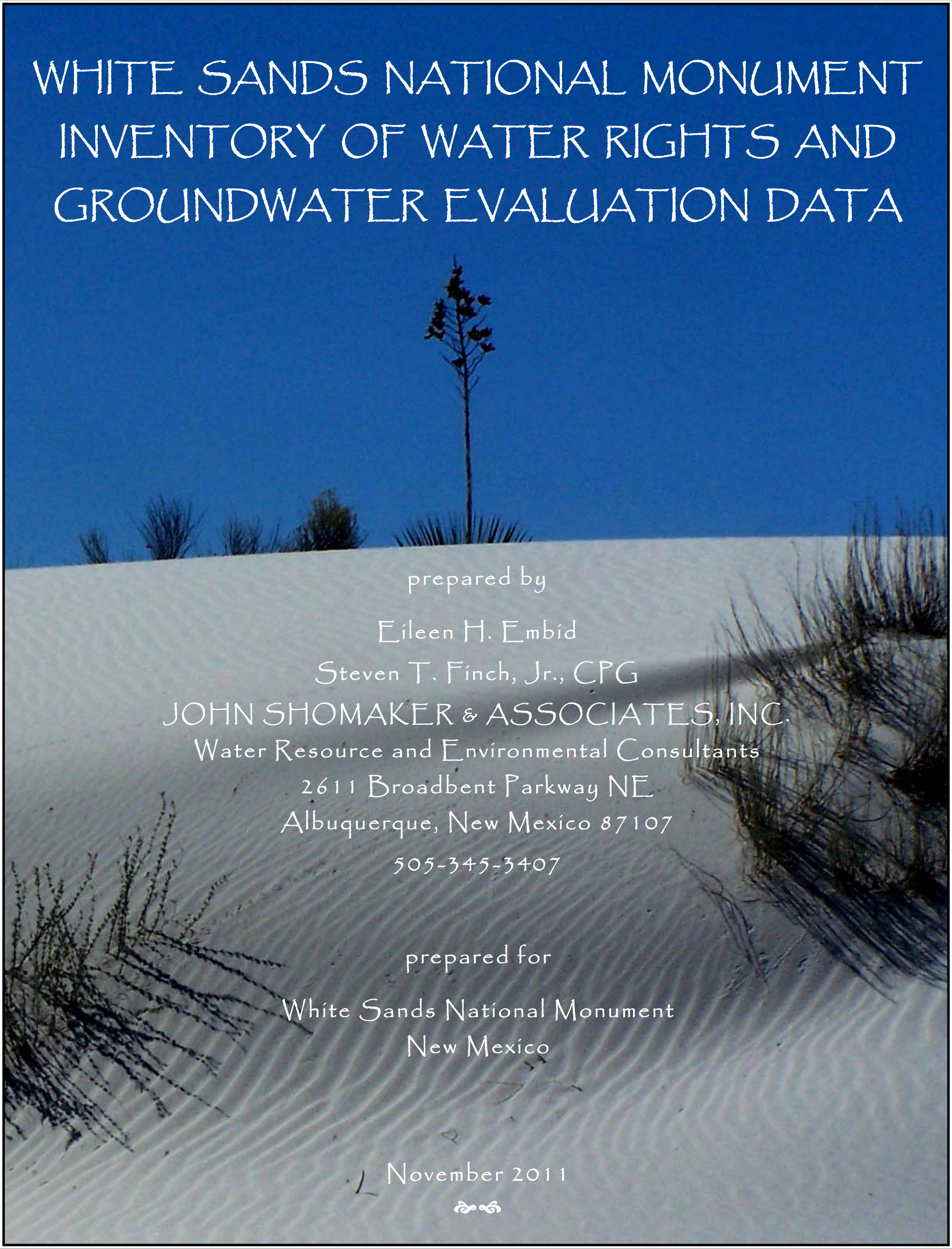
WHITE SANDS NATIONAL MONUMENT INVENTORY OF WATER RIGHTS AND GROUNDWATER EVALUATION DATA



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CONTENTS

page

TABLE

ILLUSTRATIONS

(follow text)

ILLUSTRATIONS

(follow text)

APPENDICES

(follow illustrations)

ABBREVIATIONS

ac-ft/yr	acre feet per year
CMAs	Critical Management Areas
DEM	digital elevation models
eGIS	Enterprise Geographic Information System
ft amsl	feet above mean sea level
ft bgl	feet below ground level
GIS	geographic information systems
GNIS	Geographic Names Information System
GPS	global positioning system
GQB	Groundwater Quality Bureau
JSAI	John Shomaker & Associates, Inc.
NGWA	National Groundwater Association
NHD	National Hydrography Dataset
NMED	New Mexico Environment Department
NMOSE	New Mexico Office of the State Engineer
NWIS	National Water Information System
OSW	Office of Saline Water
PLSS	Public Land Survey System
PSTB	Petroleum Storage Tank Bureaus
SWB	Solid Waste Bureau
USAF	U.S. Air Force
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WATERS	Water Administration Technical Engineering Resource System
WSMR	White Sands Missile Range
WSNM	White Sands National Monument

WHITE SANDS NATIONAL MONUMENT INVENTORY OF WATER RIGHTS AND GROUNDWATER EVALUATION DATA

1.0 INTRODUCTION

White Sands National Monument (WSNM) contracted John Shomaker & Associates, Inc. (JSAI) to prepare an inventory of water rights and groundwater evaluation data for the central portion of the Tularosa Basin (Fig. 1). The project consists of completing the following tasks:

1. Water right records research and compilation
2. Groundwater-level records research and compilation
3. Prepare water-level elevation and depth-to-water maps
4. Identification of potential monitoring wells to survey

The proposed scope of work can be referenced from Appendix A.

A hydrologic database was created to fulfill the requirements of Tasks 1 and 2. The hydrologic database consists of a survey of wells, surface-diversion permits, and springs that fall within the Tularosa Basin and inside the 3,248 mi^2 inventory area shown in Figure 1. This area includes parts of Doña Ana, Lincoln, Otero and Sierra Counties in Townships 10 to 20 South and Ranges 03 to 13 East. The inventory area is largely federal controlled land, but also includes private and state lands (Fig. 2). No attempt was made to solicit data from the Mescalero-Apache Reservation.

The data inventory is provided as a Microsoft Access database file on a DVD (Appendix B). The database is accompanied with instructions for querying and updating the database file, database documentation, and source data files.

A data dictionary that describes each field in the 'WellSites' and 'WaterLevels' tables is included as Appendix C. A user-interface data entry form has been included in the Access database file to facilitate viewing and editing the existing location and water-level data, as well as adding new data. Custom queries have also been created to view subsets of the total dataset and to use as templates for additional user-defined queries. Sections 2.0 and 3.0 describe the process used to acquire, format and merge the hydrologic data, to build the database, and to create maps and hydrographs.

2.0 WELL AND WATER-LEVEL INVENTORY

Sampling-point location and water-level monitoring data for the inventory area were gathered from multiple sources. Each source provided data in different formats, requiring different manipulation to bring them together into a cohesive database.

The hydrologic survey is a compilation of well and spring locations and water-level data gathered from unpublished JSAI data and several state and federal agencies. These agencies included the New Mexico Office of the State Engineer (NMOSE), the New Mexico Environment Department (NMED) Groundwater Quality (GQB), Solid Waste (SWB) and Petroleum Storage Tank Bureaus (PSTB), the U.S. Geological Survey (USGS), White Sands National Monument (WSNM), and the U.S. Air Force (USAF). Data from published studies of the area have also been included. In some cases, a single record may contain data from more than one source. An effort has been made to retain as much information for each location as possible and to remove duplication. Source files are included in Appendix B as an electronic attachment to this report. The primary data sources are described as follows:

- U.S. Geological Survey (USGS)
  - National Water Information System (NWIS)
    The USGS NWIS stores water-resources data for the United States, including well and spring information. Information is available at http://waterdata.usgs.gov/nwis
  - National Hydrography Dataset (NHD)
    The USGS NHD is the digital vector dataset of surface-water data used in geographic information systems (GIS). Data points identified as springs were extracted for this database. The entire source geodatabase is available for download at http://nhd.usgs.gov/
  - McLean, J.S., 1970, Saline ground-water resources of the Tularosa Basin, New Mexico: USGS Office of Saline Water Research and Development Progress Report No. 561, 128 p.

- New Mexico Office of the State Engineer's (NMOSE) Water Administration Technical Engineering Resource System (WATERS) database
  - The NMOSE WATERS database consists of water right data maintained by the NMOSE. It can be accessed at http://nmwrrs.ose.state.nm.us/nmwrrs/index.html

- The NMOSE Enterprise Geographic Information System (eGIS) maintains digital geospatial datasets of well data and declared groundwater basins in shapefile format available for download at http://www.ose.state.nm.us/water_info_data.html

➢ New Mexico Environment Department (NMED)

- The Petroleum Storage Tank Bureau (PSTB) stores data related to petroleum tank facilities with past and/or current leaks.
- The Groundwater Quality Bureau (GQB) stores paper copies of discharge plans in New Mexico.
- The Solid Waste Bureau (SWB) stores paper copies of groundwater monitoring reports from landfills in New Mexico.

➢ U.S. Department of Defense

- Holloman Air Force Base (AFB)
- White Sands Missile Range

➢ White Sands National Monument (WSNM)
An Excel file of water measurements and locations was provided by White Sands National Monument.

➢ Barud-Zubillaga, A., University of Texas at El Paso, 2000
Data were extracted from the Master's Thesis entitled: A conceptual model of the hydrogeology of White Sands National Monument, South-Central New Mexico.

2.1 Water-Rights Records

The NMOSE WATERS database was searched using the NMOSE online Water Rights Reporting System lookup http://nmwrrs.ose.state.nm.us/nmwrrs/index.html. Queries based on the townships and ranges, counties, the declared groundwater basin of interest, and by radius from selected points within the inventory area boundary were run. The output of these queries was downloaded in Microsoft Excel spreadsheets of well and surface-water diversion permit locations (point of diversion), declared or permitted water right, well depth, and associated data. These spreadsheets were consolidated and merged with an attribute data table extracted from the NMOSE eGIS well data shapefile downloaded from http://www.ose.state.nm.us/water_info_data.html that had been clipped to the inventory area.

Figure 3 is an aerial photograph of the inventory area showing the NMOSE permitted points of diversion; over 5,200 permitted points of diversion have been identified. Duplicate locations were deleted. After consulting with WSNM personnel, locations from the WATERS and eGIS datasets with expired water right permits (mostly domestic well permits) were purged from the database because it is believed that they represent applications for permits for wells that were never drilled. The locations of domestic, surface water and other (agriculture, industrial, and municipal) points of diversion are shown by individual symbols on Figure 4. The majority of the NMOSE permitted wells are domestic wells, which are shown separately on Figure 5. The locations of permitted surface-water diversions are shown on Figure 6.

2.2 Well and Water-Level Data

A retrieval of data from the USGS National Water Inventory System (NWIS) database for the inventory area was requested from the USGS New Mexico Water Science Center. These data are also available online from the following link http://nm.water.usgs.gov/ which can be used to update the database as new data become available. However, a direct request was made to the agency to ensure that the dataset would be as complete as possible. These data were received as an Excel spreadsheet.

Groundwater monitoring data relating to water treatment processing plants and landfill sites within the study area on file at the NMED GQB, SWB and PSTB were photocopied and manually entered into Excel. Electronic versions of several reports were provided in pdf format and the pertinent data were extracted and manually added into Excel.

Hard copies and electronic files of water monitoring reports were also received from the USAF Holloman AFB and White Sands Missile Range. Some data were received in Excel format and the rest were manually entered into the spreadsheet. Duplicate data were removed.

Data from the 2000 University of Texas at El Paso Master's Thesis by Alberto Barud-Zubillaga, entitled "A conceptual model of the hydrogeology of White Sands National Monument, South-Central New Mexico," and the 1970 USGS Office of Saline Water Research and Development Progress Report No. 561 by J.S. McLean, entitled "Saline ground-water resources of the Tularosa Basin, New Mexico," were manually entered into the spreadsheet. The locations and groundwater monitoring data from these reports were combined with unpublished data from JSAI studies. Locations of all wells in the database are shown on Figure 7.

These data were parsed out into a spreadsheet template in Excel and combined into consistent formats. Elevations and depth-to-water measurements expressed in metric units were converted to feet. Geographic coordinates for every location were converted to the Universal Transverse Mercator (UTM) coordinate system, Zone 13 North, in meters. When geographic coordinates were unavailable, approximate locations were derived from the Public Land Survey System (PLSS) location. The NMOSE WATERS database also cites approximate UTM coordinates derived from the PLSS for many wells. These locations are less precise than surveyed locations. When no coordinates were provided, locations were determined from report site maps and UTM coordinates were estimated using Google Earth. Land-surface elevations were estimated from USGS topographic maps when more precise data were unavailable.

Some locations and water measurement data are cited in more than one of the data sources. These duplicate data were removed when it was apparent that the wells and springs referenced were the same. However, some duplication no doubt still exists for wells that were identified by different names or slightly different coordinates in multiple source datasets.

Not all wells with water-level data have time-series datasets. The locations of wells with water-level data and no time-series datasets are shown on Figure 8, and the locations of wells with time-series water-level datasets are shown on Figure 9.

2.2 Spring Data

Spring locations were extracted from the USGS National Hydrography Dataset (NHD) downloaded as a geodatabase from http://nhd.usgs.gov/data.html. Locations within the study area were clipped, and the attribute data table was saved in Excel format. Springs from the USGS NHD are plotted with known surface-water points of diversion on Figure 6.

3.0 DATABASE

3.1 Database Structure

The master Excel spreadsheets were imported into Access. The data were then separated into two master tables: one for the site locations and one for the water-level measurement data. The unique identifier for each site was included with each record of associated data in the water-level table. Field properties and the table relationship were defined. In the Access database, all well and spring locations are listed in the 'WellSites' table with their associated data. Water-level measurements are listed in the 'WaterLevels' table which is linked to the 'WellSites' table by the unique identifier.

The 'WellSites' table stores general information specific to a sampling site, such as geographic coordinates and land-surface elevation. The 'WaterLevels' table contains time-dependent hydrologic data associated with these sites so that multiple measurements collected on different dates can be recorded for one sampling location. These two tables are linked by the unique number 'SOURCE_WELL_NBR' in the 'WellSites' table to 'SITE_ID' in the 'WaterLevels' table by a one-to-many relationship.

Figure 10 shows a datasheet view of part of the 'WellSites' table. When the **+** to the left of the 'SOURCE_WELL_NBR' is expanded, data associated with that location stored in the 'WaterLevels' table are shown in an embedded table (Fig. 11). Data can be updated in both tables simultaneously through this view.

In order for the MS Access database to function properly, time-dependent data associated with multiple water-level measurements for one location had to be stored in a separate table and linked to the location table in a one-to-many relationship. This requires a 'primary key' field in the location table with a unique identifier assigned to each location. This field can have no duplicates and no blanks. Data from the USGS NHD and NWIS, and the NMOSE eGIS datasets included a unique identifier for each location assigned by those agencies following their own conventions. All other locations were assigned a unique identifier following the USGS convention of concatenating the latitude and longitude for the site with a sequential number starting with 01.

Water-level measurement data reported in more than one data source are combined in the ‘WaterLevels’ table. In some cases, where more accurate data are available in one source than another, the data have been modified and explained in the ‘NOTE’ field. For example, some locations have surveyed land surface elevations reported in relatively recent reports. Older reports of the same locations may show measured depths to water and water-level elevations that had been calculated from those depth to water measurements relative to an estimated land surface elevation. These water-level elevations have been recalculated in the database from the depths to water in the original report and the more accurate surveyed land surface elevations in the more recent report.

3.2 Database Maintenance

Instructions are provided in Appendix D for maintaining the database and updating or extracting information in the data tables. As new data become available, the database should be updated. A user-interface data entry form is provided in the Access file that can be used to view and/or edit data in the tables. New records can also be added using this form. Instructions for using the form and for alternative methods of viewing and updating the database are described in Appendix D.

Sample queries are also included that retrieve subsets of data based on specific criteria. These queries can be copied and modified to return user-defined subsets of the total dataset. Instructions for using these forms and for filtering data in the data tables for quick summaries can be found in Appendix D.

Data queried generally includes all available data through 2010. Time-series water-level data will need to be updated in the database.

4.0 GROUNDWATER MAPS AND GRAPHS

Task 3 involved the construction of depth-to-water and water-level elevation contour maps. Water levels with elevation data were used to construct the water-level elevation contours. Similar maps have been developed by previous researchers (Meinzer, 1915; McLean, 1970; Huff, 2005; Finch and Shomaker, 2006), and the previous contouring efforts were used as guidance for interpretation between data points.

4.1 Depth-to-Water Map

The depth-to-water contour map presented as Figure 12 represents the time period 2005 to 2010. Depth-to-water contours for the San Andres and Sacramento Mountain blocks were not contrasted due to the highly variable topography and perched water-table conditions. There are not enough water-level data to reconstruct historical changes in depth to water. The region of groundwater pumping along the eastern side of the Tularosa Basin from Three Rivers to Boles Acres has shown drastic changes in water levels over the last 60 years: rapid water-level decline from heavy pumping during drought periods, and rapid water-level rise from recharge events during periods of above-average precipitation. Selected hydrographs presented in Appendix E illustrate the historical water-level changes.

In general, depth to water decreases toward the basin center and increases toward to mountain front (Fig. 12). Most of the data points around Holloman AFB have depth to water less than 20 ft because geologic conditions are forcing the groundwater to the surface (see Section 5.1). An attempt was made to refine depth-to-water contours for the interval 0 to 50 ft, but there are not enough data. The less than 50-ft depth-to-water data are shown on Figure 12 to illustrate the lack of data in the basin center and the time variability effects along the Sacramento Mountain front.

Finch and Shomaker (2006) developed a depth-to-water map showing the pre-development 25-ft depth-to-water contour and springs between Alamogordo and Holloman AFB that runs parallel to the Jarilla Fault Zone (see Appendix F).

4.2 Water-Level Elevation Contour Map

The database was used to construct a regional water-level elevation contour map of the inventory area (Fig. 13). Water-level elevation contour maps for the same area have been developed by various researchers over the last 100 years (see National Groundwater Association (NGWA) presentation in Appendix F). The primary change in contouring efforts over the 100 years has been refinement in the direction of groundwater flow rather than the elevation of the water table.

The water-level elevation contour map presented as Figure 13 was developed using 50-ft contour intervals, and the mountain block was not included in the contouring efforts. Land-surface elevation and surface-water features were considered in the interpretation of areas between water-level elevation data points.

The lateral direction of groundwater flow is perpendicular to the water-level elevation contours (see Fig. 13). Groundwater is predominately flowing from northeast to southwest, originating from recharge along the Sacramento Mountains and flowing toward the area of groundwater discharge at Lake Lucero. There appears to be a component of groundwater flow from the north, near Malpais Springs toward Lake Lucero.

The vertical direction of groundwater flow cannot be interpreted from the water-level contours shown on Figure 13. Water-level measurements from nest wells completed at different depths in the aquifer are needed to determine the vertical direction of groundwater flow.

4.3 Time-Series Water-Level Data

In the inventory area, there is an abundance of time-series water-level data (Fig. 9), but unfortunately the data are clustered in areas of detailed study such as White Sands Missile Range Headquarters and Holloman AFB. The most meaningful data to WSNM would be good time-series datasets located in the vicinity of the WSNM boundary and along the groundwater flow path from Sacramento Mountains to Lake Lucero. Selected hydrographs from the database are presented in Appendix E.

Time-series water-level data collected by the USGS have been limited to specific studies with a specific time interval, or a measurement frequency of 1- to 5-year interval. Therefore, the most robust dataset comes from monitoring wells with quarterly measurements, such as those for the City of Alamogordo’s wastewater reuse discharge permit DP-220 and environmental studies at Holloman AFB.

5.0 REGIONAL HYDROGEOLOGY AND GROUNDWATER MANAGEMENT

The regional hydrogeology and groundwater management discussion presented below is intended as background information that aids in the understanding of the recommendations presented in Section 6.0.

5.1 Regional Hydrogeology

The Tularosa Basin consists of two half-grabens with the San Andres Mountains defining the western boundary and the Sacramento Mountains defining the eastern boundary. General geology of the Tularosa Basin is shown on Figure 14, and geologic cross-sections are presented as Figure 15. The Jarilla Fault, trending south to north through the center of the basin, defines the boundary between the two half-grabens (western and eastern). A list of geologic references for the Jarilla Fault can be referenced from Appendix F. WSNM is situated in the western portion (half-graben) of the Tularosa Basin.

The Tularosa Basin is a sediment-filled basin, and the unconsolidated sediments (gravel, sand, silt, and clay) are generally coarser along the mountain front and fine toward the basin center (Finch and Shomaker, 2006). Recharge to the basin fill occurs from infiltration of runoff and groundwater inflow from the mountain block. Groundwater inflow primarily occurs from limestone units in the Sacramento Mountain block. A summary of recharge estimates for the Tularosa Basin and hydrogeologic conceptual model can be referenced from the Finch (2007) NGWA presentation in Appendix F.

Groundwater flows from the Sacramento Mountain block to the southwest (Fig. 13). As groundwater flows to the southwest toward the Jarilla Fault, a bedrock high forces the groundwater toward the land surface and evaporation and evapo-concentration of dissolved solids occurs at the water table. A significant portion of the groundwater flow is evaporated before it flows over the bedrock high along the eastern side of the Jarilla Fault zone. The groundwater flowing over the bedrock high becomes supersaturated with respect to gypsum, precipitates gypsum leaving sodium chloride enriched groundwater. The geochemical evolution of groundwater along this flow path is well documented by the data collected from wells at the National Desalination Research Facility west of Alamogordo and Holloman AFB.

As documented by deep well drilling and stable isotope analysis, there is also a deep groundwater flow path beneath the basin fill in the underlying limestone rocks. Recharge to the limestone rocks occurs in the Sacramento Mountains and follows a deep flow path to the west where is discharges from the bedrock high east of the Jarilla Fault. Spring mounds and the flowing Garton well south of Highway 70 are the evidence for the discharges from the bedrock.

Three groundwater-flow models have been developed for the eastern Tularosa Basin:

1. Regional model of the eastern Tularosa Basin for the City of Alamogordo by Finch and Shomaker (2003, 2006).
2. Regional groundwater-flow model of the eastern and western portions of the Tularosa Basin prepared by the USGS (Huff, 2005).
3. Regional groundwater-flow model of the eastern Tularosa Basin by the NMOSE (Keyes, 2005).

