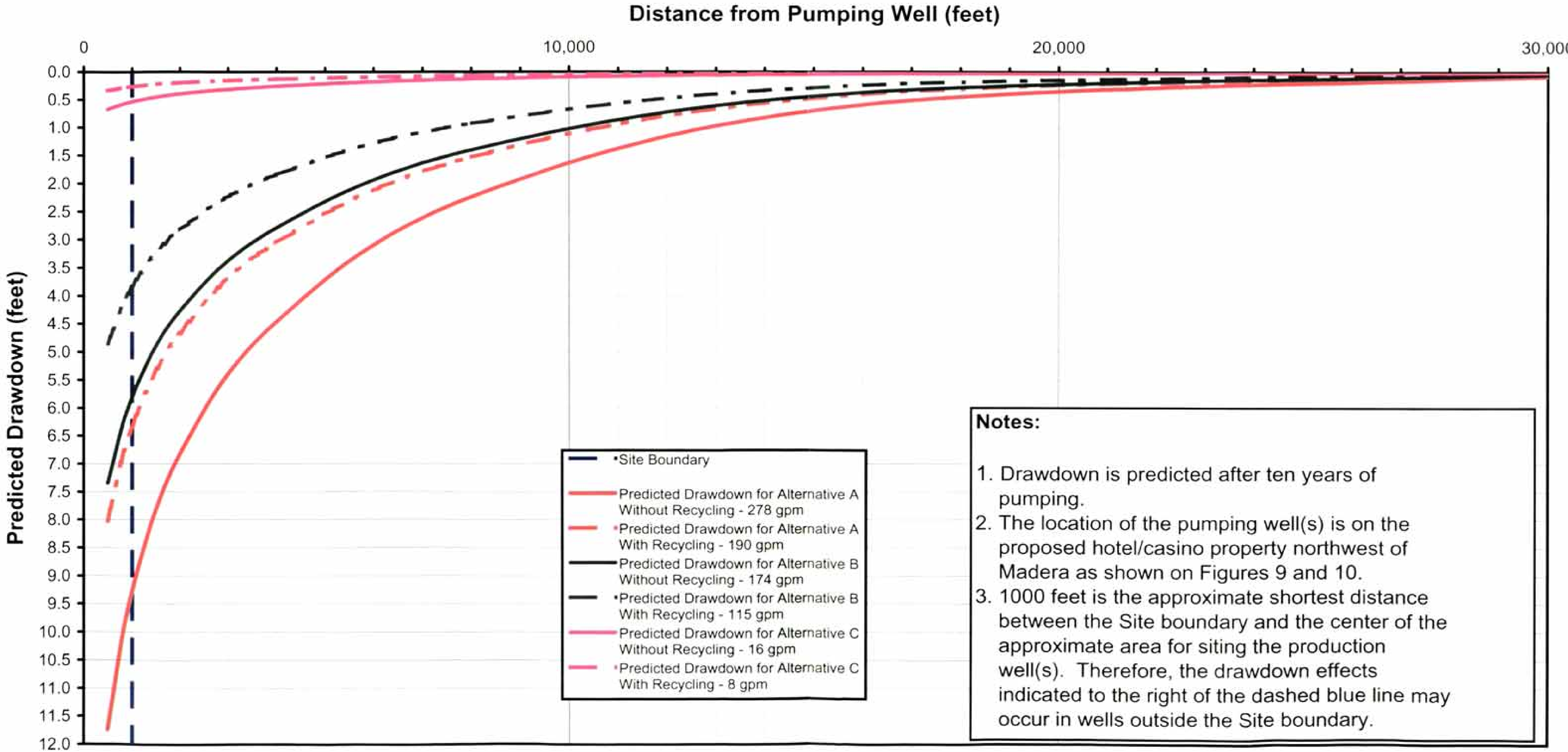
All well locations are approximate, based on the methods used and were not field verified.
Locations of monitoring wells and test wells were not plotted.
See Table 1 for well completion details.
TRS = Township-Range-Section

PROPOSED NORTHFORK CASINO		WorleyParsons Komex resources & energy	
APPROXIMATE LOCATION OF DEEP WELLS	SWL	MT	9/2006
	N0492		10

WorleyParsons Komex
resources & energy

Environment & Water Resources
2330 E. Bidwell Street, Suite 150
Folsom, CA 95630 USA
Telephone: +1 916 817 3931
Facsimile: +1 916 983 1935
worleyparsons.com

Figure 11 - Distance-Drawdown Prediction for the Proposed Pumping Well(s)



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Folsom, CA 95630 USA
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Facsimile: +1 916 983 1935
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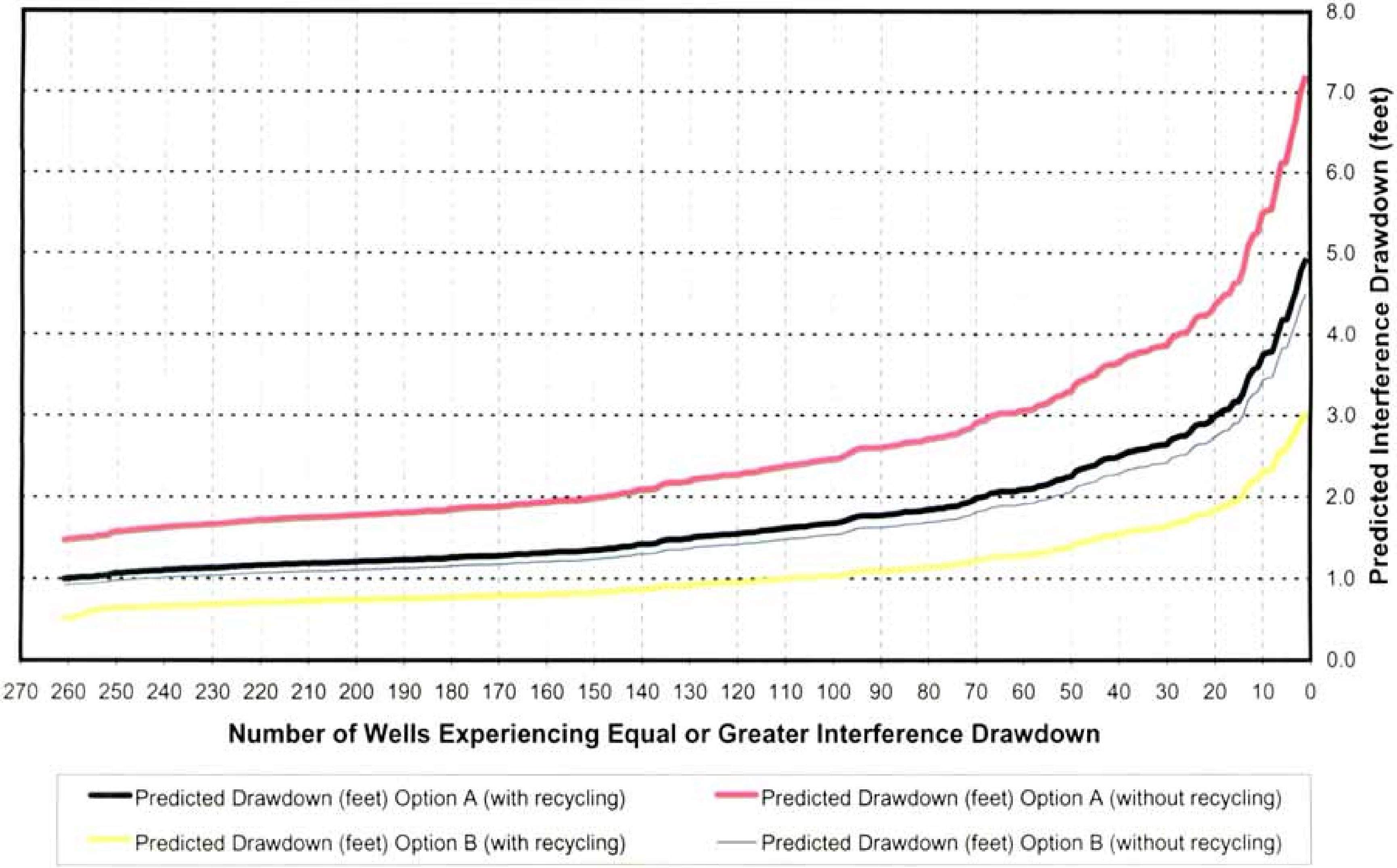
Figure 12 - Predicted Interference Drawdown Impacts on Off-Site Wells Within 2 Miles of the Proposed Project Well(s)



WorleyParsons Komex
resources & energy

Environment & Water Resources
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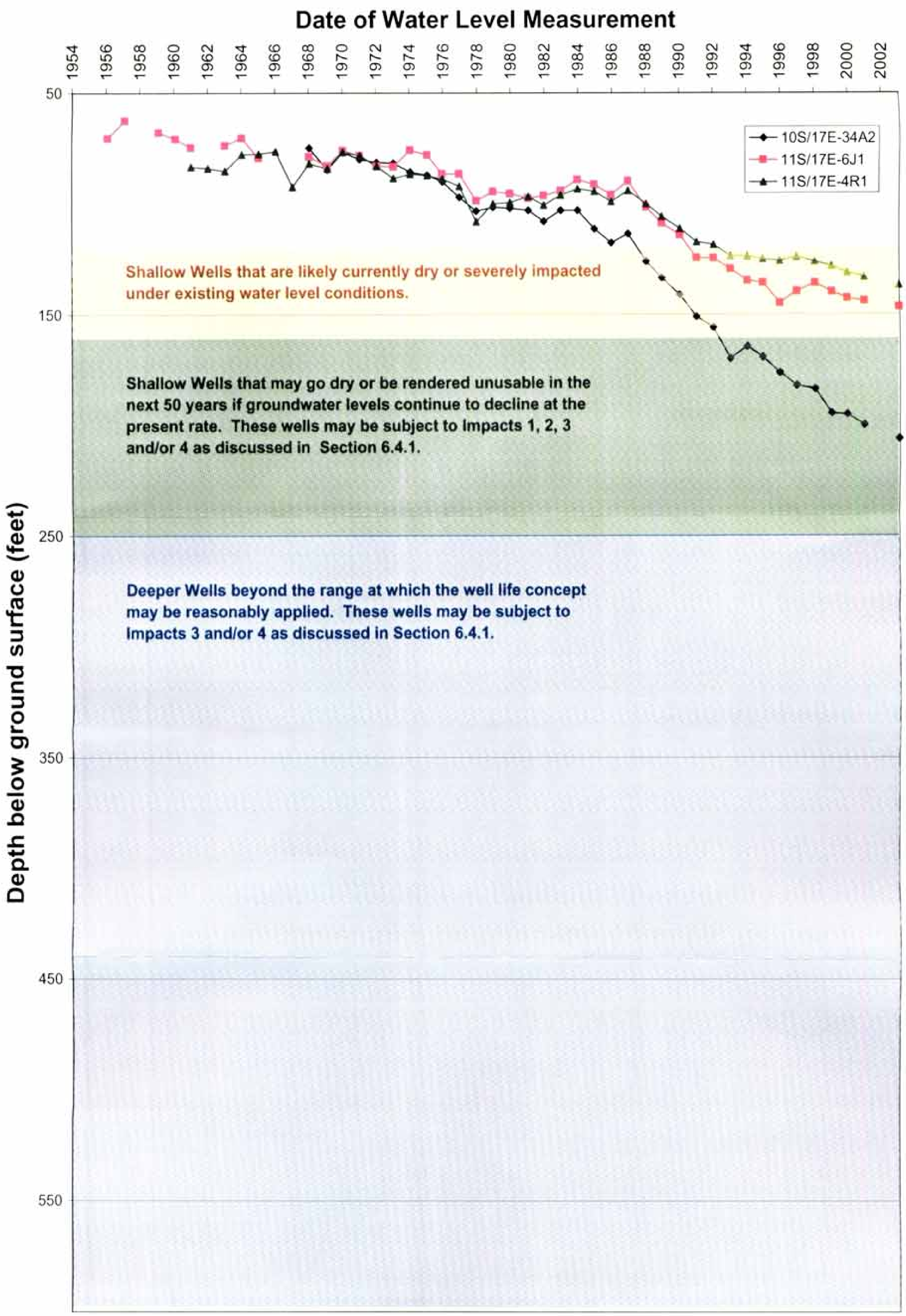
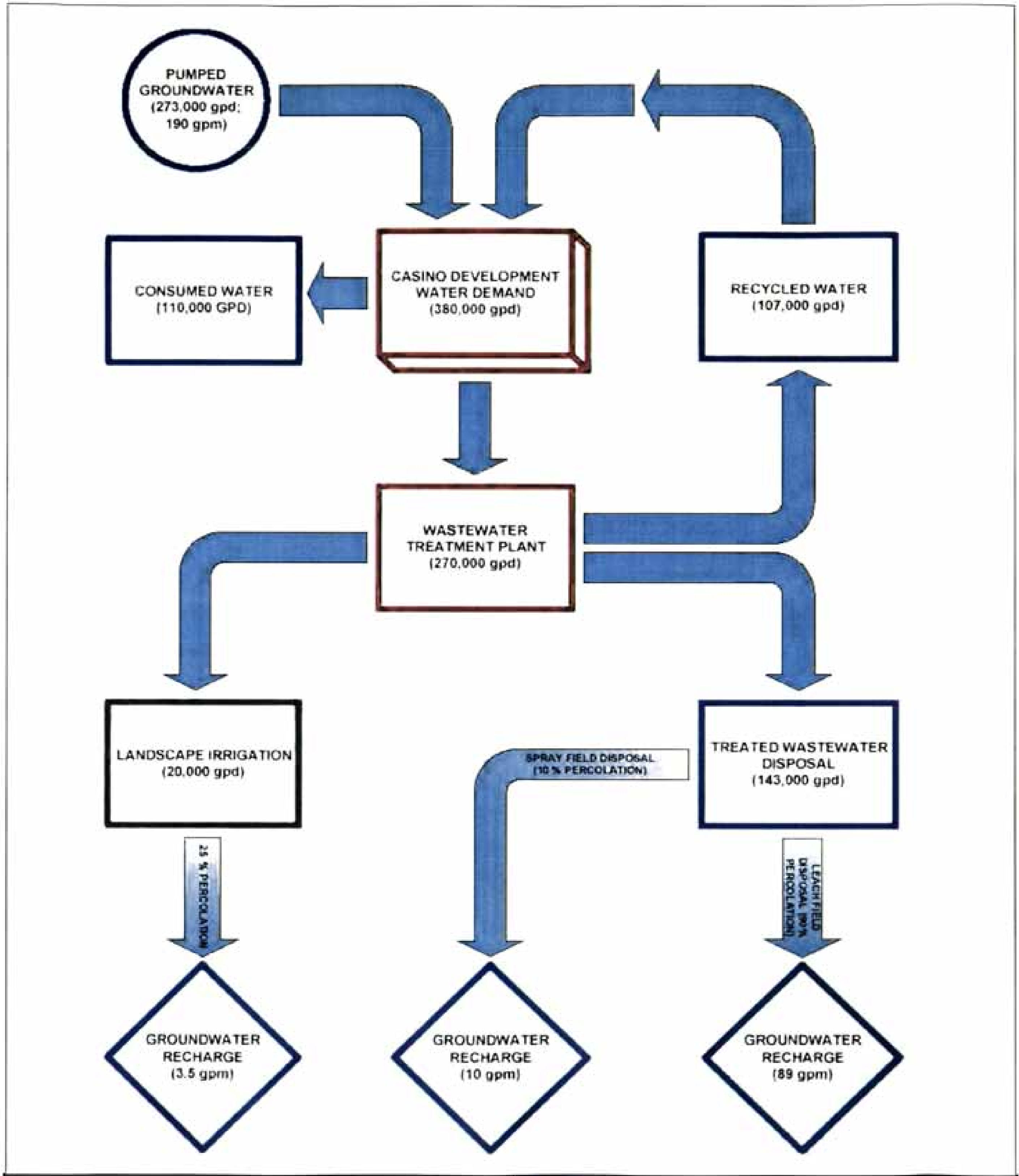
Folson, CA 95630 USA
Telephone: +1 916 817 3931
Facsimile: +1 916 983 1935
worleyparsons.com

