GRANTS RECLAMATION PROJECT
BACKGROUND WATER QUALITY EVALUATION
OF THE CHINLE AQUIFERS

FOR:

U.S. NUCLEAR REGULATORY COMMISSION
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BY:

HOMESTAKE MINING COMPANY
ALBUQUERQUE, NEW MEXICO

&

HYDRO-ENGINEERING, L.L.C.
CASPER, WYOMING

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Thomas G. Michel

THOMAS G. MICHEL, Ph.D.
HYDROLOGIST

George L. Hoffman

GEORGE L. HOFFMAN, P.E.
5831 N.M. HYDROLOGIST

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EXECUTIVE SUMMARY

Homestake Mining Company (HMC) operated the Grants Project as a uranium milling operation from 1958 through 1990. The tailings generated from the operation were placed on alluvial deposits near the mill in tailings piles herein referred to as the Large and Small Tailings Piles. Seepage from these tailings piles has been the source of ground water contamination in the alluvial aquifer and in some localized areas of the Chinle shale bedrock lying under the alluvium. Alluvial aquifer ground water restoration was initiated in 1977 and the majority of the restorative effort has been and continues to be within this uppermost aquifer. The Chinle shale has three distinct aquifers, designated the Upper, Middle and Lower Chinle aquifers, that are primarily sandstone strata within the relatively impermeable shale. These sandstones generally dip to the east or northeast, resulting in their direct contact with the alluvium (subcropping) on the west and south sides of the project area. It is in these subcrop areas where alluvial ground water flows into the Chinle aquifers. Outside of the subcrop areas, there is no natural hydraulic communication between the alluvial aquifer and the three Chinle aquifers.

There are two major faults in the Grants Project area that have resulted in an offset extending throughout the Chinle Formation. These faults are parallel to each other and exist to the east and to the west (East and West faults, respectively) of the tailings piles (see Figure ES-1 for location), effectively creating up to three hydrologically distinct zones within a single Chinle aquifer. The faults originate south of the tailings area and have a southwest to northeast orientation with a divergence that results in increased vertical displacement north of the tailings piles. The San Mateo alluvium is not directly affected by the faulting, but the fault displacement has resulted in a discontinuous subcrop area for the Chinle aquifers. The combination of the underlying bedrock aquifers (with subcrop areas of contact with the alluvium), and the displacement of the Chinle sandstones by the faulting creates a very complex geologic setting in the area potentially affected by seepage from the tailings piles.

A location of a typical geologic cross section is shown on the plan view of Figure ES-1. The typical geologic cross section showing the alluvial aquifer and underlying Chinle Formation with the three identified Chinle aquifers is presented as Figure ES-2. Figure ES-1 also provides the viewpoint orientation of three expanded three-dimensional schematics of the geologic structure in the area of concern (Figures ES-3, ES-4 and ES-5). It is important to note that there is a significant vertical exaggeration to these expanded schematic views. Three sequential views are shown with the geologic structure east of the East Fault (Figure ES-3), between the faults (ES-4), and west of the West Fault (Figure ES-5), respectively. The surface features that reflect the area projected to the underlying aquifers are shown with darker shading. These features include the tailings piles and subdivision layouts. The alluvial, Upper Chinle, Middle Chinle, and Lower Chinle aquifers are separated from underlying sandstone by the Chinle shale. The shale strata are not shown on Figures ES-3, ES-4 and ES-5 to avoid obscuring features of the sandstone aquifers.

The complex geologic setting and the isolated areas of communication between the aquifers results in a complex hydrologic system. The presence of subcrop areas that allow flow from the alluvial aquifer to portions of the Upper, Middle and Lower Chinle aquifers in their subcrops results in ground water quality that represents a mixture of alluvial ground water and the resident, or background, ground water within the particular aquifer. Areas in and adjacent to Chinle aquifer subcrops with a common ground water component resulting from the influx of alluvial ground water are designated as the "mixing zone".

The mixing zone within each Chinle aquifer can be identified by a combination of proximity to the subcrop area and distinct changes in water quality as a result of intrusion of alluvial ground water. With increasing distance from the subcrop, the ground water character transitions to the "background" water quality of that particular aquifer. The alluvial ground water system typically has an elevated calcium concentration, whereas the Chinle aquifers' ground water generally has low calcium concentration. Therefore, mixing zone ground water within the Chinle aquifers is characterized by an elevated calcium concentration, and for the purposes of defining background water quality, the mixing zone is considered a separate hydrologic system. Areas of the Chinle aquifers where the water quality has not been affected by the intrusion of alluvial ground water are referred to as the "non-mixing" zones of the particular Chinle aquifer (Upper, Middle or Lower). An interpretation of the extent of the mixing zones for the Upper Chinle and Middle Chinle aquifers based on changes in the water-quality characteristics is presented in Figures ES-3, ES-4 and ES-5. From these figures it is apparent that the mixing zone extends down-gradient from the subcrop area. The distance that the mixing zone extends from the subcrop area is not uniform and reflects heterogeneity in the hydraulic properties of the Chinle sandstones and the alluvium.

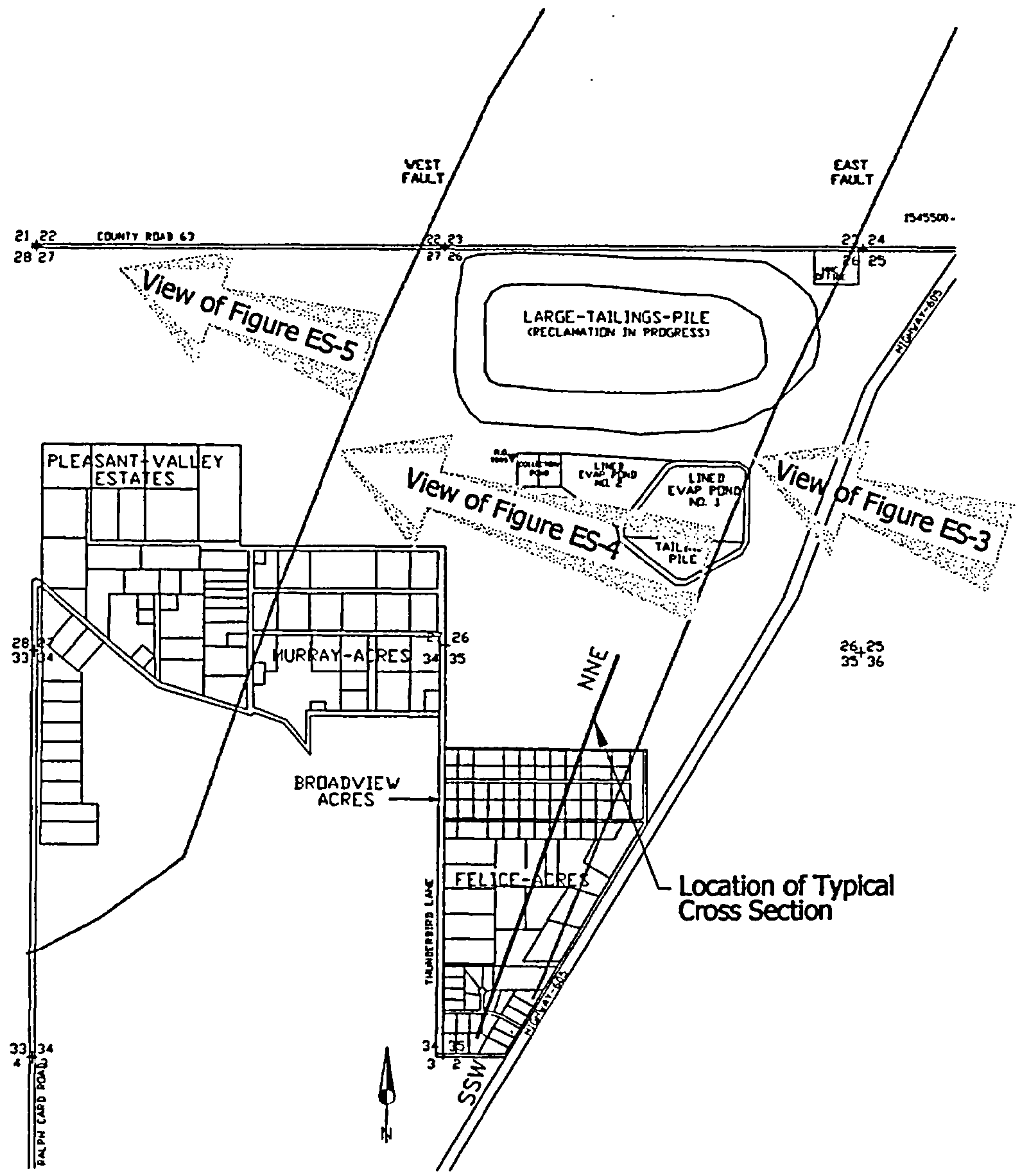
The existing ground water quality site standards for the alluvial aquifer were established by the Nuclear Regulatory Commission (NRC) in 1989 based upon a limited data set. Site standards have not been established for the Chinle aquifers. However, Chinle aquifer(s) site standards are necessary to establish ground water quality restoration objectives. A large background database has been collected since 1976 on the Grants Project site and, with subsequent additions to the data since 1989, a more complete analysis of the range of background ground water quality for the alluvial aquifer, Chinle mixing zone, and Chinle non-mixing zones is possible. Statistical analyses of the water-quality data were performed by ERG (1999 and 2003) to determine the range of background concentrations in the alluvial aquifer and the Chinle aquifers. In 2001, HMC filed an application to revise the alluvial background concentrations supported by the findings of the 1999 ERG statistical analysis. Based on both the 1999 and 2003 statistical evaluations the recommended background water-quality concentrations for the alluvial and Chinle aquifers are summarized on Table ES-1.