Each of these models is calibrated to historical data, and provides an estimate of drawdown from historical and future pumping. All three models simulate the effect of Jarilla Fault and associated bedrock high on groundwater flow and evaporation.

5.2 Groundwater Management

The following discussion regarding groundwater management is an overview of water administration, water rights in the database, and previous quantification of water use.

5.2.1 Water Administration

The NMOSE declared the Tularosa Basin for administration of water rights on July 20, 1982. Guidelines for the Alamogordo-Tularosa Administrative area were adopted in 1997, and new guidelines and water rights administration criteria are currently in progress. The Alamogordo-Tularosa Administrative area is shown on Figure 16. The NMOSE administers the Tularosa Basin as a mined groundwater basin with a limit set on the allowable water-level decline.

The NMOSE developed administrative guidelines in order to promote the orderly development of water resources in the Alamogordo-Tularosa Administrative Area, while meeting statutory obligations regarding non-impairment to existing water rights, availability of un-appropriated water, conservation of water within the state, and public welfare of the state. The guidelines do not apply to the permitting of applications filed under NMSA Section 72-12-1.1 (domestic wells), 72-12-1.2 (shared domestic) and 72-12-1.3 (stock).

Modeling studies predict the aquifer in the vicinity of Alamogordo and Tularosa will experience an average annual water-level decline of more than 2 feet per year over the planning period due to the full exercise of existing permits and declarations. The NMOSE considers this an excessive rate of decline, which may result in impairment to existing water rights. Model cells predicted to have excessive water-level decline require a greater level of restriction compared to other areas and are designated Critical Management Areas (CMAs). The CMAs are shown on Figure 16.

5.2.2 Water Rights

When the NMOSE declared jurisdiction over the Tularosa Basin in 1982, well owners and water users filed water right declarations with the NMOSE. Declarations are no more than the owners claim to a water right, and the NMOSE requires the water right to be validated with proof of beneficial use. Water right permits issues after 1982 were also subject to the requirement of proof of beneficial use.

NMOSE issued water right permits and accepted water right declarations are not validated and licensed until the permitted or declared quantity of water has been put to beneficial use. It is important to note that most of the water rights in the Tularosa Basin are declared and the full amount has not been put to beneficial use, and, due to NMOSE administration, it is unlikely water rights put to beneficial use will be greater than the current use. Details regarding water rights administration can be referenced from the NMOSE Alamogordo-Tularosa Administrative Area Guidelines (see NMOSE website).

In several cases, existing water rights have been decreased in quantity or the NMOSE has served a notice of non use. As part of a settlement agreement with the NMOSE, the City of Alamogordo's La Luz Well Field declared water rights of 4,570 acre-feet per year (ac-ft/yr) were licensed at 3,000 ac-ft/yr. Approximately 3,600 ac-ft/yr of irrigation rights near Three Rivers, under file number T-2014 through T-2026, were served a notice of non use. The database may not reflect these changes because the NMOSE WATERS database does not always reflect the updated information. Furthermore, the database should not be used for querying water right quantities, because of the complexities inherited from the NMOSE WATERS data source.

Municipalities and some agriculture in Tularosa conjunctively use surface-water and groundwater rights, to where the groundwater right is approximately equal to the surface-water right but there is not a need for the combined total.

Approximately 70 percent of the water rights in the Tularosa Basin are for irrigated agriculture, 20 percent is for municipal use, and the remainder is for other designated uses (South Central Mountain RC&D, 2002). Total groundwater rights are approximately 80,000 ac-ft/yr and total surface-water rights are over 40,000 ac-ft/yr. Groundwater is fully appropriated in the NMOSE designated CMAs, and new groundwater appropriations could be approved if the administrative criteria are met. Surface water from the Sacramento Mountains is also fully appropriated. It is important to note that groundwater and surface water rights for irrigated agriculture are mostly based on declared diversion rates. Approximately 65 percent of the water diverted for irrigated agriculture is consumptively used and the remainder is returned to the aquifer. Furthermore, there are numerous large surface-water right permits that are based on storm flows, but rarely are storm flows efficiently captured and put to beneficial use.

5.2.3 Water Use

Surface-water diversions from the Sacramento Mountains have been ongoing for over 150 years, and groundwater diversions began in around 1910. Most all of the Tularosa River is diverted for irrigated agriculture for approximately 9 months out of the year (6,000 ac-ft/yr), and applied to lands around Tularosa, New Mexico. A detailed summary of historical water use for the eastern Tularosa Basin can be referenced from Finch and Shomaker (2006). Over the last 10 years, total groundwater use in the eastern Tularosa Basin has been approximately 17,000 ac-ft/yr (Keyes, 2005; Finch and Shomaker, 2006), and total surface-water use has averaged 7,500 ac-ft/yr. Approximately 1,500 ac-ft/yr of surface water is imported to Alamogordo and Holloman AFB from Bonito Lake via the Bonito pipeline. Water use in the western Tularosa Basin is predominately for White Sands Missile Range Headquarters, and groundwater pumping has averaged about 1,500 ac-ft/yr over the last 10 years (NMOSE records).

6.0 RECOMMENDATIONS

The primary objective of the groundwater inventory and database project is to identify, monitor, and protect the source of water that stabilizes the dunes at WSNM. The recommendations are based on the scientific community's current understanding of the hydrogeologic system and groundwater-flow paths, and preview of the data in the database.

As indicated by the groundwater elevation contours on Figure 13, the primary flow path conveying groundwater to the White Sands dune field originates from the Sacramento Mountain front between Tularosa and Alamogordo, and trends southwest over the bedrock high created by the Jarilla Fault.

Results from regional groundwater-flow model indicate the diversion and use of water along the Sacramento Mountains causes drawdown (Huff, 2005; Keyes, 2005; Finch and Shomaker, 2006). The drawdown is confined to the area east of the Jarilla Fault and has not significantly reduced the quantity of groundwater flow from the eastern to western Tularosa Basin because it has been offset by salvaged evaporation (Huff, 2005; Finch and Shomaker, 2006).

6.1 Identification of Monitoring Wells to Survey

Establishing a regional groundwater monitoring network around the WSNM would provide the most robust monitoring program. There are a number of wells hydraulically upgradient of WSNM and east of the Jarilla Fault. Table 1 is a list of wells identified and recommended for a regional groundwater monitoring network. Several of the wells are located on Holloman AFB and White Sands Missile Range. It is anticipated the wells listed in Table 1 (Fig. 17) would be used to establish a water-level monitoring program and assess water-level trends over time.

Table 1. List of wells recommended for regional monitoring network and additional survey

ID	township, range, section	owner	land surface elevation (ft)	measuring point elevation (ft)	total depth (ft bgl)	original depth to water (ft)	data source	USGS Site ID
T 01514	15S.09E.9.312	Fred Utter	na	na	115	70.0	NMOSE WATERS	
13S.05E. 27.421	13S.05E. 27.421	WSMR	4,014.00	na	750	35.0	USGS NWIS	330919106290501
13S.07E.26.342	13S.07E.26.342	WSMR	4,052.00	na	na	18.0	USGS NWIS	330912106155101
13S.09E.20.234 A	13S.09E.20.234	State of New Mexico	4,300.00	na	117	na	USGS OSW Report 561, 1970	331019106055701
14S.07E.04.234	14S.07E.4.234	WSMR	4,025.00	na	20	17.0	USGS NWIS	330740106173001
14S.09E.04.100	14S.09E.4.1	na	4,275.00	na	350	29.3	USGS NWIS	330750106053601
14S.09E.33.213	14S.09E.33.213	Montie Gardenhire	4,280.00	na	110	63.0	USGS OSW Report 561, 1970	
14S.10E.31.144	14S.10E.31.144	Luther Watson	4,440.00	na	230	106.0	USGS NWIS	330321106011101
15S.05E.29.423	15S.05E.29.423	na	3,903.00	na	na	22.9	USGS NWIS	325830106285501
17S.04E.02.211 NW-30-1	17S.04E.2.211	WSMR	4,133.22	na	670	212.9	WSMR	
18S.07E.11.443	18S.07E.11.443	na	3,990.00	na	250	36.0	USGS NWIS	324522106113301
19S.06E.13.113 BAIRD SOUTH	19S.06E.13.113	WSMR	3,966.85	na	na	68.9	USGS NWIS	323945106171901
19S.06E.28.221A HELSTF-1	19S.06E.28.221	WSMR	3,951.58	na	100	69.8	USGS NWIS	323803106194201
ALM220 MW3	17S.09E.14.444	City of Alamogordo	4,155.92	na	90	58.5	NMED GQB	
HAFB 1127 MWBG01	16S.08E.1.411	HAFB	4,206.10	na	na	34.9	HAFB	
HAFB MW0401	16S.08E.27.422	HAFB	na	4,111.36	53	41.1	HAFB	
HAFB MW3701	16S.08E.33.122	HAFB	4,076.08	na	38	31.6	HAFB	
HAFB MW4101	15S.08E.26.322	HAFB	na	4,092.06	20	16.0	HAFB	

ft bgl - feet below ground level
USGS - U.S. Geological Survey
WSMR - White Sands Missile Range
NMOSE - New Mexico Office of the State Engineer
HAFB - Holloman Air Force Base

NWIS - National Water Information System
OSW - Office of Saline Water
NMED - New Mexico Environment Department
GQB - Groundwater Quality Bureau
na - not available

Table 1. List of wells recommended for regional monitoring network and additional survey (concluded)

ID	township, range, section	owner	land surface elevation (ft)	measuring point elevation (ft)	total depth (ft bgl)	original depth to water (ft)	data source	USGS Site ID
HAFB MWBG02	16S.08E.12.444	HAFB	4,197.40	na	53	46.2	HAFB	
HAFB MWBG03	16S.08E.24.232	HAFB	4,136.14	na	20	13.5	HAFB	
HAFB MWBG04	16S.08E.26.133	HAFB	4,072.65	na	19	2.0	HAFB	
HAFB S1MW1	17S.08E.1.244	HAFB	na	4,099.39	27	11.0	HAFB	
TULC MW1	14S.10E.19.344	Tularosa Chevron	na	4,509.88	115	104.0	NMED PSTB	
TULC MW3	14S.10E.19.344	Tularosa Chevron	na	4,509.91	113	104.9	NMED PSTB	
TULC MW2	14S.10E.19.344	Tularosa Chevron	na	4,509.88	113	105.6	NMED PSTB	
WSMR JIM WELL	15S.09E.29.314	WSMR	4,172.46	na	na	na	WSMR	
HAFB TDSMW01	15S.08E.14.243	HAFB	na	na	na	na	HAFB	
HAFB TDSMW03	17S.08E.9.113	HAFB	na	na	na	na	HAFB	
HAFB TDSMW04	17S.08E.21.123	HAFB	na	na	na	na	HAFB	
HAFB MW3801	16S.08E.32.122	HAFB	na	4,062.85	32	26.5	HAFB	
HAFB MW3706	16S.08E.28.412	HAFB	4,084.13	4,085.29	44	35.3	HAFB	
HAFB S10MW4	17S.08E.13.221	HAFB	na	4,081.31	20	9.1	HAFB	
T 04428	16S.09E.36.131	USBR	na	na	1,345	135.0	NMOSE WATERS	
T 04428 S	16S.09E.36.131	USBR	na	na	195	54.0	NMOSE WATERS	
T 04428 S-3	16S.09E.36.114	USBR	na	na	225	65.0	NMOSE WATERS	
T 04428 S-4	16S.09E.36.113	USBR	na	na	215	60.0	NMOSE WATERS	

ft bgl - feet below ground level
USGS - U.S. Geological Survey
WSMR - White Sands Missile Range
HAFB - Holloman Air Force Base
USBR - U.S. Bureau of Reclamation

NMED - New Mexico Environment Department
PSTB - Petroleum Storage Tank Bureau
NMOSE - New Mexico Office of the State Engineer
na - not available

There are likely additional data available for the monitoring wells to survey that could be obtained from the owner, otherwise field visits would be required to collect background information on the monitoring points.

6.2 Database Update

The primary database updates would be related to the wells associated with the recommended regional groundwater monitoring program. It is not recommended to update the water rights database, unless the Tularosa Basin is adjudicated and the court-recognized water rights are inventoried.

Water-level data could be requested, if collected by owner, or access would be required to collect independent measurements. The wells owned by Holloman AFB and White Sands Missile Range are likely monitored on a regular basis and the water-level history could be requested and updated as it becomes available. Several of the Holloman AFB wells are located along the Lost River and would provide excellent data for assessing seasonal and long-term water-level trends along the Lost River and east of the Jarilla Fault. The USBR wells (T-4428 through T-4428-S-4) would provide data for assessing the vertical hydraulic gradients in the basin-fill aquifer.

7.0 REFERENCES

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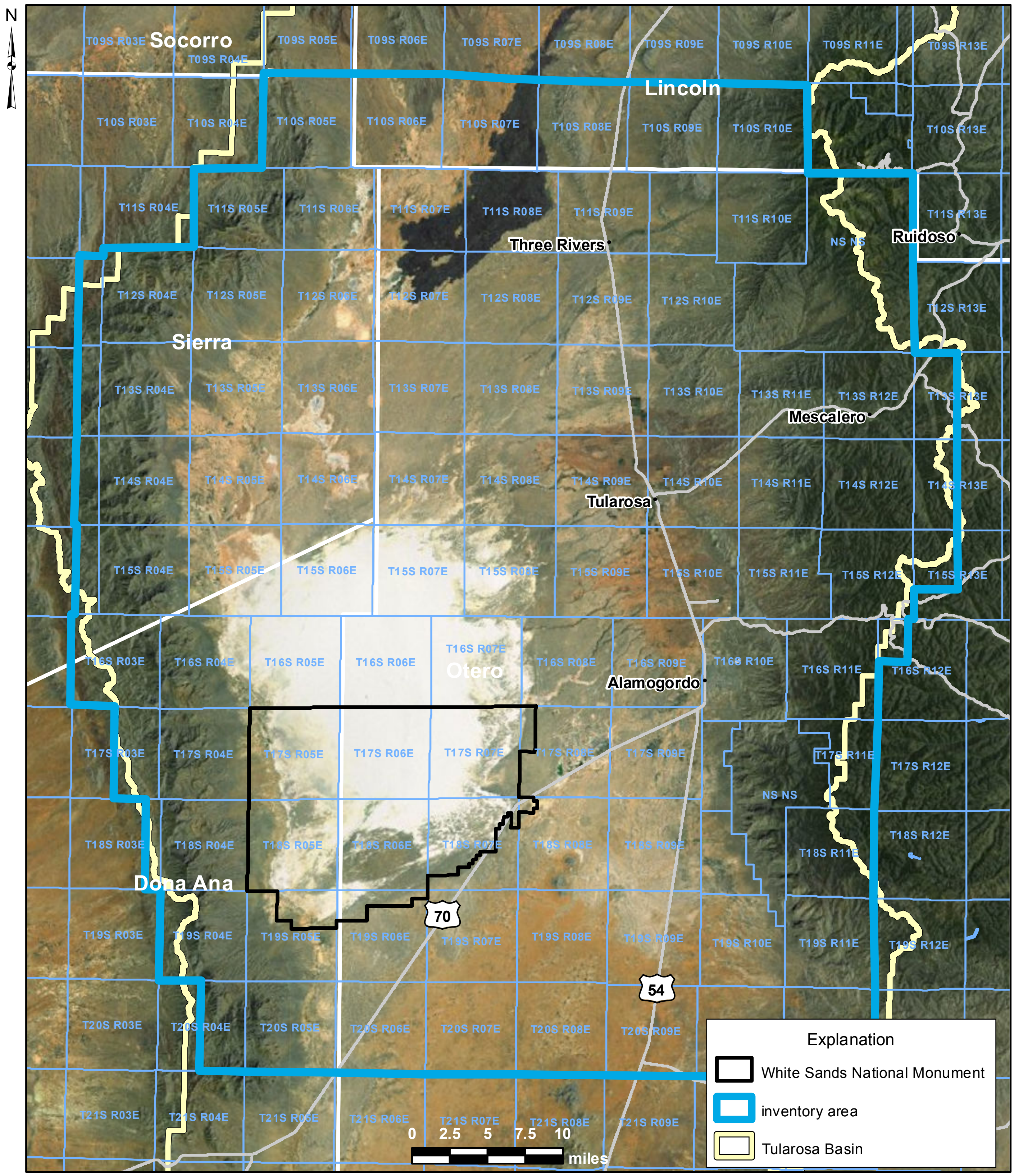
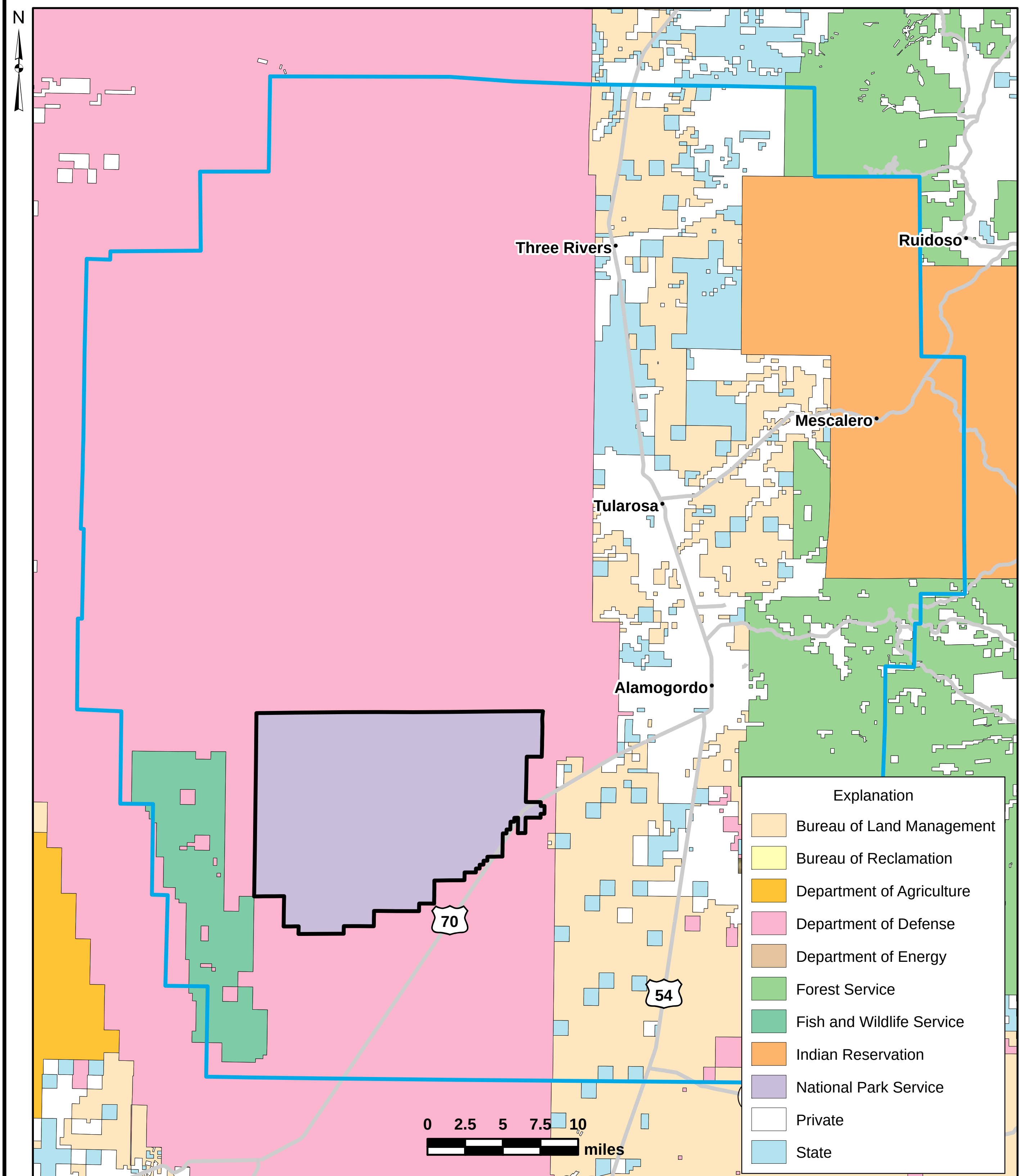
ILLUSTRATIONS



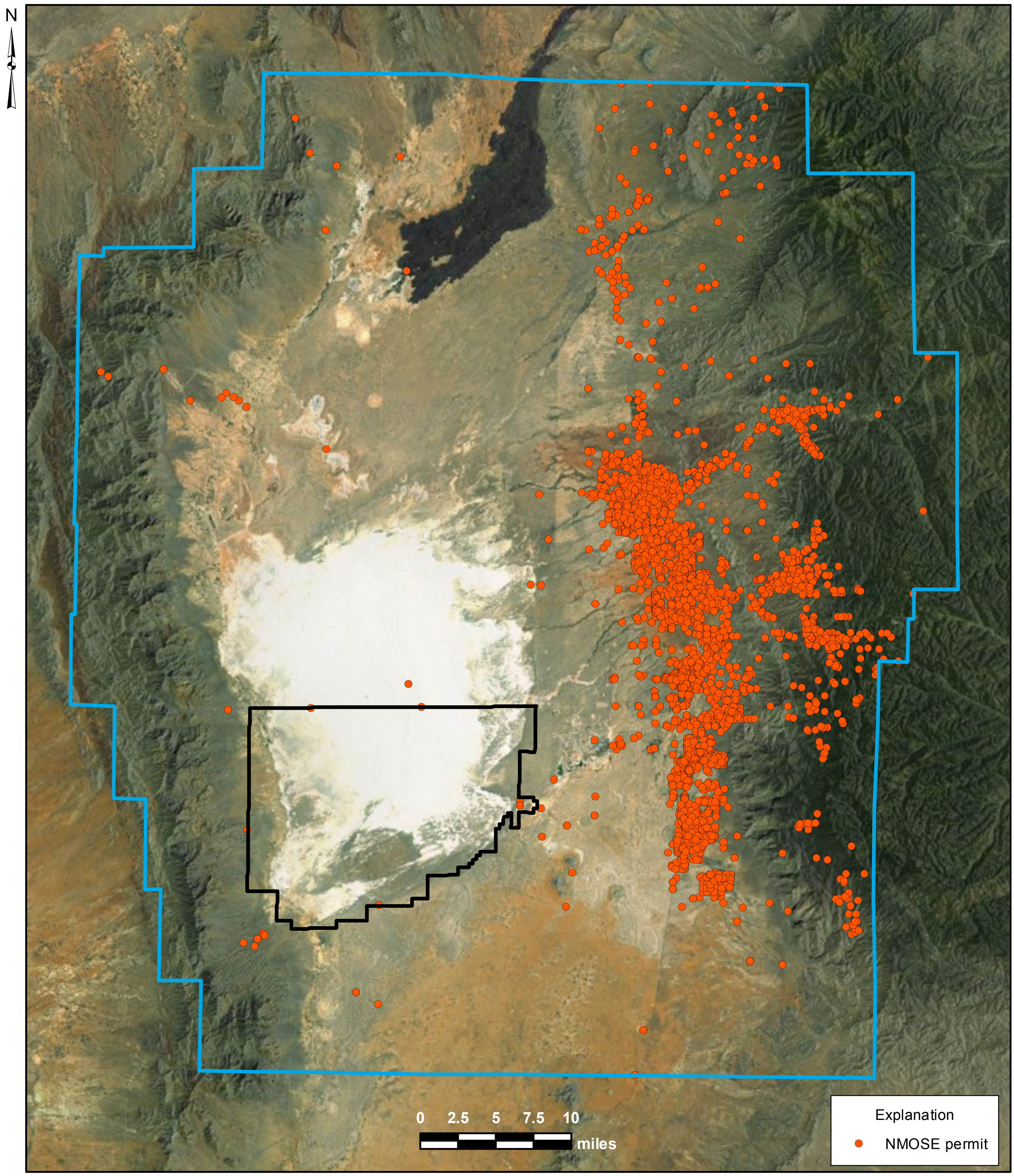
Source: ESRI i-cubed imagery, 2009.

