BW-8

PAB Services
Salty Dog Brine Station

Preliminary Conceptual Remedial
Design Report

2009

December 31, 2009

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Mr. Jim Griswold
New Mexico Oil Conservation Division
Environmental Bureau
1220 South St. Francis Drive
Santa Fe, New Mexico 87505-4225

Re: Preliminary Conceptual Remedial Design Report

Dear Mr. Griswold:

On behalf of PAB Services, Inc., Daniel B. Stephens & Associates, Inc. (DBS&A) is pleased to submit the enclosed *Preliminary Conceptual Remedial Design Report* for the Salty Dog brine station located in Lea County, New Mexico. The report provides a screening of four remedial treatment alternatives for the chloride groundwater plumes at the brine pond and brine well areas. The report was prepared in partial fulfillment of the requirements set forth in Section 15 of the New Mexico Oil Conservation Division Settlement Agreement & Stipulated Revised Final Order (Order), dated August 6, 2008.

Please don't hesitate to call me at (505) 353-9130 if you have any questions or require additional information.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.

Michael D. McVey
Senior Hydrogeologist

MDM/et
Enclosures
cc: James Millett, PAB Services Inc.

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Daniel B. Stephens & Associates, Inc.
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Albuquerque, NM 87109-3315 FAX 505-822-8877

Preliminary Conceptual Remedial Design Report

Salty Dog Brine Station

Lea County, New Mexico

Prepared for **New Mexico Energy, Minerals and Natural Resources Department**
Oil Conservation Division, Environmental Bureau

December 31, 2009

Daniel B. Stephens & Associates, Inc.

6020 Academy NE, Suite 100 • Albuquerque, New Mexico 87109

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1. Introduction

On behalf of PAB Services, Inc. (PAB), Daniel B. Stephens & Associates, Inc. (DBS&A) has prepared this *Preliminary Conceptual Remedial Design Report* for the Salty Dog brine station (Site). The Site is located in Lea County in southeastern New Mexico, approximately 12 miles west of Hobbs on the south side of the Hobbs/Carlsbad Highway (Figure 1). Formally, the Site is located in the J Unit of Section 5, Township 19 South, Range 36 East.

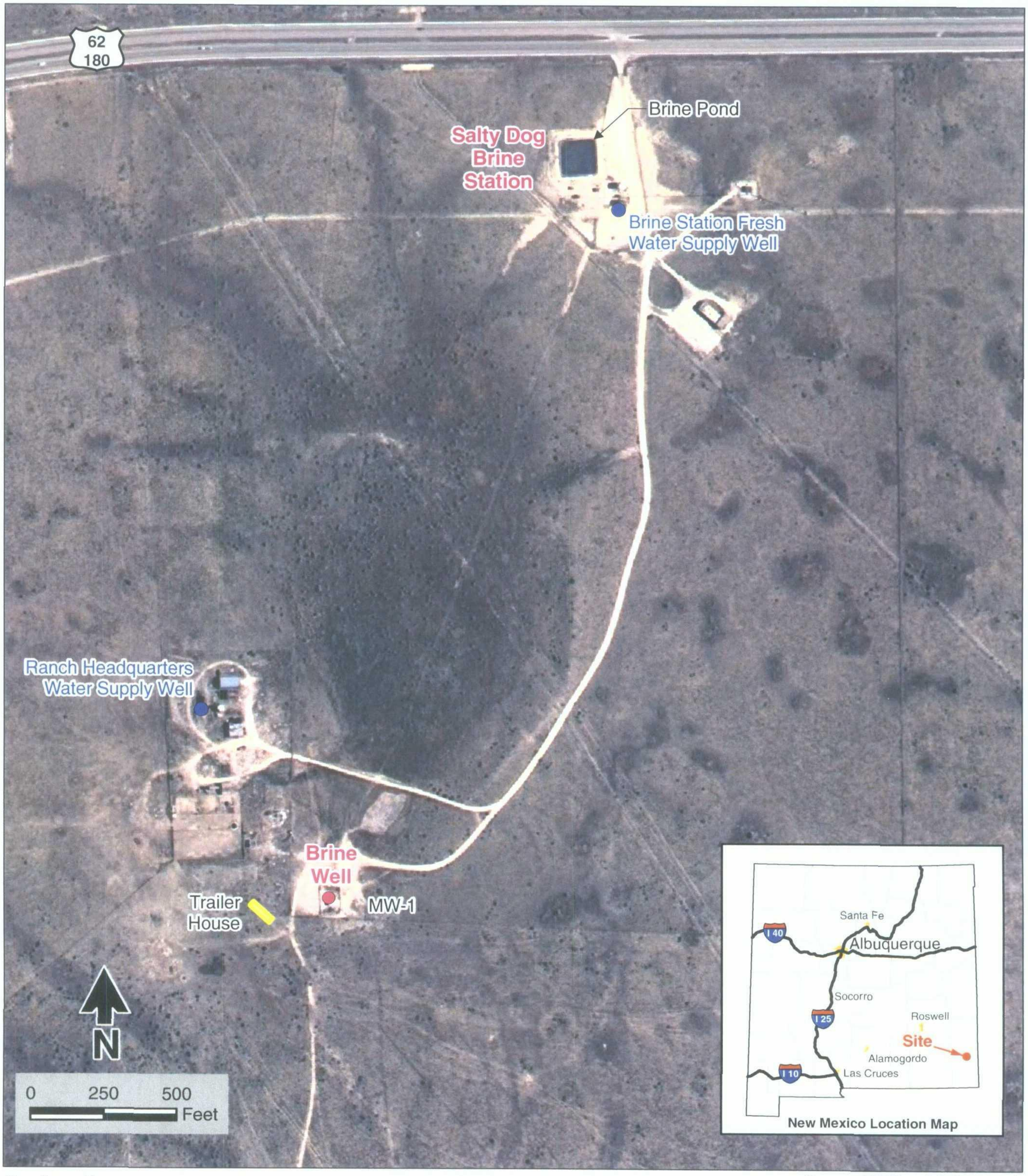
This report summarizes a hydrologic modeling effort conducted to determine groundwater extraction rates needed to capture chloride contamination originating from the area of a former brine pond and a historical release from the brine well. The report also presents an evaluation of groundwater treatment remedial alternatives and recommendations for groundwater treatment.

1.1 Background

On May 19, 2008, the New Mexico Energy, Minerals and Natural Resources Department Oil Conservation Division (OCD) issued Administrative Compliance Order (ACO) ACO 2008-02 to Mr. Pieter Bergstein (d/b/a Salty Dog, Inc.) (NM OCD, 2008a). After issuance of the ACO, OCD and Mr. Bergstein engaged in settlement discussions to resolve the outstanding issues addressed by the ACO. The OCD and Mr. Bergstein agreed to a Settlement Agreement & Stipulated Revised Final Order (Order), NM-OCD 2008-2A (NM OCD, 2008b), for the purpose of resolving the violations outlined in the ACO.

The Order requires Mr. Bergstein to complete certain actions to address environmental compliance-related issues at the Site in accordance with milestone deliverable dates agreed upon by the OCD and Salty Dog, Inc. Specifically, the Order requires Salty Dog to address contamination resulting from documented releases in 1999, 2002, and 2005, as well as releases at the brine pond and brine loading/unloading area (brine pond area).