Figure 13 - Key Well Hydrographs and Potential Impacts to Nearby Wells





PROPOSED NORTH FORK CASINO

WorleyParsons Komex

resources & energy

WATER AND WASTEWATER BALANCE ALTERNATIVE A

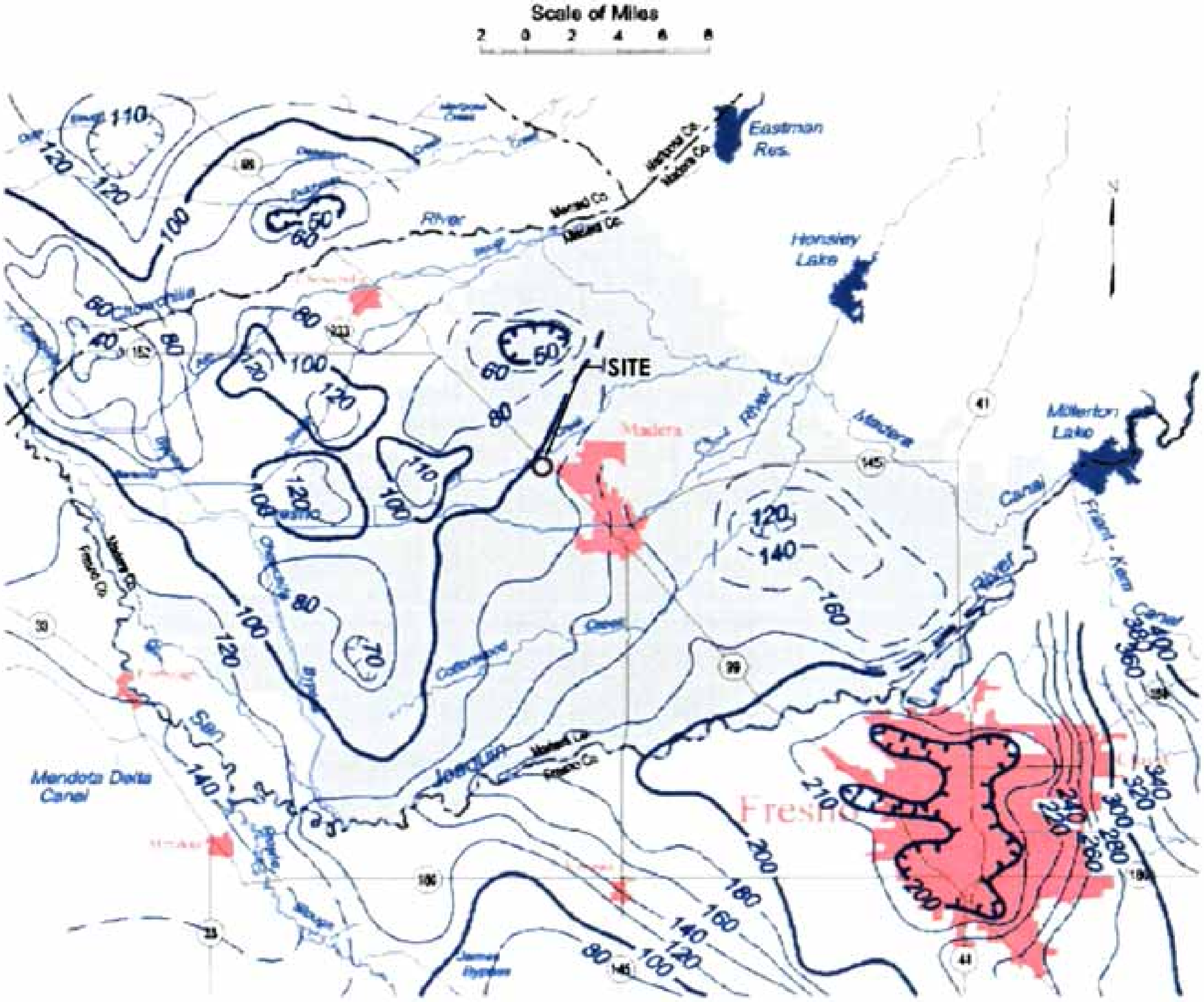
SWL	MT	05/2005
N0492	14	

APPENDIX A

DWR INTERPRETATIONS OF GROUNDWATER ELEVATION IN THE MADERA SUBBASIN

Madera Groundwater Basin

Spring 2001, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

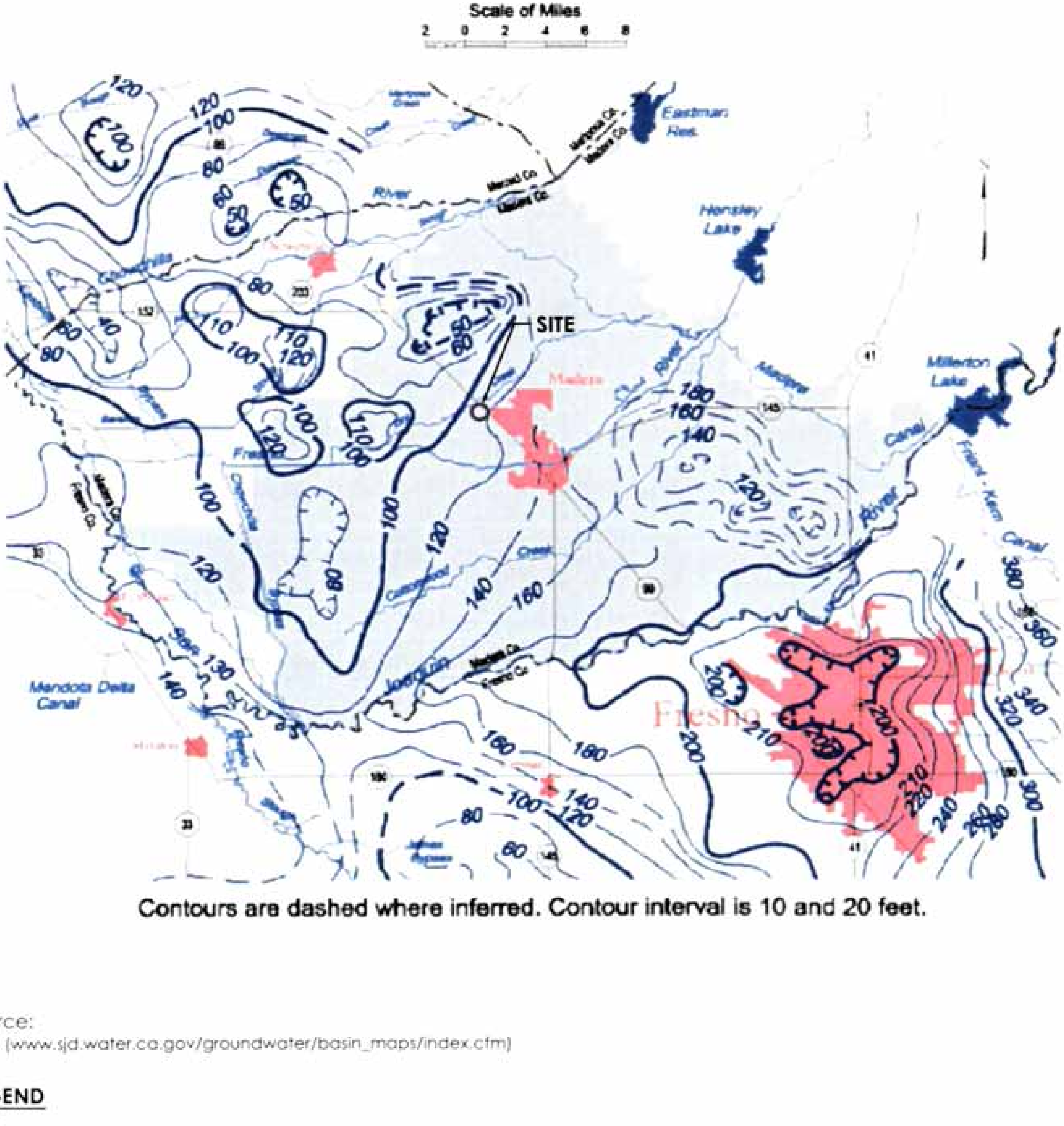
LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
		AB	N0492A
	GROUNDWATER ELEVATION CONTOURS, SPRING 2001	A	

Madera Groundwater Basin

Spring 2000, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

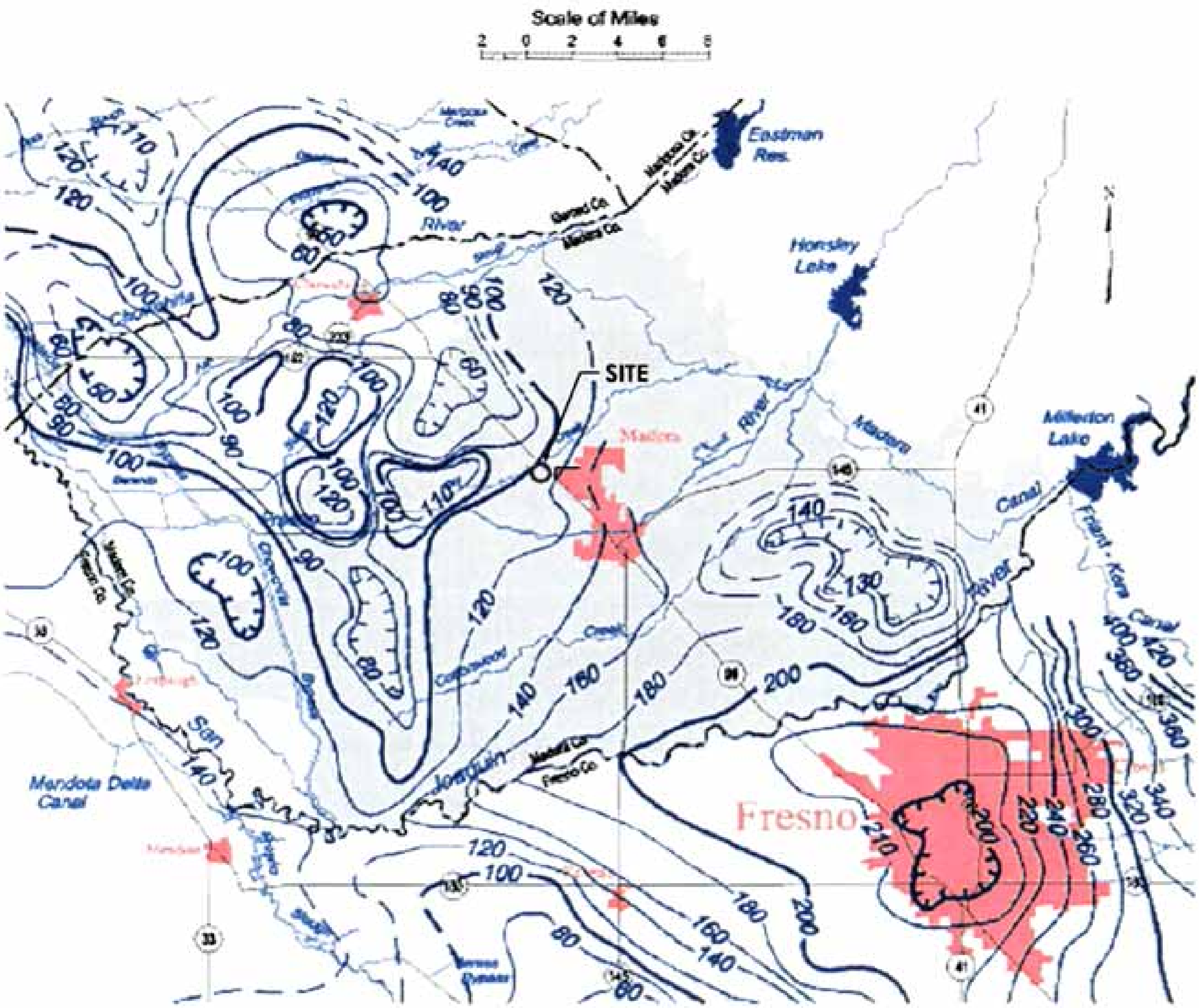
LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
		AB	N0492A
	GROUNDWATER ELEVATION CONTOURS, SPRING 2000	A	

Madera Groundwater Basin

Spring 1999, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

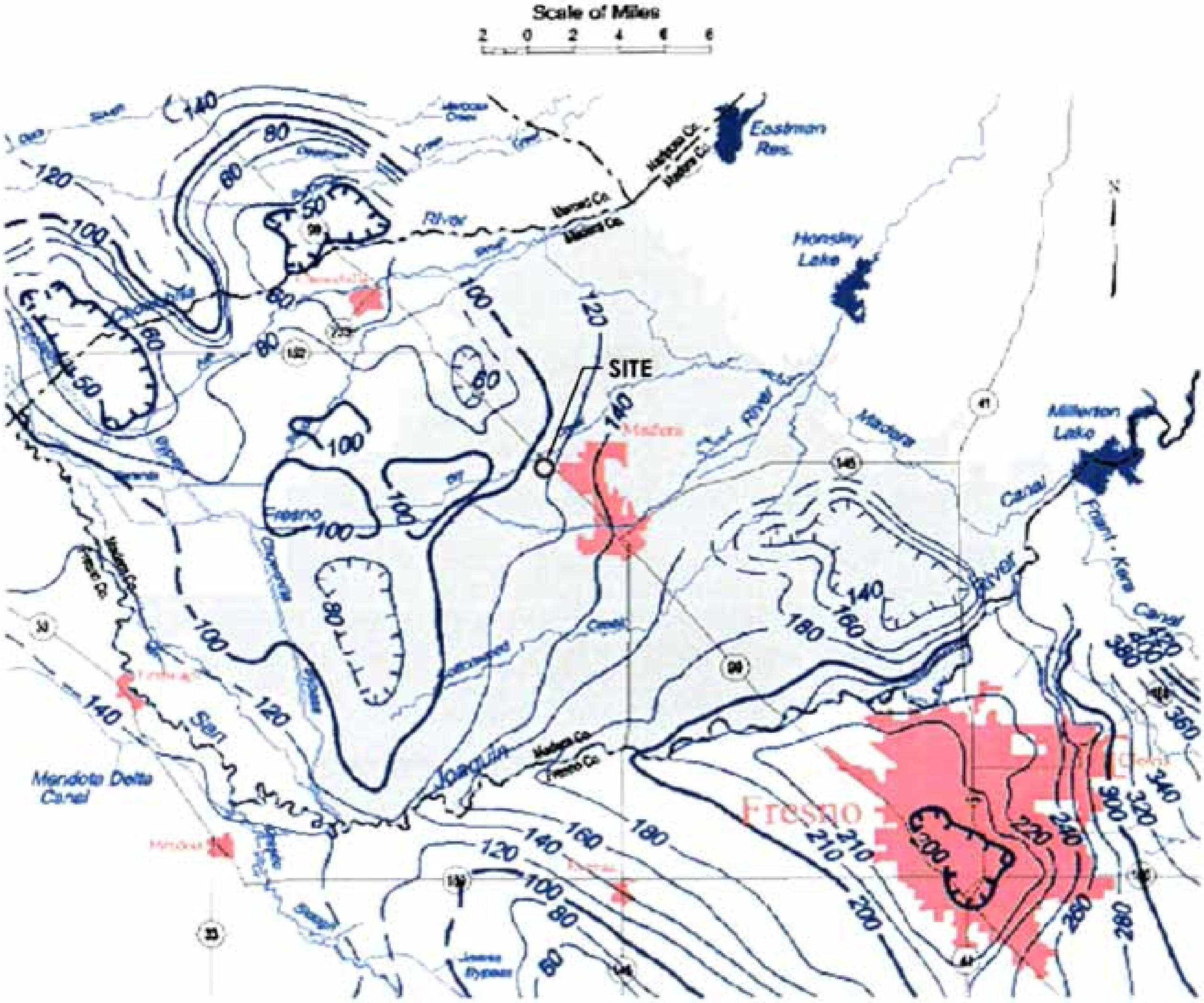
LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
		AB	N0492A
	GROUNDWATER ELEVATION CONTOURS, SPRING 1999	A	