Figure 1. Aerial photograph showing White Sands National Monument groundwater database inventory boundary, Tularosa Basin, New Mexico.



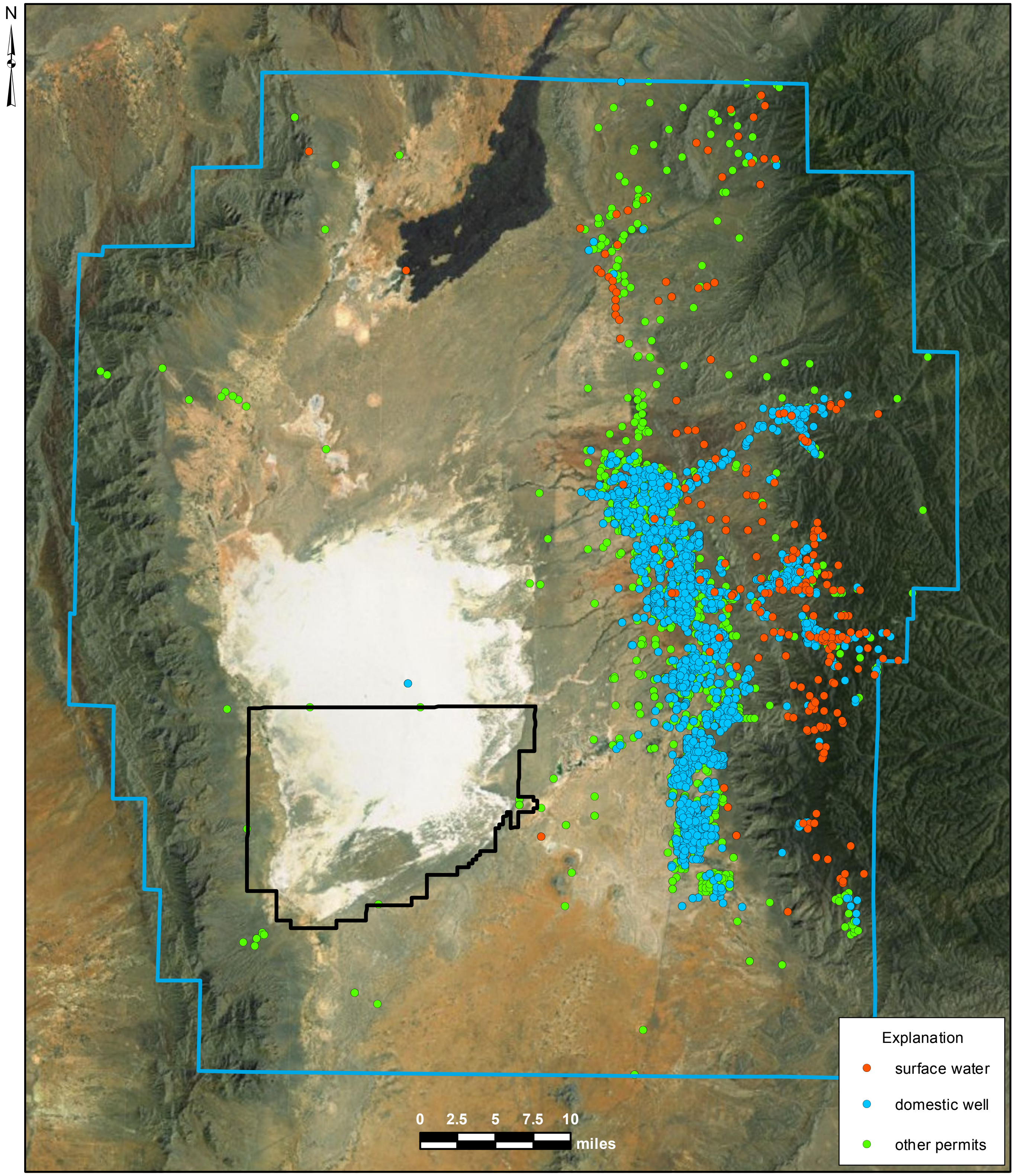
Source: Bureau of Land Management.

Figure 2. Land ownership map for the White Sands National Monument groundwater database inventory area, Tularosa Basin, New Mexico.



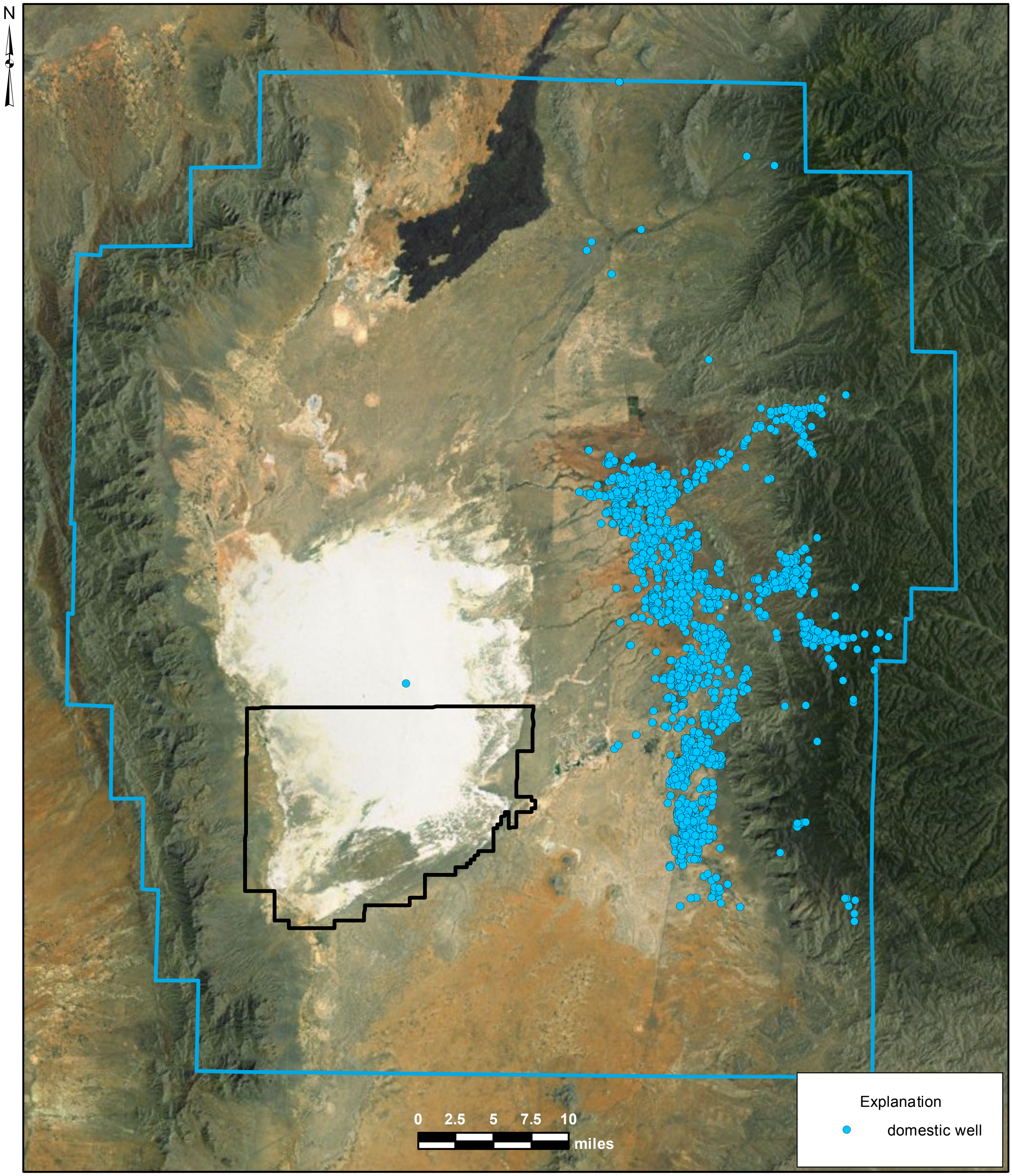
Source: ESRI i-cubed imagery, 2009.

Figure 3. Aerial photograph showing locations of NMOSE permitted points of diversion identified in the database inventory area, Tularosa Basin, New Mexico.



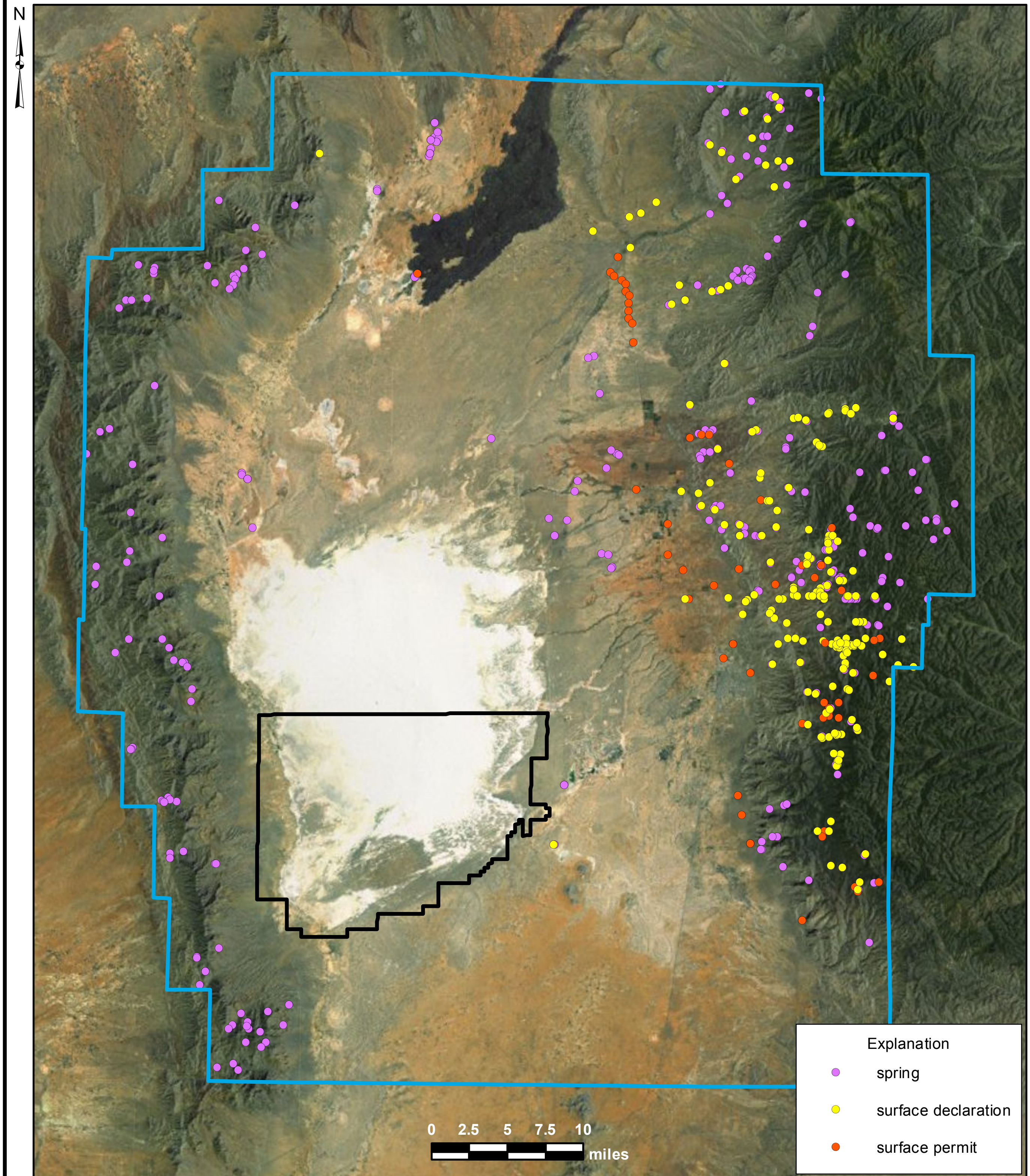
Source: ESRI i-cubed imagery, 2009.

Figure 4. Aerial photograph showing locations of domestic, surface water, and other (agriculture, industrial, and municipal) NMOSE permitted points of diversion identified in the database inventory area, Tularosa Basin, New Mexico.



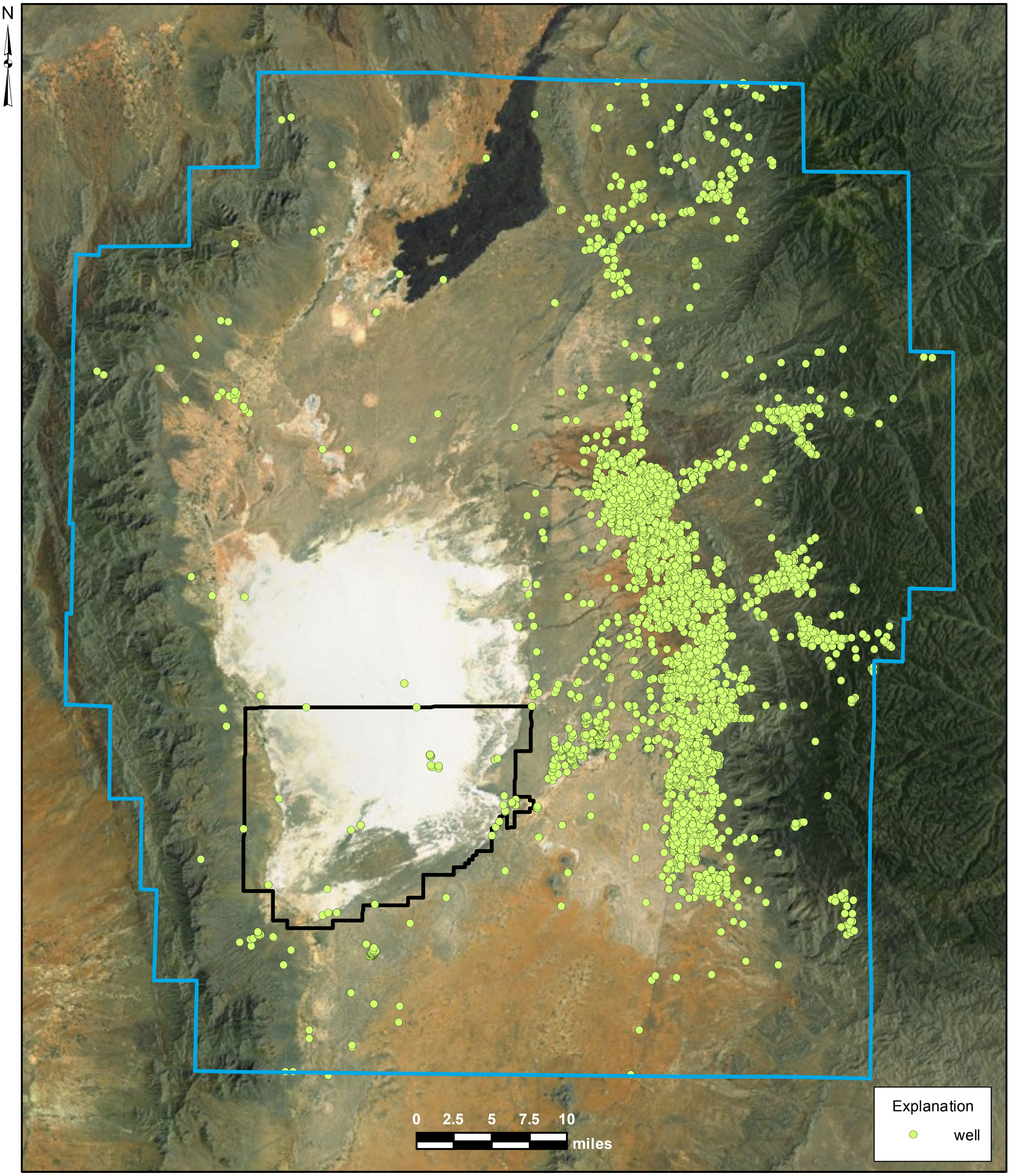
Source: ESRI i-cubed imagery, 2009.

Figure 5. Aerial photograph showing locations of NMOSE permitted domestic wells identified in the database inventory area, Tularosa Basin, New Mexico.



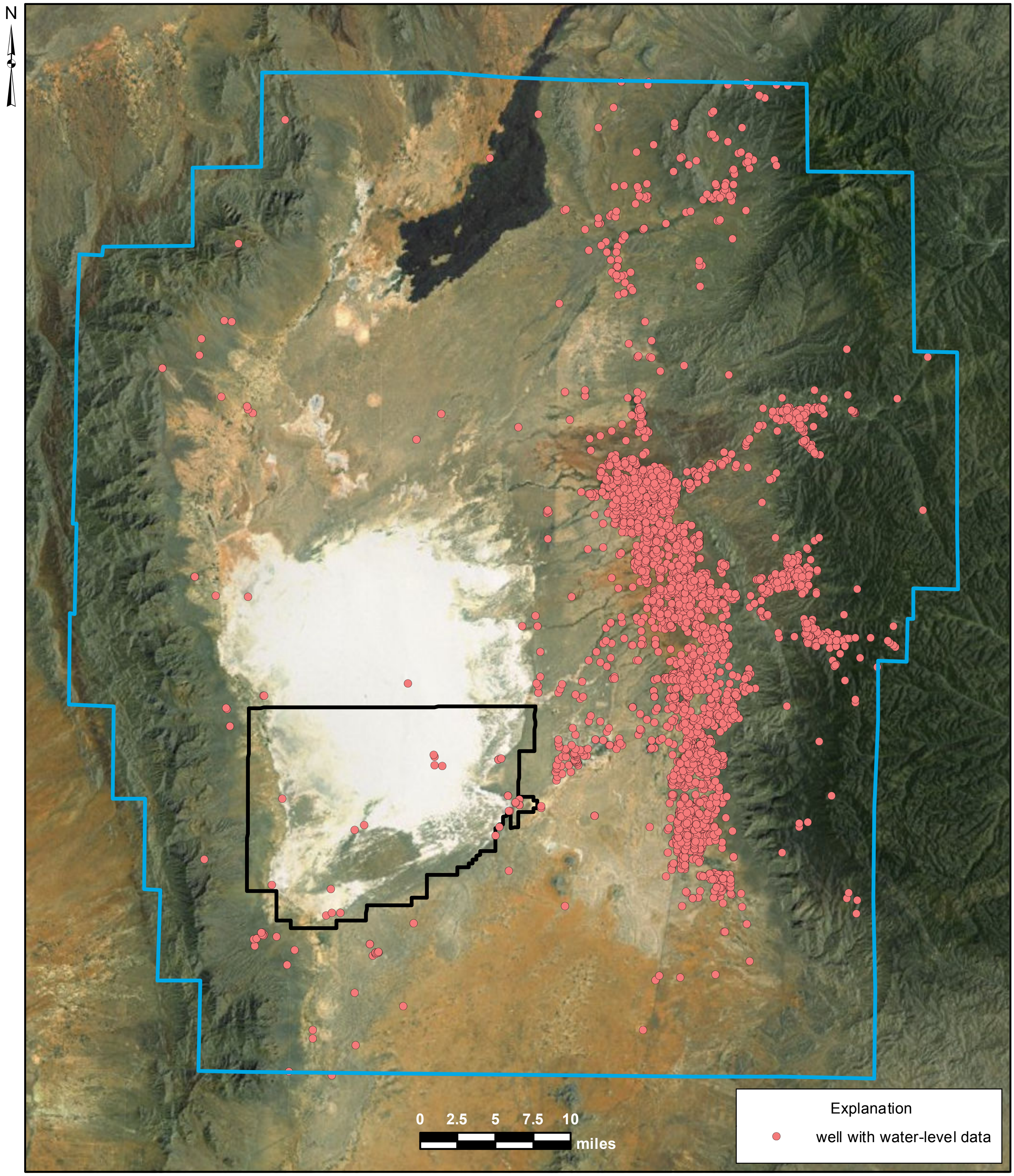
Source: ESRI i-cubed imagery, 2009.

Figure 6. Aerial photograph showing locations of springs and NMOSE permitted surface-water points of diversion identified in the database inventory area, Tularosa Basin, New Mexico.