The ACO provides a description of each of these releases (NM OCD, 2008b). The 1999 release was caused by a hole in the casing of the Salty Dog brine well and resulted in



Explanation

● Water supply well

Source: RGIS aerial photograph dated July 2005

S:/PROJECTS/ES08.0118.01_SALTY_DOG_INC/GIS/MXDS/CAPTURE_SYSTEM_REPORT/FIG01_SITE_LOCATION_MAP.MXD 902221

Daniel B. Stephens & Associates, Inc.
11/20/2009 JN ES08.0118.01

SALTY DOG BRINE STATION
Site Location Map

Figure 1

contamination of the fresh water well on Snyder Ranches, adjacent to the Site. The 2002 release was caused by a leaking tank in the vicinity of the brine well, and the 2005 release was caused by a rupture in the brine supply pipeline. The 2002 and 2005 releases were noted to have entered a fresh water playa located just north of the brine well (NM OCD, 2008b).

1.2 Previous Work Conducted by DBS&A at the Site

To date, DBS&A has performed the following activities at the Site under contract to PAB: (1) groundwater monitoring, (2) preparation of a Comprehensive Site Plan, (3) removal of the brine pond, (4) monitor well installation and groundwater monitoring, and (5) pumping tests. These activities are summarized in Sections 1.2.1 through 1.2.5.

1.2.1 Groundwater Monitoring

In June 2008, DBS&A collected groundwater samples from existing monitor wells PMW-1 and MW-1 through MW-6, and from the ranch headquarters' water supply well and the brine station fresh water supply (DBS&A, 2008a). Laboratory results showed that, since the wells were last sampled by employees of Salty Dog in May 2008, chloride concentrations increased in six of the seven existing groundwater monitor wells (PMW-1 and MW-1 through MW-5) and in the brine station fresh water well. In six of the nine samples collected (PMW-1, MW-2 through MW-5, and the brine station fresh water supply well), chloride concentrations exceeded the New Mexico Water Quality Control Commission (NMWQCC) standard of 250 milligrams per liter (mg/L).

The groundwater monitoring results indicated that the extent of the chloride groundwater plume beneath the brine pond area in the northern portion of the Site had not been delineated. In addition, the monitoring results indicated that the cross-gradient extent of the chloride groundwater plume at the brine well area in the southern portion of the Site had also not been delineated. Complete details and findings of the groundwater monitoring event are reported in the *Groundwater Monitoring Report* submitted to PAB on July 15, 2008 (DBS&A, 2008a).

1.2.2 Comprehensive Site Plan

In September 2008, DBS&A submitted a Comprehensive Site Plan (Plan) (DBS&A, 2008b) to OCD addressing the requirements set forth in Section 15 of the Order (NM OCD, 2008b). The Plan presented a proposed project schedule and individual specifications and proposals for addressing the environmental compliance-related issues at the Site and formed the basis for future investigation, characterization, and remediation of the Site. The OCD approved the Plan on September 17, 2008.

1.2.3 Brine Pond Removal

In October 2008, the brine pond located in the northern portion of the Site was removed in accordance with the Order (NM OCD, 2008b). Employees of Salty Dog pumped all of the aqueous brine from the pond into aboveground frac tanks located on-site. A trackhoe was then used to excavate the accumulated salt from the interior of the pond. The excavated salt was loaded into sealed bins and dump trucks and transported to Sundance Services, Inc. (Sundance) in Eunice, New Mexico for disposal. After the salt was removed from the pond interior, the underlying plastic liner was removed and 6 inches of clay beneath the liner was excavated. The liner and excavated clay were transported to Sundance for disposal. A total of 2,128 cubic yards of salt and contaminated soil were hauled to Sundance for disposal.

In November 2008, DBS&A completed soil sampling beneath the former brine pond and in the former brine loading area located on the east side of the pond. A total of 76 composite soil samples were submitted for chloride analysis using U.S. Environmental Protection Agency (EPA) method 300.0. Of those samples, 61 were collected from depths of 4 feet below ground surface (ft bgs) or less, and 15 were collected from depths greater than 4 ft bgs. Excavation to depths greater than 3 to 4 ft bgs was limited in most cases by the presence of caliche in the shallow subsurface.

Laboratory results indicated significant concentrations of chloride in the shallow interval (0 to 4 ft bgs) beneath the former brine pond and brine loading area. Although the number of samples collected at depths greater than 4 ft bgs was limited, there was no noticeable difference in chloride concentration between the shallower (0 to 4 ft bgs) and deeper (4 to 8 ft bgs) samples.

Complete details and findings of the brine pond excavation and soil sampling are reported in the *Closure Report, Brine Pond and Brine Loading Area*, submitted to the OCD on December 3, 2008 (DBS&A, 2008c).

1.2.4 Monitor Well Installation and Groundwater Monitoring

In March and April 2009, DBS&A completed a field investigation at the Site to determine the magnitude and extent of impacts to soil and groundwater from the 1999, 2002, 2005, and the brine pond area releases (DBS&A, 2009a). The investigation was performed in accordance with the requirements of the Order and Sections 3.1, 3.2, and 3.3 of the Plan (DBS&A, 2008b).

The Order (NM OCD, 2008b) identified three areas of primary concern (AOPCs) requiring investigation and/or further delineation of the extent of contamination: (1) the brine pond area, (2) the brine well, and (3) the playa. To address the AOPCs and groundwater quality at the Site, DBS&A completed a field investigation program that included the installation of nine groundwater monitor wells and two nested wells. DBS&A also instituted an analytical program to assess the likely contaminants of concern (COCs) in soil and groundwater at the Site.

The soil investigation program included the installation of 11 soil borings, all of which were later completed as monitor wells to assess groundwater quality. These included 6 soil borings installed at the brine pond area in the northern portion of the Site, 4 soil borings installed downgradient at the brine well area in the southern portion of the Site, and 1 soil boring installed in the fresh water playa lake located just north of the brine well. From the 11 soil borings, a total of 89 soil samples were submitted for chloride analysis. The samples collected from the boring installed in the fresh water playa lake were also analyzed for total petroleum hydrocarbons (TPH).

Chloride concentrations in the soil were generally below the OCD standard of 500 milligrams per kilogram (mg/kg). However, 2 or more samples taken from 3 borings installed downgradient and east of the brine pond and brine loading/unloading areas contained chloride concentrations in excess of 500 mg/kg.

TPH results from soil samples submitted from the playa lake boring showed TPH concentrations exceeding the New Mexico Environment Petroleum Storage Tank Bureau action level of 100 mg/kg in the 20 to 22-ft bgs sample.

The groundwater investigation included the installation of nine monitor wells and two nested wells and the collection of groundwater samples for chloride analysis. The sample collected from the playa lake well was also analyzed for TPH. The monitor and nested wells were completed at predetermined locations as specified in Sections 3.1 and 3.2 of the Plan (DBS&A, 2008b). The locations specified in the Plan were selected to delineate the extent of the chloride groundwater plume at the brine pond area and the cross-gradient extent of the chloride plume resulting from the 1999 release at the brine well, and to determine if groundwater beneath the playa lake was impacted as a result of the 2002 and 2005 releases. A total of 21 groundwater samples were submitted for laboratory analysis: 15 from the newly installed monitor wells and 6 from the existing monitor wells.