Madera Groundwater Basin

Spring 1998, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

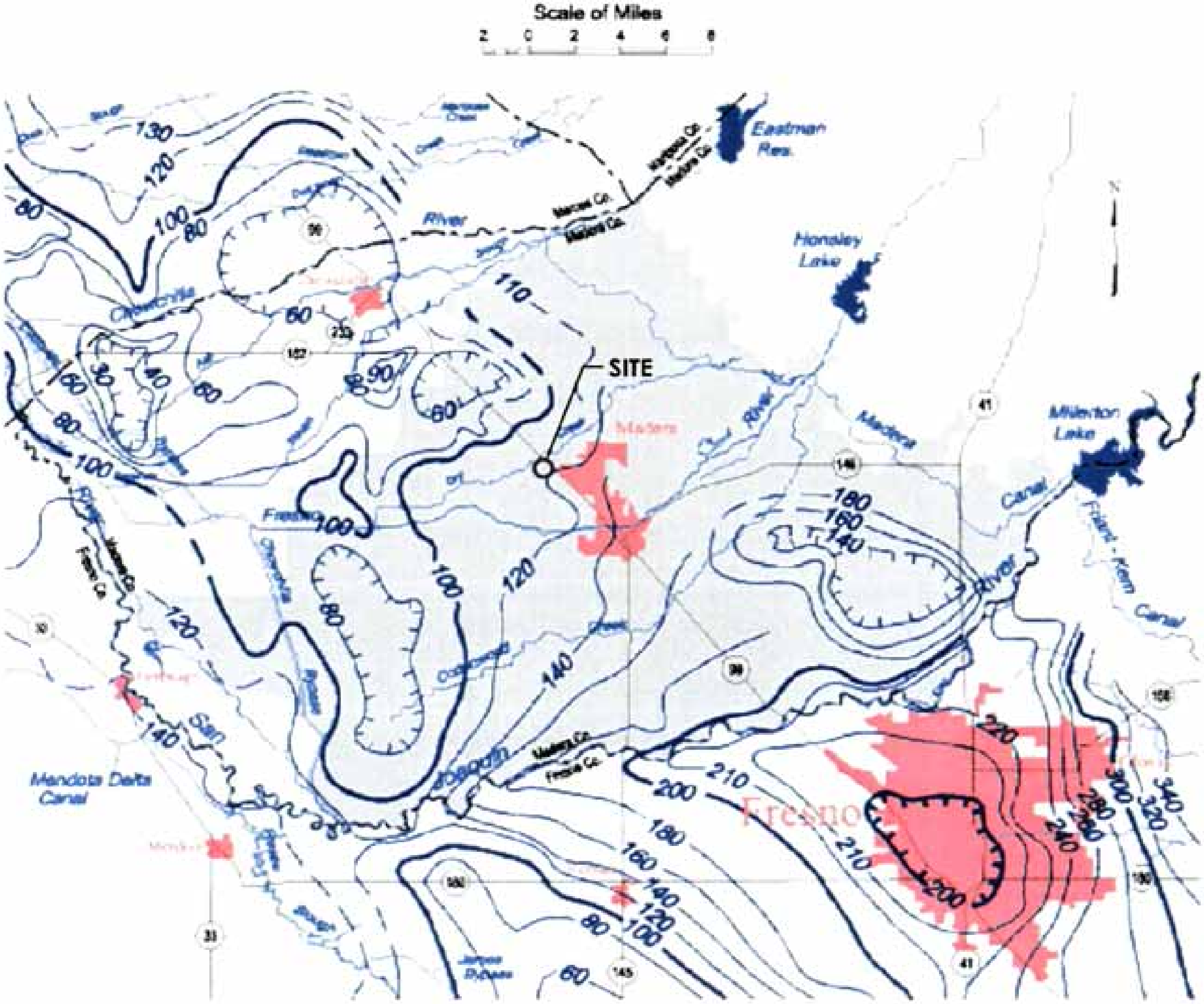
LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
		AB	N0492A
	GROUNDWATER ELEVATION CONTOURS, SPRING 1998		A

Madera Groundwater Basin

Spring 1997, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

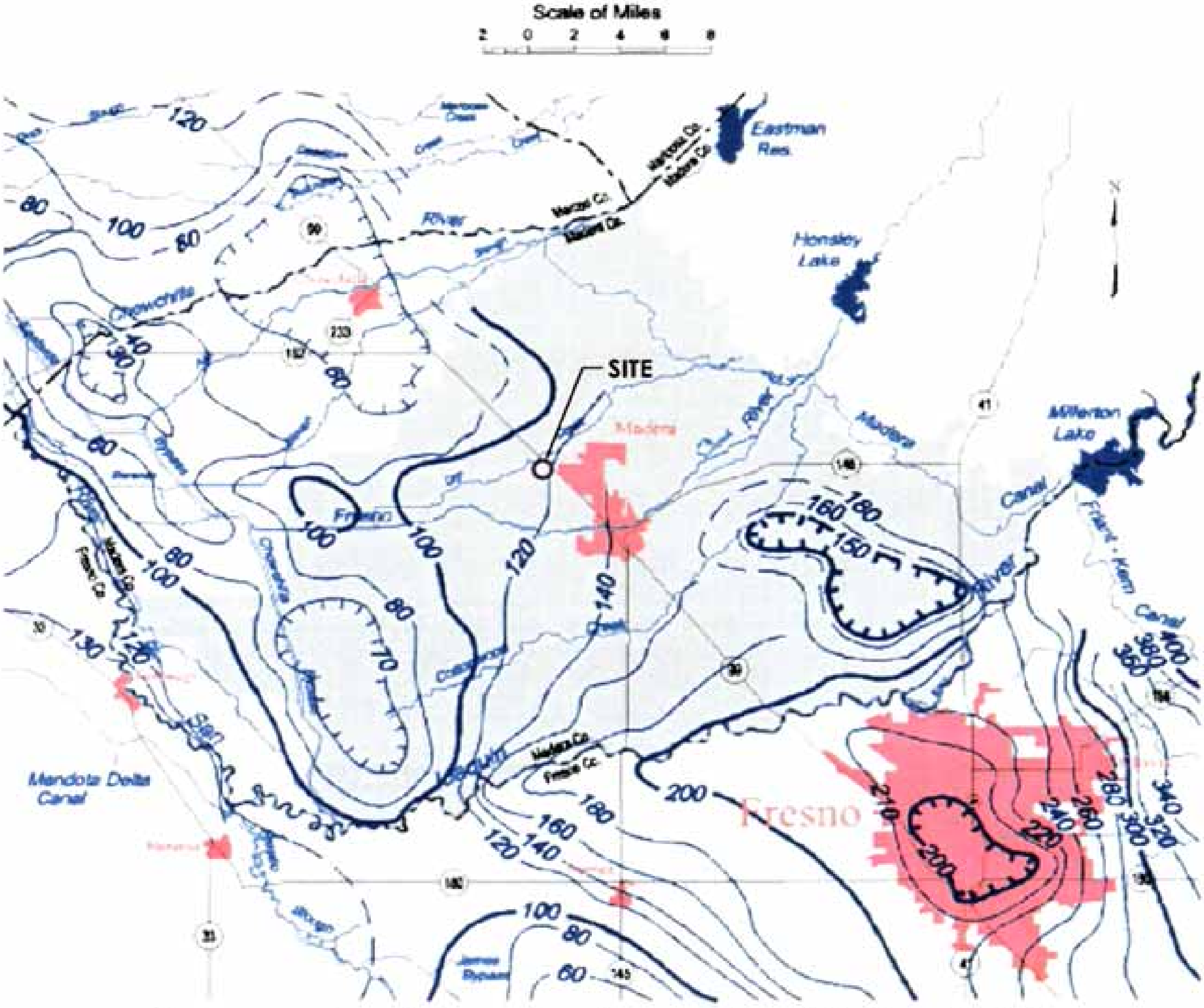
LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
		AB	N0492A
	GROUNDWATER ELEVATION CONTOURS, SPRING 1997	A	

Madera Groundwater Basin

Spring 1996, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

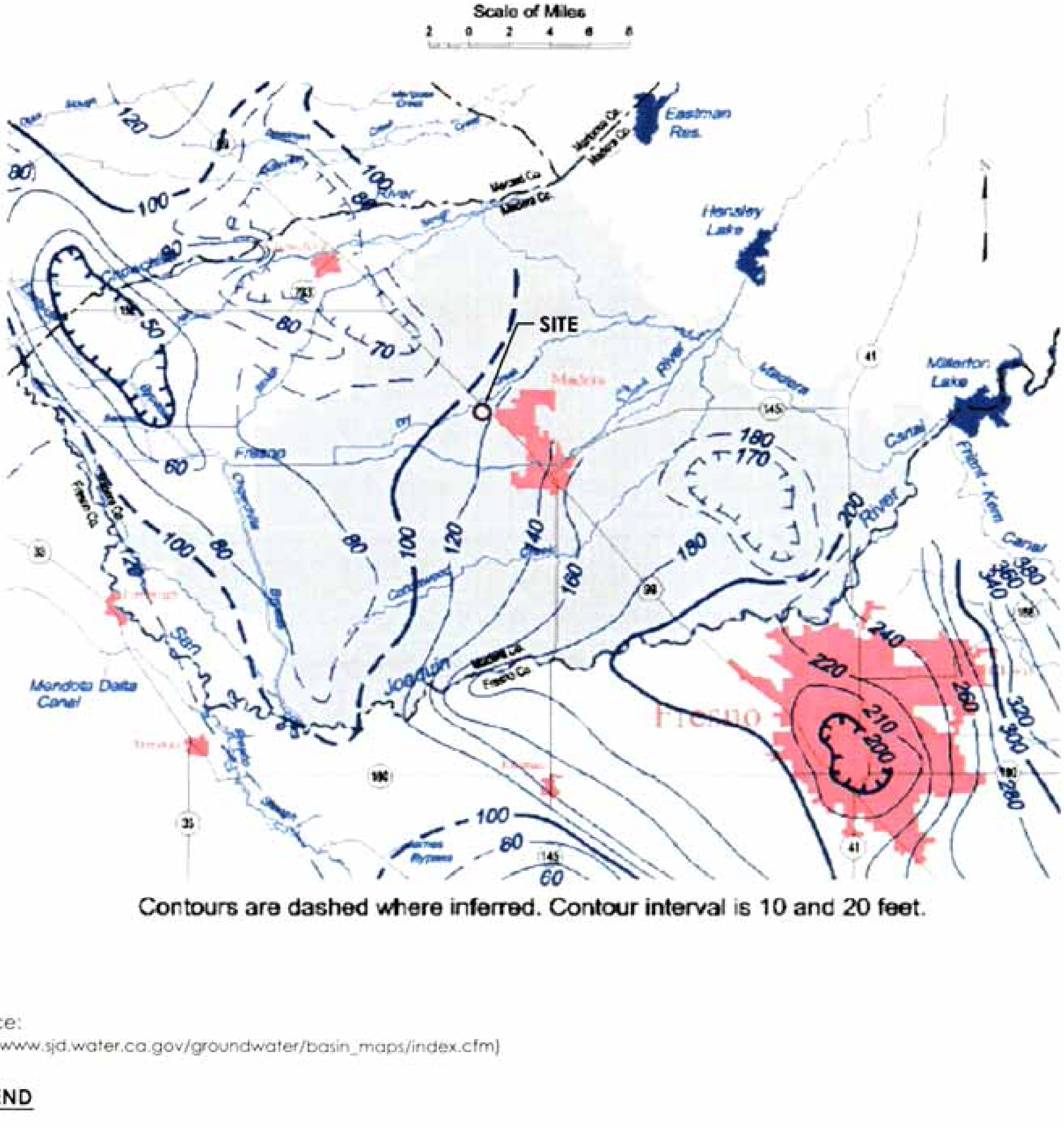
LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
		AB	N0492A
	GROUNDWATER ELEVATION CONTOURS, SPRING 1996	A	

Madera Groundwater Basin

Spring 1995, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

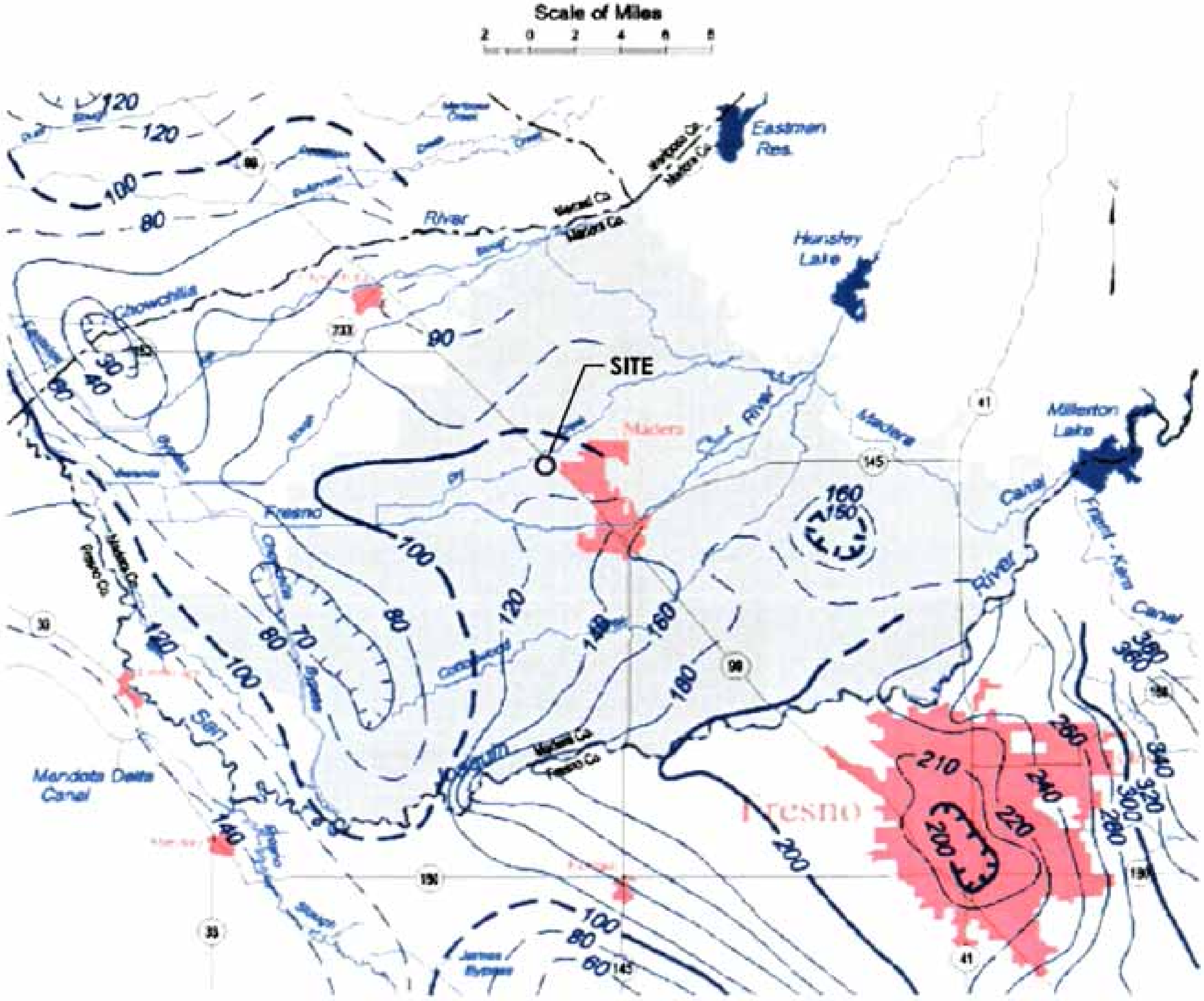
LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
	GROUNDWATER ELEVATION CONTOURS, SPRING 1995	AB	N0492A
			A

Madera Groundwater Basin

Spring 1994, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

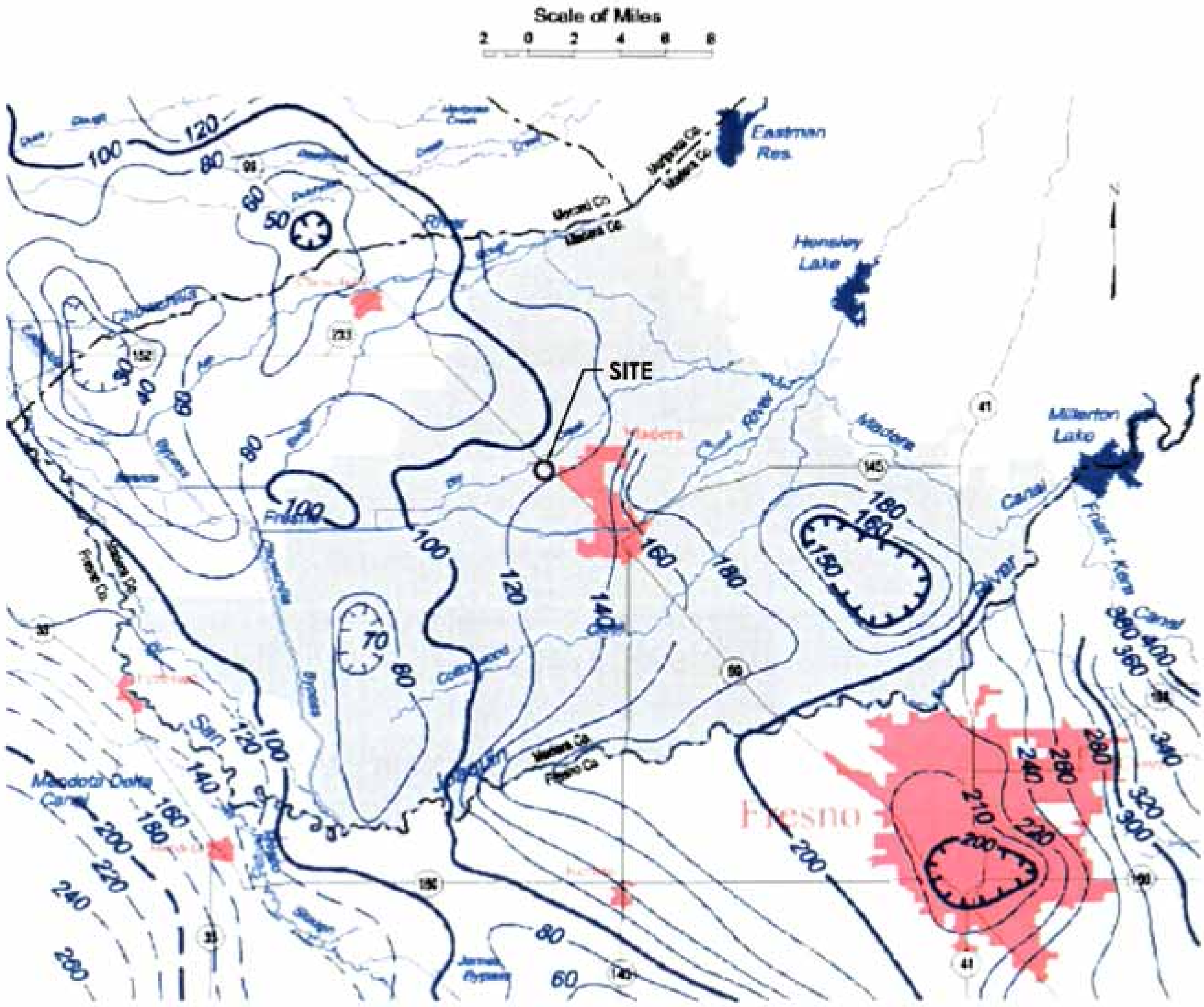
LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
		AB	N0492A
	GROUNDWATER ELEVATION CONTOURS, SPRING 1994	A	