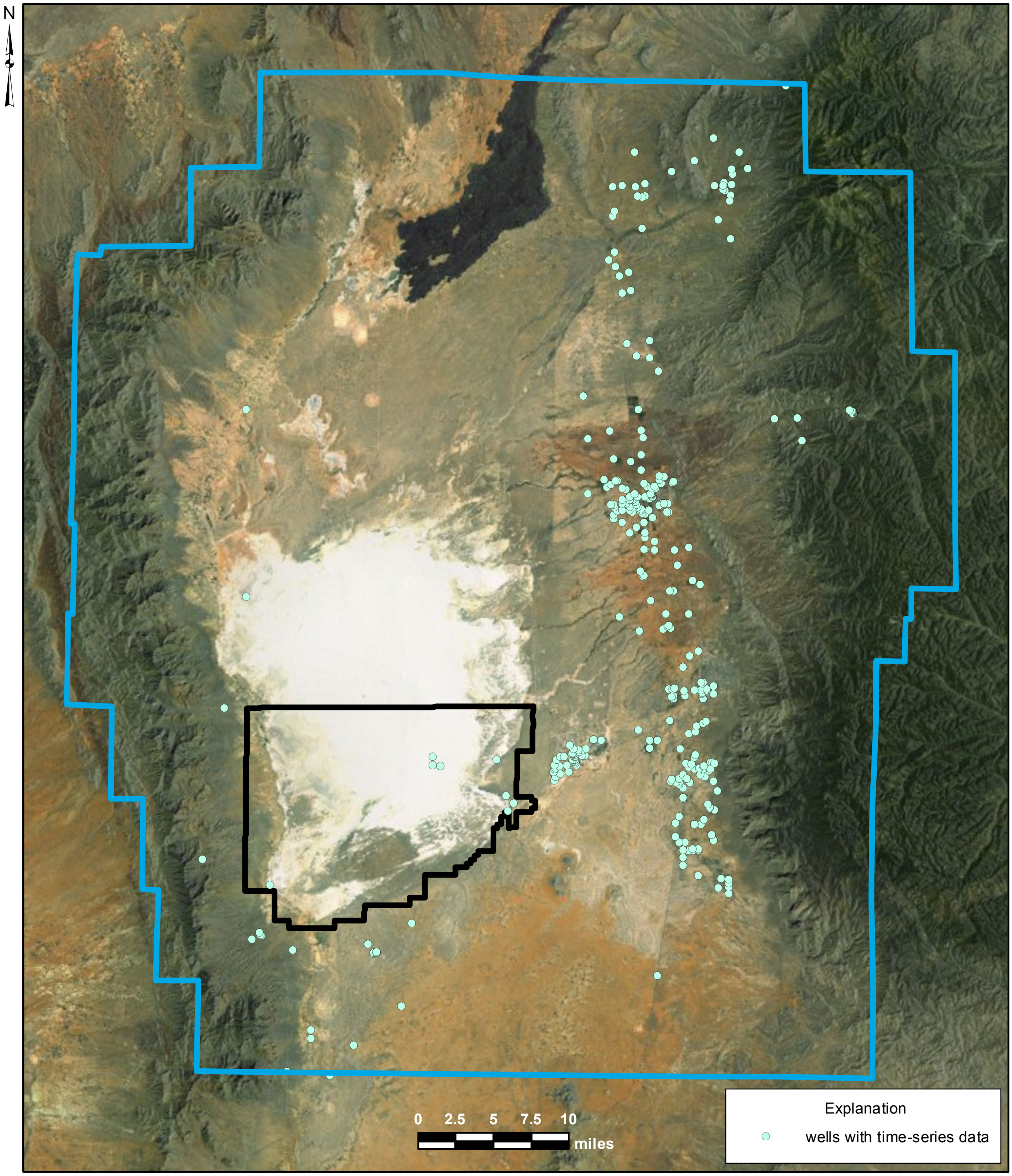
Source: ESRI i-cubed imagery, 2009.

Figure 7. Aerial photograph showing locations of wells identified in the database inventory area, Tularosa Basin, New Mexico.



Source: ESRI i-cubed imagery, 2009.

Figure 8. Aerial photograph showing locations of wells with water-level data identified in the database inventory area, Tularosa Basin, New Mexico.



Source: ESRI i-cubed imagery, 2009.

Figure 9. Aerial photograph showing locations of wells with time-series water-level data identified in the database inventory area, Tularosa Basin, New Mexico.

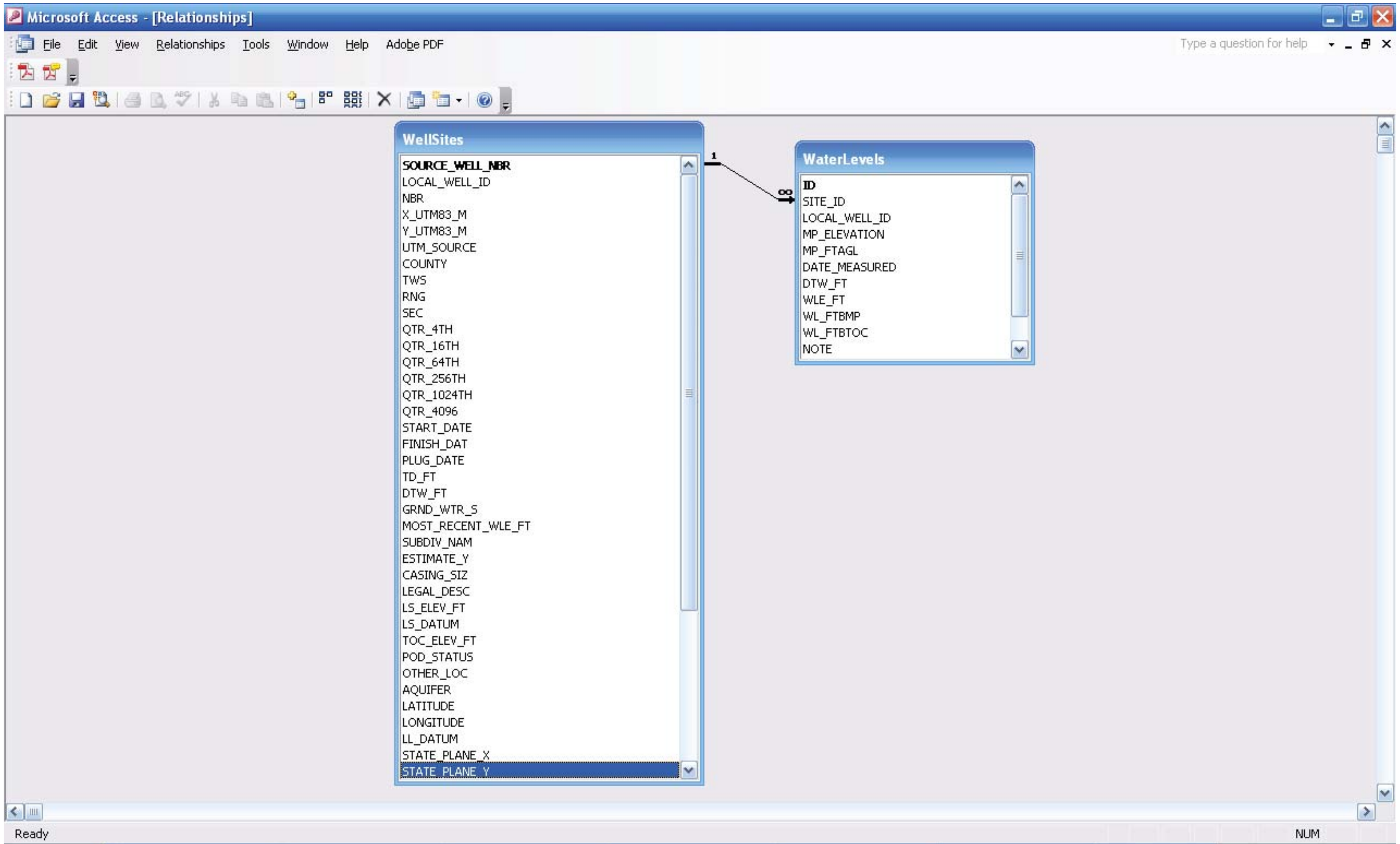
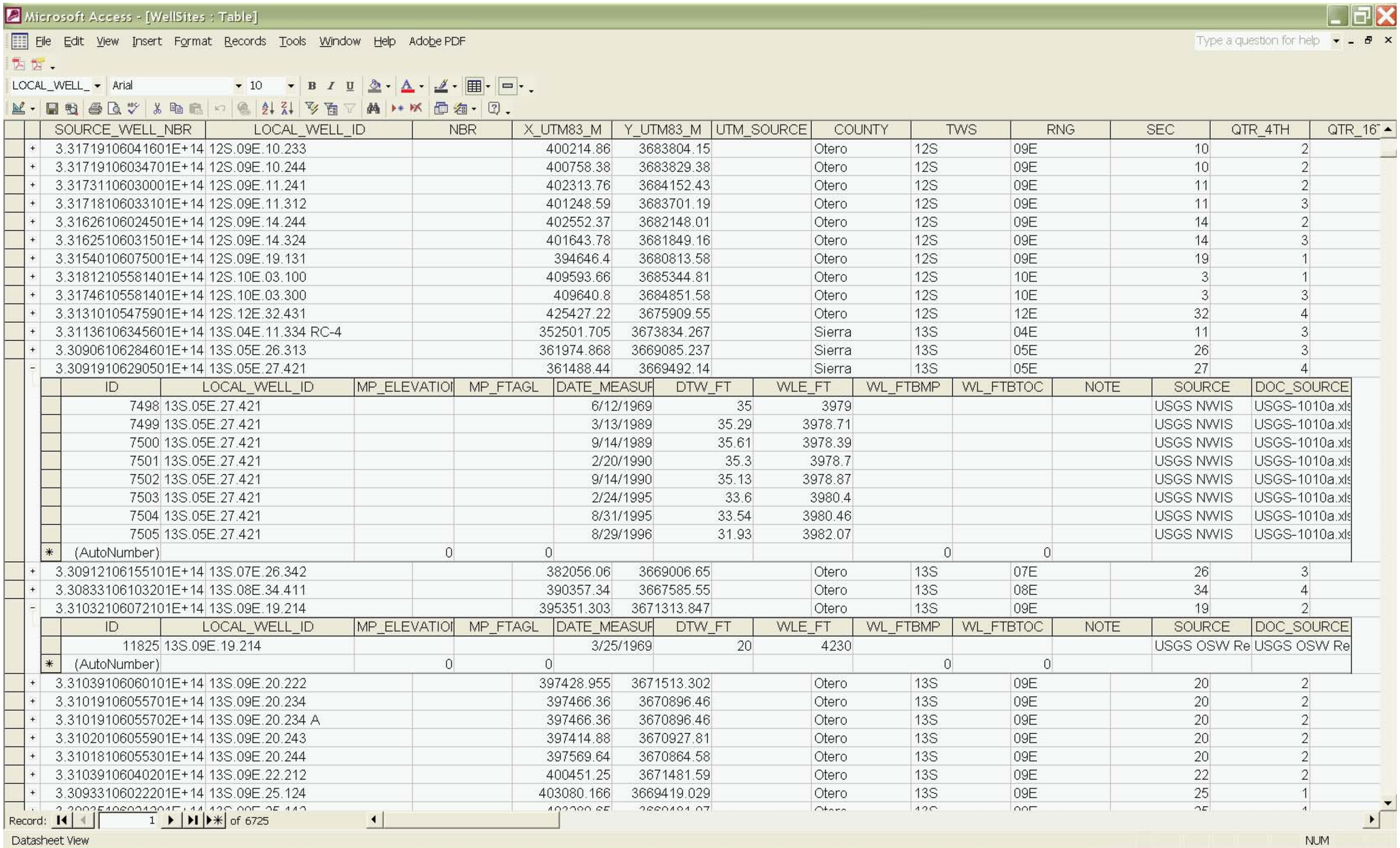


Figure 10. A view of the relationships between the data tables defined in the Access database.



	SOURCE_WELL_NBR	LOCAL_WELL_ID	NBR	X_UTM83_M	Y_UTM83_M	UTM_SOURCE	COUNTY	TWS	RNG	SEC	QTR_4TH	QTR_16
+	3.31719106041601E+14	12S.09E.10.233		400214.86	3683804.15		Otero	12S	09E	10	2	
+	3.31719106034701E+14	12S.09E.10.244		400758.38	3683829.38		Otero	12S	09E	10	2	
+	3.31731106030001E+14	12S.09E.11.241		402313.76	3684152.43		Otero	12S	09E	11	2	
+	3.31718106033101E+14	12S.09E.11.312		401248.59	3683701.19		Otero	12S	09E	11	3	
+	3.31626106024501E+14	12S.09E.14.244		402552.37	3682148.01		Otero	12S	09E	14	2	
+	3.31625106031501E+14	12S.09E.14.324		401643.78	3681849.16		Otero	12S	09E	14	3	
+	3.31540106075001E+14	12S.09E.19.131		394646.4	3680813.58		Otero	12S	09E	19	1	
+	3.31812105581401E+14	12S.10E.03.100		409593.66	3685344.81		Otero	12S	10E	3	1	
+	3.31746105581401E+14	12S.10E.03.300		409640.8	3684851.58		Otero	12S	10E	3	3	
+	3.31310105475901E+14	12S.12E.32.431		425427.22	3675909.55		Otero	12S	12E	32	4	
+	3.31136106345601E+14	13S.04E.11.334 RC-4		352501.705	3673834.267		Sierra	13S	04E	11	3	
+	3.30906106284601E+14	13S.05E.26.313		361974.868	3669085.237		Sierra	13S	05E	26	3	
-	3.30919106290501E+14	13S.05E.27.421		361488.44	3669492.14		Sierra	13S	05E	27	4	

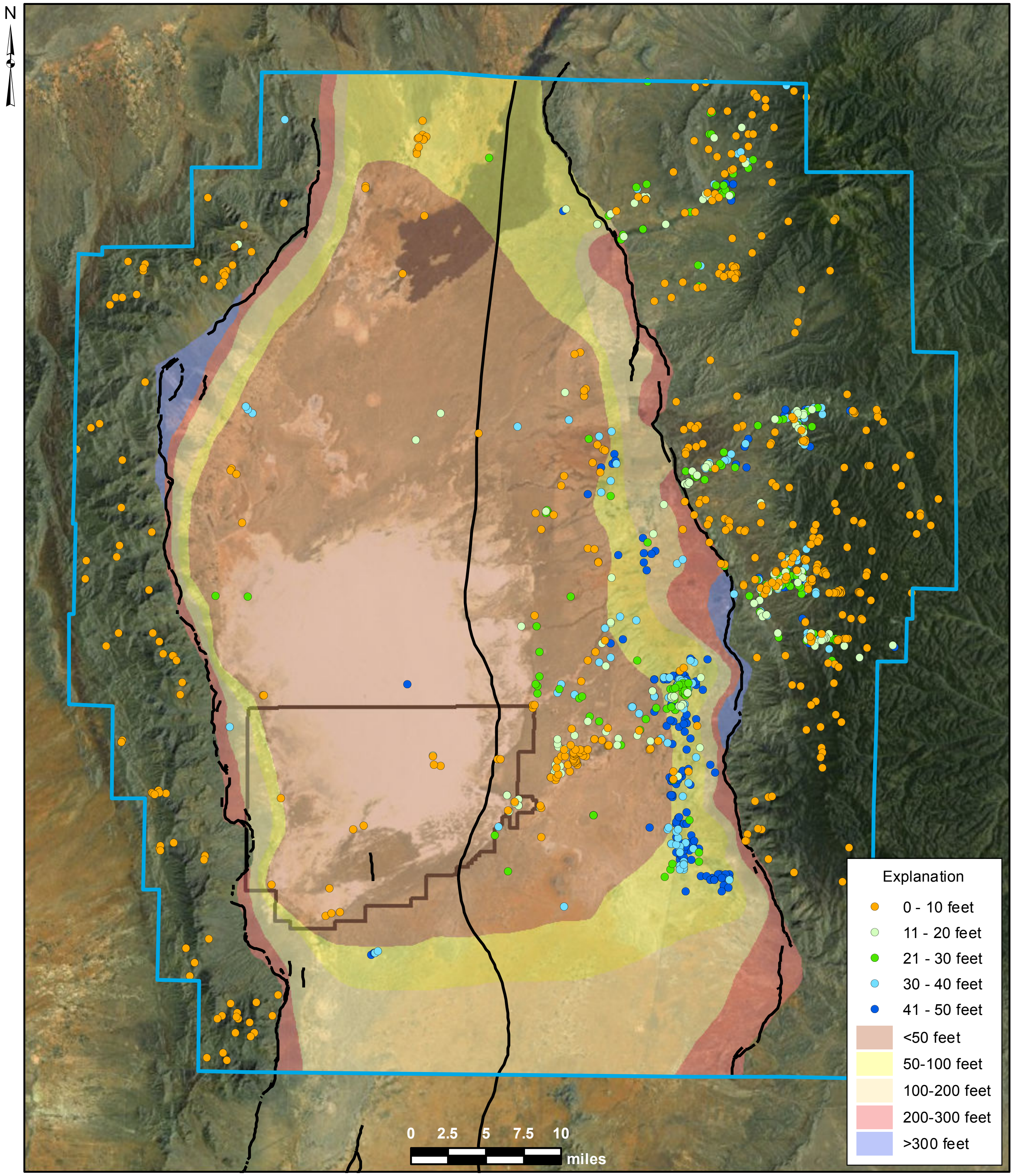
ID	LOCAL_WELL_ID	MP_ELEVATIO	MP_FTAGL	DATE_MEASUF	DTW_FT	WLE_FT	WL_FTBMP	WL_FTBTOC	NOTE	SOURCE	DOC_SOURCE
7498	13S.05E.27.421			6/12/1969	35	3979				USGS NWIS	USGS-1010a.xls
7499	13S.05E.27.421			3/13/1989	35.29	3978.71				USGS NWIS	USGS-1010a.xls
7500	13S.05E.27.421			9/14/1989	35.61	3978.39				USGS NWIS	USGS-1010a.xls
7501	13S.05E.27.421			2/20/1990	35.3	3978.7				USGS NWIS	USGS-1010a.xls
7502	13S.05E.27.421			9/14/1990	35.13	3978.87				USGS NWIS	USGS-1010a.xls
7503	13S.05E.27.421			2/24/1995	33.6	3980.4				USGS NWIS	USGS-1010a.xls
7504	13S.05E.27.421			8/31/1995	33.54	3980.46				USGS NWIS	USGS-1010a.xls
7505	13S.05E.27.421			8/29/1996	31.93	3982.07				USGS NWIS	USGS-1010a.xls
* (AutoNumber)		0	0				0	0			

	SOURCE_WELL_NBR	LOCAL_WELL_ID	NBR	X_UTM83_M	Y_UTM83_M	UTM_SOURCE	COUNTY	TWS	RNG	SEC	QTR_4TH	QTR_16
+	3.30912106155101E+14	13S.07E.26.342		382056.06	3669006.65		Otero	13S	07E	26	3	
+	3.30833106103201E+14	13S.08E.34.411		390357.34	3667585.55		Otero	13S	08E	34	4	
-	3.31032106072101E+14	13S.09E.19.214		395351.303	3671313.847		Otero	13S	09E	19	2	

ID	LOCAL_WELL_ID	MP_ELEVATIO	MP_FTAGL	DATE_MEASUF	DTW_FT	WLE_FT	WL_FTBMP	WL_FTBTOC	NOTE	SOURCE	DOC_SOURCE
11825	13S.09E.19.214			3/25/1969	20	4230				USGS OSW Re	USGS OSW Re
* (AutoNumber)		0	0				0	0			

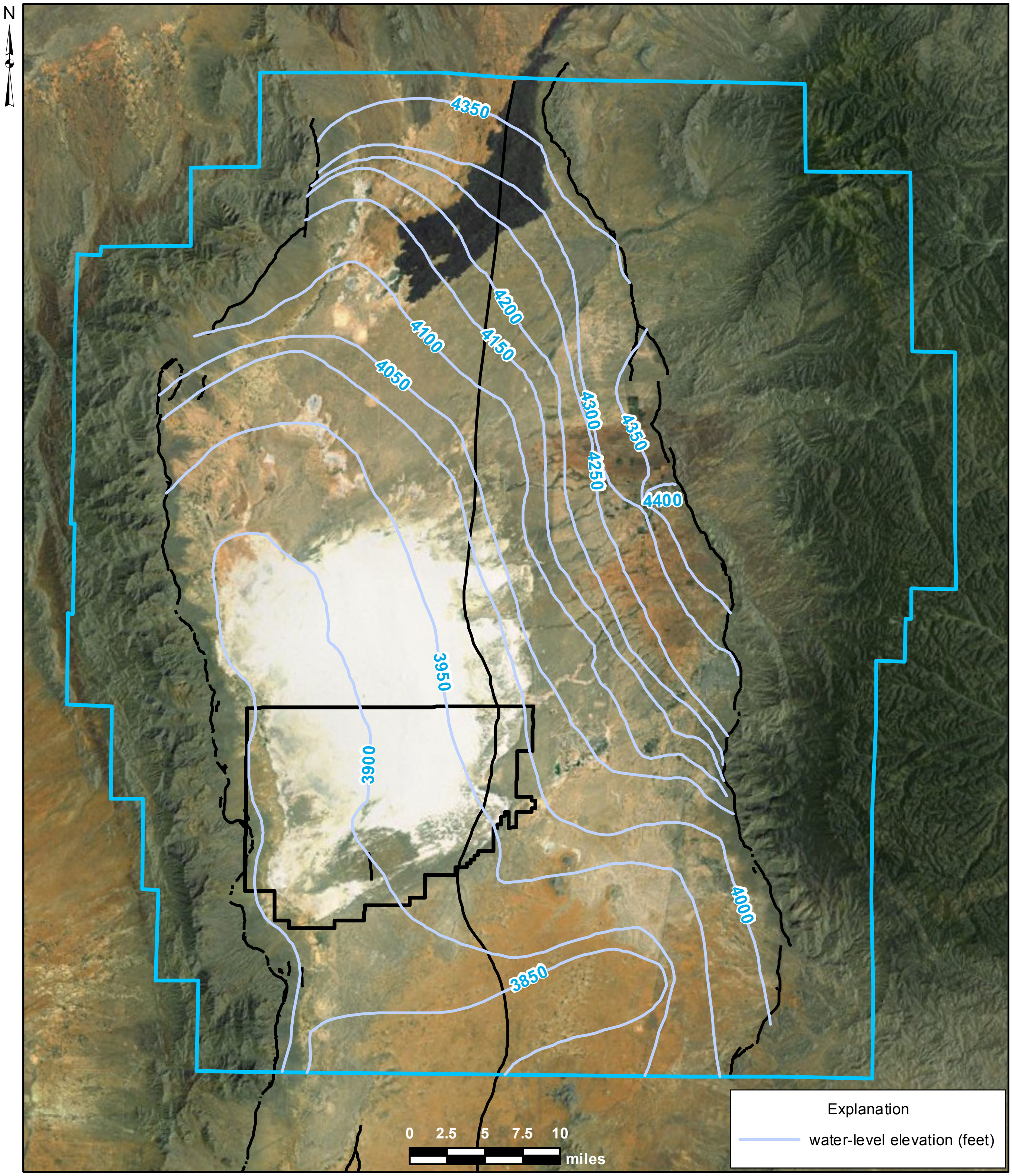
	SOURCE_WELL_NBR	LOCAL_WELL_ID	NBR	X_UTM83_M	Y_UTM83_M	UTM_SOURCE	COUNTY	TWS	RNG	SEC	QTR_4TH	QTR_16
+	3.31039106060101E+14	13S.09E.20.222		397428.955	3671513.302		Otero	13S	09E	20	2	
+	3.31019106055701E+14	13S.09E.20.234		397466.36	3670896.46		Otero	13S	09E	20	2	
+	3.31019106055702E+14	13S.09E.20.234 A		397466.36	3670896.46		Otero	13S	09E	20	2	
+	3.31020106055901E+14	13S.09E.20.243		397414.88	3670927.81		Otero	13S	09E	20	2	
+	3.31018106055301E+14	13S.09E.20.244		397569.64	3670864.58		Otero	13S	09E	20	2	
+	3.31039106040201E+14	13S.09E.22.212		400451.25	3671481.59		Otero	13S	09E	22	2	
+	3.30933106022201E+14	13S.09E.25.124		403080.166	3669419.029		Otero	13S	09E	25	1	

Figure 11. Datasheet view of the ‘WellSites’ table showing how location data can be viewed with associated water-level measurment records for the location from the ‘WaterLevels’ table.