Complete details and findings of the soil and groundwater investigation are reported in the *Monitor Well Installation and Groundwater Monitoring Report* submitted to the OCD on September 18, 2009 (DBS&A, 2009a).

1.2.5 Pumping Tests

In November 2009, DBS&A oversaw the installation of two groundwater extraction wells (RW-1 and RW-2) at the Site. After the wells were installed, DBS&A performed pumping tests at both recovery wells to determine aquifer properties at the well locations (DBS&A, 2009b). These activities were performed in accordance with the requirements of the Order (NM OCD, 2008b) and Sections 3.1 and 3.4 of the Plan (DBS&A, 2008b).

RW-1 is located at the brine pond area and is screened across the top of the water table, where chloride concentrations appear to be greatest based on water quality data collected at nested well NW-1. Based on analysis of RW-1 recovery data, estimated aquifer transmissivity and hydraulic conductivity values in the area of RW-1 are 23 square feet per day (ft^2/d) and 1.5 feet per day (ft/d), respectively. Analysis of step drawdown data shows that the well efficiency of RW-1 is approximately 53 percent.

RW-2 is located at the brine well area, completely penetrates the Ogallala aquifer, and is screened for 40 feet near the bottom of the aquifer. Water quality data collected at nested well NW-2 show that the greatest chloride concentrations are observed near the bottom of the aquifer. Estimated aquifer transmissivity in the area of RW-2 is 690 ft^2/d and estimated hydraulic conductivity is 7.7 ft/d. The well efficiency of RW-2 is between 49 and 60 percent.

Complete details of the recovery well installations and pumping tests are reported in the *Recovery Well Installation and Pump Test Report* submitted to the OCD on November 20, 2009 (DBS&A, 2009a)

1.3 Purpose

The purpose of this preliminary conceptual remedial design study is to develop a groundwater extraction system approach and identify a groundwater treatment alternative that together will effectively abate groundwater impacts at both the brine pond and brine well areas. The study consists of a hydrologic modeling component and an evaluation of water treatment alternatives.

This report constitutes the last of three milestone deliverables: (1) the *Monitor Well Installation and Ground Water Monitoring* report, submitted to the OCD on September 18, 2009, (2) the *Recovery Well Installation and Pump Test* report, submitted to the OCD on November 20, 2009, and (3) this *Preliminary Conceptual Remedial Design Report.*

1.4 Project Scope

The Order (NM OCD, 2008b) requires that two recovery wells be installed at the Site: one at the brine pond area in the northern portion of the Site and one at the brine well area in the southern portion of the Site. The Order also specifies that aquifer pumping tests be conducted on each recovery well to demonstrate the aquifer characteristics.

To meet these requirements, DBS&A performed hydrologic modeling to determine the groundwater extraction rates necessary to establish capture zones to intercept chloride impacts at both the brine pond and brine wells areas, and evaluated various groundwater treatment alternatives for the extracted groundwater. Section 2 of this report describes the capture zone modeling performed for the two areas at the Site. Section 3 presents an evaluation of groundwater treatment alternatives, and Section 4 provides preliminary conceptual remedial system costs and DBS&A's recommendations.

2. Capture Zone Analyses

DBS&A performed hydrologic modeling to delineate capture zones at both the brine pond and brine well areas. DBS&A selected WinFlow (version 3.20) for the modeling exercise. WinFlow is distributed by Environmental Simulations, Inc. and is a Windows based analytical modeling program that simulates two-dimensional steady-state and transient groundwater flow. The model can be used to simulate the effects of wells, uniform recharge, circular recharge and discharge areas, and line sources or sinks in either confined or unconfined aquifers. The model depicts flow fields using streamlines, particle traces, and contours of hydraulic head. The model requires basic aquifer property values (e.g., hydraulic gradient and conductivity, storativity, thickness, and porosity).

The objectives of the hydrologic modeling were to:

- Determine whether pumping from existing extraction wells, RW-1 and RW-2, can provide sufficient capture of chloride-impacted groundwater at the brine pond and brine well areas

- Identify pumping rates necessary to achieve capture

- Evaluate drawdown caused by extraction well pumping and determine whether RW-1 and RW-2 have sufficient water columns to support the identified pumping rates

Before WinFlow simulations were conducted, simple capture zone width calculations were performed based on an equation presented by Fetter (1994). The purpose of the simple calculations was to explore whether pumping from only the existing extraction wells (RW-1 and RW-2) may provide sufficient capture or whether additional pumping wells may be required. This was done before more thorough analyses were performed using WinFlow and to help establish initial pumping rates used in WinFlow. The calculations demonstrated that pumping from existing extraction wells RW-1 and RW-2 can provide sufficient capture zone widths to intercept the transverse extent of chloride impacts in the two brine-impacted areas without the need for additional pumping wells. These calculations are provided in Appendix A. Appendix B contains the WinFlow modeling files.

2.1 Modeling Approach

Two WinFlow simulations were performed:

- Brine pond area with pumping at RW-1
- Brine well area with pumping at RW-2

The WinFlow simulations were run using a steady-state solution to solve for contours of hydraulic head and to delineate capture zones at each pumping well. The capture zones were created by reverse-particle tracking: particles were placed at pumping wells, and their paths were tracked in a reverse direction upgradient of the pumping wells. Pumping rates at the extraction wells were adjusted so that capture zones enclosed the lateral extent of chloride impacts. The extents of chloride impacts at both the brine pond and brine well areas were determined from data collected in April 2009 (DBS&A, 2009a).

The WinFlow steady-state solution requires the following aquifer property values: magnitude and direction of hydraulic gradient, hydraulic conductivity, thickness, storativity, and porosity. These values were obtained from site-specific data generated during the field investigation performed in March and April 2009 (DBS&A, 2009a) and published information on the Ogallala aquifer:

- Based on groundwater elevation data collected during the field investigation (Figures 2 and 3) groundwater in both the brine pond and brine well areas flows to the southeast at a hydraulic gradient of 0.004 foot per foot (ft/ft). Table 1 summarizes historical groundwater level data, showing that groundwater levels have been fairly constant over the last two years.

- In November 2009, DBS&A performed pumping tests at both RW-1 and RW-2 (DBS&A, 2009b). Hydraulic conductivity and thickness values determined from these pumping tests were used in the modeling.

- Storativity and porosity values were obtained from information for the Ogallala aquifer presented in scientific literature (i.e., Blandford et al., 2008; Nativ and Smith, 1987).

Explanation

DBS-1 Well designation
3754.71 Groundwater elevation, ft msl
Monitor well location
Water level elevation contour (ft msl)

Source: Google Earth aerial photograph dated September 2002

SALTY DOG BRINE STATION

Brine Pond Area
Water Level Elevations in
April 2009

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12/15/2009
JN ES08.0118.01

Figure 2

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Explanation

MW-2 Well designation

3751.03 Groundwater elevation, ft msl

Monitor well location

Water level elevation contour (ft msl)

Source: Google Earth aerial photograph dated September 2002

SALTY DOG BRINE STATION

Brine Well Area
Water level Elevations in April 2009

Daniel B. Stephens & Associates, Inc.