Madera Groundwater Basin

Spring 1993, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

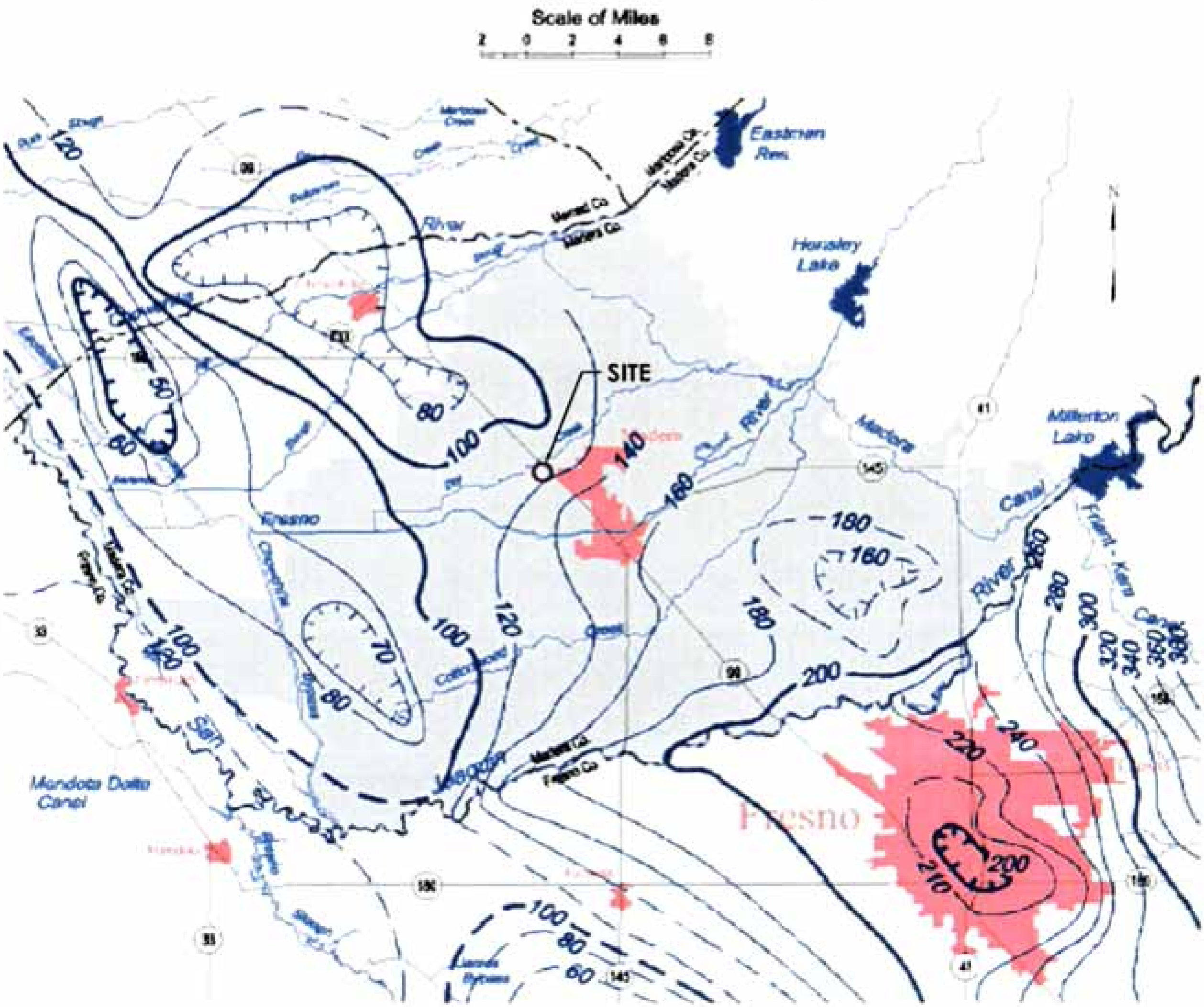
LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
	GROUNDWATER ELEVATION CONTOURS, SPRING 1993	AB	N0492A
		A	

Madera Groundwater Basin

Spring 1992, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

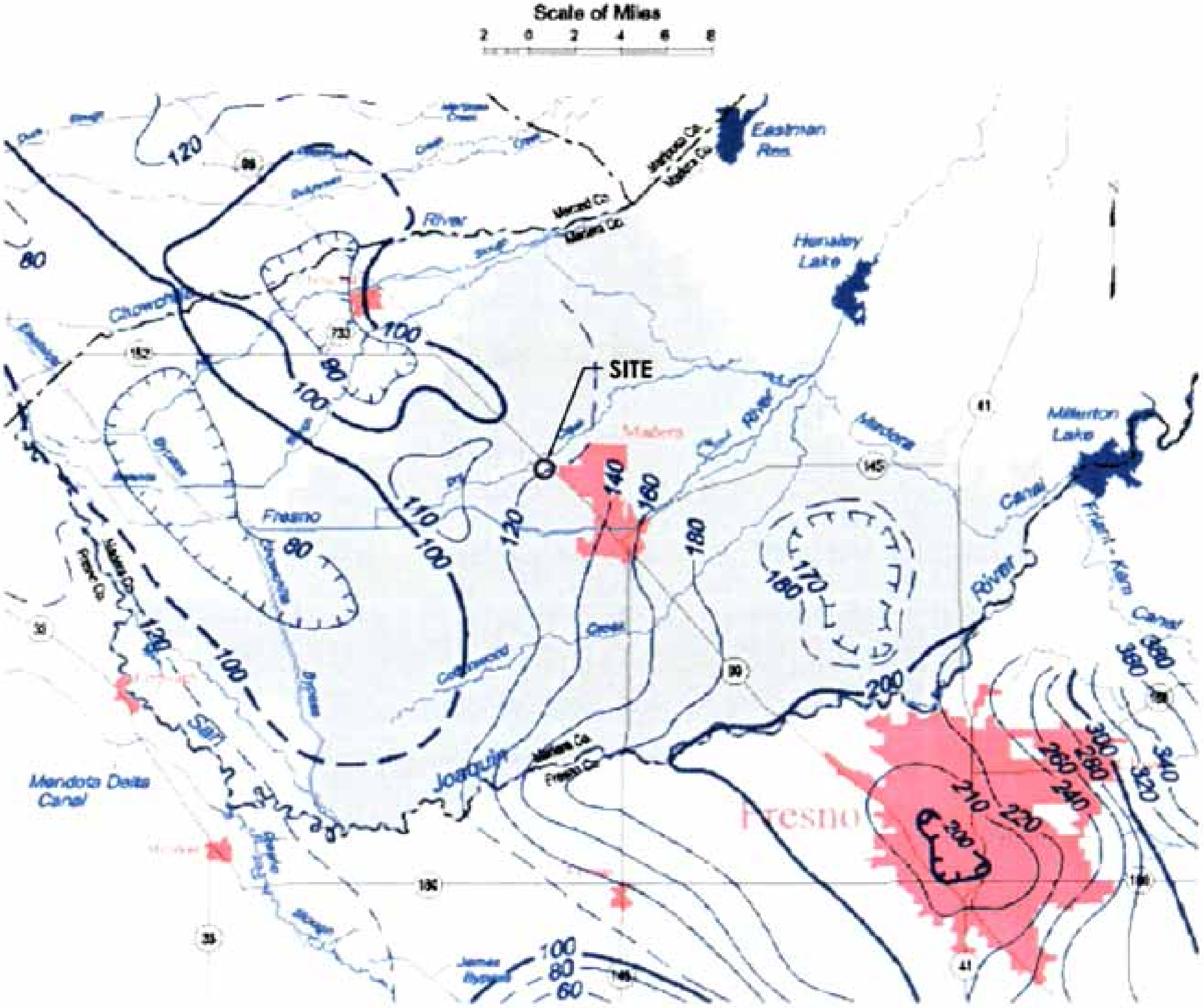
LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
	GROUNDWATER ELEVATION CONTOURS, SPRING 1992	AB	N0492A
		A	

Madera Groundwater Basin

Spring 1991, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
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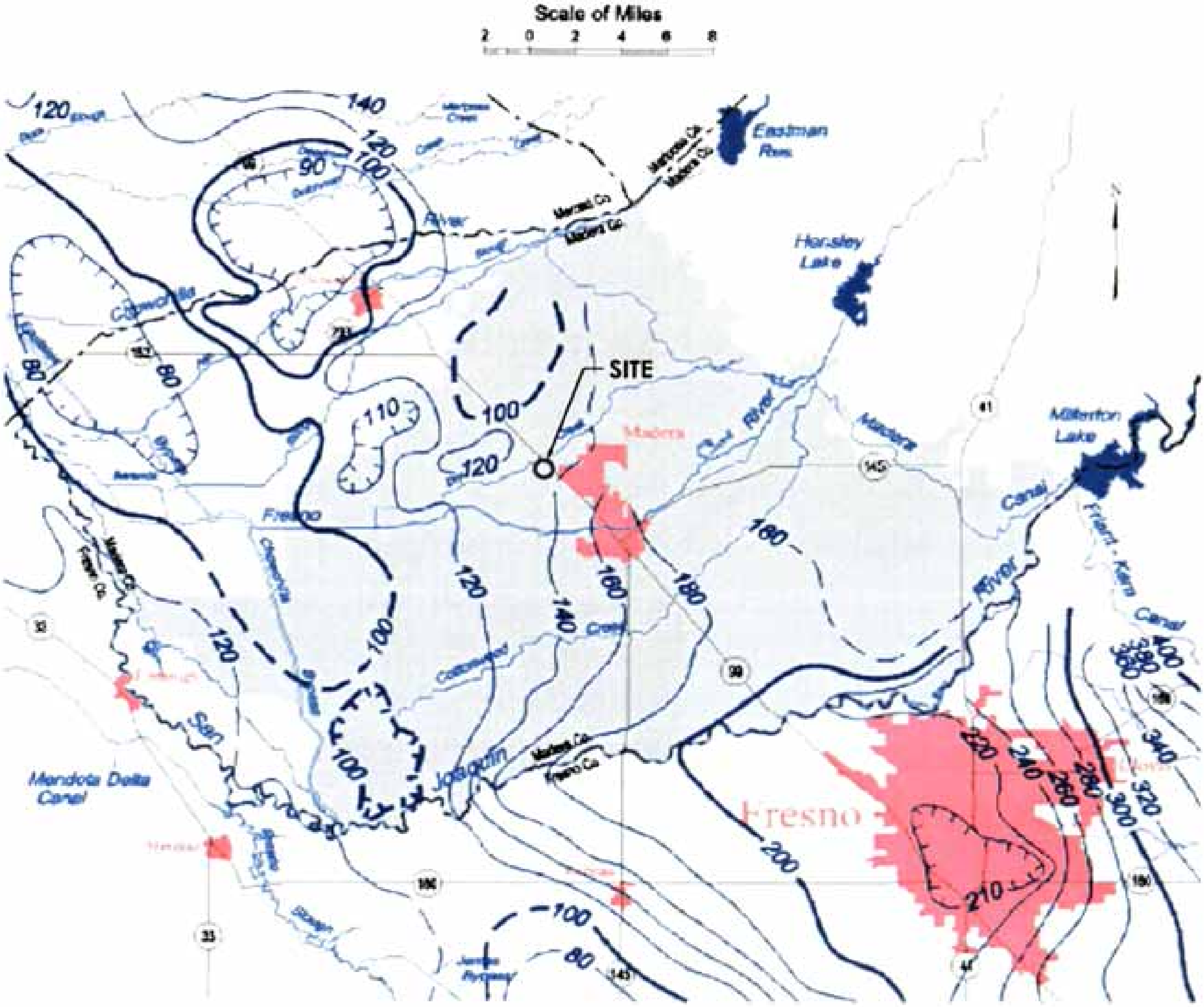
LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
		AB	N0492A
	GROUNDWATER ELEVATION CONTOURS, SPRING 1991	A	

Madera Groundwater Basin

Spring 1990, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

LEGEND

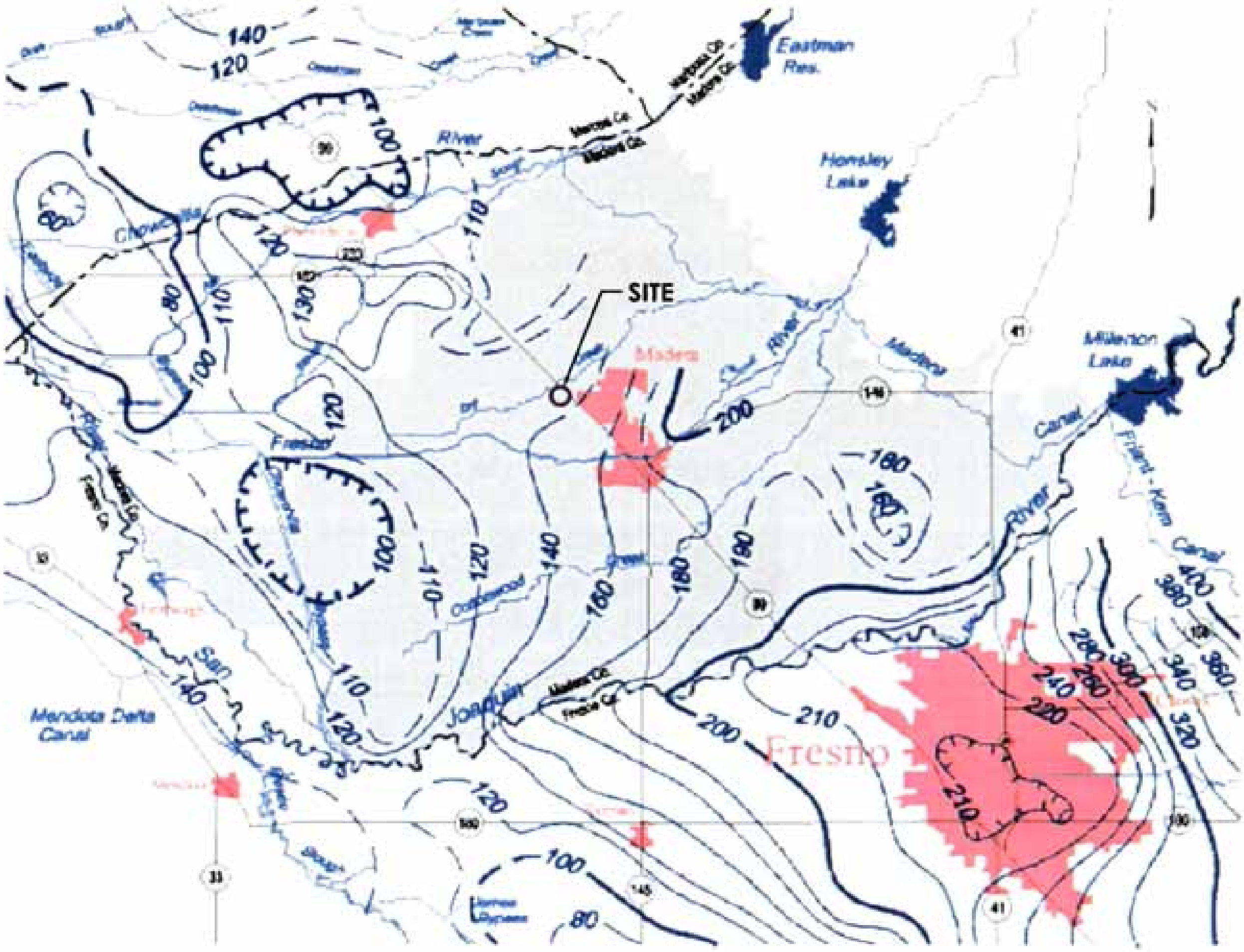
O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
	GROUNDWATER ELEVATION CONTOURS, SPRING 1990	AB	N0492A
		A	