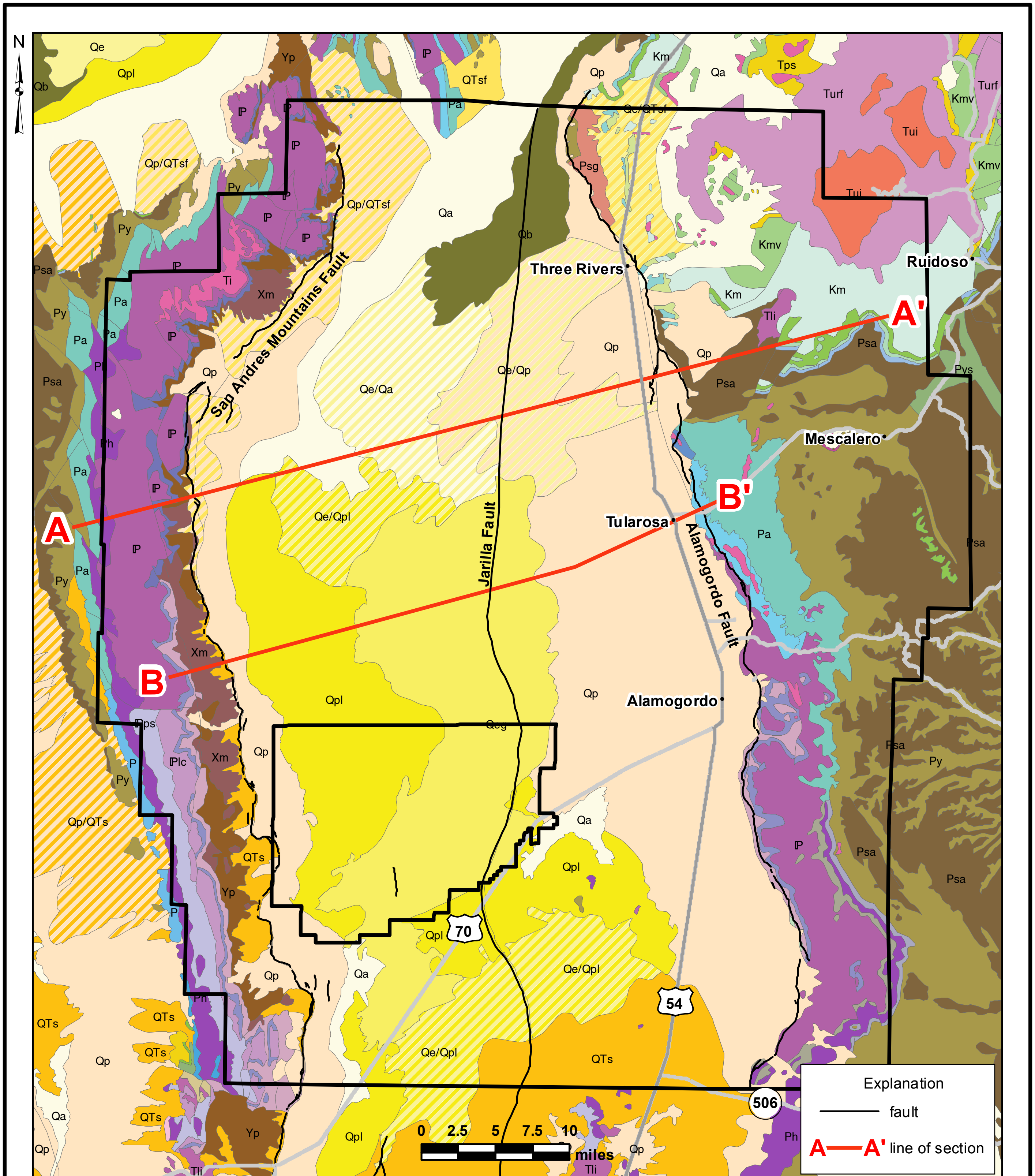
Source: ESRI i-cubed imagery, 2009.

Figure 12. Aerial photograph showing depth to water for the database inventory area, Tularosa Basin, New Mexico.



Source: ESRI i-cubed imagery, 2009.

Figure 13. Aerial photograph showing water-level elevation contours for the database inventory area, Tularosa Basin, New Mexico.



Source: USGS OF-97-52, 1997

Figure 14. Map showing general geology of the study area, Tularosa Basin, New Mexico. See Figure 14b for unit descriptions. See Figure 15 for cross-sections A - A' and B - B'.

UNIT DESCRIPTION

Quaternary

Qa	Alluvium
Qe	Eolian deposits
Qeg	Gypsiferous eolian deposits
Qpl	Lacustrine and playa-lake deposits
Qp	Piedmont alluvial deposits
Qb	Basalt and andesite flows

interbedded units

- Qe/QTsf
- Qe/Qa
- Qe/Qp
- Qe/Qpl
- Qp/QTsf
- Qp/QTs

Quaternary and Tertiary

QTsf	Santa Fe Group
QTs	Upper Santa Fe Group

Tertiary

Turf	Upper Oligocene silicic flows, domes, and associated pyroclastic rocks
Ti	Tertiary intrusive rocks, undifferentiated
Tui	Miocene to Oligocene silicic to intermediate intrusive rocks
Tli	Intermediate to felsic dikes and plugs of Oligocene and Eocene age
Tla	Lower Tertiary (Lower Oligocene and Eocene) andesite and basaltic andesite flows and associated volcaniclastic units
Tps	Poison Canyon Formation

Cretaceous

K	Cretaceous rocks, undivided
Kmv	Mesaverde Group
Km	Mancos Shale
Kd	Dakota Sandstone
Kdg	Dakota Group
Kbm	Mancos Formation and Beartooth Quartzite

Triassic

TRc	Chinle Group
TRm	Moenkopi Formation

Paleozoic

Pz	Paleozoic rocks
P	Permian rocks, undivided
Pat	Artesia Group
Psa	San Andres Formation
Psg	San Andres Limestone and Glorieta Sandstone
Py	Yeso Formation
Pa	Abo Formation
Pau	Upper Abo Formation
Pal	Lower Abo Formation
Pys	Yeso, Glorieta, and San Andres Formations, undivided
Pay	Abo and Yeso Formations, undivided
Ph	Hueco Formation
Pb	Bursum Formation
Pℙ	Permian and Pennsylvanian rocks, undivided
ℙ	Pennsylvanian rocks, undivided
ℙps	Panther Seep Formation
ℙlc	Lead Camp Formation
MD	Mississippian and Devonian rocks, undivided
MꞒ	Mississippian through Cambrian rocks, undivided
SOꞒ	Silurian through Cambrian rocks, undivided
OꞒ	Ordovician and Cambrian rocks, undivided

Precambrian

Ys	Middle Proterozoic sedimentary rocks
Yp	Middle Proterozoic plutonic rocks (younger than 1600 Ma)
Xm	Lower Proterozoic metamorphic rocks (1650 - 1700+ Ma)

Source: USGS OF-97-52, 1997

Figure 14b. Geologic unit descriptions, Tularosa Basin, New Mexico.

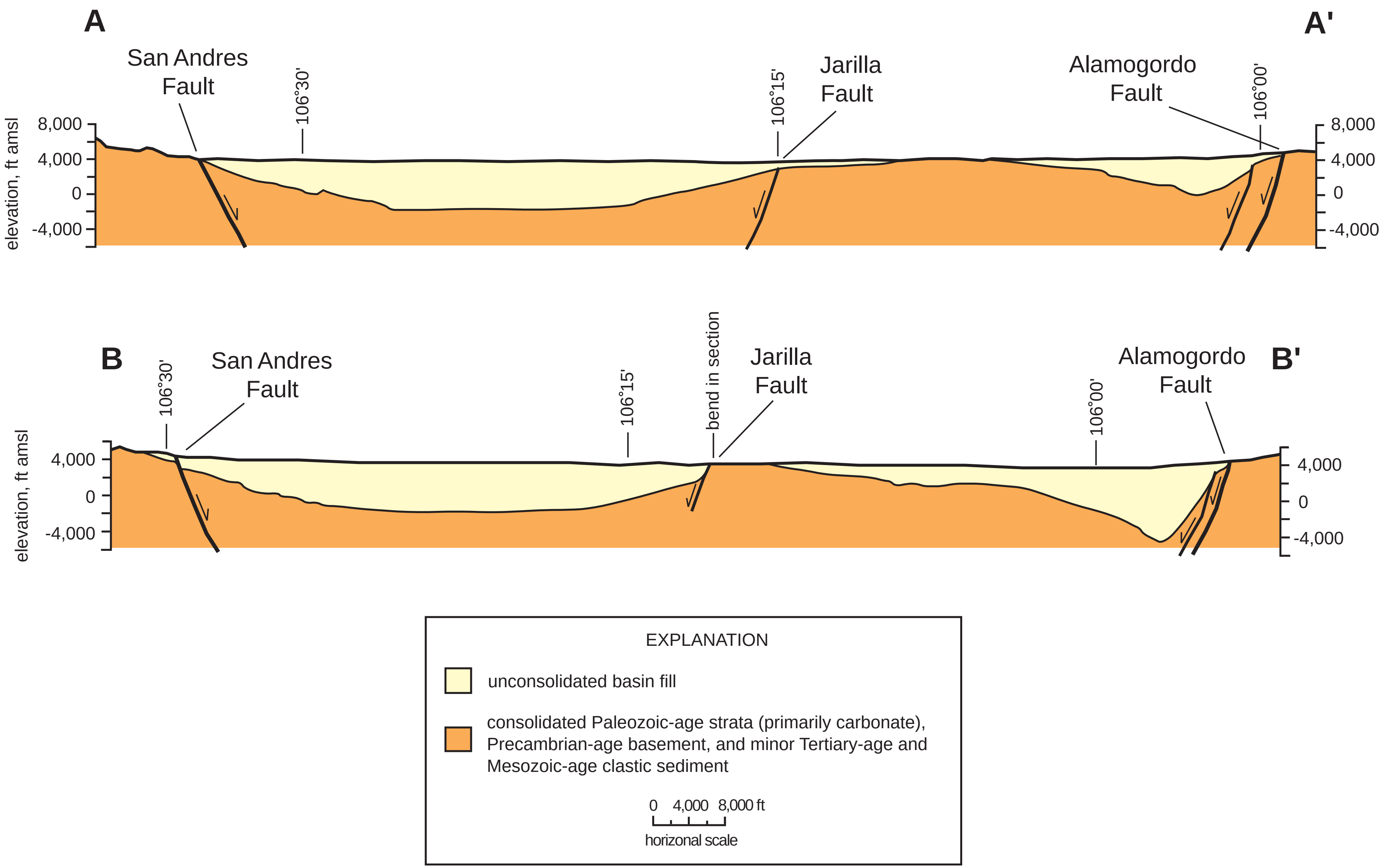


Figure 15. Hydrogeologic cross-sections A-A' and B-B', Tularosa Basin (modified from Healy et al., 1978). See Figure 14 for lines of section.

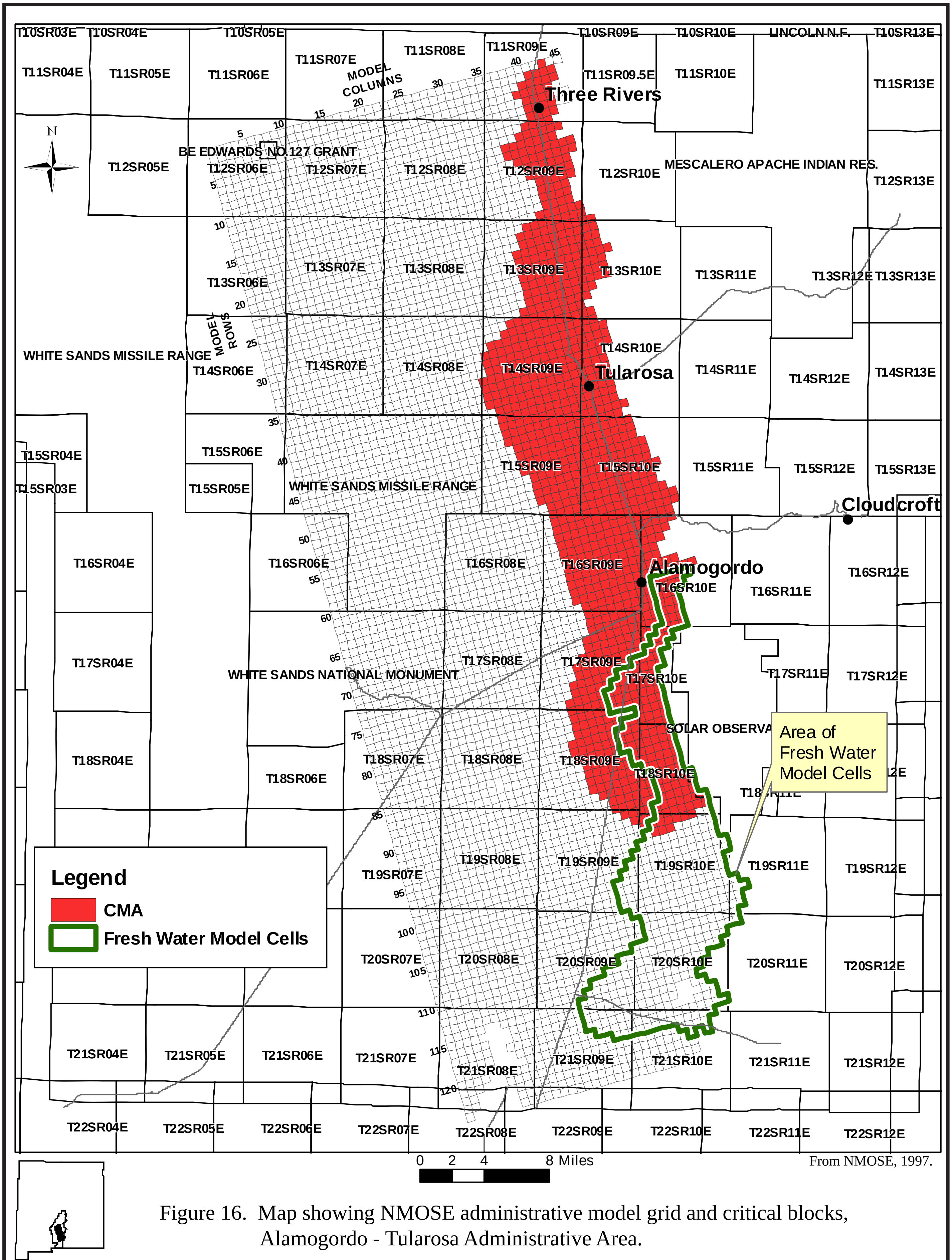
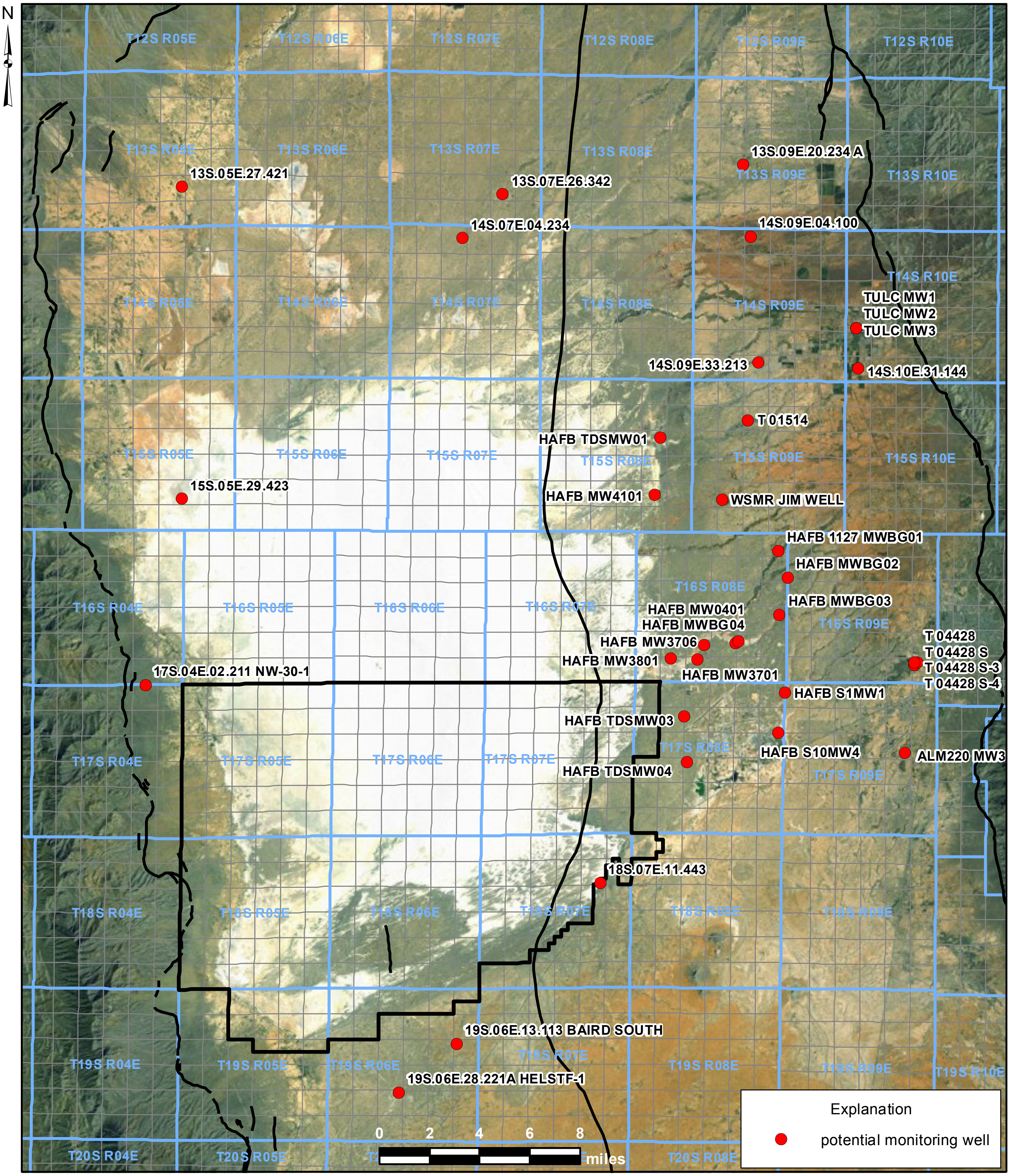


Figure 16. Map showing NMOSE administrative model grid and critical blocks, Alamogordo - Tularosa Administrative Area.



Source: ESRI i-cubed imagery, 2009.

Figure 17. Aerial photograph showing water-level monitoring wells within the database inventory area that are recommended for assessing groundwater conditions outside of the White Sands National Monument Boundary, Tularosa Basin, New Mexico.

APPENDICES

Appendix A.

Proposed Scope of Work

E. SCOPE OF WORK AND PROJECT APPROACH

The scope of work is well defined in the White Sands National Monument Request for Quotation Q7810100041 documents. The inventory area is described by location and by illustration in the Scope of Work, and generally includes the Eastern and Western portions of the Tularosa Basin defined in the Tularosa Basin Regional Water Plan. JSAI understands the project objective is to compile an inventory of existing water rights, water wells, and groundwater elevation data for the inventory area.

Task 1. Water-Rights Records Research and Compilation

JSAI will use available existing water-rights databases developed from previous projects as a starting point for the water-rights records research and compilation. Water-rights information will be obtained from the New Mexico Office of the State Engineer (NMOSE) WATERS online database, and from the NMOSE District Office in Las Cruces. Information from these two sources will be merged into a database.

The Scope of Work includes compiling a water-rights database containing information on owner name, water-rights permit number, source, priority date, quantity, rate, point of diversion, point of use, beneficial use, and period of use. It is our understanding that beneficial use is referring to purpose of use assigned to the water right and not the quantity of water that has been put to beneficial use. Details regarding priority date, beneficial use, and period of use are typically not readily available, and vast amounts of time and resources could be spent quantifying unmetered use such as irrigated agriculture. JSAI will limit this task to readily available, data, reports, and documents regarding water use.

A great number of water-rights files pertain to domestic well permits. The WATERS database will list all domestic well permits regardless if the water well was never drilled, if the permit expired, or if the well was drilled and the permit expired. JSAI will make a best effort to sort out domestic well permits to best reflect the number of actual domestic wells drilled in the Inventory Area.

Task 2. Groundwater-Level Records Research and Compilation

JSAI has a great deal of compiled water-level data for the Tularosa Basin stemming from the Regional Water Plan, WSMR study, and the City of Alamogordo Desalination project. Most of the existing water-level data sources compiled come from USGS and NMOSE databases. JSAI will compile publically available data from Holloman Air Force, White Sands National Monument, New Mexico Environment Department Petroleum Storage Tank Bureau sites, and other sources.

In summary, the water-level database will include the following:

- Available well information (as specified in the Scope of Work)
- Time-series data
- Forms and macros to facilitate data viewing and export
- A data dictionary and sources of data (reference)
- Verification of data

JSAI will include a user friendly check list of recommended procedures for using, maintaining, and updating the database. JSAI will not include water-level data lacking proper identification such as location, measuring point elevation, and well depth.

Task 3. Create Water-Level Elevation and Depth-to-Water Maps

Water-level elevation and depth-to-water maps will be based on the most current water-level data (references for publically available water-level elevation and depth to water maps based on historical data can be provided). JSAI anticipates White Sands National Monument will request maps representing the following three settings:

1. Regional aquifer depth-to-water and water-level elevation contours for the Inventory Area.
2. Perched aquifer depth-to-water and water-level elevation contours for the Inventory Area.
3. Regional and perched water conditions within White Sands National Monument.

The water-level elevation and depth-to-water contours will be based on hydrogeologic interpretation between points, and will not be generated from a software contouring package. Software contouring packages are notorious for creating errors in contours from datasets not evenly distributed over the subject area. The contours will be digitized and the maps will be made available in digital and hardcopy format.