12/15/2009 JN ES08.0118.01

Figure 3

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Table 1. Summary of Historical Water Level Measurements Salty Dog Brine Station, Lea County, New Mexico

Monitor Well	Screen Interval (ft bgs)	Top of Casing Elevation [a] (ft msl)	Date Measured	Depth to Water (ft btoc)	Groundwater Elevation (ft msl)
DBS-1	56.0-76.0	3817.09	04/08/09	62.38	3754.71
DBS-2	58.0-78.0	3820.50	04/08/09	65.45	3755.05
DBS-3	56.0-76.72	3816.66	04/08/09	60.67	3755.99
DBS-4	56.0-76.0	3820.37	04/08/09	66.27	3754.10
DBS-5	56.9-76.9	3820.37	04/08/09	62.99	3757.67
DBS-6	56.7-76.7	3812.65	04/07/09	62.75	3749.90
DBS-7	55.1-75.1	3810.21	04/07/09	61.74	3748.47
DBS-8	55.2-75.2	3810.70	04/07/09	61.20	3749.50
DBS-9	48.0-68.0	3806.26	04/08/09	53.93	3752.33
NW-1(s)	52.95-72.95	3817.33	04/08/09	62.35	3754.98
NW-1 (m)	99.31-119.31	3817.35	04/08/09	62.25	3755.10
NW-1 (d)	149.45-169.45	3817.35	04/08/09	62.04	3755.31
NW-2 (s)	53.35-73.35	3812.50	04/08/09	63.08	3749.42
NW-2 (m)	93.72-113.72	3812.45	04/08/09	63.27	3749.18
NW-2 (d)	126.87-146.87	3812.46	04/08/09	66.41	3746.05
PMW-1	63-78	3821.17	06/23/08	67.51	3753.66
			04/08/09	65.97	3755.20
MW-1	120-140	NA	06/23/08	59.90	NA
MW-2	127-147	3812.68	06/23/08	61.42	3751.26
			04/07/09	61.65	3751.03
MW-3	NA	3812.50	06/23/08	62.06	3750.44
			04/07/09	62.02	3750.03
MW-4	111-131	3811.33	06/23/08	62.12	3749.21
			04/07/09	62.51	3748.82
MW-5	112-132	3808.96	06/23/08	60.60	3748.36
			04/07/09	60.79	3748.17
MW-6	NA	3810.17	06/23/08	62.17	3748.00
			04/07/09	62.41	3747.76

[a] Top of casing elevations surveyed by Pettigrew & Associates on May 28, 2009.

ft bgs = Feet below ground surface
ft btoc= Feet below top of casing
ft msl = Feet above mean sea level
NA = Not available

Sections 2.1.1 and 2.1.2 provide details regarding the WinFlow simulations for each of the two areas.

2.1.1 Brine Pond Area Capture

Capture at the brine pond area (including the brine loading/unloading area) was simulated through groundwater extraction at RW-1. Table 2 presents hydraulic property values used in the simulation. Well RW-1 partially penetrates the aquifer. The screen of RW-1 is 20 feet long and was placed across the water table with approximately 5 feet above and 15 feet below the static water table. Although only 15 feet of screen is saturated under static water table conditions, the aquifer thickness was doubled to 30 feet because the well partially penetrates the aquifer, and therefore, some extracted groundwater will be derived from deeper depths. This approach provides a more conservative estimate than using a thickness of 15 feet, as the greater 30-foot thickness results in a smaller capture zone.

Table 2. Brine Pond Area Simulated Hydraulic Property Values

Parameter	Value	Source
Hydraulic conductivity	1.5 ft/d	DBS&A (2009b)
Thickness	30 feet	Assumed
Specific yield	0.15	Based on information in Blandford et al. (2008) and Nativ and Smith (1987)
Effective porosity	0.15	
Hydraulic gradient		
Magnitude	0.004	DBS&A (2009a); Figure 1
Direction (counterclockwise from x-axis)	321º	

Figure 4 shows the approximate extent of chloride impacts at the brine pond area. The chloride plume extends approximately 375 feet from the vicinity of the former brine pond to just southeast of DBS-1. The highest chloride concentrations are observed at PNW-1, located just upgradient of RW-1. The width of the chloride plume is estimated to be approximately 200 feet (Figure 4). Chloride concentrations at nested well NW-1 show that chloride impacts are limited to the shallow screened zone.

Explanation

DBS-1 Well designation
320 Chloride concentration (mg/L)

Monitor well location

Extraction well location

Chloride concentration contour (mg/L) (dashed where inferred)

BOLD indicates concentration equal to or greater than the NMWQCC standard of 250 mg/L.

Source: Google Earth aerial photograph dated September 2002

SALTY DOG BRINE STATION

Brine Pond Area
Extent of Chloride Impacts in April 2009

Daniel B. Stephens & Associates, Inc.
12/15/2009
JN ES08.0118.01

Figure 4

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The pumping rate at RW-1 was adjusted in WinFlow until reverse-particle tracking analysis demonstrated that pumping created a capture zone that covered the width of the chloride plume shown on Figure 4.