TABLE ES-1. GRANTS PROJECT ALLUVIAL AND CHINLE BACKGROUND CONCENTRATIONS

Aquifer Zone	CONSTITUENT (in mg/l except Thorium-230 and Ra226+Ra228 in pCi/L)									
	Selenium	Uranium	Molybdenum	TDS	Sulfate	Chloride	Nitrate	Vanadium	Thorium-230	Ra-226 +Ra-228
Alluvial	0.27	0.15	0.05	3060	1870	*250	23	* 0.02	*0.30	*5
Chinle Mixing	0.14	0.18	0.10	3140	1750	96	15	0.08	0.97	3.5
Upper Chinle Non-Mixing	0.06	0.09	0.08	2010	914	412	4.9	0.02	0.55	3.7
Middle Chinle Non-Mixing	0.07	0.07	0.05	1560	857	63	4.0	0.02	0.86	2.2
Lower Chinle Non-Mixing	0.32	0.02	0.03	4140	2000	634	3.0	0.01	0.72	3.2

NOTE: * = Existing site standard, background not calculated for this parameter.

PLAN VIEW



HOMESTAKE MINING COMPANY
GRANTS PROJECT

FIGURE ES-1. LOCATION OF TYPICAL CROSS SECTION AND VIEWS OF GEOLOGIC STRUCTURE SCHEMATICS

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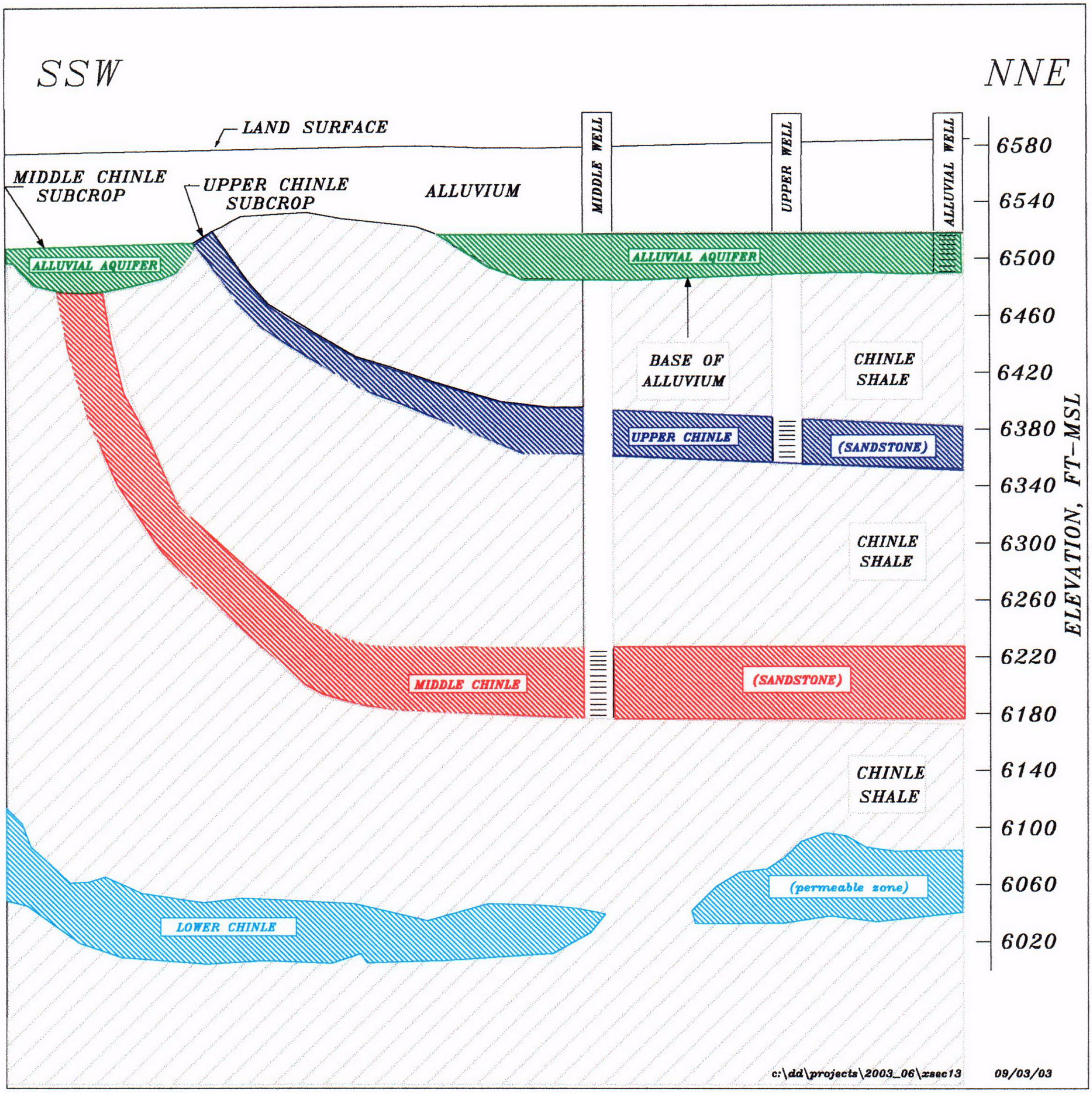
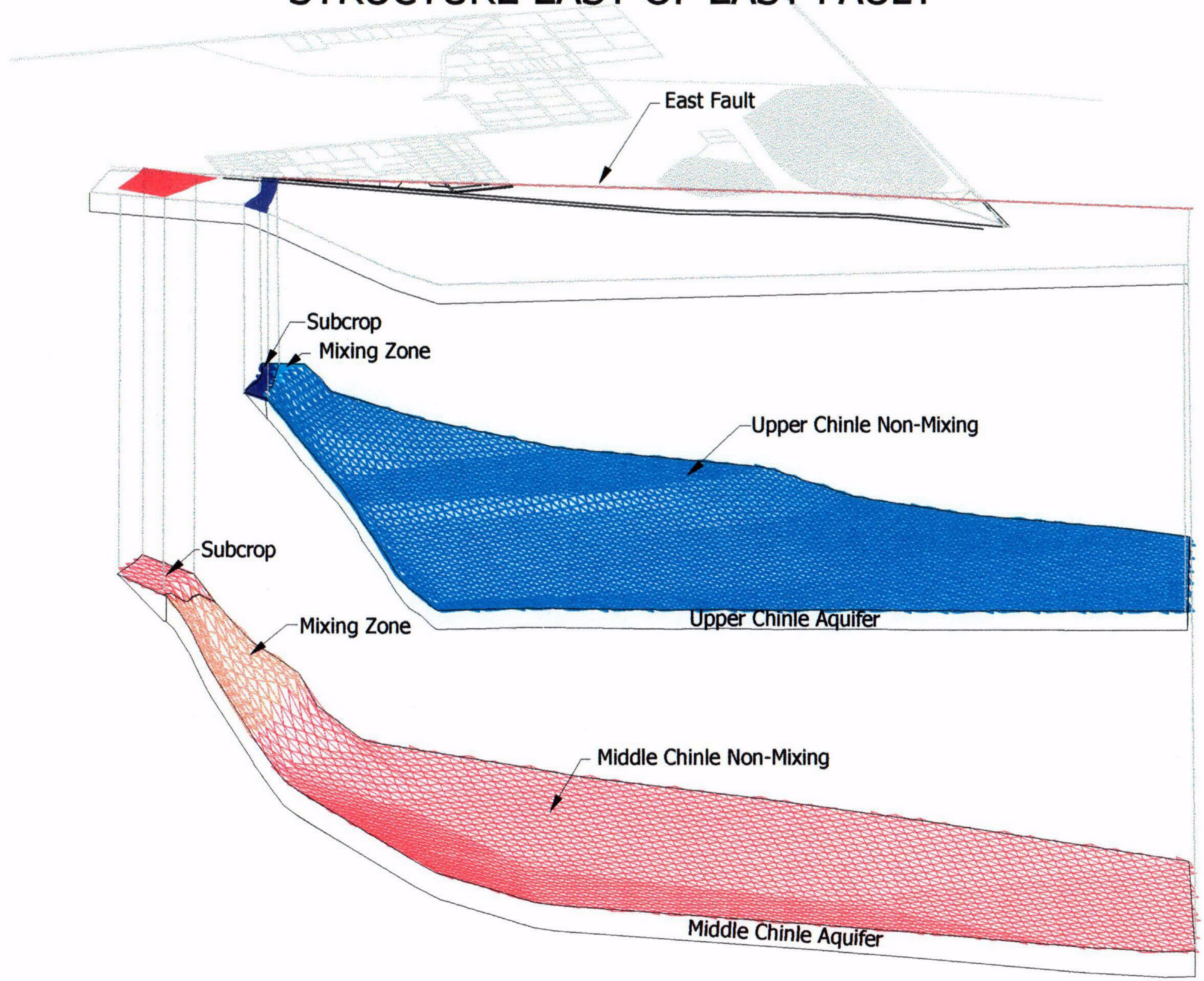


FIGURE ES-2. TYPICAL GEOLOGIC CROSS SECTION SHOWING CHINLE CONNECTION WITH THE ALLUVIUM

C01

STRUCTURE EAST OF EAST FAULT



Note: The Chinle sandstones are separated from overlying features and a vertical exaggeration is applied for illustration purposes. Patterns for the subcrops are displayed at the land surface for illustration purposes and may obscure other surface features. The subcrop is actually located at the base of the alluvium. The Lower Chinle aquifer is located beneath the Middle Chinle aquifer and is not displayed.