Task 4. Identification of Monitoring Wells to Survey

The Scope of Work for Task 4 involves identifying the accuracy of survey data for water well measuring points, and requires performing the following:

- Examine well records and identify wells not accurately surveyed.
- Examine the methods used to determine well location and elevation, and include comments on the survey data at each well location.
- Create a list of wells recommended to be surveyed.

The water-level database at WSMR is extensive, and a similar exercise has been performed. It was found that the biggest problem with survey data was not the data, but the documentation of the measuring point reference. JSAI will complete the Scope of Work for Task 4 using available data and information. It is our understanding that this task does not include field checks of each well and its measuring point reference.

Appendix B.

DVD Containing Electronic Copy of Final Database

Appendix C.

Data Dictionary

APPENDIX C.

DATA DICTIONARY

The White Sands National Monument Groundwater Database consists of two data tables:

- WellSites
- WaterLevels

THE 'WellSites' TABLE

The 'WellSites' table contains information related to 6,725 well and spring locations. The fields (columns) in the table are listed below along with a description of the data included in each field and any codes used. Source files are included in Appendix B.

SOURCE_WELL_NBR — This field is a unique identifier for each sampling point. No duplicates are allowed in this field and it is not allowed to be blank. It is the 'primary key' field in the database that links the related water-level measurement for each location in the 'WaterLevels' table. Locations derived from NMOSE WATERS and eGIS and the USGS National Hydrography Dataset retain the identifier from those sources. Identifiers for USGS NWIS data points are numeric concatenations of the latitude and longitude, with no symbols or spaces followed by a sequential number starting with 01 (e.g., the first well located at 36º 4' 5" latitude, 105º 57' 2" longitude would be represented as 360405105570201 and a second well at that location would be 360405105570202, etc.). Identifiers for data from all other sources follow the USGS convention. A value must be created for a new sampling point in order to add that location to the database.

LOCAL_WELL_ID

The common name for the location. NMOSE locations are identified by the Water Right File Number for the site with the prefix 'T' for the Tularosa Basin, 'SD' for Surface Declaration, or 'SP' for Surface Permit. USGS NWIS data points are identified by the concatenated PLSS description: township, range, section, 1/4 section, 1/16 section, 1/64 section, 1/256 section, 1/1024 section, 1/4096 section (e.g., 10S.09E.20.213 indicates Township 10 South, Range 09 East, Section 20, SW 1/4 of the NW 1/4 of the NE 1/4). Data points from other sources retain the designation in the source data but because so many wells are designated by the same ID number, the locations in the database are preceded by an abbreviated code for the site, e.g., BC MW1 indicates MW1 at the Big Chief site. Site prefixes are listed in the table below.

LOCAL_WELL_ID	SITE
ALM	DP-220 Alamagordo Wastewater Treatment Plant
BC	Big Chief
BEKINS	Bekins Moving and Storage
BF	Bar-F No. 15
BOCMS	Brewer Oil Co. - Midtown Shell
CAP	CAP II
HAFB	Holloman Air Force Base
HG	H&G MiniMart
JJMM	J&J MiniMart Store 5
RMC	Richardson Motor Co.
STC	South Town Chevron
TUL	DP-82 Village of Tularosa Wastewater Treatment Plant
TUL66	Former Phillips 66, Tularosa
TULC	Tularosa Chevron
WHSA	White Sands National Monument
WSMR	White Sands Missile Range

NBR

This field is populated for records (rows) from the NMOSE WATERS database with the NMOSE Water Right File Number. For records from the USGS National Hydrography Dataset, the ‘NBR’ is the Geographic Names Information System (GNIS) ID number.

X_UTM83_M This is the easting coordinate of the sampling location in Universal Transverse Mercator (UTM) 1983 projection, Zone 13 North, in meters. Coordinates may be provided by the water permit applicant, derived from field work, estimated from Google Earth, or calculated from the PLSS description, from latitude and longitude, from State Plane Central Zone values, or from lot and block information.

Y_UTM83_M This is the northing coordinate of the sampling location in Universal Transverse Mercator (UTM) 1983 projection, Zone 13 North, in meters. Coordinates may be provided by the water permit applicant, derived from field work, estimated from Google Earth, or calculated from the PLSS description, from latitude and longitude, from State Plane Central Zone values, or from lot and block information.

UTM_SOURCE This field is populated for records from the NMOSE WATERS database with the source of the UTM coordinates. The NMOSE codes used are listed in the table below.

UTM_SOURCE	SOURCE
D	Discrepancy
EG	Measured by the NMOSE with a GPS unit.
EM	Estimated by NMOSE from a photograph.
G	Converted from PLSS description.
PA	Provided by water right permit applicant.
PD	Provided by driller.
UA	Updated by water right permit applicant.
UN	Unknown source

COUNTY County in which the well is located.

TWS Township in which the site is located according to the PLSS description.

RNG Range in which the site is located according to the PLSS description.

SEC Section in which the site is located according to the PLSS description.

QTR_4TH — This field is a numeric code for the quarter section in which the well is located according to the PLSS description. This code corresponds to the section quadrant indicated in the table below.

QTR	QUADRANT
1	Northwest
2	Northeast
3	Southwest
4	Southeast

QTR_16TH — A numeric code for the quarter quarter section in which the well is located according to the PLSS description, using the same codes as for the quarter section shown above.

QTR_64TH — A numeric code for the quarter quarter quarter section in which the well is located according to the PLSS description, using the same codes as for the quarter section shown above.

QTR_256TH — A numeric code for the quarter quarter quarter quarter section in which the well is located according to the PLSS description, using the same codes as for the quarter section shown above.

QTR_1024TH — A numeric code for the quarter quarter quarter quarter quarter section in which the well is located according to the PLSS description, using the same codes as for the quarter section shown above.

QTR_4096TH — A numeric code for the quarter quarter quarter quarter quarter quarter section in which the well is located according to the PLSS description, using the same codes as for the quarter section shown above.

START_DATE — The date the well construction was started. If just the year was reported in the source document, the date is listed as January 1 of that year. If just the month was reported, the day used is the first of that month.

FINISH_DAT — The date of completion of well construction. If just the year was reported in the source document, the date is listed as January 1 of that year. If just the month was reported, the day used is the first of that month.

PLUG_DATE — The date the well was plugged. If just the year was reported in the source document, the date is listed as January 1 of that year. If just the month was reported, the day used is the first of the month.

TD_FT	Total well depth in feet.
DTW_FT	Depth to water in feet. This field stores the most recent measured value for wells with multiple measurements shown in the 'WaterLevels' table. Values in this field may be from historical or recent measurements ranging in date 1900 to 2010. Measurements from the WATERS database are shown to the nearest foot.
GRND_WTR_S	This field is the groundwater source code populated in records from the NMOSE WATERS database using the codes listed in the table below.

GRND_WTR_S	DESCRIPTION
A	Artesian groundwater (confined)
D	Dry
S	Shallow groundwater (unconfined)

MOST_RECENT_WLE_FT	This field shows the most recent water-level elevation for each location, in feet. Where more than one water-level measurement has been recorded for a location, the measurement data are shown in the 'WaterLevels' table. Values in this field may be from historical or recent measurements ranging in date from 1900 to 2010. Water-level elevation may be from the source data or calculated from depth-to-water measurements and the best available land surface or measuring point elevation for the location.
SUBDIV_NAM	The subdivision name when identified in the NMOSE WATERS database.
ESTIMATE_Y	The estimated yield when identified in the NMOSE WATERS database.
CASING_SIZ	Well casing diameter, in inches.
LEGAL_DES	The legal description of the property on which the well is located when indicated in the WATERS database.
LS_ELEV_FT	Land surface elevation, in feet. Elevations may be from surveys or global positioning system (GPS) measurements, or estimated from digital elevation models (DEM), USGS topographic maps, or Google Earth. Locations with data from numerous sources show the elevation that is considered to be most accurate in this field.

LS_DATUM — The vertical reference datum for the land surface elevation.

LS_DATUM	DESCRIPTION
NGVD29	National Geodetic Vertical Datum of 1929
NAVD88	North American Vertical Datum of 1988

TOC_ELEV_FT — The elevation of the top of the well casing, in feet.

POD_STATUS — The status of the Point of Diversion in the NMOSE WATERS database using the codes listed in the table below.

POD_STATUS	DESCRIPTION
ACT	Active well or drilled well
CLW	Changed location of well
INC	Incomplete application
PEN	Pending well log
PLG	Plugged well

OTHER_LOC — Additional location information when provided in the NMOSE WATERS database.

AQUIFER — The aquifer in which the well is completed as indicated in the data source. Designations from the original data source have been maintained even though there is some obvious overlap.

AQUIFER	GEOLOGIC UNIT
Alluvium	Alluvium
Shallow	Shallow
Km	Mancos Shale
Kmv	Mesaverde Group
Pb	Bursum Formation
Permian	Permian undifferentiated
Qal	Quaternary alluvium
TKc	Cub Mountain Formation
Tu	Tertiary igneous rock
110AVMB	Quaternary fill
110BLSN	Bolson fill
110PTODC	Pediment, terrace, and other deposits
313SADR	San Andres Limestone

LATITUDE — Latitude of the well location.

LONGITUDE — Longitude of the well location.

LL_DATUM — Datum of the latitude and longitude.

LL_DATUM	DESCRIPTION
NAD27	North American Datum of 1927
NAD83	North American Datum of 1983

STATE_PLANE_X — The easting coordinate of the well in New Mexico State Plane Central Zone projection system when reported in the source document.

STATE_PLANE_Y — The northing coordinate of the well in New Mexico State Plane Central Zone projection system when reported in the source document.

OWN_LNAME — Last name of the well owner. For locations where the listed owner is a business, the company name is indicated in this field.

OWN_FNAME — First name of the well owner.

ADDR1 — Address of the well owner.

ADDR2 — Additional address information for the well owner.

CITY — City of the well owner.

STATE — State of the well owner.

ZIP — Zip code of the well owner.

USE

The purpose of use of the well when indicated in the NMOSE WATERS database, using the codes listed in the table below.

USE	DESCRIPTION
AGR	Agriculture other than irrigation
COM	Commercial
CON	Construction
DCN	Domestic construction
DOL	72-12-1 domestic and livestock watering
DOM	72-12-1 domestic one household
EXP	Exploration
FGP	Fish and game propogation
GEO	Geothermal borehole
HWY	Highway construction
IND	Industrial
INJ	Injection
IRR	Irrigation
MDW	Community type use -MDWCA, private or commercial supplied
MFG	Manufacturing
MIL	Military - military installation
MIN	Mining or milling or oil
MOB	Mobile home park
MON	Monitoring well
MUL	72-12-1 multiple domestic households
MUN	Municipal - city or county supplied water
NOT	No use of right or POD
OBS	Observation
PDL	Non 72-12-1 domestic and livestock
PDM	Non 72-12-1 domestic
PLS	Non 72-12-1 livestock watering
PMH	Non 72-12-1 multiple household use
POL	Pollution control well
PRO	72-12-1 prospecting or development of natural resource
PUB	72-12-1 construction of public works
SAN	72-12-1 sanitary in conjunction with a commercial use
STK	72-12-1 livestock watering
SUB	Subdivision
UTL	Public utility

TOTAL_DIV

This field is populated for wells in the NMOSE WATERS database and represents the permitted amount of water available to be diverted for beneficial use under a water right permit. Permitted diversion amount generally exceeds actual consumption.

TYPE — This field identifies the location type.

TYPE
Lake
Spring
Surface Declaration
Surface Permit
Well

NOTES — This field contains information specific to the sampling point regarding the method of determining the location, elevation, etc.

SOURCE — The agency that provided the data or the reference publication.

DOC_SOURCE — The source document for the data. Copies of the data files are provided in Appendix B on the DVD that accompanies this report. An effort was made to consolidate data from multiple reports when it was apparent that the reports referred to the same location.

THE 'WaterLevels' TABLE

The 'WaterLevels' table contains 5,403 records of information related to water-level measurements at 955 of the locations listed in the 'WellSites' table. The fields in the table are listed below along with a definition of the data included in each field and any codes used:

ID — A sequential number automatically generated by the Access software for each new record added to the table.

SITE_ID — The unique identifier for each location that matches the 'SOURCE_WELL_NBR' in the 'WellSites' table that is used to link the water-level data. It is the "primary key" for the database and therefore no duplicates are allowed and the field cannot be left blank. Water-level data cannot be entered in the 'WaterLevels' table unless the 'SITE_ID' corresponds to an existing 'SOURCE_WELL_NBR' in the 'WellSites' table. A new record must be created in the 'WellSites' table before associated water-level data can be added to the 'WaterLevels' table. All associated water-level records must also be deleted from the 'WaterLevels' table before the corresponding location record can be deleted from the 'WellSites' table.

LOCAL_WELL_ID	The common name of the location as indicated in the ‘WellSites’ table.
MP_ELEVATION	Elevation, in feet, of the measuring point indicated in the source data.
MP_FTAGL	Distance, in feet, of the measuring point above the ground surface when indicated in the source data.
DATE_MEASURED	Date the water-level measurement was taken. In cases where just the year is indicated in the original source, the date shown is January 1 of that year. When just the month is indicated in the source data, the date shown is the first of the month.
DTW_FT	Depth to water, in feet.
WLE_FT	Water-level elevation, in feet. This is the water-level elevation reported in the original source data. If no water-level elevation was reported, it is calculated from the ground surface or measuring point elevation and the measured depth to water. When discrepancies exist between multiple data sources, an effort has been made to use the data with the highest confidence level. For example, land surface elevations estimated from Digital Elevation Models (DEM) in one source are replaced with surveyed elevations from another source and the derived water-level elevation has been recalculated. Modifications in the data are indicated in the ‘NOTE’ field.
WL_FTBMP	Water level, in feet, below the measuring point when indicated in the source data.
WL_FTBTOC	Water level, in feet, below the top of casing when specified in the source data.
NOTE	This field contains information related to the sampling point or water-level measurement.
SOURCE	The agency that provided the data or the reference publication. When data are combined from more than one source, the modifications are indicated in the ‘NOTE’ field. Duplicate information has been removed.
DOC_SOURCE	The source document for the data. A list of documents is provided below and copies of the source files are included in Appendix B on the DVD accompanying this report.

DOC_SOURCE	SOURCE AGENCY
pod_waters_june2010_Clip.shp	New Mexico Office of the State Engineer (NMOSE) Enterprise Geographic Information System (eGIS) and Water Rights Reporting System database (WATERS)
DP220 Alamogordo WWTP Monitoring.pdf DP82 Tularosa WWTP Monitoring.pdf	New Mexico Environment Department (NMED) Groundwater Quality Bureau (GQB)
Bar-F_No.15_1994_report.pdf Bar-F_No.15_2000-02_report boring sieve 1.pdf Bar-F_No.15_2002.pdf Bar-F_No.15_2007_report.pdf Bekins_Moving_and_Storage _2006-09-25_report.pdf Bekins_Moving_and_Storage _S35C-110102714130.pdf Big_Chief_Store_gw monitoring _12-2007.pdf Brewer_Oil_Co_Midtown_all logs.pdf Brewer_Oil_Co_Midtown_fig 1.pdf Brewer_Oil_Co_Midtown_table 1.pdf CAP_II_GW_Monitoring_Report _5-10-08.doc H&G_Minimart_7_boring logs.pdf H&G_Minimart_HG 10- 22-2009 report.pdf H&G_Minimart_mw-1 log.pdf J&J_Minimart_Store_5_Map and Well information.pdf Richardson_Motor_Co_2006_report.pdf South_Town_Chevron_well_elevation _coordinates.xls South_Town_Chevron_Maps.xls Tularosa_66_well_information_and _maps.pdf Tularosa_Chevron_cover.pdf Tularosa_Chevron_fig_2_contaminant.pdf Tularosa_Chevron_table_analysis.pdf Tularosa_Chevron_table_dtw.pdf Tularosa_Chevron_water_table_elev.pdf	NMED Petroleum Storage Tank Bureau (PSTB)
Otero-Lincoln Seismic Review Report 8-19-2010.pdf NMED_SWB_OteroLincolnRegional Landfill.pdf DogCanyonLandfill.pdf	NMED Solid Waste Bureau (SWB)

DOC_SOURCE (continued)	SOURCE AGENCY (continued)
USGS-1010a.xls	United States Geological Survey (USGS) National Water Inventory System (NWIS)
USGS OSW Report 561	USGS Office of Saline Water Saline Ground-Water Resources of the Tularosa Basin, New Mexico, Research and Development Progress Report No. 561, July 1970, 128 p.
NHDspringsUTM83.shp	USGS National Hydrography Dataset (NHD)
Lake_Holloman.xlsx Lake Holloman MW Map.pdf Holloman Groundwater Monitoring 2003.pdf Holloman Groundwater Monitoring 2003 chemistry.pdf Holloman_Basewide_Background_Study_Revised_Final_120109.pdf	United States Air Force (USAF), Holloman Air Force Base
WSMR_water_monitoring_Jun-98.pdf WSMR_water_monitoring_Aug-99.pdf	USAF, White Sands Missile Range
Barud-Zubillaga, 2000	Barud-Zubillaga, Alberto, 2000: A Conceptual Model of the Hydrogeology of White Sands National Monument, south-central New Mexico, Masters Thesis, University of Texas at El Paso, 154 p.
WHSA_pts.xls	White Sands National Monument

Appendix D.

White Sands National Monument Groundwater Database User Guide

APPENDIX D.

WHITE SANDS NATIONAL MONUMENT GROUNDWATER DATABASE USER GUIDE

GENERAL RECOMMENDATIONS

It is a good practice to always keep an up-to-date backup copy of the database. Unless you have a strong understanding of Microsoft Access, do not modify the structure of the data tables because some changes could lead to an unintended loss of data. Keep a record of the number of records (rows) in each table so that you will realize if data have accidentally been deleted. If this happens you can revert to the latest backup copy of the database.

Access will warn you when you have modified a table's structure and when you are deleting rows of data but if you delete or change data in a table cell there is no back-up. You won't have the option of saving or not saving that kind of change. If you inadvertently change the data in a cell, hit the 'Esc' key before hitting 'Enter' or moving the cursor away from the cell to cancel the change.

NAVIGATING THROUGH THE DATABASE

When you open an Access database, the main Database window shows a list of object categories in a panel on the left side of the screen as shown in Figure D-1 below. These categories are Tables, Queries, Forms, Reports, Macros, Modules, Groups, and Favorites. Clicking a category opens the window with a list of the corresponding objects. When you select the Tables tab in the White Sands National Monument Groundwater Database, you will see the two data tables: 'WellSites' and 'WaterLevels'. The Queries tab shows five sample select queries: 'Water Level Elevations', 'Depth to Water', '2008 Water Levels', 'Non-domestic NMOSE wells', and 'Water Levels 2005 – 2011'. The Forms tab shows the 'Well Site Data Entry Form' and 'subfrmWater Level Measurement Subform'. The Reports tab shows a simple report to view the water-level measurements by location called 'WaterLevelsBySite'. The other possible object types have not been created for this database.

To open an object, click the category on the left and then double-click on the name of the object. By default, objects open in the datasheet or form view.

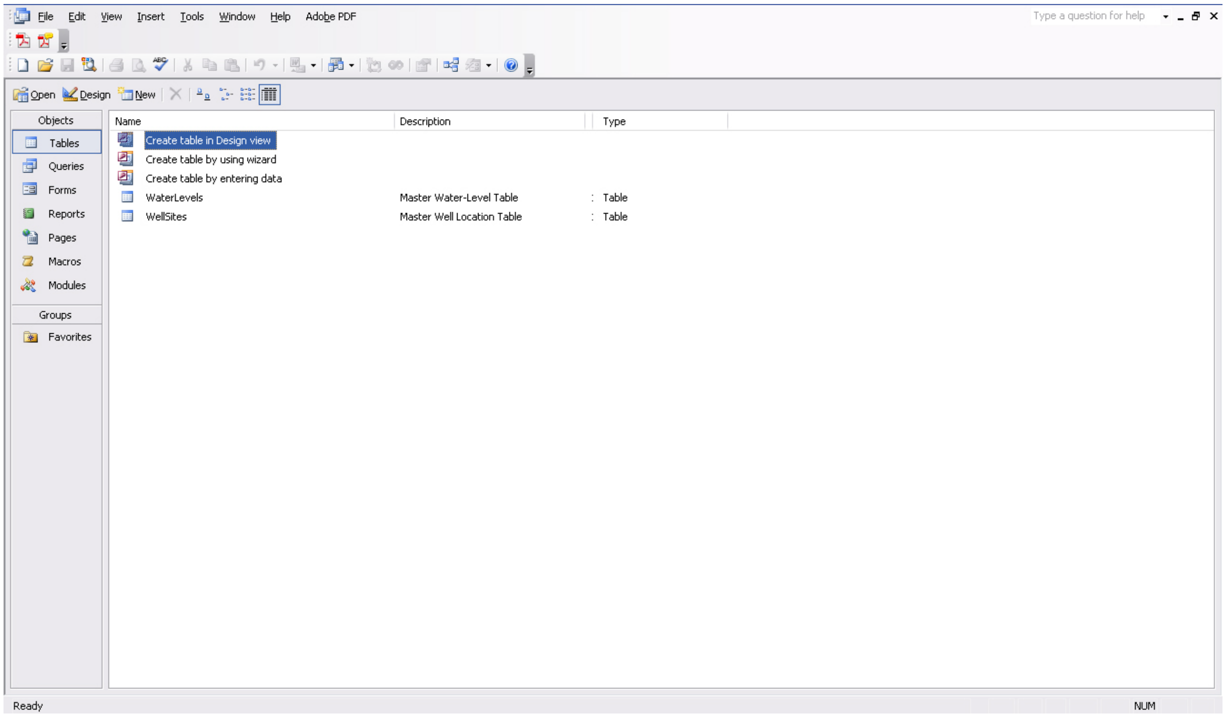


Figure D-1. View of the Database window showing 'Objects' categories on the left and the corresponding objects of the selected category listed in the main part of the window.

USER-INTERFACE WELL SITE DATA ENTRY FORM

A user-friendly data entry form called 'Well Site Data Entry Form' has been created to view and edit data in the White Sands National Monument Groundwater Database. The form joins the well location data from the 'WellSites' table with the corresponding water-level measurement data from the 'WaterLevels' table.

The 'Well Site Data Entry Form' can be used to view, edit, or delete data in the database. It can also be used to input new data. A view of the form is shown in Figure D-2 below. The main form shows all of the fields in the 'WellSites' table, displaying one record at a time. The inset subform, 'Water Level Measurement Subform', shows all of the fields in the 'WaterLevels' table. The data visible in the subform include all of the records from the 'WaterLevels' table that pertain to the well location currently displayed in the main form. Any changes made in the 'Well Site Data Entry Form' will permanently change the data in the 'WellSites' and/or 'WaterLevels' tables.