2.1.2 Brine Well Area Capture

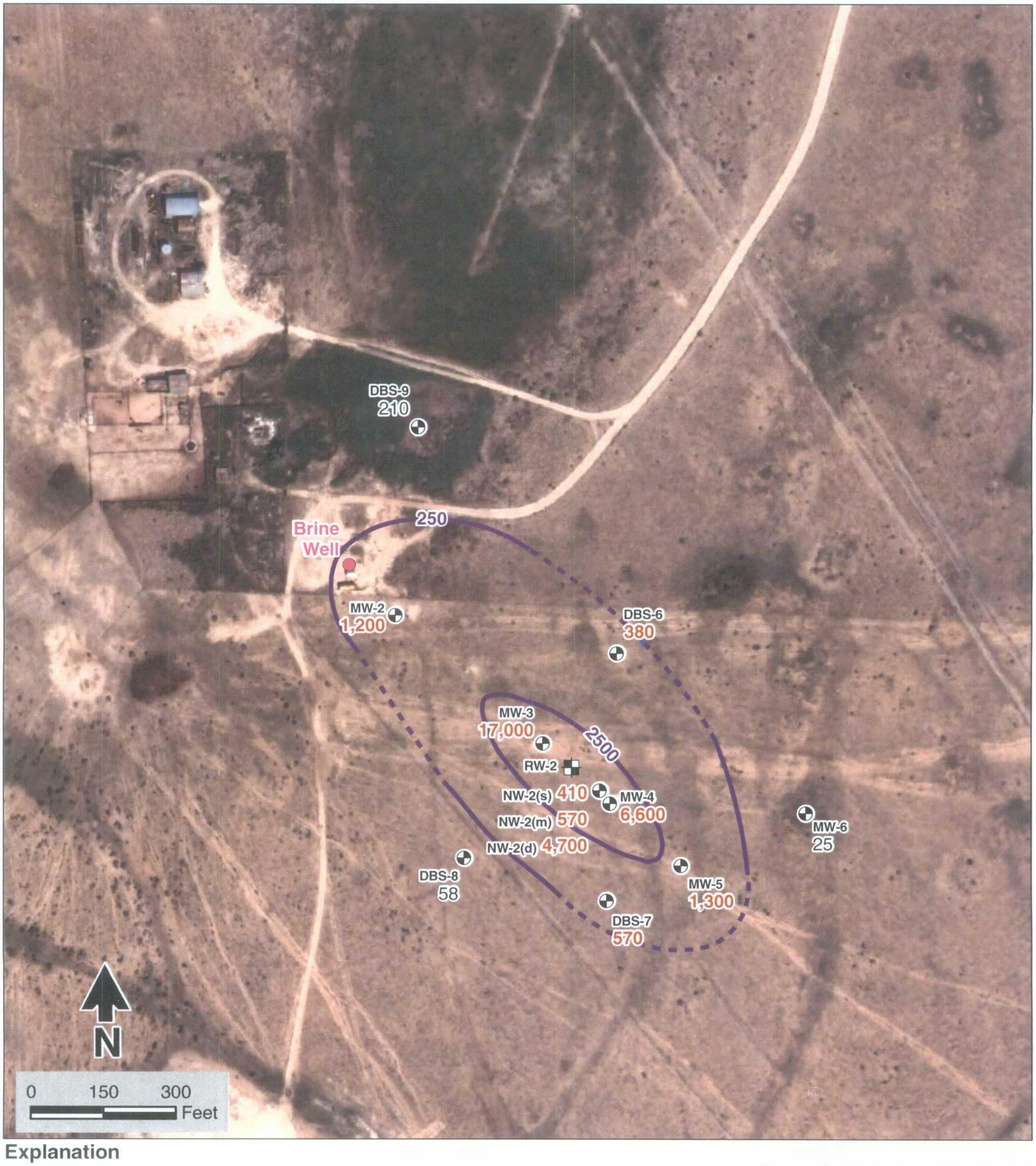
Capture at the brine well area was simulated through groundwater extraction at RW-2. Table 3 presents hydraulic property values used in the simulation. Well RW-2 fully penetrates and is screened for 40 feet above the base of the aquifer. The aquifer thickness is 90 feet (DBS&A, 2009b).

Table 3. Brine Well Area Simulated Hydraulic Property Values

Parameter	Value	Source
Hydraulic conductivity	7.7 ft/d	DBS&A (2009b)
Thickness	90 feet	
Specific yield	0.15	Based on information in Blandford et al. (2008) and Nativ and Smith (1987)
Effective porosity	0.15	
Hydraulic gradient		
Magnitude	0.004	DBS&A (2009a); Figure 2
Direction (counter clockwise from x-axis)	315º	

Figure 5 shows the approximate extent of the chloride plume at the brine well area, extending from the brine well for approximately 750 feet to the southeast. The highest chloride concentrations are observed at MW-3, located upgradient of RW-2. The width of the chloride plume is estimated to be approximately 325 feet (Figure 5). Chloride concentrations at nested well NW-2 increase with depth and are greatest in the deep screened zone near the base of the aquifer.

The pumping rate at RW-2 was adjusted in WinFlow until reverse-particle tracking analysis showed that pumping created a capture zone that covered the width of the chloride plume shown on Figure 5.



Explanation

MW-2 Well designation

1,200 Chloride concentration (mg/L)

Monitor well location

Extraction well location

Chloride concentration contour (mg/L) (dashed where inferred)

BOLD indicates concentration equal to or greater than the NMWQCC standard of 250 mg/L.

Source: Google Earth aerial photograph dated September 2002

SALTY DOG BRINE STATION

Brine Well Area
Extent of Chloride Impacts in April 2009

Daniel B. Stephens & Associates, Inc.

12/15/2009 JN ES08.0118.01

Figure 5

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2.2 Modeling Results

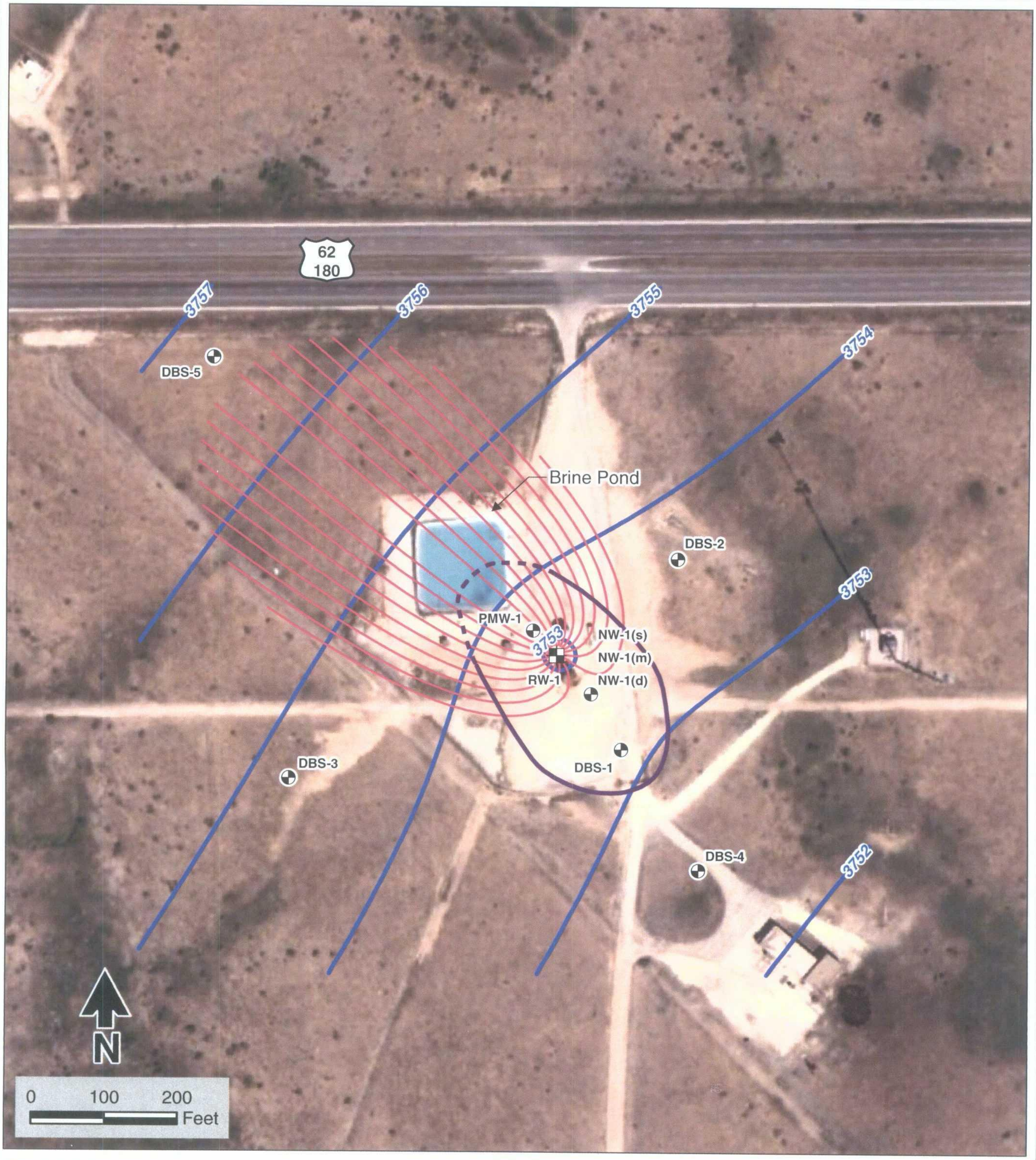
Sections 2.2.1 and 2.2.2 summarize the WinFlow modeling results and provide estimates of the expected duration of extraction system pumping for the two areas.