HOMESTAKE MINING COMPANY GRANTS PROJECT		
FIGURE ES-3. SCHEMATIC OF GEOLOGIC STRUCTURE EAST OF EAST FAULT		
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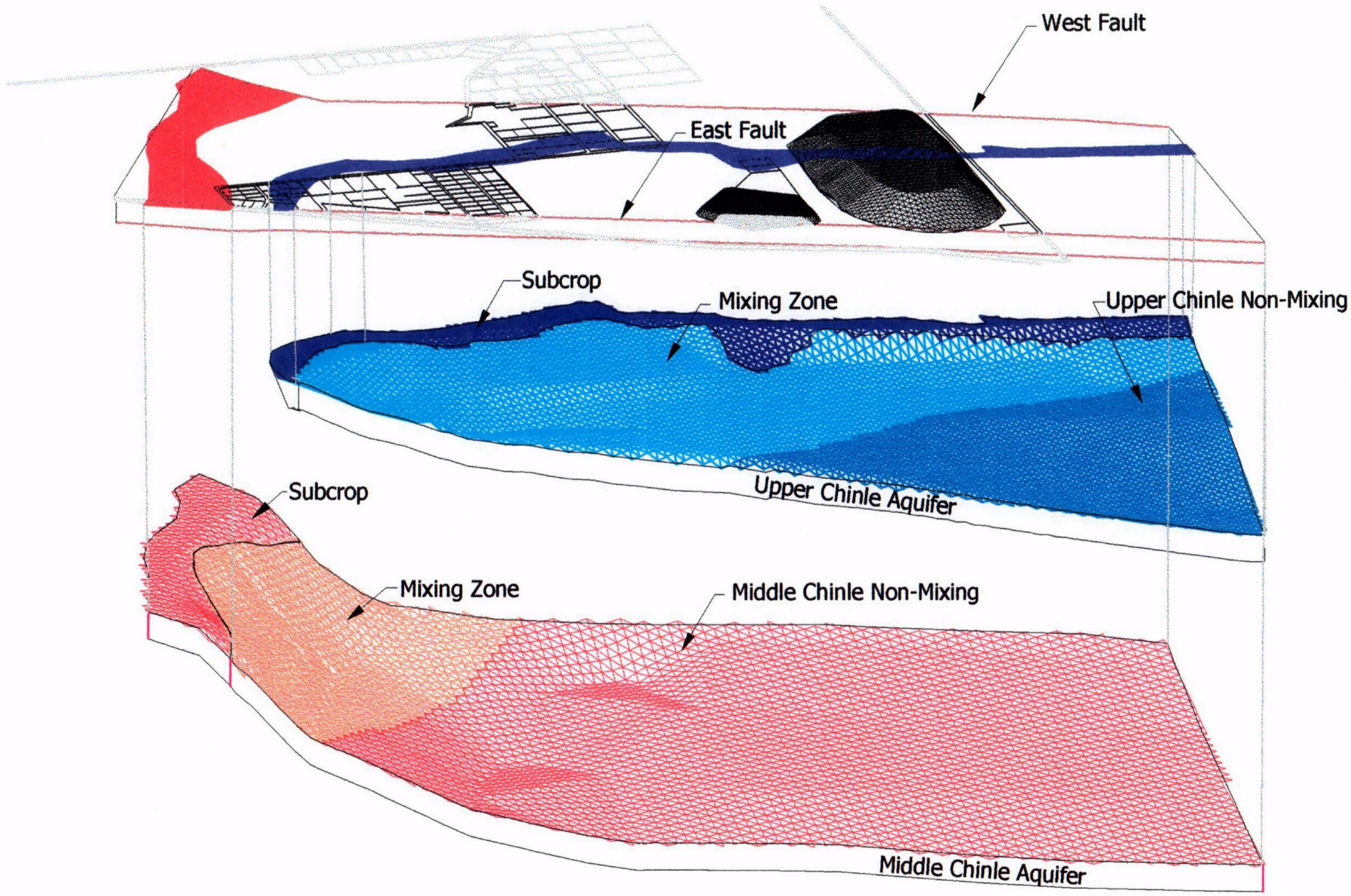
C02

STRUCTURE BETWEEN FAULTS



Note: The Chinle sandstones are separated from overlying features and a vertical exaggeration is applied for illustration purposes. Patterns for the subcrops are displayed at the land surface for illustration purposes and may obscure other surface features. The subcrop is actually located at the base of the alluvium. The Lower Chinle aquifer is located beneath the Middle Chinle aquifer and is not displayed.

HOMESTAKE MINING COMPANY GRANTS PROJECT		
FIGURE ES-4. SCHEMATIC OF GEOLOGIC STRUCTURE BETWEEN FAULTS		
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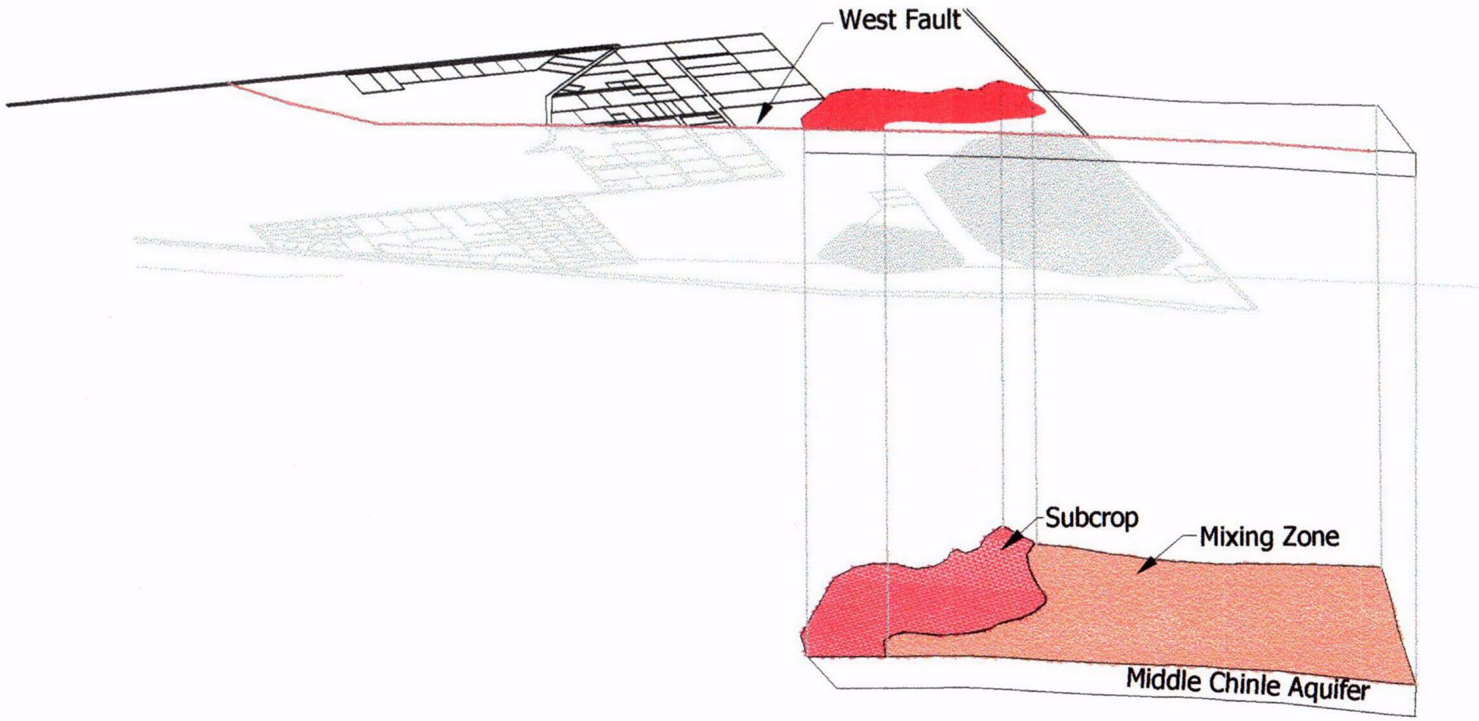
C03

STRUCTURE WEST OF WEST FAULT



Note: The Chinle sandstones are separated from overlying features and a vertical exaggeration is applied for illustration purposes. Patterns for the subcrops are displayed at the land surface for illustration purposes and may obscure other surface features. The subcrop is actually located at the base of the alluvium. The Lower Chinle aquifer is located beneath the Middle Chinle aquifer and is not displayed.