Madera Groundwater Basin

Spring 1989, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles
2 0 2 4 6 8



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
		AB	N0492A
	GROUNDWATER ELEVATION CONTOURS, SPRING 1989	A	

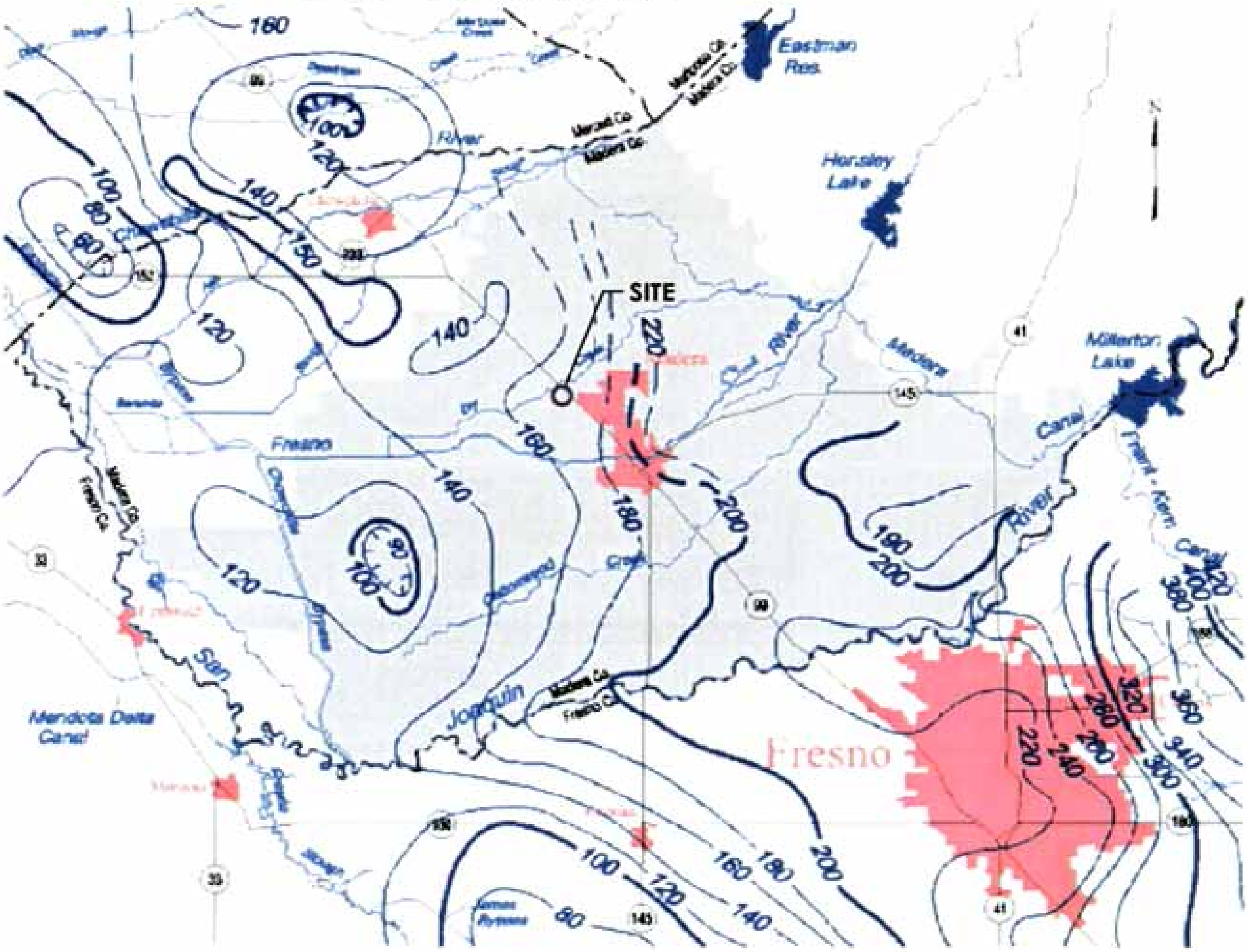
Madera Groundwater Basin

Spring 1984, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles

2 0 2 4 6 8

Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
		AB	N0492A
	GROUNDWATER ELEVATION CONTOURS, SPRING 1984	A	

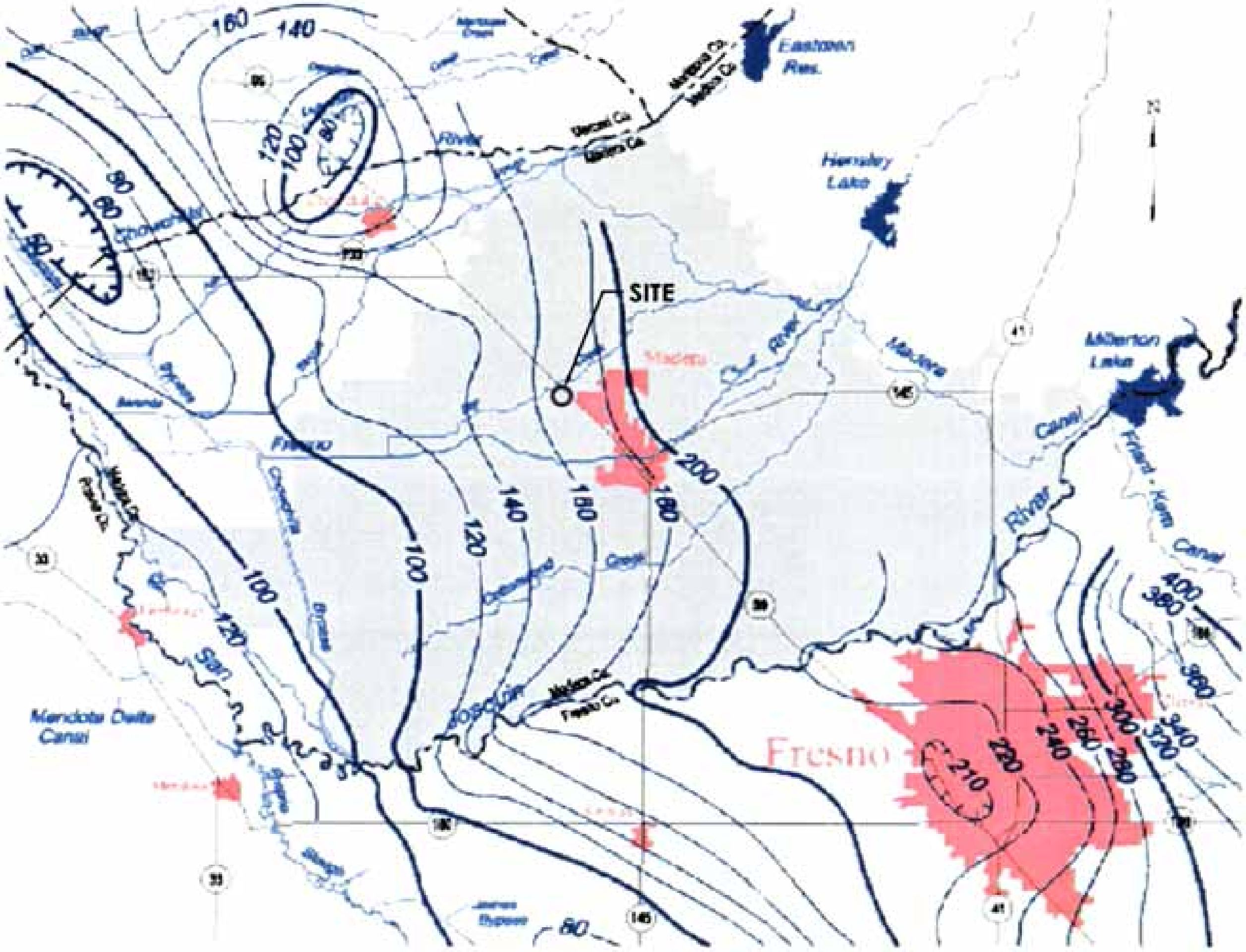
Madera Groundwater Basin

Spring 1976, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles

2 0 2 4 6 8

Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

LEGEND

O MADERA SITE

KOMEX

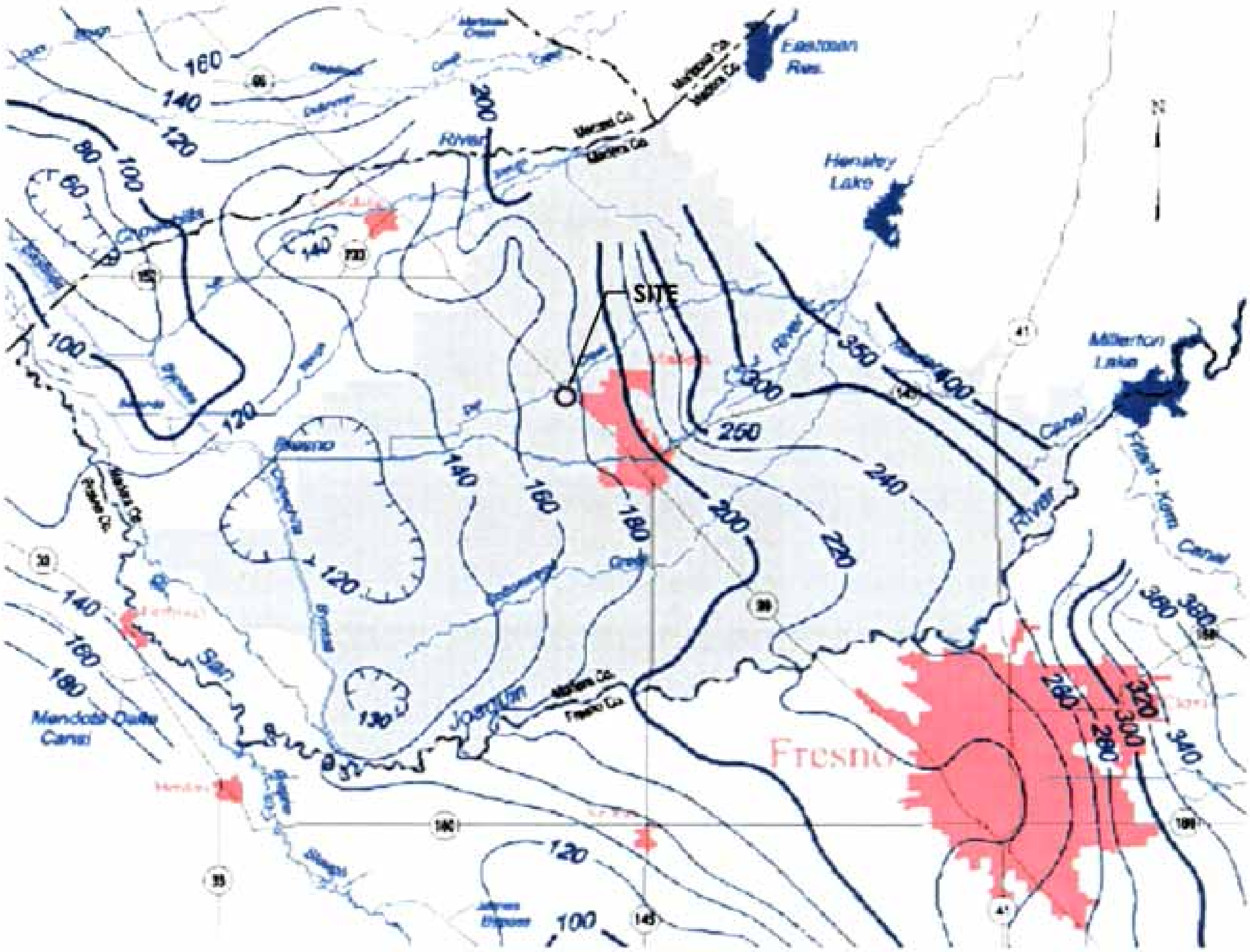
PROPOSED NORTH FORK CASINO	CT	05/2005
GROUNDWATER ELEVATION CONTOURS, SPRING 1976	AB	N0492A
	A	

Madera Groundwater Basin

Spring 1970, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles
2 0 2 4 6 8

Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

LEGEND

O MADERA SITE

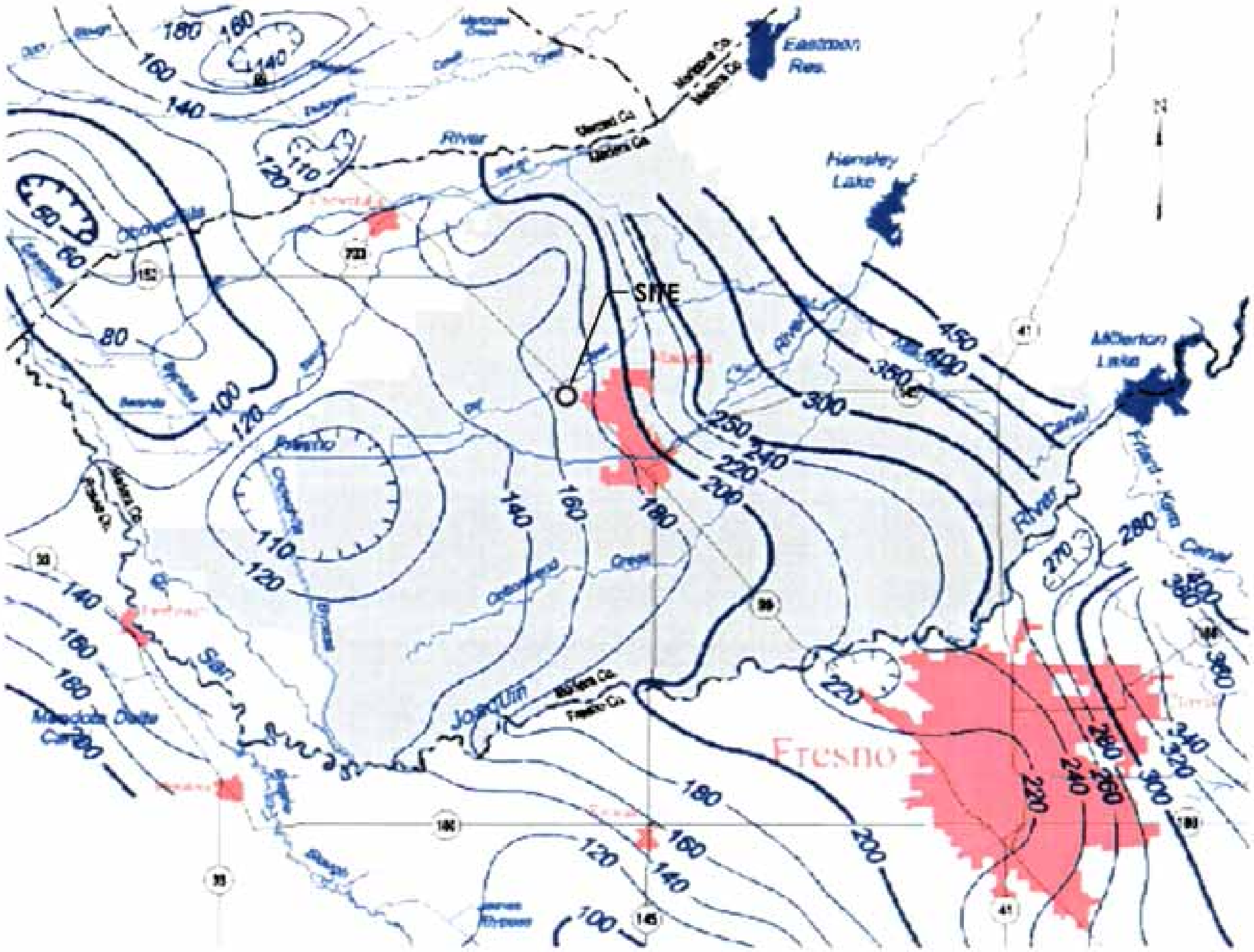
KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
	GROUNDWATER ELEVATION CONTOURS, SPRING 1970	AB	N0492A
		A	