2.2.1 Brine Pond Area Capture

Pumping RW-1 at a rate of 0.5 gallon per minute (gpm) (720 gallons per day [gpd]) provides sufficient capture of chloride-impacted groundwater originating from the former brine pond and brine loading/unloading area. Figure 6 shows WinFlow simulation results for the brine pond area. Predicted total drawdown in the area of RW-1 is 2 feet. Well RW-1 has sufficient water column (~15 feet) to support a pumping rate of 0.5 gpm. Estimated drawdown within the well casing, including a well efficiency of 53 percent, is 4 feet. The well efficiency of 53 percent was determined from the RW-1 pumping test performed in November 2009 (DBS&A, 2009b). During that pumping test, RW-1 was pumped at a maximum rate of 4.6 gpm, and total drawdown at the well stabilized to approximately 9.5 feet. RW-1 is therefore expected to be able to sustain a pumping rate of 0.5 gpm.

The expected duration of extraction system operation at the brine pond area is 4.2 years. This estimate represents the time required to remove existing groundwater impacts upgradient of RW-1. The volume of impacted groundwater upgradient of RW-1 is approximately 1.10×10^6 gallons. This volume was calculated by multiplying the area of impacts intercepted by RW-1 (Figure 7) by a thickness of 30 feet (Table 2) and an effective porosity of 0.15 (Table 2). Pumping 1.10×10^6 gallons of chloride-impacted groundwater at 0.5 gpm will take 4.2 years. Appendix A contains a worksheet with the calculation.

Chloride impacts downgradient of RW-1 that are not captured by groundwater extraction have much lower chloride concentrations than those removed by RW-1 (Figure 4). These impacts are expected to be naturally attenuated through mixing and dilution with ambient groundwater, as the area with higher chloride concentration is removed and hydraulically contained. Wells located downgradient of RW-1 will be monitored. Chloride concentrations at these monitor wells are expected to decrease after the groundwater extraction system is operating.



Explanation

DBS-1 Well designation

Monitor well location

Extraction well location

Extent of Chloride impacts in April 2009

Reverse particle path

Simulated water level elevation (ft msl)

Source: Google Earth aerial photograph dated September 2002

Note: Reverse particle paths and simulated water levels created using WinFlow

SALTY DOG BRINE STATION

Brine Pond Area

Simulated Capture Zone

Daniel B. Stephens & Associates, Inc.

12/16/2009

JN ES08.0118.01

Figure 6

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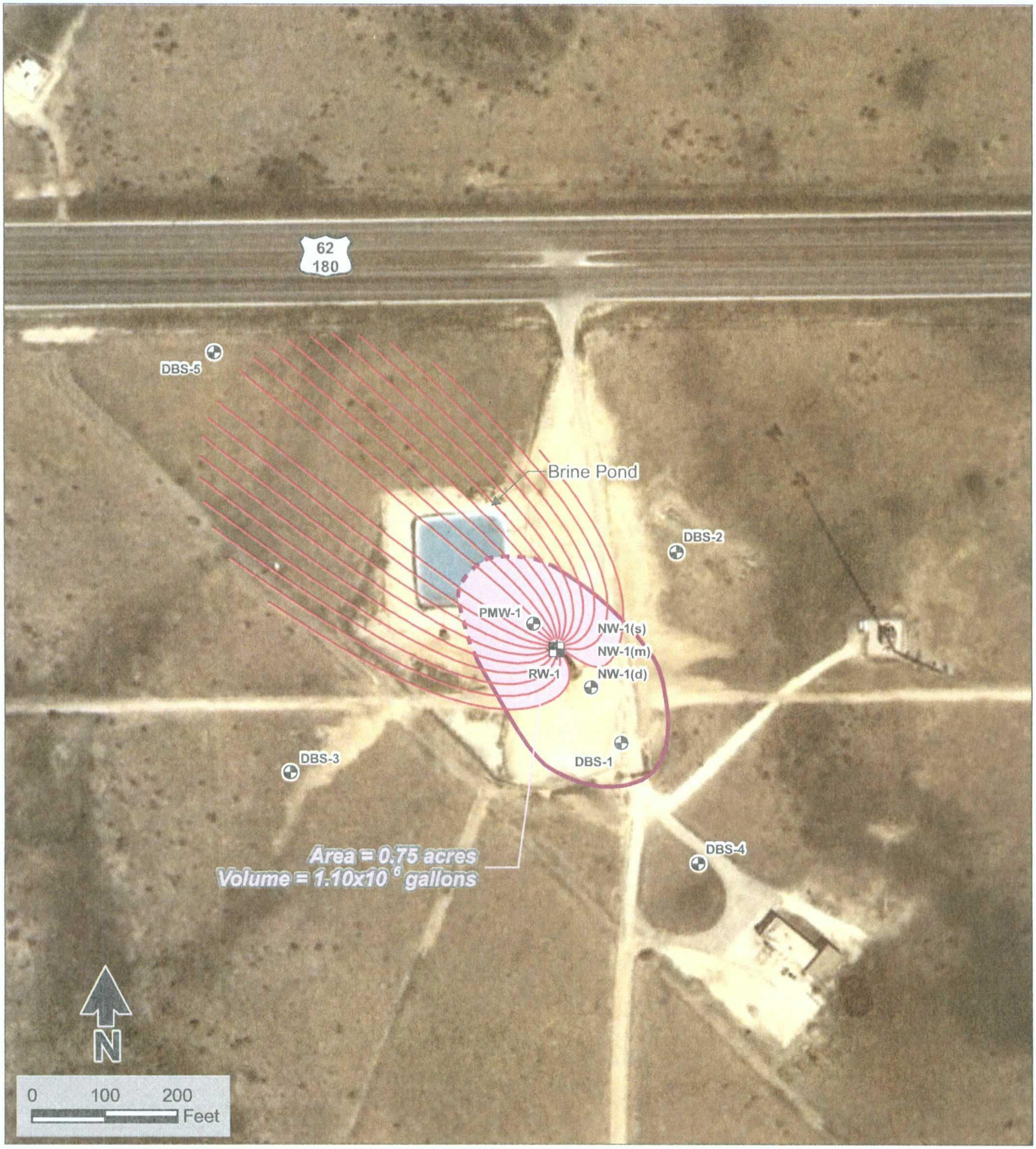