HOMESTAKE MINING COMPANY GRANTS PROJECT		
FIGURE ES-5. SCHEMATIC OF GEOLOGIC STRUCTURE WEST OF WEST FAULT		
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1.0 INTRODUCTION

Uranium ore processing at the Grants mill site started in the late-1950's and continued until 1990. Tailings generated from the milling operation were placed on two piles, a Large Pile and Small Pile, with the Large Pile accepting tailings until 1990. Seepage from the tailings piles was noted in down-gradient alluvial monitoring wells in 1975. Hometake Mining Company (HMC) began alluvial aquifer restoration in 1977 in an attempt to contain the contaminant plume.

In 1989, the U.S. Nuclear Regulatory Commission (NRC) established standards for the San Mateo alluvial aquifer in Radioactive Materials License number SUA 1471, Condition 35B. The NRC standards were established using averaging methods from a limited data set, with one well being selected as the "background" well. The standards contained in the Ground Water Discharge Plan (DP-200) issued by the New Mexico Environmental Department (NMED) were established in 1984 using a similar averaging method. At that time, standards were not established for the underlying Chinle aquifers.

In 1999, ERG prepared a two-volume report titled "Statistical Evaluation of Alluvial Ground Water Quality Up Gradient of the Homestake Site Near Grants, NM" (ERG 1999). The report provided a statistical evaluation of alluvial ground water data collected from 1976 through 1998 to determine the range of background water-quality concentrations within the alluvium. In December 2001, Homestake submitted an application to revise the alluvial aquifer background water-quality levels in the Material License based upon the statistical evaluation in the 1999 ERG report. The NRC responded in a June 11, 2003 letter that included comments from the NMED and the US Environmental Protection Agency (EPA). The NRC, NMED and EPA referenced meetings and conversations between the agencies pursuant to their "Memorandums of Understanding", and affirmed that the ground water standards established in 1989 are not representative of actual background water quality, and also the need for an updated Corrective Action Plan (CAP) that delineates the current ground water restoration program. A conference call was held on June 30, 2003 between the NRC, EPA, NMED and HMC where the following items were discussed:

- Background water quality for the San Mateo alluvial aquifer;
- the need for a background water-quality evaluation for the Upper, Middle and Lower Chinle aquifers and related mixing zone;

- the suitability of Chinle wells to determine background constituent concentrations;
- the value of the far-up-gradient well data; and
- restoration program.

In a letter of July 7, 2003 to NRC, HMC agreed to address each of the items above in forthcoming documents, beginning with report on the background water quality in the alluvial aquifer and it's relationship to the underlying aquifers, and an evaluation of background water quality in the Chinle aquifers.

It has been agreed that the procedures used in ERG's 1999 statistical evaluation provide an accurate accounting of the range of background water quality in the alluvial aquifer. As such, this background water-quality report addresses both the alluvial and Chinle aquifers, but to avoid duplication and redundancies, it summarizes the technical information contained in the 2001 application and related support documents (including the 1999 ERG Report and previous annual reports) as they apply to the San Mateo alluvium. A similar statistical evaluation of ground water data is employed here for establishing background water quality for the Chinle aquifers.

The objective of this document is to provide the range of background constituent concentrations for the three Chinle aquifers and the associated alluvial mixing zone to facilitate the development of restoration objectives and standards.

Once background levels are established for the affected ground water systems, an updated Corrective Action Plan (CAP) will be prepared that provides details on methods/procedures to achieve aquifer cleanup objectives based on the range of background constituent concentrations. The CAP will include restoration of the area outside of the present NRC permitted boundary. The CAP monitoring program will establish monitoring at the Points of Compliance wells near the tailings and down-gradient of the site at points adequate to demonstrate the success of the restoration program. In addition, Alternative Concentration Limitations (ACL's) may be proposed after the CAP that will establish Points of Exposure (POE's).

The following sections address the hydrogeology of the Grants Project area and the suitability of background wells in the mixing zone and non-mixing zones of the Chinle aquifers. Also discussed is the relationship between the alluvial and Chinle aquifers and the physical properties of the various aquifers, including flow directions, aquifer types and water-quality characterization, and the background water-quality concentrations within the Chinle mixing zone and non-mixing zones. Appropriate background concentrations for key chemical constituents within each ground water system are presented based on the hydrologic information and an updated statistical evaluation of water-quality data.

2.0 GEOLOGIC SETTING, AQUIFER COMMUNICATION AND WELL COMPLETION INFORMATION

2.1 GEOLOGIC SETTING AND AQUIFER COMMUNICATION

The surface geology and structure contours of the Grants site are presented on United States Geological Survey (USGS) quadrangle topographic maps. Geologic maps and other geologic information for the Grants area have been compiled and presented in various reports by the New Mexico Bureau of Mines and Mineral Resources (NMBM) and the USGS. The following reports have been used in defining the geologic setting at this site and support the hydrologic interpretations presented in this report:

- Thaden & Ostling (1967)
- Thaden et al. (1967a)
- Thaden et al. (1967b)
- Dillinger (1990)
- Huffman & Condon (1993)

The New Mexico State Engineer (NMSE), NMBM and the USGS reports used to define the hydrologic conditions in this area are listed below:

- Gordon (1961)
- Brod & Stone (1981)
- Stone et al. (1983)
- Baldwin & Rankin (1995)
- Baldwin & Anderholm (1992)
- Dam et al. (1990)
- Frenzel (1992)

Ground water conditions for the immediate HMC Grants site have been defined in previous documents submitted to the NRC (see Hoffman 1976, Hoffman 1977 and Hydro-Engineering 1981 through 2003) and are referenced in the HMC's annual reports to the NRC on the site. These hydrologic reports have been used in developing the summary of hydrologic conditions at the Grants site that is presented in this report. Hydrologic reports by the New Mexico Environmental Improvement Division (1981) and Hydro-Search (1981) on adjacent areas were also used.

The uranium ore bearing rocks that were previously mined in this region are exposed in the San Mateo drainage system upstream from the Grants Project site. These geologic units contain naturally occurring concentrations of uranium and selenium. Alluvial material receiving drainage from these source areas therefore can be expected to contain elevated concentrations of uranium and selenium. The Chinle Formation is located immediately beneath the San Mateo Alluvium at the Grants site. The Chinle rock units also contain naturally elevated uranium and selenium concentrations. In summary, the geologic setting, the topography and the natural presence of concentrations of these constituents within source geologic materials have a significant influence on the natural water quality at the Grants site.

The Grants Project site is located on the San Mateo alluvial system. The alluvial aquifer beyond the Grants site includes the saturated portion of the San Mateo down-gradient of the site, and the Lobo Canyon and Rio San Jose alluviums. The alluvial aquifer can be defined as the water table to the base of the alluvium. The alluvial aquifer system follows the San Mateo drainage system. San Mateo Creek is a tributary to the Rio San Jose drainage while Lobo Canyon is a tributary to the San Mateo. The alluvial aquifer is present from northeast of the Grants Project site, through the site and continuing to the south and to the west. Chinle shales are present as outcrop to the northeast and southeast of the alluvial material. Chinle Formation also extends above the alluvial water table at some locations. This results in local areas where either no alluvium is present or where there is no saturation of the alluvium. These intrusions of Chinle material above the alluvial aquifer water table form barriers to alluvial ground water flow.

Beneath the tailings piles, the Chinle Formation lies beneath the alluvium. The Chinle Formation is a massive shale, approximately 800 feet thick. The shale is a very effective aquitard and greatly restricts vertical ground water flow from the overlying alluvial aquifer. Sandstone units are found within the Chinle shale and these sandstones form aquifers in this area. The sandstone unit closest to the ground surface has been named the Upper Chinle aquifer. A typical cross section (see Figure ES-2) shows the Upper Chinle sandstone in blue and illustrates the contact between the Upper Chinle sandstone and the alluvium in the subcrop area.

The second major continuous sandstone unit in the Chinle Formation is the Middle Chinle. This sandstone is shown in red in the cross section and subcrops beneath the alluvium further to the south.

As shown on Figure ES-2, the deepest permeable zone within the Chinle shale is the Lower Chinle aquifer. The Lower Chinle aquifer is located approximately 200 feet above the base of the Chinle Formation and consists mainly of fractured shale rather than continuous sandstone. Hence, the hydraulic properties are largely dependent on secondary permeability within the shale. The ability of the Lower Chinle aquifer to produce water is much lower and less consistent than in the overlying Middle and Upper Chinle sandstone aquifers. Recharge to the Lower Chinle aquifer is limited to communication in its subcrop area with the alluvium and, to a much lesser extent, from vertical water flux through the overlying shale. Due to the greater depth to the Lower Chinle aquifer and the naturally poor water quality, this aquifer is not extensively used as a water source. A few wells in the general site area are completed in the Lower Chinle, where the alluvial, Upper and Middle Chinle aquifers are absent.

The San Andres aquifer underlies the Chinle Formation at a depth of greater than 800 feet from surface. This is the regional aquifer in the area. Details for the San Andres aquifer are not presented in this report because it has not been affected by tailings seepage related to the site.