Madera Groundwater Basin

Spring 1969, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles
2 0 2 4 6 8

Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
		AB	N0492A
	GROUNDWATER ELEVATION CONTOURS, SPRING 1969	A	

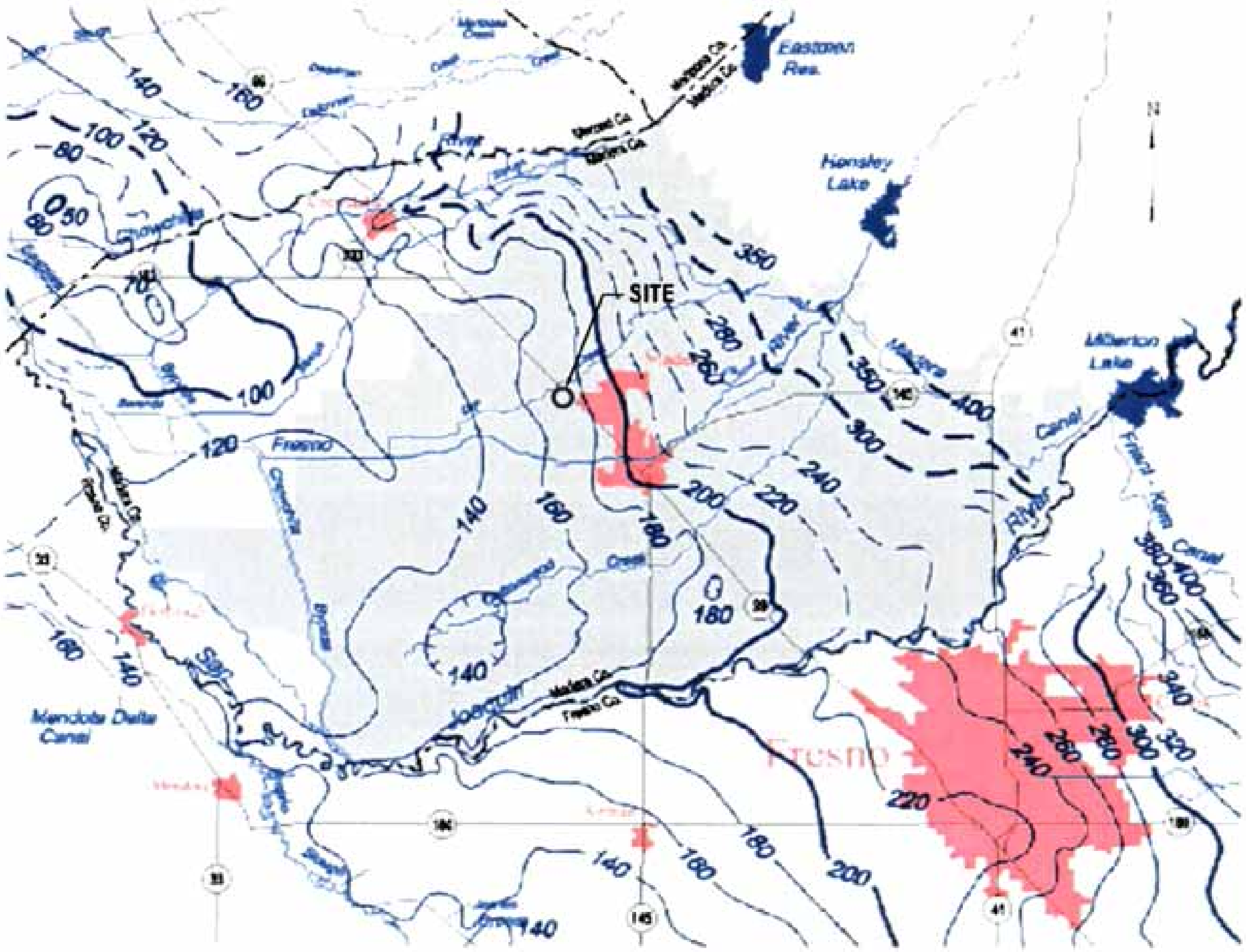
Madera Groundwater Basin

Spring 1962, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

Scale of Miles

2 0 2 4 6 8

Disclaimer: Base map created from current USGS 1:24,000 and 1:100,000 maps. Some base map features may not have been present (i.e. roads, canals, reservoirs) for the water year shown.



Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

LEGEND

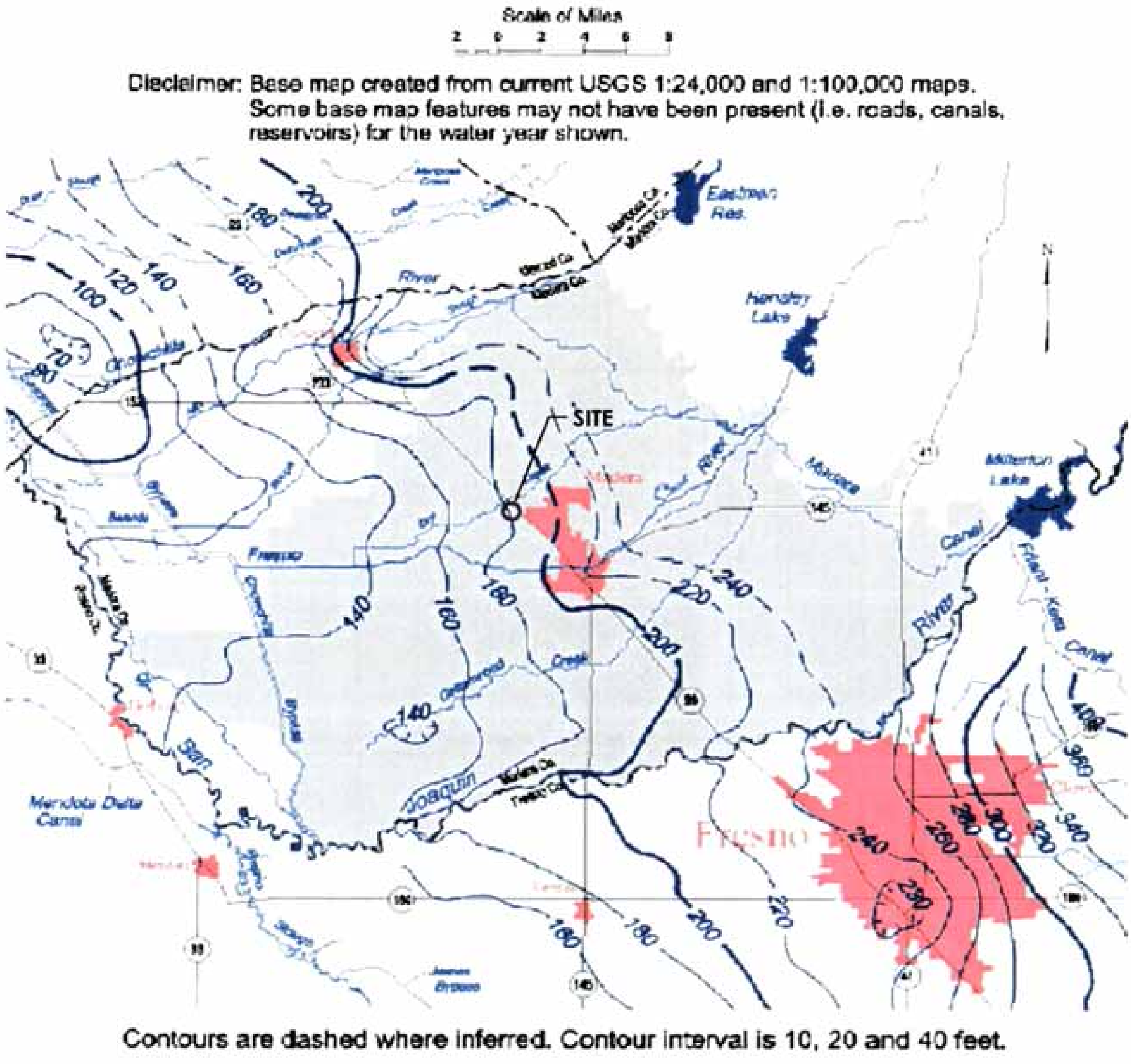
O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
	GROUNDWATER ELEVATION CONTOURS, SPRING 1962	AB	N0492A
		A	

PREPARED SOLELY FOR THE USE OF OUR CLIENT AND NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH KOMEX HAS NOT ENTERED INTO A CONTRACT.

Madera Groundwater Basin

Spring 1958, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

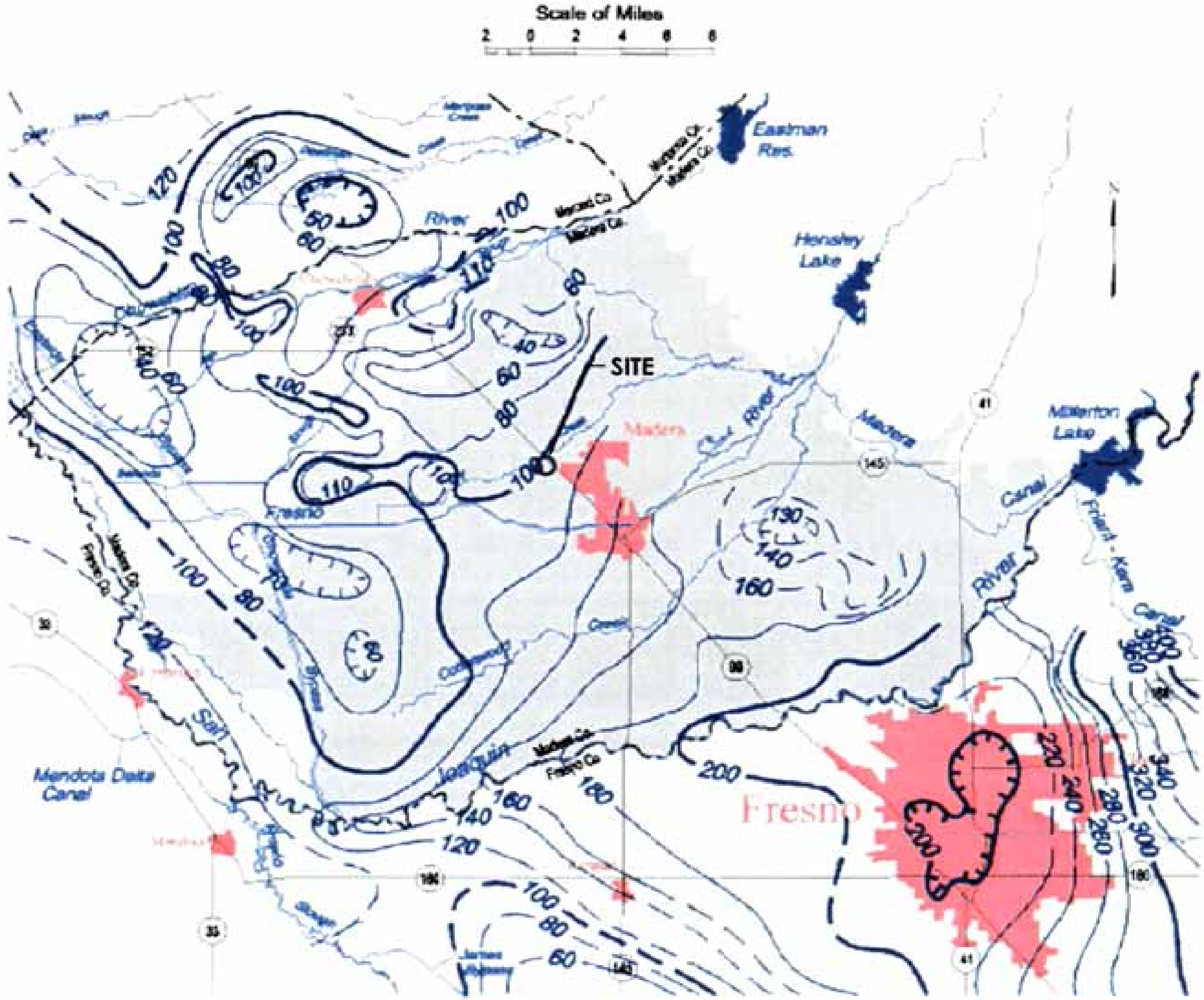
LEGEND

O MADERA SITE

KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
		AB	N0492A
	GROUNDWATER ELEVATION CONTOURS, SPRING 1958	A	

Madera Groundwater Basin

Spring 2002, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 and 20 feet.

Source:
DWR (www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm)

LEGEND

O MADERA SITE

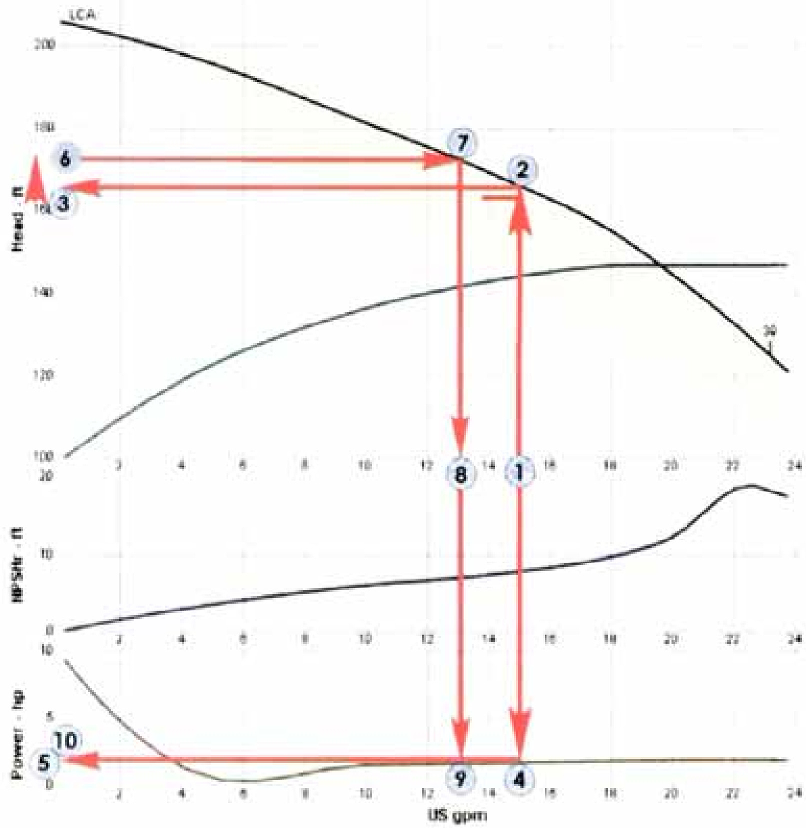
KOMEX	PROPOSED NORTH FORK CASINO	CT	05/2005
		AB	N0492A
	GROUNDWATER ELEVATION CONTOURS, SPRING 2002	A	

APPENDIX B

DATA REGARDING WELLS NEAR THE NORTH FORK SITE

APPENDIX C

EVALUATION OF WELL PUMP ELECTRICAL CONSUMPTION



Methodology Summary

Once a suitable pump has been found that satisfies the discharge and head requirements for a particular case, the discharge (Q), head (H) , and power (P) analysis starts at Point #1 shown on the figure.

From Point #1 at the required Q, a vertical line is drawn upward to intersect the pump curve at Point #2.

From Point #2, a horizontal line is drawn to the left (to Point #3) and the H associated with that particular Q is determined.

From Point #1, a vertical line is drawn downward to intersect the power curve at Point #4.

From Point #4, a horizontal line is drawn to the left (to Point #5) and the P associated with that particular Q is determined.

The Q, H, and P determined by the steps shown above represent the baseline conditions for a particular case.

Additional drawdown is then imposed, and the incremental effects on the Q, H, and P are then determined. This change in value of the parameters Q, H, and P are used later to estimate the impact to the power requirements to pump one acre-foot of water.

Additional drawdown is the equivalent of moving higher up the pump curve (higher head).

From Point #3, a vertical line is drawn upwards to Point #6. The length of this line is the imposed drawdown and will either be 2.0 feet or 6.0 feet.

From Point #6, a horizontal line is drawn to the right to intersect the pump curve at Point #7.

From Point #7, a vertical line is drawn downwards to Point #8. Where this line intersects the Q axis determines what the new Q for the pump will be given the additional head (imposed drawdown) for that case. For monotonically decreasing pump curves, as H increases, Q decreases, and conversely, as H decreases, Q increases.

From Point #8, a vertical line is drawn downwards to intersect the power curve at Point #9.

From Point #9, a horizontal line is drawn to the left (to Point #10) and the new P associated with the new Q is determined.