Explanation

DBS-1 Well designation

Monitor well location

Extraction well location

Extent of Chloride impacts in April 2009

Reverse particle path

Captured impacted area

Source: Google Earth aerial photograph dated September 2002

Note: Reverse particle paths and simulated water levels created using WinFlow

SALTY DOG BRINE STATION

Brine Pond Area

Captured Impacted Groundwater

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12/22/2009

JN ES08.0118.01

Figure 7

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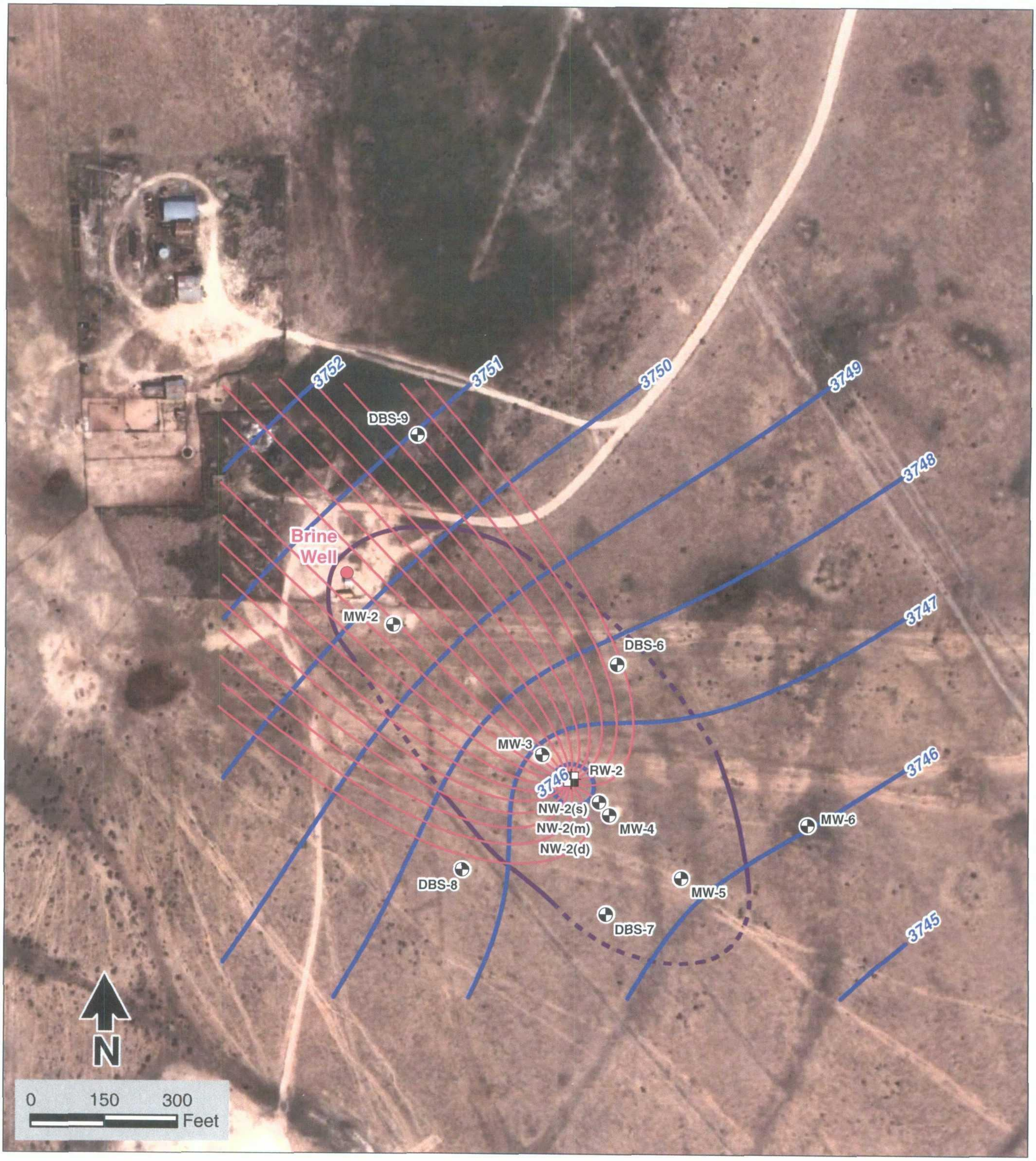
2.2.2 Brine Well Area Capture

Pumping RW-2 at 15 gpm (21,600 gpd) provides sufficient capture of chloride-impacted groundwater originating from the vicinity of the brine well. Figure 8 shows WinFlow simulation results from the brine well area capture zone analysis. Well RW-2 has sufficient water column (~90 feet) to support an extraction system pumping rate of 15 gpm. Predicted total drawdown in the vicinity of RW-1 is less than 4 feet. The well efficiency of RW-2, as determined from the November 2009 pumping test, ranges from 49 to 60 percent. Using the lower well efficiency value, estimated drawdown within the well casing of RW-2 is 8 feet. During the pumping test performed in November 2009, RW-2 sustained a pumping rate of 39.4 gpm with total drawdown stabilizing at approximately 23 feet. RW-2 is therefore expected to be able to sustain a pumping rate of 15 gpm.

The expected duration of extraction system operation at the brine well area is 3.7 years. This estimate represents the time required to remove existing chloride groundwater impacts upgradient of RW-2. The volume of impacted groundwater upgradient of RW-2 is approximately 29.0 x 10^6 gallons. This volume was calculated by multiplying the area of impacts intercepted by RW-2 (Figure 9) by an aquifer thickness of 90 feet (Table 3) and an effective porosity of 0.15 (Table 3). Pumping 29.0 x 10^6 gallons of chloride impacted groundwater at 15 gpm will take 3.7 years. Appendix A contains a worksheet with the calculation.

Chloride impacts downgradient of RW-2 that are not removed through pumping exhibit lower chloride concentrations than those captured by RW-2 (Figure 5). These impacts are expected to be naturally attenuated through mixing and dilution with ambient groundwater, as the area with the greatest chloride impact is removed and hydraulically contained. Wells located downgradient of RW-2 will be monitored and are expected to show decreases in chloride concentrations after the groundwater extraction system is operating.



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Explanation

- MW-2 Well designation
- Monitor well location
- Extraction well location
- Extent of Chloride impacts in April 2009
- Reverse particle path
- Simulated water level elevation (ft msl)