Two detailed geologic cross sections, located as shown on Figure 2-1, are presented to further illustrate the geologic setting. Figure 2-2 (cross section B-B') runs generally from the west to the east, south of the Large Tailings Pile. Cross section D-D' is shown on Figure 2-3. Cross-sections B-B' and D-D' were selected from numerous cross sections that have been developed because they have an orthogonal orientation through the central area of the study. The geologic cross section location map, Figure 2-1, also shows the location of the wells used to develop each of the cross sections. The depths and completion intervals of these wells are shown on the cross sections with a crosshatch line pattern indicating the completion interval. The complex geologic setting defies complete portrayal with cross sections, and Figures ES-3 through ES-5 in the Executive Summary of this report should be reviewed in conjunction with cross sections B-B' and D-D'.

2.1.1 SAN MATEO ALLUVIUM

This subsection presents the geologic setting for the San Mateo alluvial aquifer. The location of the alluvial wells that have been used to define the geology and ground water conditions in the alluvial aquifer at the Grants Project site are shown on Figure 2-4.

Colors of well names are used in Figure 2-4 to indicate the current operational status as injection or collection wells. However, the restoration program is dynamic, so the status of individual wells is subject to change. The areal extent of the alluvial aquifer is indicated by the green "plus" pattern.

HMC has drilled nearly 500 wells at the Grants site. The geophysical and lithologic logs from these wells, as well as logs and information for residential wells not owned by HMC, have been used to define the base of the alluvium. The contours of the base of the alluvium are shown on Figure 2-5. The deepest portion of the alluvial aquifer is present below the western portion of the

Large Tailings Pile. It turns to the southwest near the southwest corner of the Large Tailings Pile. The land surface elevation in this area is at approximately 6580 ft msl, so the alluvium, at its thickest point, extends 120 feet below the ground surface.

The elevation of the base of the alluvium is shallower in an area extending from the eastern Murray Acres subdivision to the Small Tailings Pile. In this area, the alluvium is approximately 60 feet thick. The reduction in saturated thickness and a generally lower permeability of the alluvial material in this area combine to decrease the rate of alluvial flow. The boundary of the alluvial aquifer is defined where the elevation of the base of the alluvium is equal to the water-level elevation (see green line on Figure 2-5).

2.1.2 UPPER CHINLE

The Upper Chinle aquifer is an important ground water system at the Grants site because of the direct communication between the ground water in the alluvium and this aquifer in the subcrop area shown on Figure 2-6. The degree of hydraulic communication in the subcrop area influences the water quality of the Upper Chinle aquifer because the subcrop extends below the alluvium under the Large Tailings Pile. The Upper Chinle aquifer is the uppermost sandstone in the Chinle Formation in this area and is shown in blue on the cross section figures (see Figures ES-2, ES-3, ES-4, ES-5, 2-2 and 2-3). This sandstone varies from a few feet up to 40 feet in thickness.

The elevation of the top of the Upper Chinle aquifer and the base of the alluvial aquifer define where these two aquifers are in direct communication. Two faults (West and East) extend through the Grants site and are also significant in defining the extent of the Upper Chinle aquifer.

The areal extent of the Upper Chinle aquifer (see blue dot pattern) and locations of wells completed in the Upper Chinle aquifer are shown on Figure 2-6. The Upper Chinle also exists in its subcrop area where it is in direct contact with the alluvium. Except in the subcrop area, the Chinle shale separates the alluvium and the Upper Chinle sandstone. The Upper Chinle does not extend to the west of the West Fault but subcrops against the alluvial aquifer on its western and southern borders.

Contours of the elevation of the top of the Upper Chinle aquifer are shown in Figure 2-7. This figure illustrates that the Upper Chinle sandstone between the two faults generally dips to the east. East of the East Fault, the general dip is also to the east. On the south side of the project area, the top of the Upper Chinle sandstone dips to the northeast with a steeper gradient, and it subcrops beneath the alluvium in the area of southern Felice Acres.

2.1.3 MIDDLE CHINLE

The Middle Chinle aquifer is significant because direct communication between this aquifer and the alluvium occurs in the subcrop area near the south edge of the Felice Acres subdivision. The areal extent of the subcrop of the Middle Chinle aquifer is significantly smaller than that for the Upper Chinle aquifer, and the subcrop is located a greater distance from the seepage source in the tailings. However, there are detectable seepage influences in the alluvial aquifer in the area of the Middle Chinle aquifer subcrop, and thus, there has been limited seepage to the Middle Chinle aquifer proximal to the subcrop area. The increased distance from the tailings seepage source renders the Middle Chinle aquifer less affected than the alluvial aquifer or the Upper Chinle aquifer. However, the aquifer is still close enough to the source to require evaluation.

The Middle Chinle aquifer is generally the thickest of the sandstone units in the Chinle Formation, reaching a thickness of up to forty feet in some locations. Figure ES-2 shows a typical cross section of the alluvial and Chinle aquifers in this area, with the Middle Chinle aquifer shown in red. This figure shows Chinle shale present between the Upper Chinle and the Middle Chinle sandstone units. In addition to the subcrops in the Felice Acres area, the Middle Chinle sandstone ~~subcrops against the alluvial aquifer in some areas of the project site to the west of the West Fault~~ and the Large Tailings Pile. The Middle Chinle aquifer is also shown in red in cross section B-B' and cross section D-D' respectively.

The areal extent of the Middle Chinle aquifer is shown on Figure 2-8, along with the Middle Chinle well locations. Patterns in red depict the Middle Chinle sandstone and its associated aquifer. The Middle Chinle sandstone extends to the west of the West Fault in a limited area and is present more extensively east of the West Fault.

The elevation contours of the top of the Middle Chinle sandstone are provided in Figure 2-9. This structure map shows the elevation of the top of the Middle Chinle sandstone on each side of the two faults in the area of the Large Tailings Pile. The displacement of the sandstone unit due to faulting results in three discontinuous sandstone units. Multi-well pump tests in the Middle Chinle aquifer have shown that two of the three sandstone units of the Middle Chinle aquifer in this area act as separate fault-bound aquifers. The exception is the Middle Chinle aquifer near the southern end of the East Fault where there is little or no displacement of the sandstone.

The Middle Chinle sandstone dips at a steeper incline in southern Felice Acres, and, therefore, the Middle Chinle sandstone subcrops against the alluvium on the south side of Felice Acres. In this subcrop area, direct communication exists between the Middle Chinle and the alluvial aquifers and as a result alluvial water has influenced the water quality in the Middle Chinle aquifer in and immediately adjacent to the subcrop area.

2.1.4 LOWER CHINLE

Although less of a concern than overlying aquifers, the Lower Chinle aquifer is important because direct communication occurs between this aquifer and the alluvium in the subcrop area to the southwest of the site. However, the potential for seepage impacts to the Lower Chinle aquifer is significantly reduced because the subcrop is a large distance from the seepage source. Also, the natural water quality in the shaly Lower Chinle aquifer is poor so there is generally less use of this aquifer as a water source. Water quality in the Lower Chinle is poor because of the low permeability of the shale and the associated long residence time for ground water.

The Lower Chinle aquifer is the deepest permeable zone in the lower portion of the Chinle Formation. The Lower Chinle aquifer is not a sandstone unit, like the Upper and Middle Chinle aquifers. Instead, higher permeability in portions of the Chinle shale is adequate in some locations to allow this zone to function as an aquifer. The higher permeability in the shale is secondary permeability associated with fracturing. A typical cross section of the aquifer system in this area is shown on Figure ES-2. This figure shows the Lower Chinle aquifer as discontinuous because the permeability is not consistently high enough to function as a viable aquifer. Therefore, areas exist in the Lower Chinle where the aquifer is effectively absent. The Lower Chinle aquifer subcrops against the alluvial aquifer in some areas to the southwest of the project site. Cross-sections B-B' and D-D' (see Figures 2-2 and 2-3, respectively) show the Lower Chinle aquifer in relation to the overlying Upper and Middle Chinle units.

The areal extent of the Lower Chinle aquifer is shown on Figure 2-10. The cyan pattern shows where the Lower Chinle aquifer is present. The Lower Chinle aquifer is continuous on both sides of the East Fault south of the area where this fault terminates. Therefore, in the main area of interest in the Lower Chinle, the aquifer functions as a single hydrologic unit on both sides of the

East Fault. The Lower Chinle also extends to the west of the West Fault. South of the project area, the Lower Chinle subcrops against the unsaturated alluvium to the east and the alluvial aquifer to the west. The subcrop area occurs where the top of the Lower Chinle aquifer intersects the base of the alluvial aquifer.

The two faults significantly alter the Lower Chinle structure in the tailings area. Like the upper aquifers, numerous cross sections have been developed to correlate geophysical logs in Lower Chinle drill holes and wells. These cross sections were subsequently used in developing the structure maps. Elevations of the top of the Lower Chinle aquifer are shown in Figure 2-11. The Lower Chinle aquifer between the two faults and near the tailings piles generally dips to the east. West of the West Fault, the general dip is also to the east. On the south side of the project area, the Lower Chinle dips to the north-northeast at a steeper gradient, such that the unit subcrops at the base of the alluvium in areas of Sections 3, 4, 28, 33 and 34 as previously described.