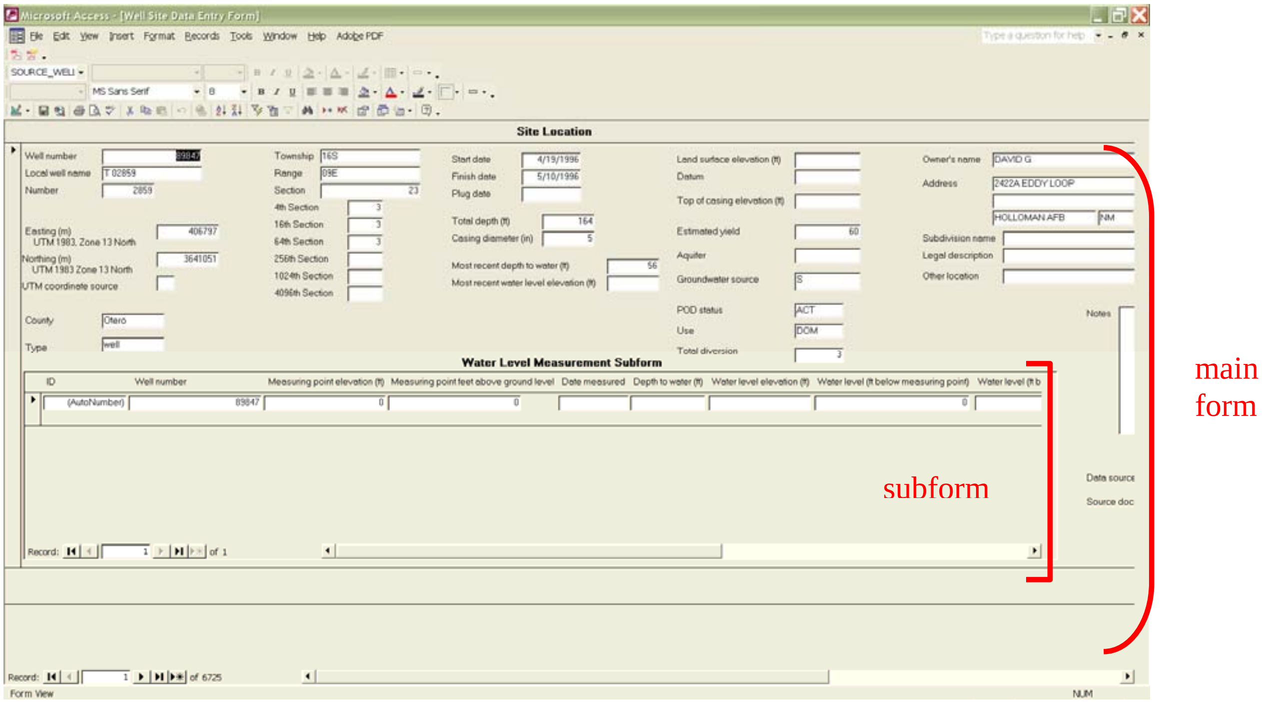


Figure D-2. ‘Well Site Data Entry Form’ with subform ‘Water Level Measurement Form’.

The main form is connected to the ‘WellSites’ table. Scroll across the screen to see all of the fields using the scroll bar at the bottom of the main form, if necessary. Navigate from record to record using the record selector buttons  at the bottom left of the form or you can type a record number in the inset box to move to a specific record or to skip forward. The  button will take you to the first record and the  button will take you to the last record in the table. Note that the labels in the form have been modified slightly from the field names in the data tables to make them easier to understand, for example ‘TWS’ is shown as ‘Township’ and ‘RNG’ is shown as ‘Range’. Refer to the data dictionary, Appendix C, for the exact field headers used in the tables.

The subform is connected to the ‘WaterLevels’ table. Use the scroll bar at the bottom of the subform to view or input data in all of the fields in the ‘WaterLevels’ table. The record selector buttons at the bottom of the subform apply only to the records in the ‘WaterLevels’ table that relate to the site location currently in view in the main form.

CREATING A NEW DATABASE RECORD USING THE DATA ENTRY FORM

To add a new well or spring location, open the 'Well Sites Data Entry Form'. Click the  button at the bottom left of the main form to add a new record to the 'WellSites' table. You must first assign a unique 'SOURCE_WELL_NBR' and then you can add data related to the location in the appropriate boxes in the upper part of the main form. You can use the tab key to move from field to field or move the cursor with the mouse. The new record will be saved to the 'WellSites' table when you move to another record or close the form. The error message shown below will appear if another record with the same 'Well number' already exists in the 'WellSites' table and the data will not be saved.

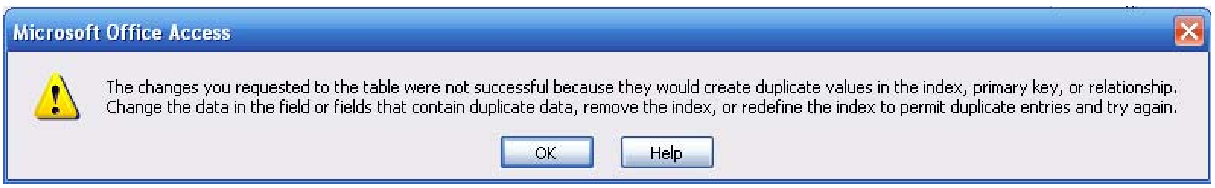


Figure D-3. Error message warning the 'SOURCE_WELL_NBR' already exists.

Water-level measurement data can also be added using the subform in the 'Well Sites Data Entry Form'. You must first verify that the sampling location already exists in the 'WellSites' table. If not, add a new record in the 'WellSites' table as described above. Once the location is in the 'WellSites' table, navigate to that record using the record navigation buttons at the bottom left of the main form or by typing a record number into the box. The 'Water Level Measurement Subform' automatically shows one empty row where a new record associated with each location can be added. An 'ID' number will automatically be generated in the 'WaterLevels' table, and the 'SITE_ID' matching the 'SOURCE_WELL_NBR' in the main form will be inserted when data are added to the row. When you move the cursor out of the record or close the form, the data will be added to the 'WaterLevels' table. Data can also be added and/or edited without using the data entry form, if preferred, by following the instructions for the datasheet view below.

EDITING EXISTING DATA

Use caution when editing data in a form or table in an Access database. To change data, type the new value in a cell. The new value will be saved to the data table when the cursor is moved out of the cell. Note that it is very easy to inadvertently delete or change data and, once you have moved the cursor away from the cell, the deletion or change cannot be undone. If you begin to change the value in a cell and want to undo it, hit the esc key before moving the cursor out of the cell.

DATASHEET VIEW

Viewing and modifying data can also be accomplished directly in the data table in the datasheet view. To open a table in this mode, double-click on the table name in the Database window. Figure D-4 below shows the datasheet view of the 'WellSites' table. To select a record, click on the gray box on the left side of the table. Click on the **+** to the left of the 'SOURCE_WELL_NBR' to expand the row. The inset table that appears shows the records from the 'WaterLevels' table that correspond to that location.

You can use 'Ctrl' + f to open the 'Find and Replace' dialog box to find a specific value in the table. Use caution when using the 'Replace' function. You will not be able to undo that operation.

A new record can be added to the 'WellSites' table by clicking on the  button at the bottom of the screen. Assign a new 'SOURCE_WELL_NBR' as described above for the same process using the data entry form. To delete an entire record or multiple records from a table, select the row(s) by clicking on the gray box(es) on the left and hit the delete key. A confirmation window will warn you that you will be deleting records. Check the number of records that will be deleted before clicking OK.

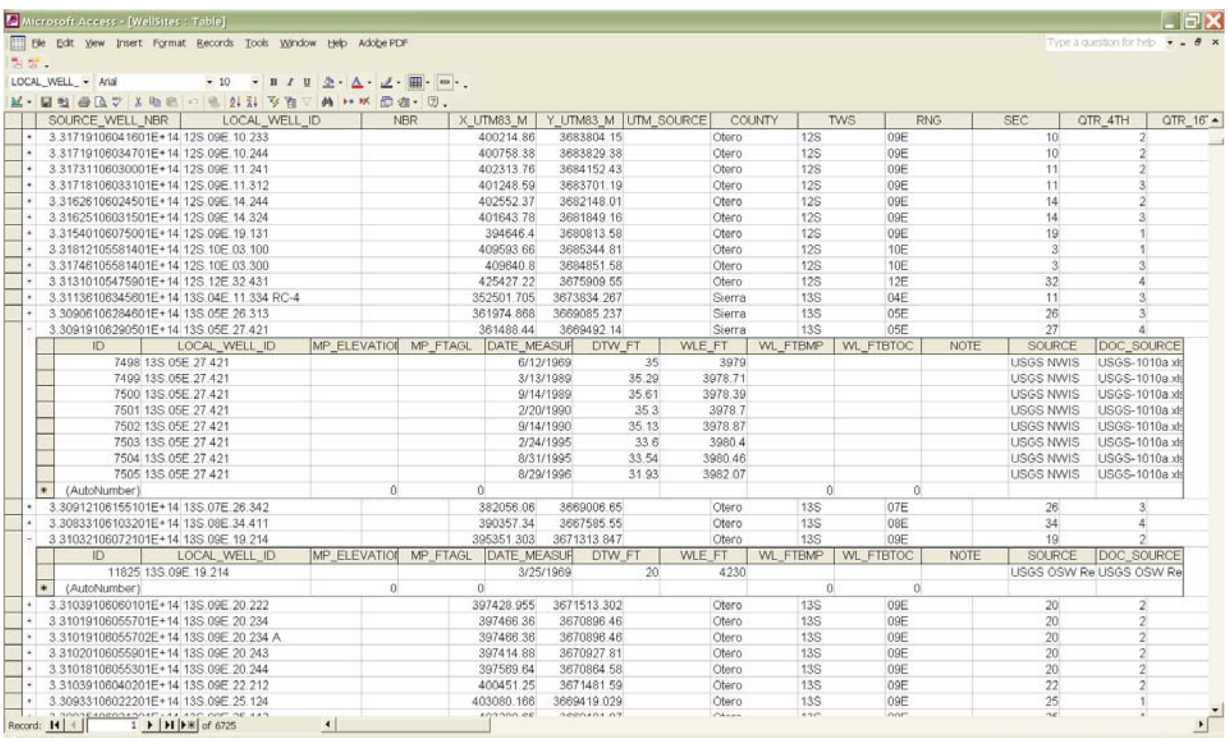


Figure D-4. Datasheet view of the 'WellSites' table with inset records from the 'WaterLevels' table.

FILTERING DATA

It is often useful to temporarily sort and/or filter data by a field in a data table without designing a new query. Filtering or sorting will change the view of the data without modifying the tables themselves. Right click on the column header of the field you want to sort by and choose ‘Sort Ascending’ or ‘Sort Descending’ to reorganize the table in numeric or alphabetical order. If desired, select the value or part of a value in a cell to filter out matching records. For example, you can select the word ‘Otero’ in the ‘COUNTY’ field to create a subset of only the wells in Otero County, or select 10 in the ‘RNG’ field to select the records in Range 10E. The ‘Filter’ toolbar has a ‘Filter By Selection’ button on the left and a ‘Remove Filter’ button on the right . After selecting your criterion, click the ‘Filter By Selection’ button and a table view of only the records that match your selection will appear. The number of filtered records will appear in the status bar at the bottom of the table. This can be useful to tally the number of records in different categories. You can save these filtered records as a new table in Excel, if desired, by clicking the gray box at the top left corner of the table to select everything. Copy the table and use ‘Paste Special’ as ‘Unicode Text’ to add it to a new Excel spreadsheet. Note that if you use the Export command from Access, you will get the entire table rather than the filtered selection. You can also filter data more than once to get a consecutively smaller subset of data, including filtering first by a criterion in one field and then re-filtering by another criterion in another field. Click the ‘Remove Filter’ button to remove the filter(s). **Always reply ‘No’** when asked if you want to save the changes to the table structure after sorting or filtering.

SELECT QUERIES

Select queries also allow you to view data in a variety of ways without modifying the data. You can query data based on multiple criteria simultaneously to select out only the records of interest in answering a specific question. You can create queries with a limited list of fields to create a more focused summary table without losing any of the information available for other needs. The White Sands National Monument Groundwater Database has several sample select queries set up that can serve as templates for queries customized to your needs.

MODIFYING A QUERY

To modify one of the sample queries, open the main database window. Click on the ‘Queries’ button on the left. Click on the name of the query you want to modify to select it. Right-click and choose ‘Copy’. Click away from the query name in the same window and right-click again and choose ‘Paste’. You will be prompted to name the new query and click ‘OK’. Click on the new query name and click on the ‘Design View’ button on the toolbar above the Objects list 

.

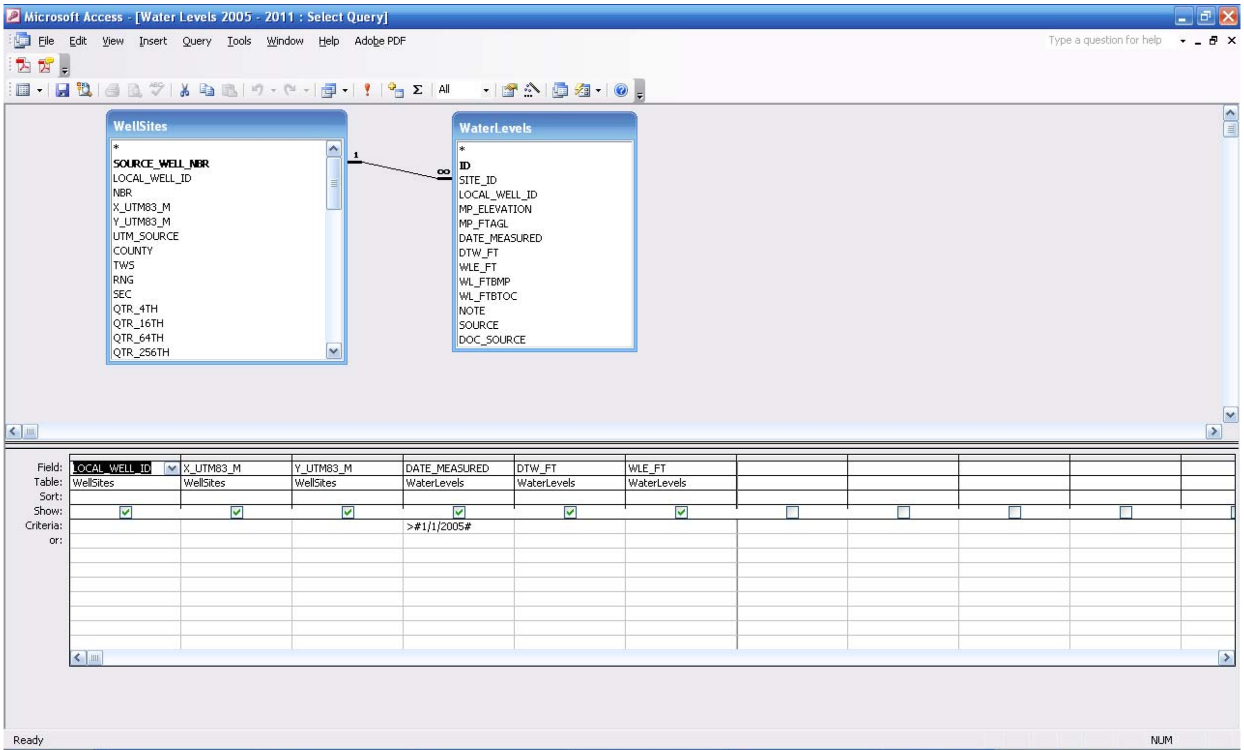


Figure D-5. Query Design View.

Figure D-5 above shows a query in Design View. The tables used in the query and their relationship are shown in the upper part of the window. The lower part of the window shows the fields that are part of the query, the table they are stored in, sort options, a 'Show' checkbox, and rows for criteria.

Fields can be added by double-clicking on the field name in the appropriate table list in the upper part of the window. Rearrange the order of the fields by clicking on the gray bar above the field name to select it, holding down the right mouse button and dragging to the desired location. Right click on the gray bar above the field name and select 'Cut' to remove a field from the query. You can also uncheck the 'Show' button so that a field does not show when the query is run. Click in the 'Sort' cell for a field you want to sort by and use the drop down to select 'Ascending' or 'Descending' for alphabetical or numeric order. You can sort by multiple fields and the data will be sorted by each field in order from left to right. A list of some of the most common simple criteria is provided below. There are many more options available.

To limit the results of a query by multiple criteria, enter criteria for each field in the order of priority. Reorder the fields, if necessary. In the ‘Criteria:’ row, criteria are applied as criterion for field 1 AND criterion for field 2 etc., moving from left to right. For example, to select out the records that are both in Otero County AND springs, you would use “Otero” in the ‘COUNTY’ field and “spring” in the ‘TYPE’ field. Using the AND operation limits the results to only the records that satisfy all of the criteria in that row. Use the ‘Or:’ row to enter criteria if you want to include results that satisfy either one criterion OR another.

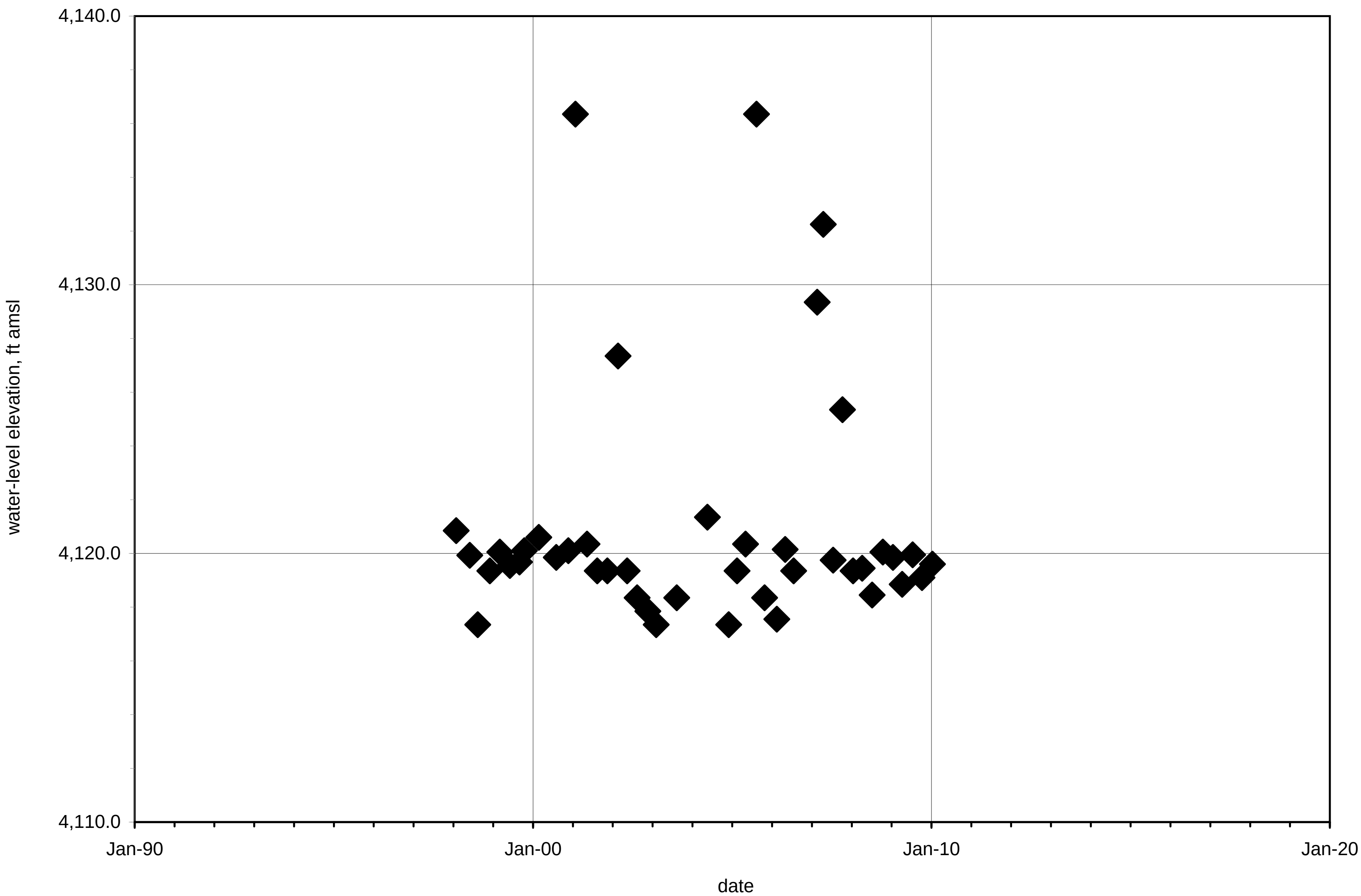
Run the query by clicking on the **!** button on the toolbar. The results of the query will be displayed in datasheet view. You can return to design view to modify your query and run it again, if desired. If new data are added to the data tables, the query results will be updated when the query is run again.