Example

Baseline
Q = 15.0 gpm, H = 166.3 feet, P = 1.73 h.p. (Point #1, #3, and #5, respectively).

Impose an additional drawdown of 6.0 feet (Point #3 to #6).

New
Q = 13.1 gpm, H = 172.3 feet, P = 1.61 h.p. (Point #8, #6, and #10, respectively).

Incremental Difference
Q = -1.9 gpm, H = +6.0 feet, P = -0.12 h.p.

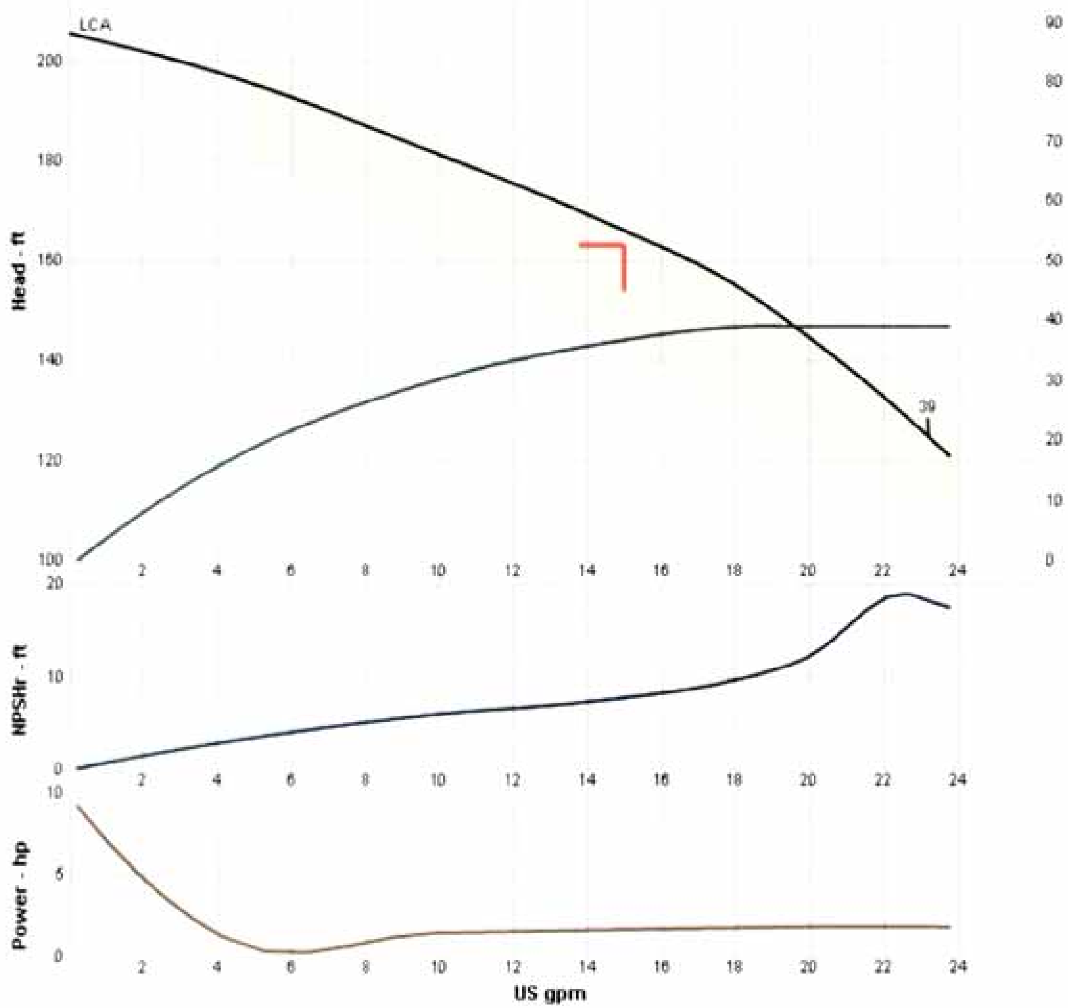
ANALYTICAL ENVIRONMENTAL SERVICES
CITY OF MADERA

WorleyParsons Komex
resources & energy

DRAWN BY:	EDITED BY:	DATE:
WM	WM	07/2006
APPROVED: MT	1	

METHODOLOGY SUMMARY

GOULDS PUMPS



CLEAR LIQUID ONLY in multistage pumps.

Request for Quote

Submit your selection to Goulds Pumps.

Pump

Type	MULTISTAGE	
Size	LCA	
Curve	Goulds LC	
Speed	3550	rpm
Line	LCA	

Redraw Reset

Display Options [?]

- (●) Manufacturer settings
- ( ) Custom

Multiple Pumps

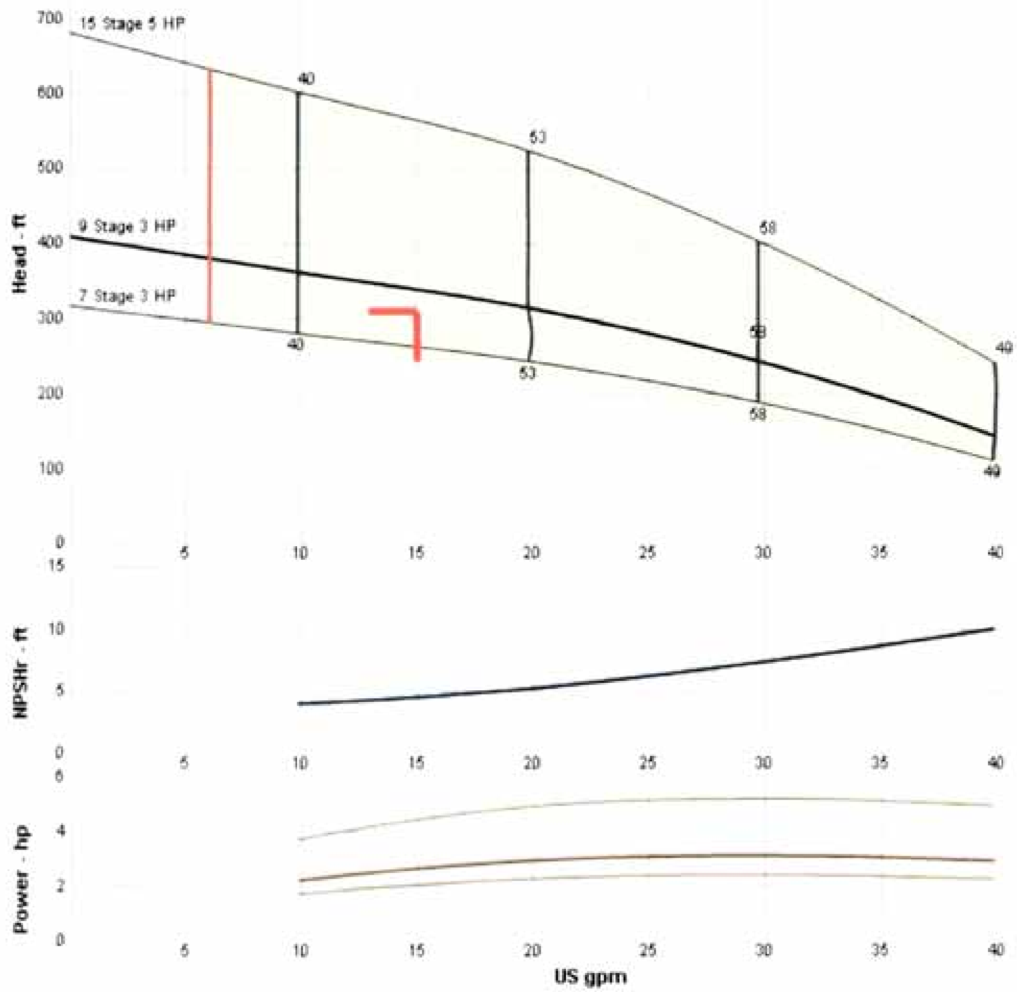
Number of pumps 1

(●) Parallel ( ) Series

Multiple Speeds (rpm)

1180 rpm - 3550 rpm

Flow	Head	Eff	BEP	NPSHr	Power	Motor	Frame	Min flow	Sphere
15 US gpm	166 ft	37 %	39 %	7.97 ft	1.71 hp	---	---	5 US gpm	---



Stages will show up as diameters.

Request for Quote

Submit your selection to Goulds Pumps.

Pump

Type	MULTISTAGE
Size	2SV-1
Curve	Goulds SSV
Speed	3450 rpm
Line	9 Stage 3 HP

Redraw Reset

Display Options

- Manufacturer settings
- Custom

Multiple Pumps

Number of pumps 1

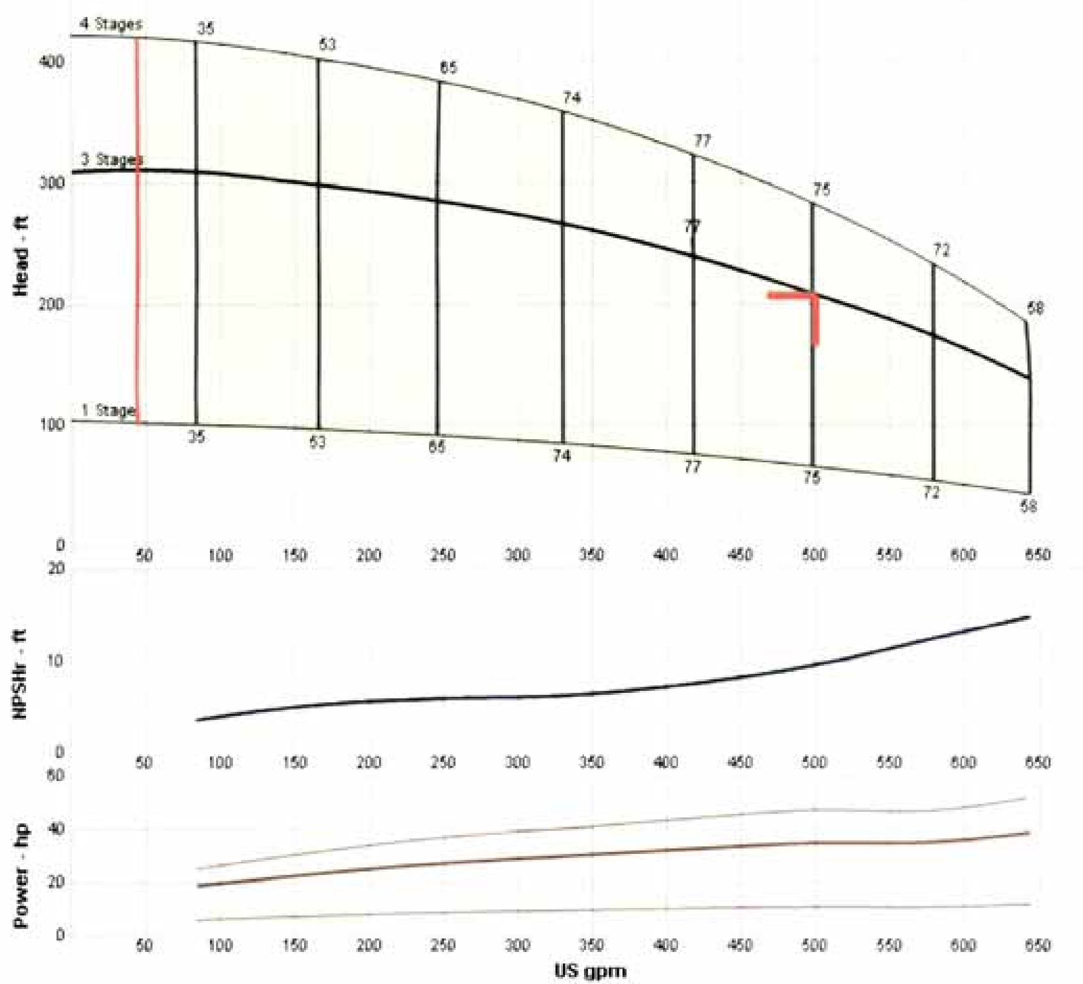
- Parallel
- Series

Multiple Speeds (rpm)

2900 rpm - 3450 rpm

Flow	Head	Eff	BEP	NPSHr	Power	Motor	Frame	Min flow	Sphere
15 US gpm	336 ft	47 %	58 %	4.63 ft	2.61 hp	---	---	6 US gpm	0.0625 in

GOULDS PUMPS



Request for Quote

Submit your selection to Goulds Pumps.

Pump

Type	MULTISTAGE
Size	100.2-1-4
Curve	GP MPVN
Speed	1750 rpm
Line	3 Stages

Redraw Reset

Display Options

- Manufacturer settings
- Custom

Multiple Pumps

Number of pumps 1

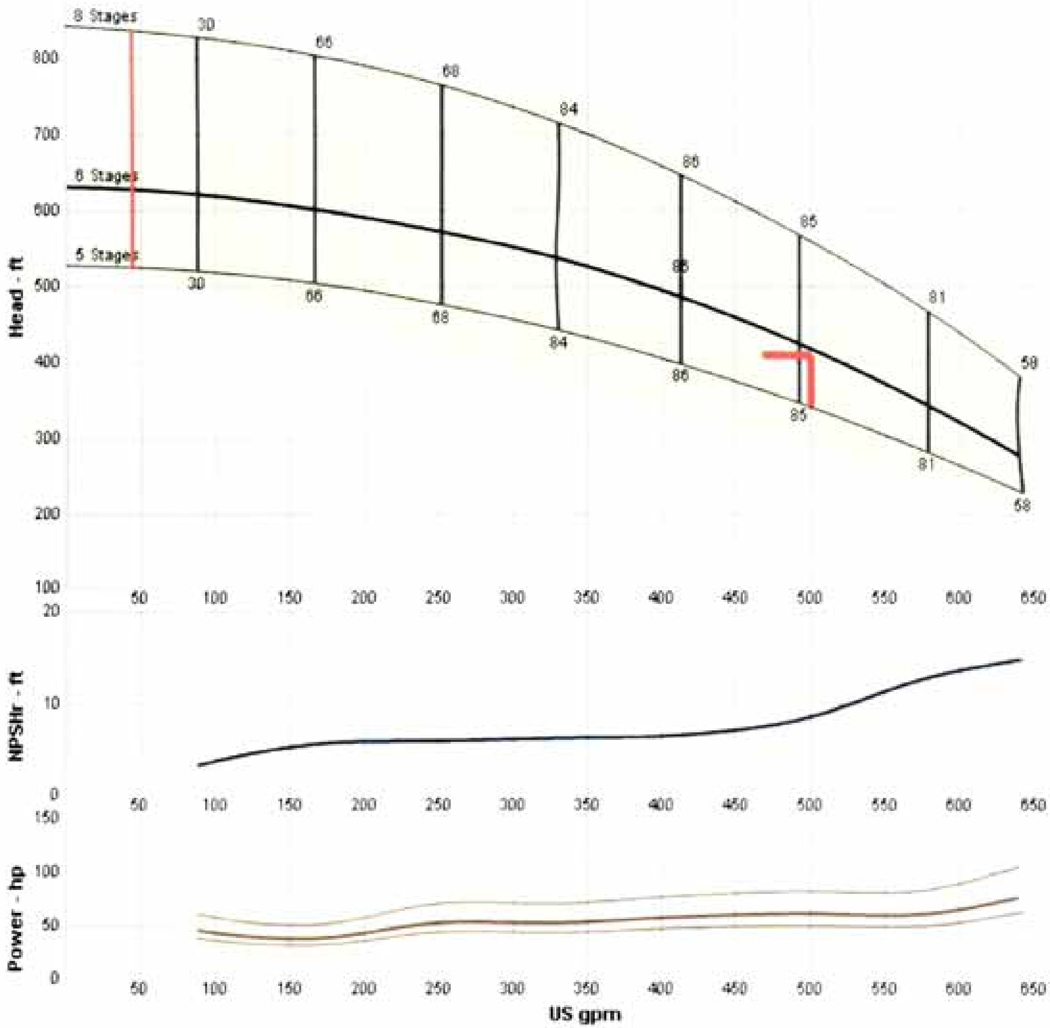
- Parallel
- Series

Multiple Speeds (rpm)

1180 rpm - 1750 rpm

Flow	Head	Eff	BEP	NPSHr	Power	Motor	Frame	Min flow	Sphere
500 US gpm	208 ft	75 %	77 %	9.59 ft	35.1 hp	---	---	44 US gpm	---

GOULDS PUMPS



Request for Quote

Submit your selection to Goulds Pumps.