2.2 WELL COMPLETIONS

2.2.1 ALLUVIUM

The background well data for the "near" alluvial wells (up-gradient, but close to the project) and "far" alluvial wells (farther up-gradient) at the Grants site are presented in Tables 2-1 and Tables 2-2, respectively. Annual site reports present the well data for all other wells at the site. Annual reports are not included with this document because they were previously submitted to the NRC and are not required for this analysis. The locations of the nine near up-gradient wells north of the Large Tailings Pile, which are listed in Table 2-1, are shown on Figure 2-12. The locations of the six far up-gradient wells, which are listed in Table 2-2, are shown on Figure 2-12. The distinction between near and far up-gradient wells is made because statistical analysis of alluvial ground water quality to establish background values was performed only on data from the near up-gradient wells. The far up-gradient wells are of interest because they represent background conditions and provide some insight into long-term changes in alluvial ground water quality. They were not, however, included in the statistical analysis.

TABLE 2-1. WELL DATA FOR GRANTS PROJECT NEAR UP-GRADIENT ALLUVIAL WELLS

WELL NAME	NORTH COORD.	EAST COORD.	WELL DEPTH (FT-MP)	CASING DIAM. (IN)	WATER LEVEL DATE	WATER LEVEL DEPTH (FT-MP)	WATER LEVEL ELEV. (FT-MSL)	MP ABOVE LSD (FT)	MP ELEV. (FT-MSL)	DEPTH TO BASE OF ALLUVIUM (FT-LSD)	ELEV. TO BASE OF ALLUVIUM (FT-MSL)	CASING PERFOR-ATIONS (FT-LSD)	SATURATED THICHNESS (FT)
DD	1546989	488943	78.5	4.0	05/14/2002	58.20	6534.39	1.9	6592.59	83	6507.7 A	40-80	26.7
ND	1545927	494872	70.0	4.0	05/14/2002	47.63	6545.26	1.1	6592.89	65	6526.8 A	50-70	18.5
P	1546691	491058	109.1	4.0	07/15/2002	57.39	6529.87	1.7	6587.26	107	6478.6 A	82-112	51.3
P1	1547017	491060	105.0	6.0	11/28/2000	55.75	6536.72	0.8	6592.47	105	6486.7 A	60-105	50.1
P2	1546555	490912	105.0	6.0	04/23/2003	53.88	6535.91	0.9	6589.79	105	6483.9 A	60-105	52.0
P3	1546159	490785	95.0	5.0	04/23/2003	54.13	6535.82	2.2	6589.95	85	6502.8 A	55-95	33.1
P4	1546504	491899	92.0	5.0	04/23/2003	50.90	6538.62	3.6	6589.52	84	6501.9 A	52-92	36.7
Q	1548693	492153	98.3	4.0	05/14/2002	50.32	6543.50	2.3	6593.82	100	6491.5 A	72-102	52.0
R	1550372	494514	85.0	4.0	05/14/2002	43.24	6560.79	0.3	6604.03	95	6508.7 A	60-90	52.1

NOTE: A = Alluvial Aquifer; MP = Measuring Point; LSD = Land Surface Datum; IN = Inches; FT = Feet; MSL = Mean Sea Level

TABLE 2-2. WELL DATA FOR GRANTS PROJECT FAR UP-GRADIENT ALLUVIAL WELLS

WELL NAME	NORTH COORD.	EAST COORD.	WELL DEPTH (FT-MP)	CASING DIAM. (IN)	WATER LEVEL DATE	WATER LEVEL DEPTH (FT-MP)	WATER LEVEL ELEV. (FT-MSL)	MP ABOVE LSD (FT)	MP ELEV. (FT-MSL)	DEPTH TO BASE OF ALLUVIUM (FT-LSD)	ELEV. TO BASE OF ALLUVIUM (FT-MSL)	CASING PERFOR-ATIONS (FT-LSD)	SATURATED THICHNESS (FT)
0914	1555500	500850	93.0	6.0	05/09/2002	40.41	6601.59	1.4	6642.00	—	—A	—	—
0916	1552350	499600	160.0	4.0	—	—	—	0.0	6625.00	—	—A	45-70	—
0920	1555800	496900	—	7.0	—	—	—	0.7	6627.60	—	—A	—	—
0921	1555400	495800	73.0	5.0	05/08/2002	38.43	6585.57	1.9	6624.00	—	—A	—	—
0922	1555200	492500	96.0	6.0	05/08/2002	52.28	6569.42	1.7	6621.70	—	—A	—	—
0950	1560400	498300	81.0	5.0	07/12/2000	25.70	6631.30	0.5	6657.00	—	—A	—	—

NOTE: A = Alluvial Aquifer; MP = Measuring Point; LSD = Land Surface Datum; IN = Inches; FT = Feet; MSL = Mean Sea Level

2.2.2 UPPER CHINLE

Locations of the Upper Chinle wells are shown on Figure 2-6. Basic well construction data for the Chinle wells are presented in site annual reports. The well construction information for the Upper Chinle wells that are used in the background definition are presented in Table 2-3. This table includes the well completion information for two recently completed Upper Chinle wells, CW50 and CW52. Geophysical logs are presented in Appendix A for each of the Upper Chinle wells used to define background concentrations. Section A.1 in Appendix A presents the geophysical logs for the Upper Chinle wells. Neutron logs or resistivity logs have been used to identify the sandstones that characterize the Upper Chinle aquifer. Neutron and resistivity logs are provided for wells CW50, CW52, CW9, CW10, 931 and 934 and CW3, CW13 and CW18, respectively.

Appendix B presents well schematics for these Upper Chinle wells. Figures B.1-1 through B.1-9 depict well schematics for the nine Upper Chinle wells. These figures also show the slotted interval, sand pack and seal intervals for each well.

TABLE 2-3. WELL DATA FOR GRANTS PROJECT BACKGROUND UPPER CHINLE WELLS

WELL NAME	NORTH COORD.	EAST COORD.	WELL DEPTH (FT-MP)	CASING DIAM. (IN)	WATER LEVEL DATE	WATER LEVEL DEPTH (FT-MP)	WATER LEVEL ELEV. (FT-MSL)	MP ABOVE LSD (FT)	MP ELEV. (FT-MSL)	DEPTH TO AQUIFER (FT-LSD)	ELEV. OF AQUIFER (FT-MSL)	CASING PERFOR-ATIONS (FT-LSD)	AQUIFER
0931	1542461	495207	366.7	6.0	12/12/2002	197.85	6412.71	0.9	6610.56	339	6271 U	—	Upper
0934	1540641	493941	293.0	6.0	06/02/2003	183.52	6402.07	2.0	6585.59	30	6554 A	—	—
										282	6302 U	—	Upper
CW3	1545200	493496	235.0	5.0	06/02/2003	134.58	6452.60	0.7	6587.18	70	6516 A	—	—
										209	6377 U	210-235	Upper
										348	6238 M	—	—
CW9	1542840	491015	180.0	5.0	12/12/2002	65.56	6526.27	0.0	6591.83	—	— U	130-180	Upper
										80	6512 A	—	—
*CW10	1542823	491803	185.0	5.0	—	—	—	0.0	6587.89	75	6513 A	—	—
										167	6421 U	155-185	Upper
CW13	1538349	491827	267.7	6.0	06/02/2003	1.00	6575.70	2.7	6576.70	230	6344 U	225-265	Upper
										378	6196 M	—	—
CW18	1535924	491378	230.7	5.0	06/02/2003	83.29	6489.36	1.5	6572.65	90	6481 A	—	—
										190	6381 U	177-232	Upper
										340	6231 M	—	—
CW50	1546700	491150	170.9	5.0	06/24/2003	61.71	6525.29	3.0	6587.00	128	6456 U	130-170	Upper
CW52	1548250	491900	182.6	5.0	06/24/2003	89.44	6508.56	2.0	6598.00	138	6458 U	140-180	Upper
										302	6294 M	—	—

NOTE: A = Alluvial Aquifer, Base; U = Upper Chinle Aquifer, Top; M = Middle Chinle Aquifer, Top; * = Abandoned; MP = Measuring Point; LSD = Land Surface Datum; IN = Inches; FT = Feet; MSL = Mean Sea Level

2.2.3 MIDDLE CHINLE

The locations of the Middle Chinle wells are shown in Figure 2-8. Well data for the Middle Chinle wells used to define background concentrations are provided in Table 2-4. This table presents the completion interval and the total well depths for these wells. The geophysical logs for the Middle Chinle aquifer wells listed in the associated Section A.2 figures are presented in Appendix A. Each of the wells in Table 2-4 have a geophysical log except for well ACW, which is a Middle Chinle well drilled by HMC in the Murray Acres subdivision. HMC also drilled the nearby Middle Chinle well WCW which was geophysically logged and supports our well ACW interpretation. Table A.2-1 presents the lithologic log for well ACW. Appendix B includes Figures B.2-1 through B.2-11, the well schematics for the Middle Chinle wells.