Syntax is important in expressing your criteria although Access will automatically correct some syntax errors. Below is a list of commonly used query criteria:

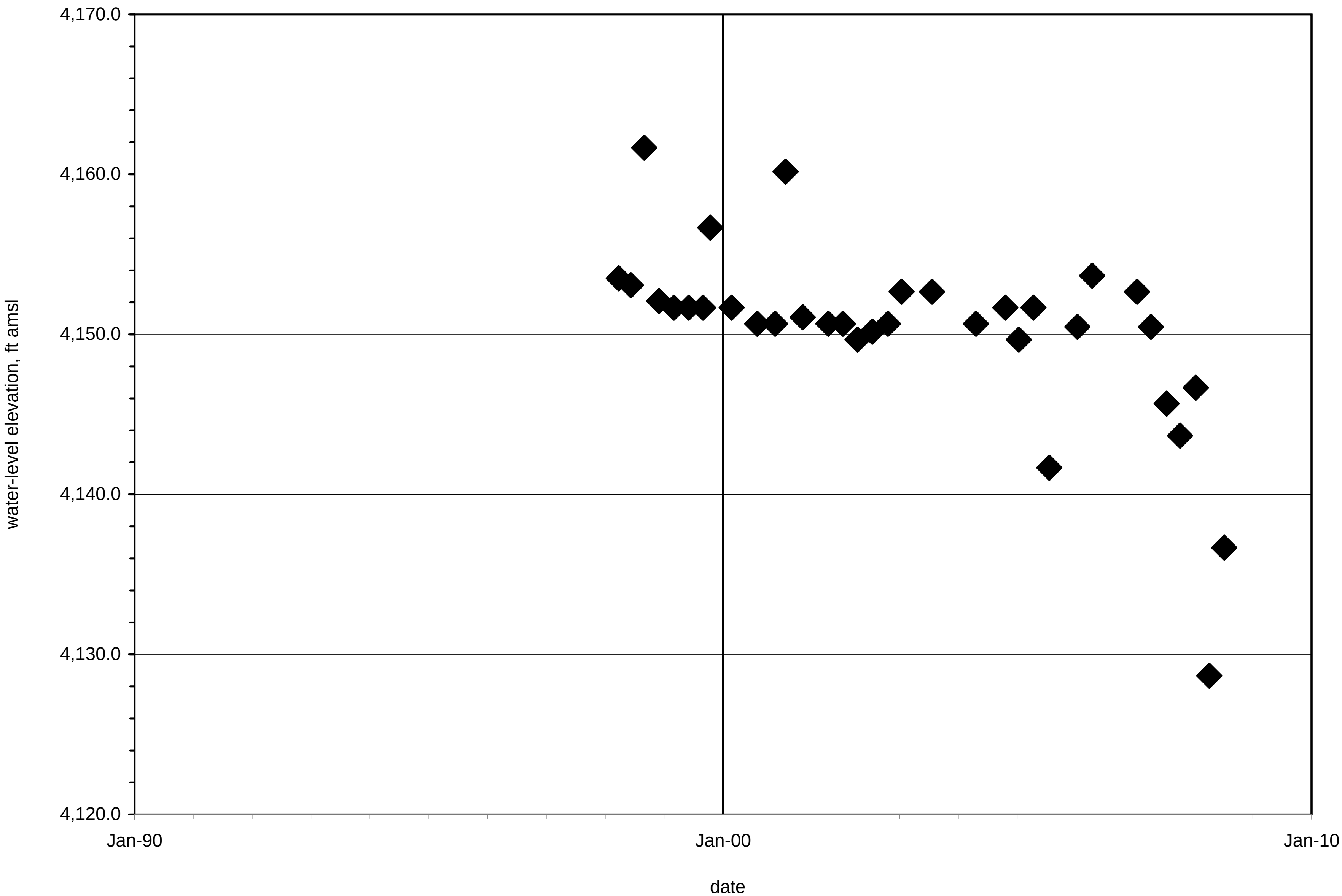
“ “	quotation marks enclosing text you want to match in a text field.
*****	a wildcard, can precede or follow part of a value
Like	followed by a text string enclosed in quotation marks, used to match text
Like “ “	returns null values in a text field when the quotation marks enclose nothing
Is Not Null	returns only records that have a value in the field
#1/1/2010#	enclose dates in # symbols
Between #1/1/2010# and #6/1/2010#	for a range of dates
>	greater than, returns records with numerical or alphabetical values
>=	greater than or equal to
=	equal to
< >	not equal to
<	less than

Appendix E.

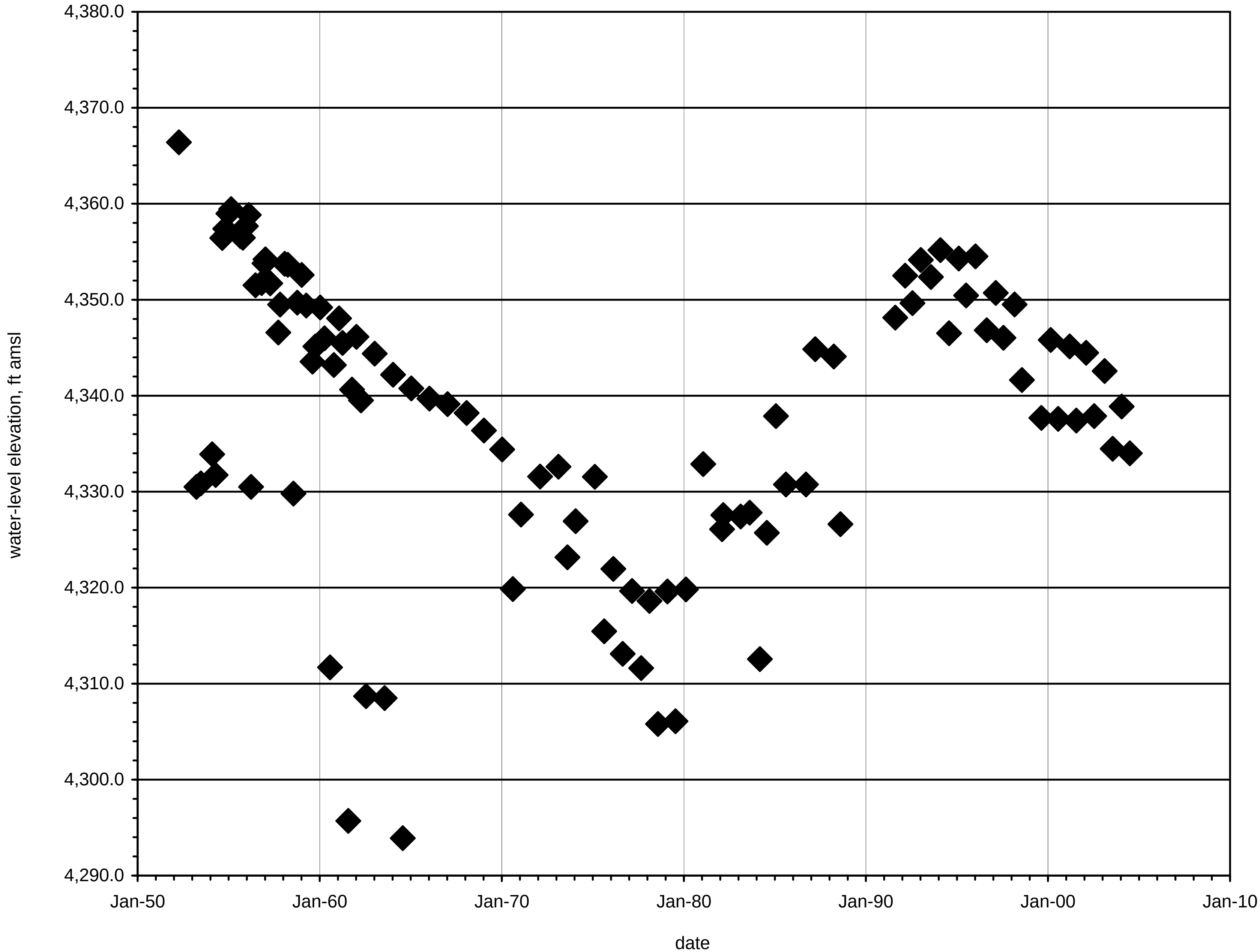
Selected Hydrographs



Hydrograph of DP-220 MW-7, Wastewater Treatment Plant (ALM220 MW7).



Hydrograph of DP-220 MW-4 (ALM 220 MW4).



Hydrograph of T14S R10E 31.144 (14S.10E.31.144).

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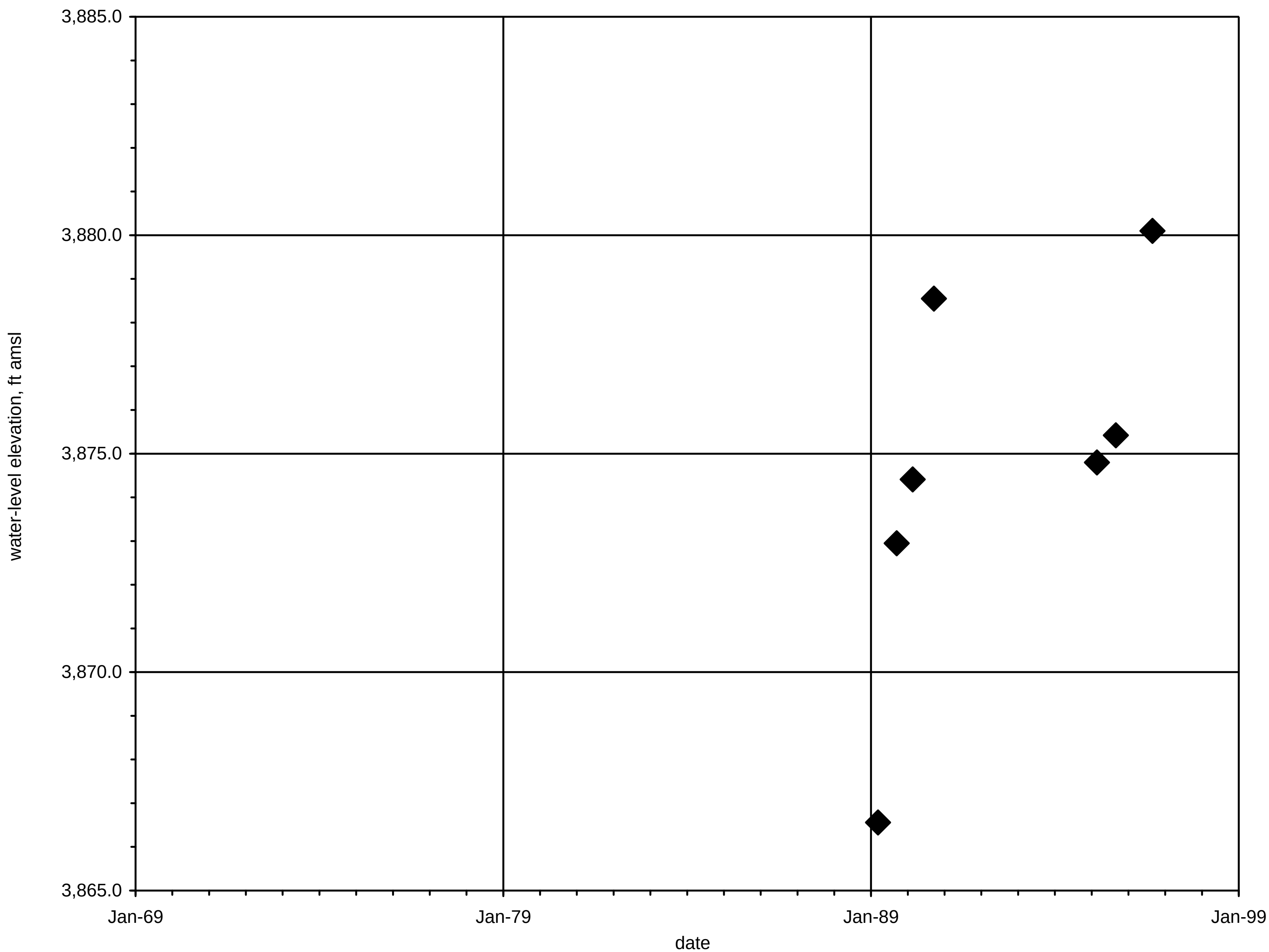
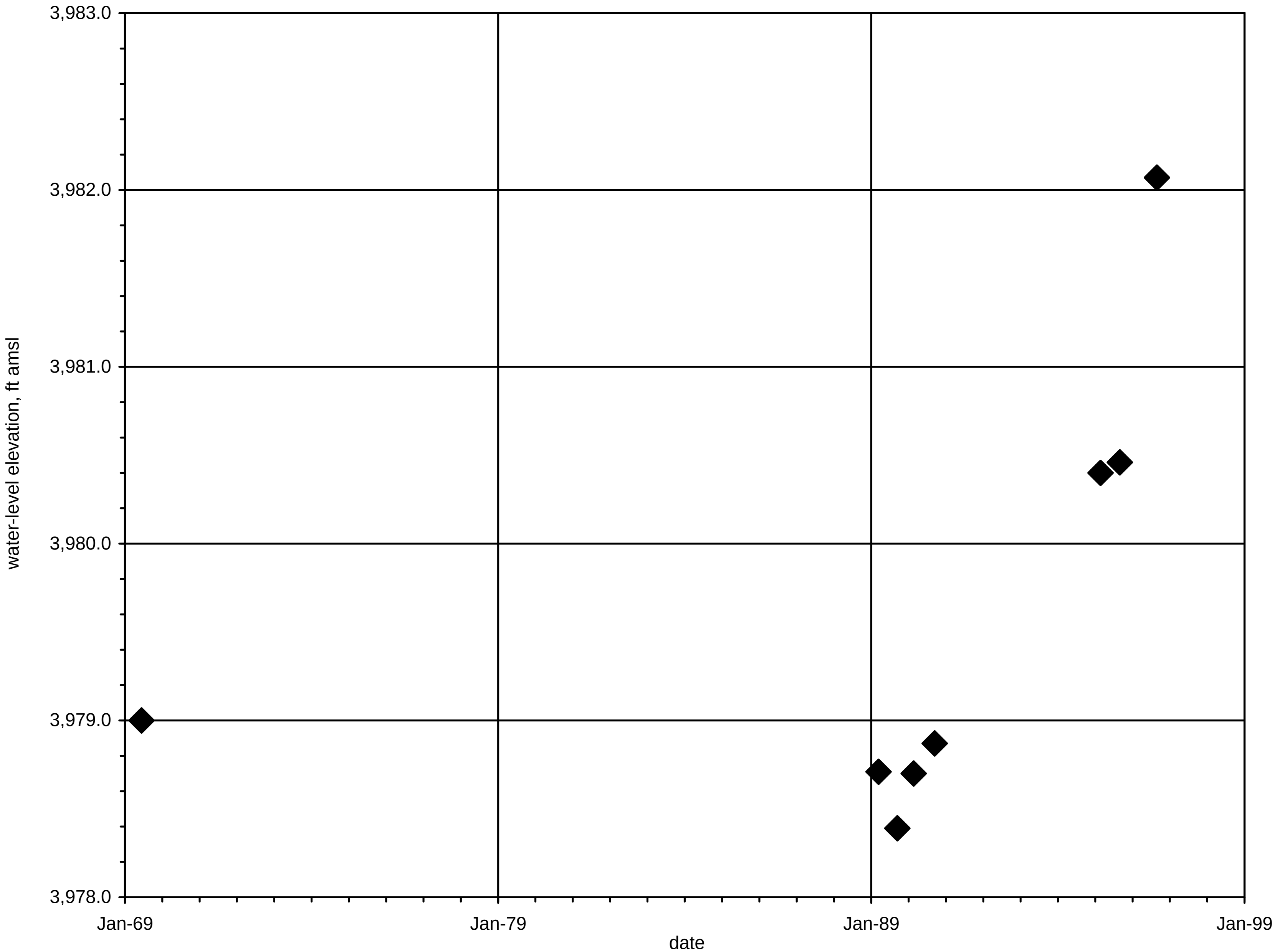
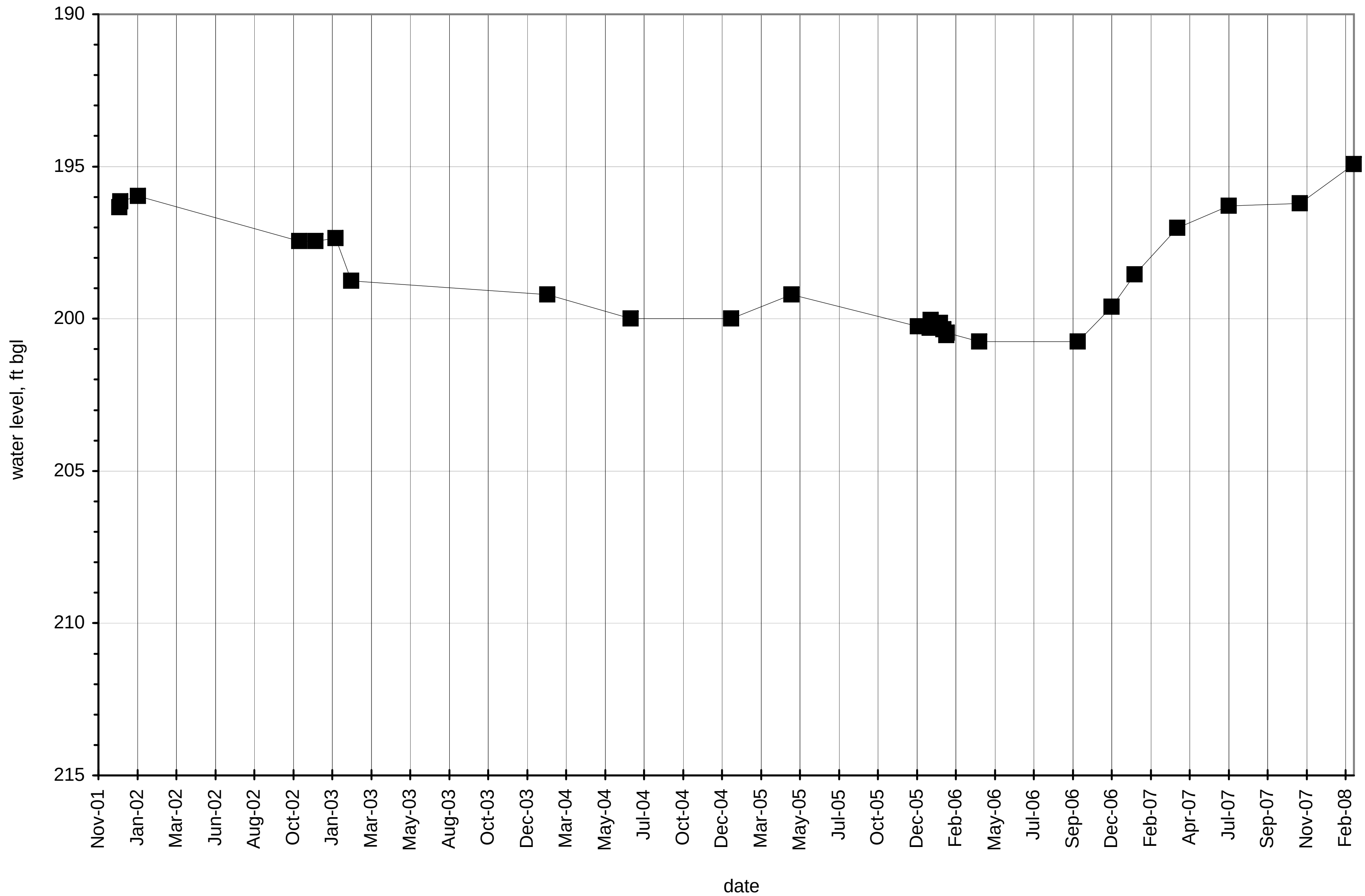


Hydrograph of T15S R5E 29.423 (15S.05E.29.423).

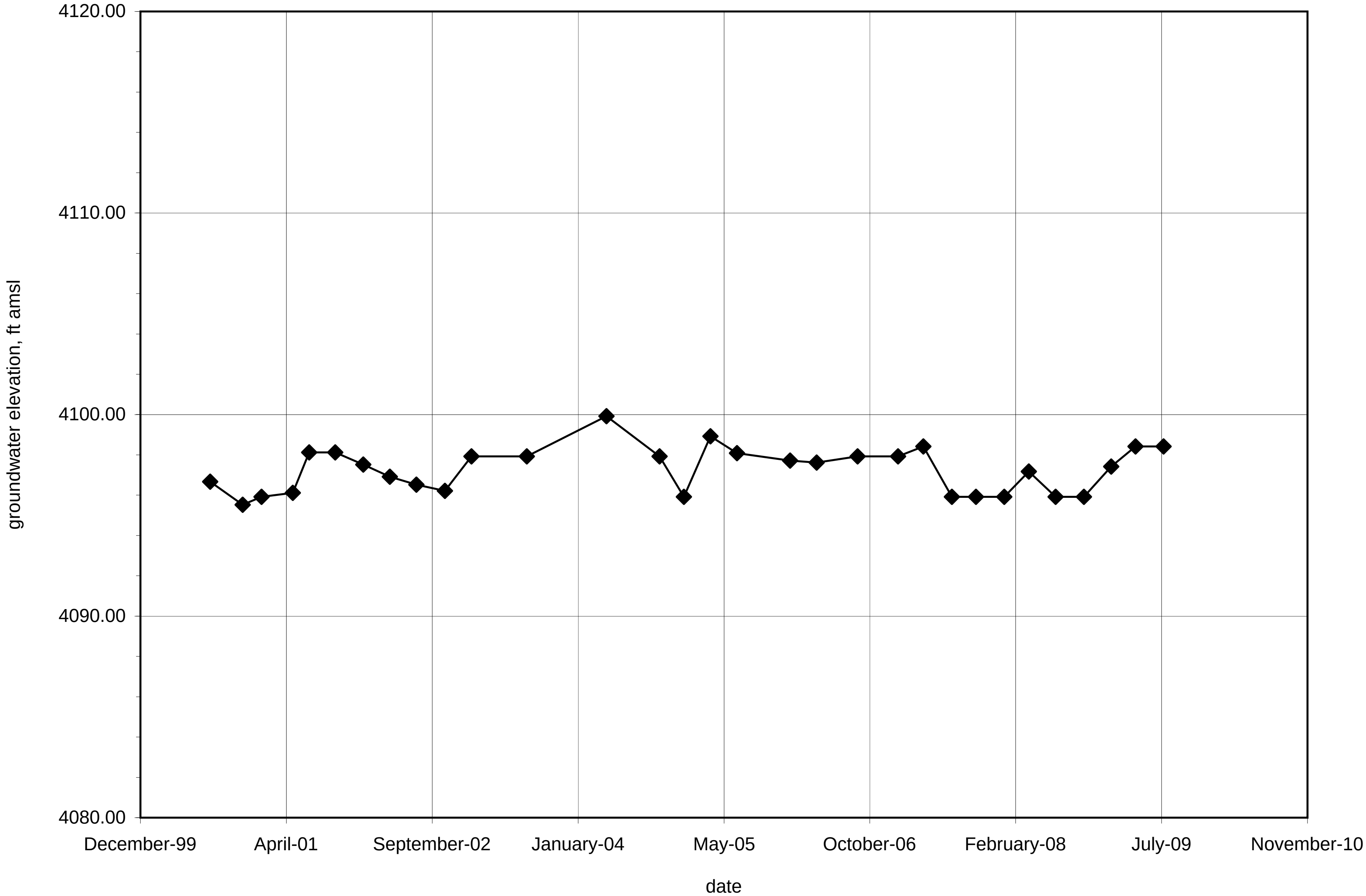
JOHN SHOMAKER & ASSOCIATES, INC.



Hydrograph of T13S R5E 27.421 (13S.05E.27.421).



Hydrograph for Well No. T-3837 (T03837) .



Hydrograph for Monitoring Well 3, City of Alamogordo DP-220 (ALM220 MW3).

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Appendix F.

CD Containing Selected Reports and References for Jarilla Fault