Pump

Type	MULTISTAGE
Size	100.2-5-8
Curve	GP MPVN
Speed	1750 rpm
Line	6 Stages

Redraw Reset

Display Options

- Manufacturer settings
- Custom

Multiple Pumps

Number of pumps 1

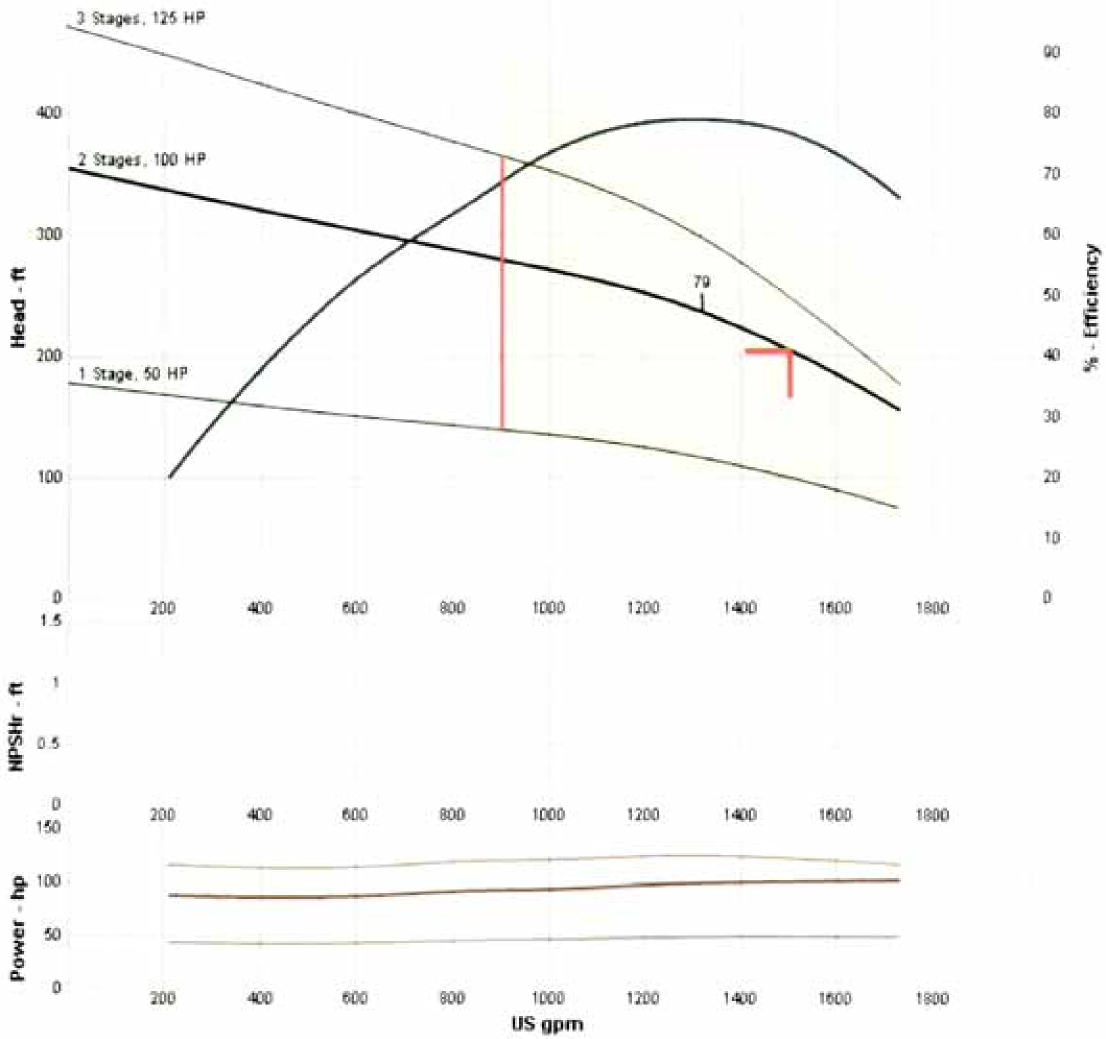
- Parallel
- Series

Multiple Speeds (rpm)

1180 rpm - 1750 rpm

Flow	Head	Eff	BEP	NPSHr	Power	Motor	Frame	Min flow	Sphere
500 US gpm	416 ft	85 %	86 %	8.62 ft	61.9 hp	---	---	44 US gpm	---

GOULDS PUMPS



Open suction pump. CLEAR LIQUID ONLY

Request for Quote

Submit your selection to Goulds Pumps.

Pump

Type	SUB	
Size	9TNHC	
Curve	Goulds 9TNHC	
Speed	3450	rpm
Line	2 Stages, 100 I	

Redraw Reset

Pump Warnings

1 Catalog does not contain data to verify that NPSHa is sufficient

Display Options [?]

- (•) Manufacturer settings
- ( ) Custom

Multiple Pumps

Number of pumps 1

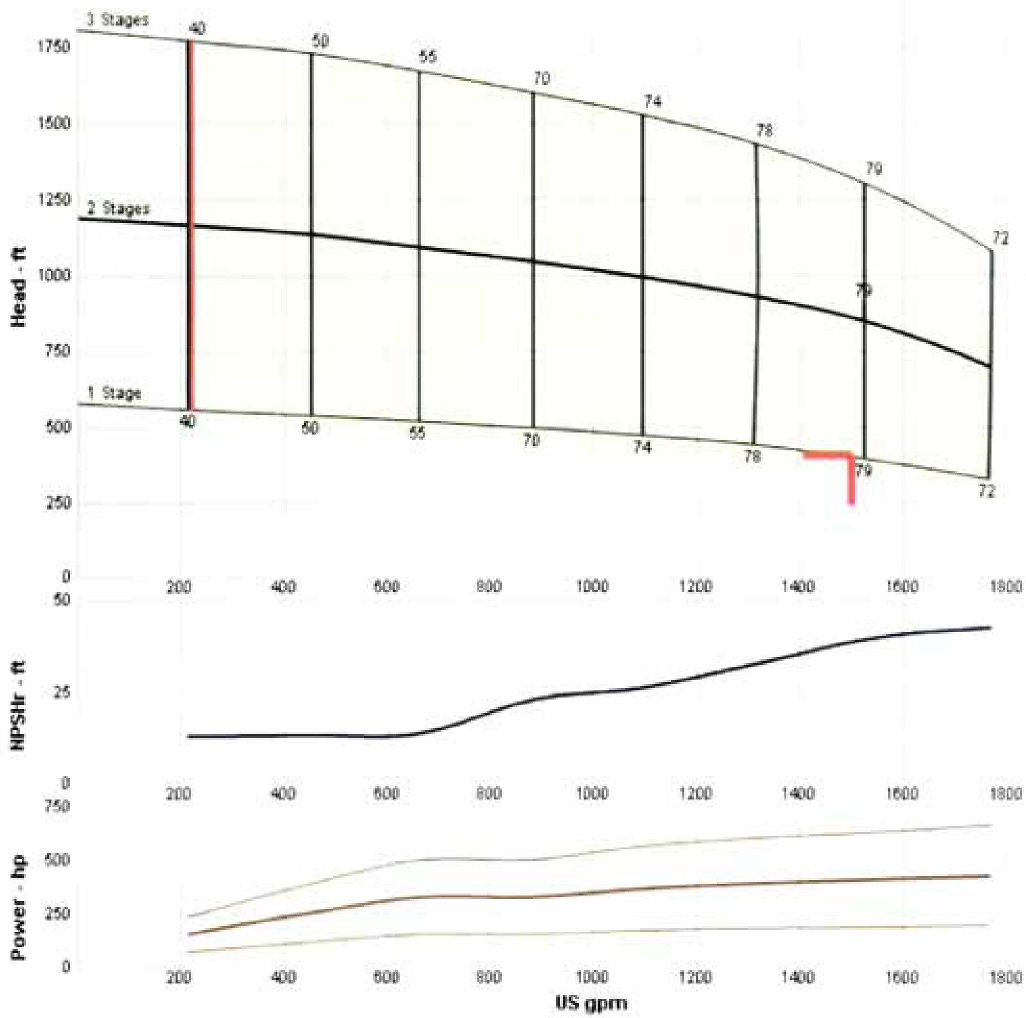
(•) Parallel ( ) Series

Multiple Speeds (rpm)

3450 rpm - 3450 rpm

Flow	Head	Eff	BEP	NPSHr	Power	Motor	Frame	Min flow	Sphere

GOULDS PUMPS



Request for Quote

Submit your selection to Goulds Pumps.

Pump

Type	MULTISTAGE
Size	125.2
Curve	GP MPVN
Speed	3550 rpm
Line	2 Stages

Redraw Reset

Display Options

- Manufacturer settings
- Custom

Multiple Pumps

Number of pumps 1

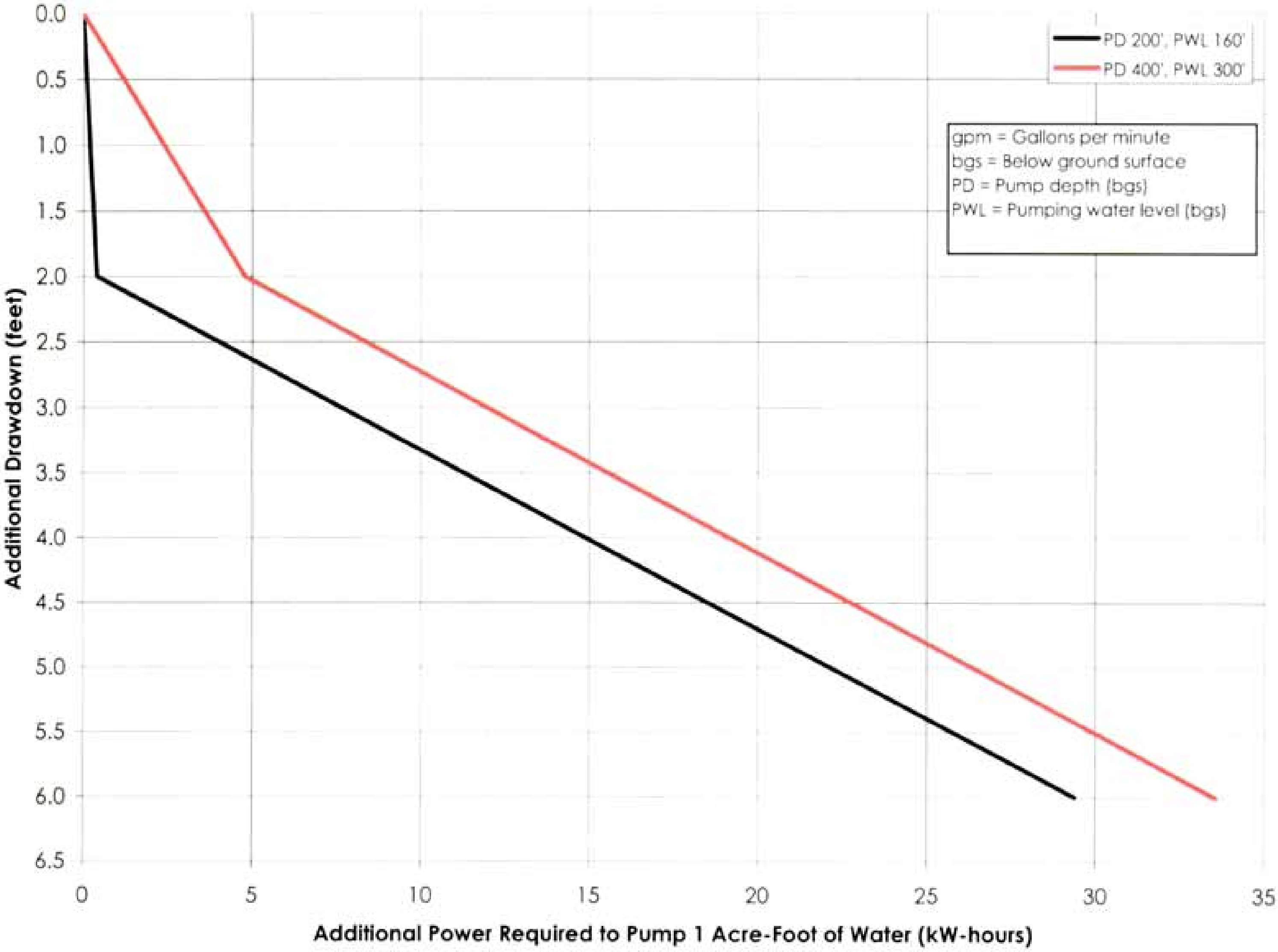
Parallel Series

Multiple Speeds (rpm)

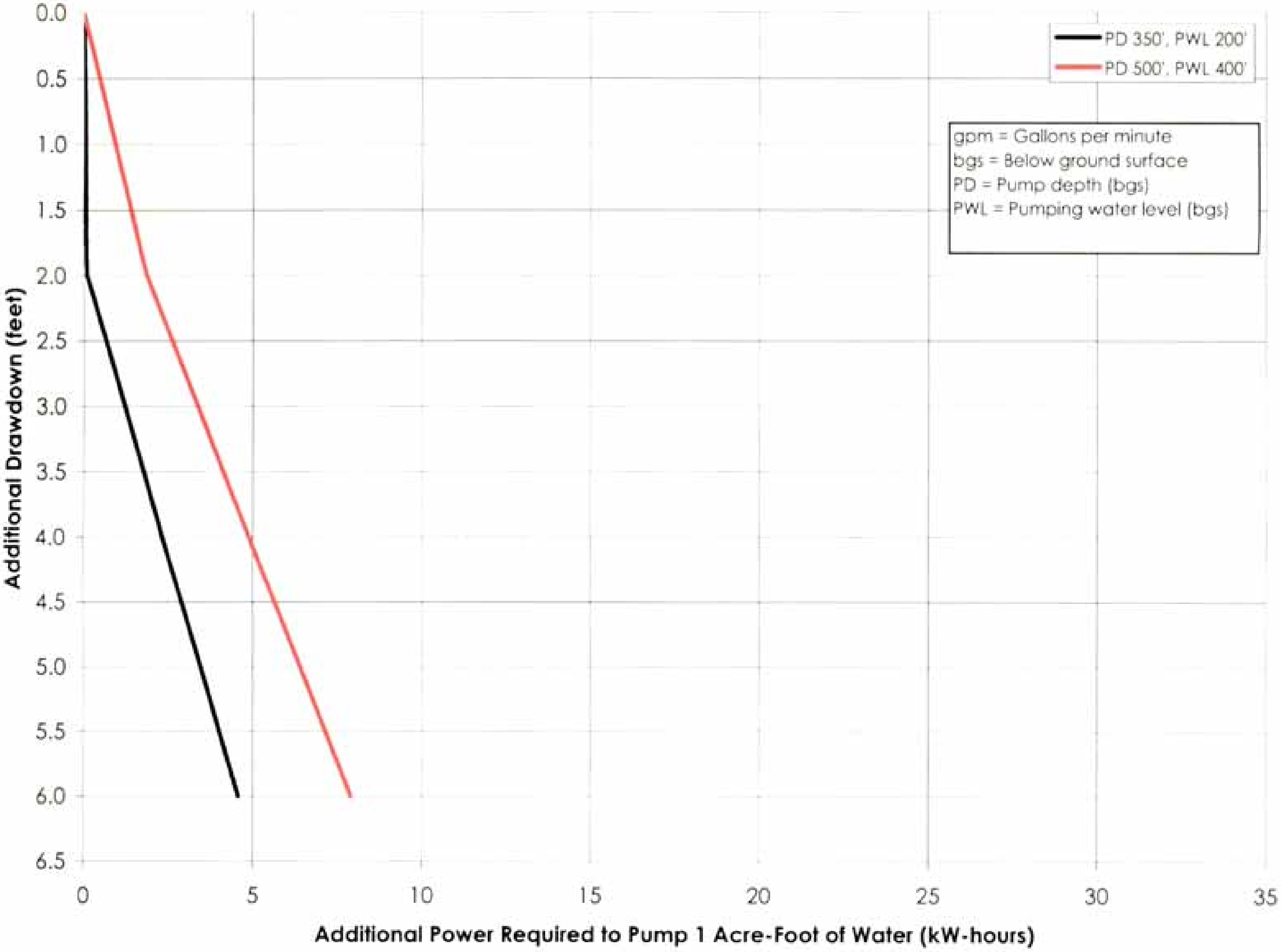
1750 rpm - 3550 rpm

Flow	Head	Eff	BEP	NPSHr	Power	Motor	Frame	Min flow	Sphere
1500 US gpm	857 ft	79 %	79 %	38.7 ft	411 hp	---	---	220 US gpm	---

15 gpm Baseline Pumping Rate
Additional Power Required to Pump 1 Acre-Foot of Water as a Function of Additional Drawdown



500 gpm Baseline Pumping Rate
Additional Power Required to Pump 1 Acre-Foot of Water as a Function of Additional Drawdown



150 gpm Baseline Pumping Rate
Additional Power Required to Pump 1 Acre-Foot of Water as a Function of Additional Drawdown