TABLE 2-4. WELL DATA FOR GRANTS PROJECT BACKGROUND MIDDLE CHINLE WELLS

WELL NAME	NORTH COORD.	EAST COORD.	WELL DEPTH (FT-MP)	CASING DIAM. (IN)	WATER LEVEL DATE	WATER LEVEL DEPTH (FT-MP)	WATER LEVEL ELEV. (FT-MSL)	MP ABOVE LSD (FT)	MP ELEV. (FT-MSL)	DEPTH TO AQUIFER (FT-LSD)	ELEV OF AQUIFER (FT-MSL)	CASING PERFORATIONS (FT-LSD)	AQUIFER
ACW	1540235	488070	325.0	6.0	—	—	—	1.2	6563.80	40	6523 A	--	—
										57	6506 U	--	—
										264	6299 M	265-325	Middle
CW1	1545235	490295	325.0	5.0	06/02/2003	159.15	6426.07	0.7	6585.22	105	6480 A	--	—
										272	6313 M	212-323	Middle
CW2	1545212	491302	355.0	5.0	06/02/2003	157.87	6427.61	1.7	6585.48	85	6499 A	--	—
										136	6448 U	--	—
										305	6279 M	306-353	Middle
CW14	1538786	488884	360.9	6.0	06/02/2003	16.26	6549.83	2.9	6566.09	56	6507 A	--	—
										66	6497 U	--	—
										310	6253 M	278-358	Middle
CW15	1536259	485961	134.6	5.0	12/12/02	75.98	6475.34	2.6	6551.32	50	6499 A	--	—
										91	6458 M	73-133	Middle
										311	6238 L	--	—
CW17	1545279	487771	108.0	5.0	06/27/2002	60.20	6529.12	3.1	6589.32	73	6513 A	--	—
										85	6501 M	83-103	Middle
CW24	1545773	487760	118.0	5.0	10/03/2000	57.79	6530.88	3.0	6588.67	61	6525 A	--	—
										65	6521 M	78-118	Middle
CW28	1535112	491008	370.0	5.0	06/02/2003	195.90	6375.78	1.9	6571.68	90	6480 A	--	—
										110	6460 U	--	—
										294	6276 M	280-360	Middle
CW35	1547001	488794	120.0	5.0	06/27/2002	59.39	6531.78	1.9	6591.17	63	6526 A	--	—
										90	6499 M	93-118	Middle
WCW	1541045	488520	307.0	6.0	12/12/2002	126.31	6441.06	0.8	6567.37	83	6484 A	--	—
										254	6313 M	257-307	Middle
WR25	1545267	487430	113.3	5.0	10/03/2000	61.10	6525.36	2.8	6586.46	50	6534 A	--	—
										71	6513 M	71-111	Middle

NOTE: A = Alluvial Aquifer, Base; U = Upper Chinle Aquifer, Top; M = Middle Chinle Aquifer, Top; MP = Measuring Point; LSD = Land Surface Datum; IN = Inches; FT = Feet; MSL = Mean Sea Level

2.2.4 LOWER CHINLE

The locations of the Lower Chinle wells are shown on Figure 2-10. HMC drilled more than half of the Lower Chinle wells, including all of the CW wells and wells 653 and 853, to support structural and water-quality definition of this aquifer. Only 2 or 3 of the 27 existing Lower Chinle wells shown on Figure 2-10 are currently used as a domestic water supply.

The well completion data for the Lower Chinle wells which were used in the background analyses are presented in Table 2-5. This table presents the well depth, water level and casing perforation interval for these Lower Chinle wells. HMC drilled all of these Lower Chinle wells. Appendix A includes the geophysical logs for the Lower Chinle wells. Resistivity logs were used for each of these wells to define the lithology. The well schematics for the Lower Chinle wells are provided on Figure B.3-1 through B.3-10 in Appendix B.

TABLE 2-5. WELL DATA FOR GRANTS PROJECT BACKGROUND LOWER CHINLE WELLS

WELL NAME	NORTH COORD.	EAST COORD.	WELL DEPTH (FT-MP)	CASING DIAM. (IN)	WATER LEVEL DATE	WATER LEVEL DEPTH (FT-MP)	WATER LEVEL ELEV. (FT-MSL)	MP ABOVE LSD (FT)	MP ELEV. (FT-MSL)	DEPTH TO AQUIFER (FT-LSD)	ELEV. OF AQUIFER (FT-MSL)	CASING PERFOR-ATIONS (FT-LSD)	AQUIFER
CW26	1534116	489593	300.0	5.0	01/02/2003	91.85	6469.58	0.5	6561.43	50	6511 M	—	—
										50	6511 A	—	—
										231	6330 L	245-285	Lower
CW29	1534551	487435	290.0	5.0	06/02/2003	85.71	6466.51	1.7	6552.22	52	6499 A	—	—
										52	6499 M	—	—
										228	6323 L	230-270	Lower
CW31	1540689	482738	311.0	6.0	12/12/2002	83.82	6476.44	2.0	6560.26	111	6447 A	—	—
										254	6304 L	231-271	—
										254	6304 L	291-311	—
										254	6304 L	136-156	Lower
CW32	1543413	483523	300.0	6.0	12/12/2002	120.83	6446.45	1.7	6567.28	70	6496 A	—	—
										157	6409 L	218-303	—
										157	6409 L	158-188	Lower
CW33	1543814	486347	347.0	6.0	12/12/2002	106.04	6468.85	1.8	6574.89	83	6490 A	—	—
										272	6301 L	267-287	Lower
										272	6301 L	307-347	—
CW36	1540053	481329	180.0	5.0	12/12/2002	75.10	6475.99	2.8	6551.09	96	6452 A	—	—
										152	6396 L	155-177	Lower
CW37	1537240	484853	150.1	5.0	12/12/2002	60.46	6490.71	1.3	6551.17	55	6495 A	—	—
										100	6450 L	100-150	Lower
CW39	1537260	483754	126.3	5.0	12/12/2002	63.22	6487.49	3.4	6550.71	40	6507 A	—	—
										87	6460 L	90-123	Lower
CW41	1533174	488584	206.0	6.0	12/12/2002	86.00	6469.41	1.5	6555.41	59	6495 A	—	—
										138	6416 L	146-206	Lower
CW43	1537587	482493	104.1	5.0	12/12/2002	66.36	6482.43	2.0	6548.79	57	6490 L	81-101	Lower
										57	6490 A	—	—

NOTE: A = Alluvial Aquifer, Base; M = Middle Chinle Aquifer, Top; L = Lower Chinle Aquifer, Top; MP = Measuring Point; LSD = Land Surface Datum; IN = Inches; FT = Feet; MSL = Mean Sea Level

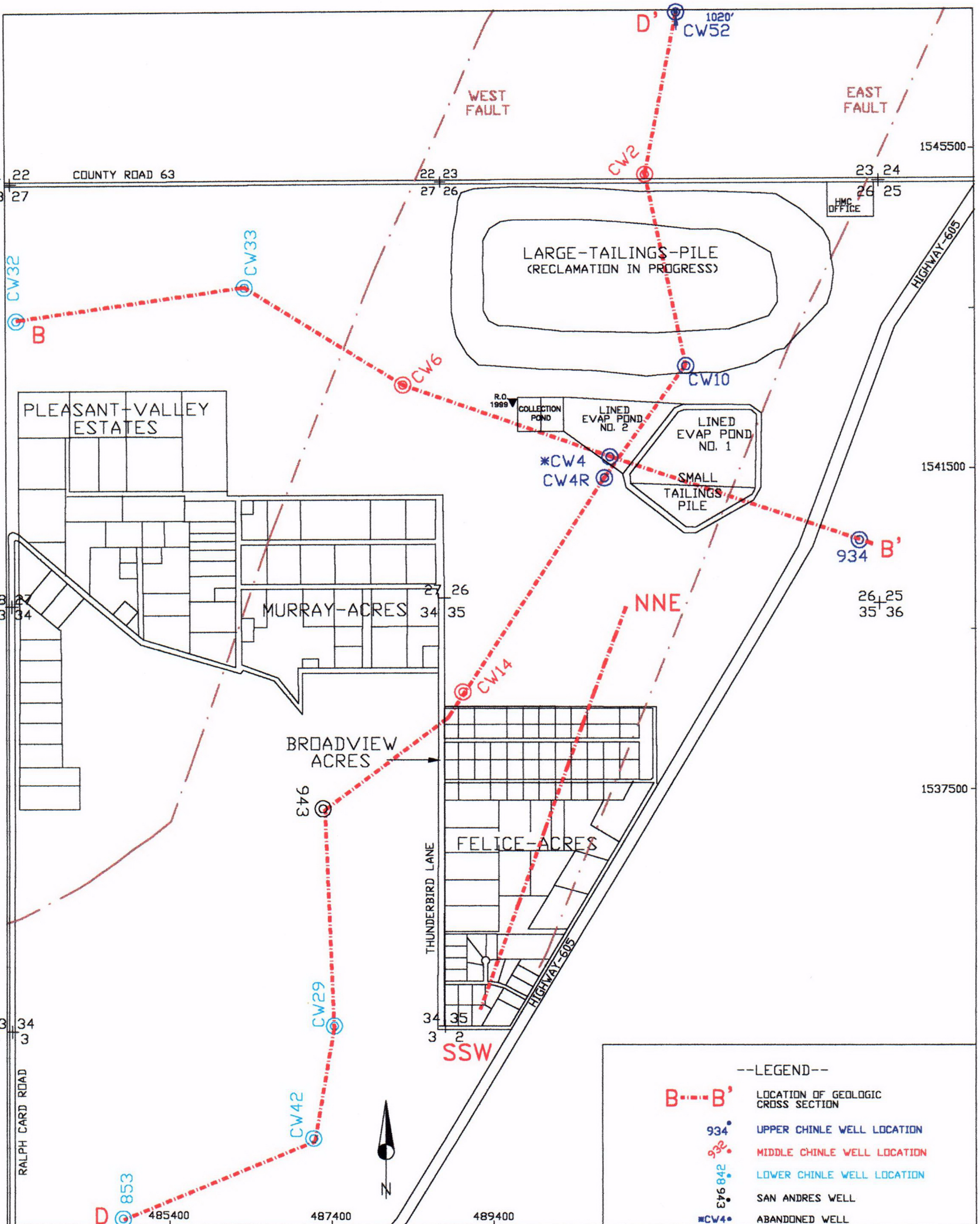

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	FIGURE 2-1. LOCATIONS OF GEOLOGIC CROSS SECTIONS	c:\dd\projects\2003-06\geoxsect
		page 2-12

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HOMESTAKE MINING COMPANY, FIGURE 2-2 , GEOLOGIC CROSS-SECTION B-B WITH POST RESTORATION FLOW DIRECTION

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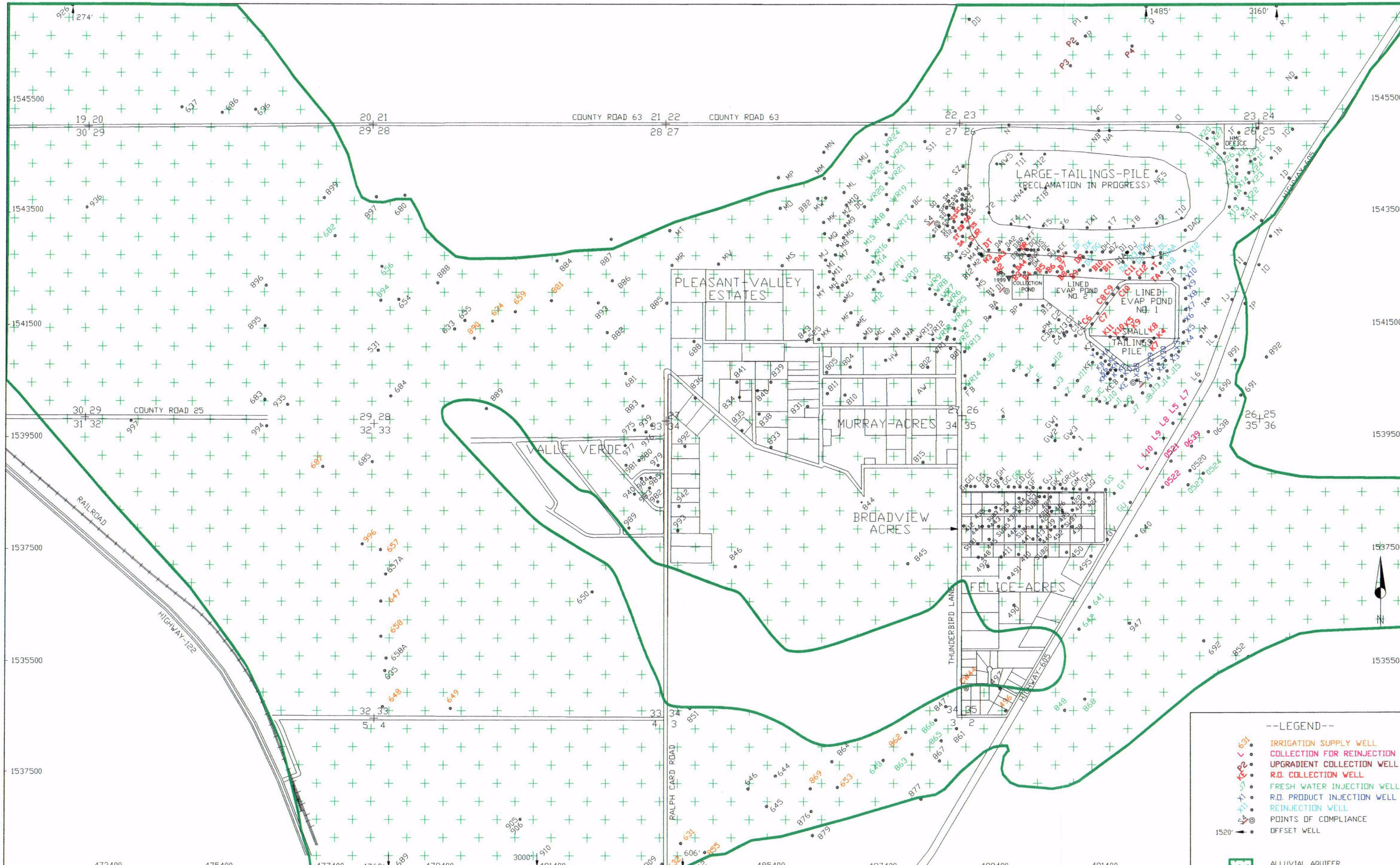

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FIGURE 2-4. AREAL EXTENT OF THE ALLUVIAL AQUIFER & WELL LOCATIONS

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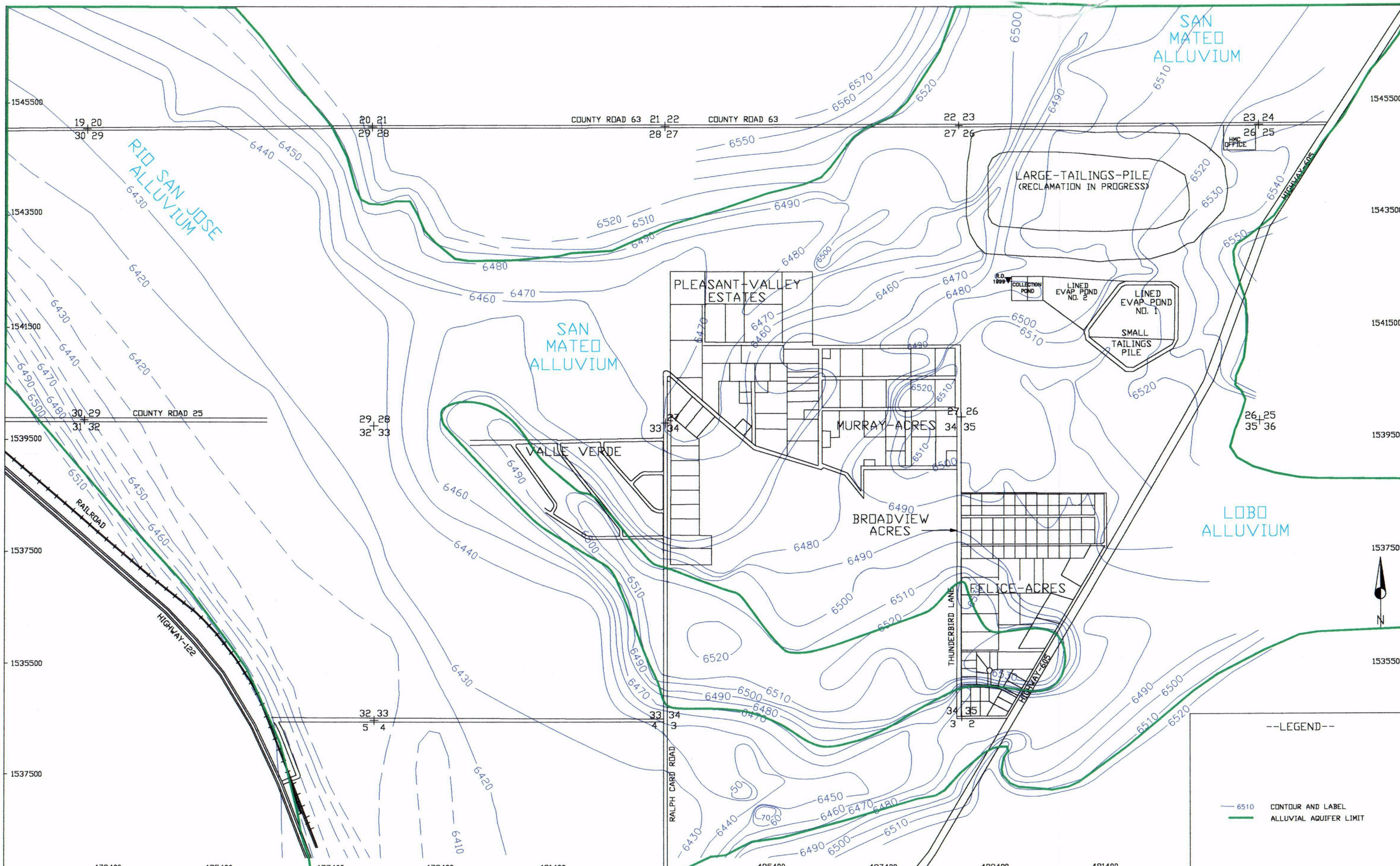

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FIGURE 2-5. ELEVATION OF THE BASE OF THE ALLUVIUM, in FT-MSL

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