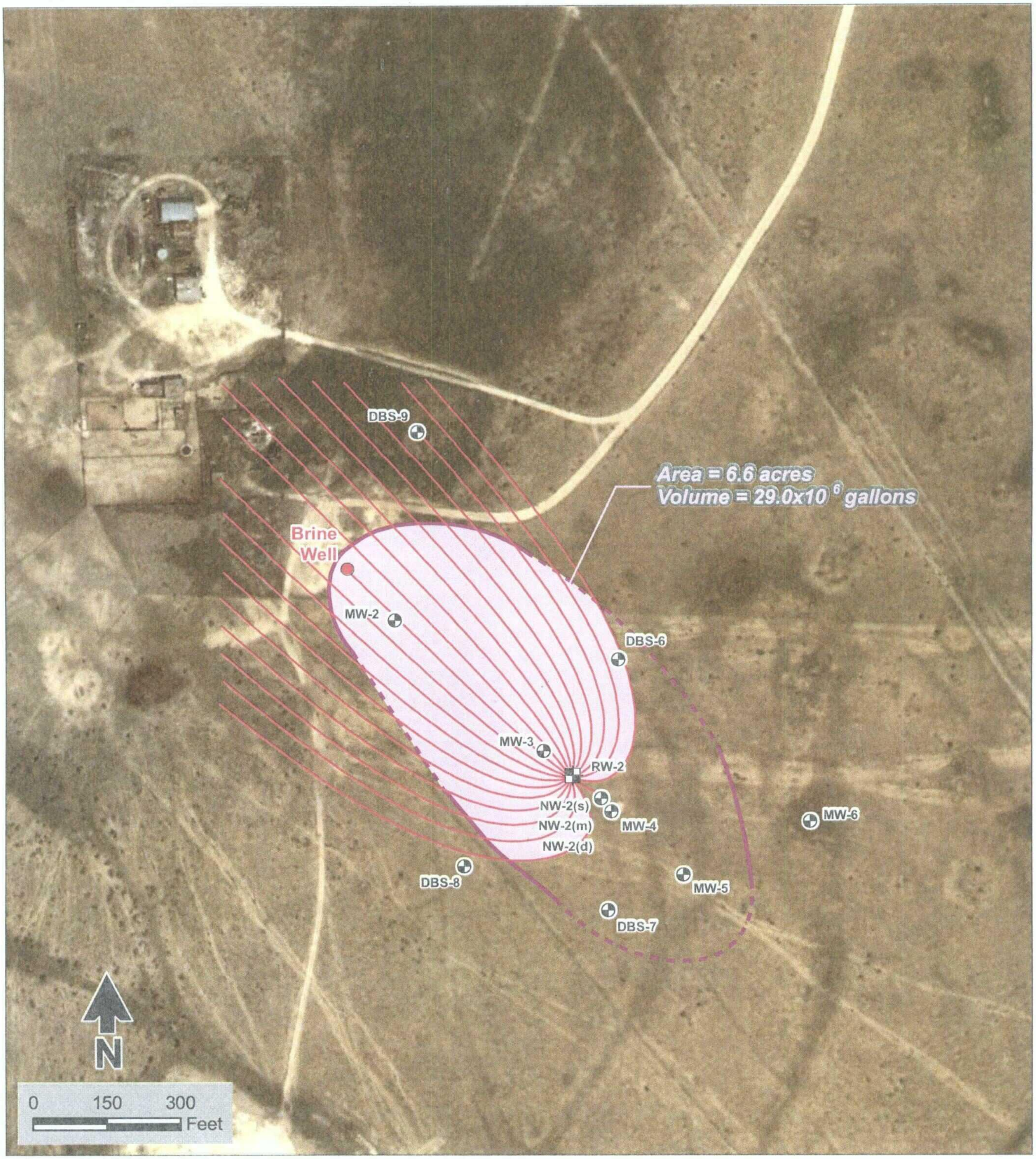
Source: Google Earth aerial photograph dated September 2002

Note: Reverse particle paths and simulated water levels created using WinFlow

SALTY DOG BRINE STATION
Brine Well Area
Simulated Capture Zone

Daniel B. Stephens & Associates, Inc.
12/16/2009 JN ES08.0118.01

Figure 8



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Explanation

MW-2 Well designation
Monitor well location
Extraction well location
Extent of chloride impacts in April 2009
Reverse particle path
Captured impacted area

Source: Google Earth aerial photograph dated September 2002

Note: Reverse particle paths and simulated water levels created using WinFlow

SALTY DOG BRINE STATION
Brine Well Area
Captured Impacted Groundwater

Daniel B. Stephens & Associates, Inc.
12/22/2009 JN ES08.0118.01

Figure 9

3. Treatment Alternatives

Four groundwater treatment alternatives were evaluated for the extracted groundwater:

- Pumping and reinjection into existing brine well
- Pumping and treatment by reverse osmosis (RO)
- Pumping and evaporation
- Pumping and hauling for disposal at a permitted off-site facility

Based on the modeling results detailed in Section 2.2, pumping rates of 0.5 gpm for RW-1 and 15 gpm for RW-2 are required to hydraulically contain the chloride plumes at the brine pond and brine well areas. A total pumping rate for the treatment of the anticipated flows from the two recovery wells were rounded to 16 gpm (approximately 550 barrels per day) for the evaluation of the treatment alternatives. The expected duration of extraction system operation at the brine pond and brine well areas is approximately 5 years. Using the flow rates above, a ⅛-horsepower (HP) pump is required for RW-1 and a ½-HP pump is required for RW-2. The well casings for RW-1 and RW-2 are both 6-inch-diameter and will easily accommodate the installation of these pump sizes. The four alternatives are described and evaluated in Sections 3.1 through 3.2. A comparison of costs and DBS&A's recommendations are presented in the Section 4.

Each alternative discussed will require a pipeline to convey the extracted groundwater between the brine pond and brine well areas. DBS&A has assumed that only one treatment system will be installed at either the brine pond area or the brine well area. For the reinjection, RO, and pond alternatives, a discharge permit or injection permit will be required from either the OCD or the New Mexico Environment Department Groundwater Quality Bureau (NMED GWQB).

3.1 Pumping and Reinjection

The pumping and reinjection alternative will directly reinject the extracted groundwater from recovery wells RW-1 and RW-2 into the existing brine well. This alternative will require no treatment of the extracted groundwater prior to reinjection. Under this alternative, groundwater extracted from RW-1 and RW-2 will be pumped to an equalization tank located near the brine well, and a third pump will be used to reinject the water into the brine well for disposal. Based on a discussion with James Millett of Salty Dog, approximately 1,000 to 1,500 barrels per day can be reinjected into the brine well.

A new pipeline from RW-1 will be installed under this option. Since the flow rate from RW-1 will be less than 1 gpm, the line can be either 1-inch Schedule 40 polyvinyl chloride (PVC) or high-density polyethylene (HDPE), approximately 2,600 feet in length.

Due to the high total dissolved solids (TDS) of the reinjected groundwater, rehabilitation of the brine well will be necessary on a regular basis. The efficiency of the well will decrease due to buildup of scaling on the well screen. Rehabilitation of the well would include acidification, scrubbing, and developing to remove the built-up scale from the well screen.

An Underground Injection Control (UIC) Class I well permit from the OCD will be required prior to beginning reinjection. The UIC permit will entail testing of the brine well and potentially groundwater monitoring.

3.2 Pumping and Treatment by Reverse Osmosis

The pumping and treatment by RO alternative will treat extracted groundwater from RW-1 and RW-2 by RO to remove chloride and other dissolved solids. RO is a membrane treatment process that separates the dissolved solids by pressure-driven diffusion across a permeable membrane. A typical RO membrane is made of synthetic material that is permeable to some components in the feed stream and impermeable to other components. Water to be treated is pumped at high pressure across the surface of the membranes, causing a portion of the water to pass through the membranes. Water passing through the membranes is greatly reduced of dissolved solids, while the rejected water is highly concentrated in dissolved solids (MWH, 2005).

Treatment of the extracted groundwater by RO will require construction of a new facility to house the treatment system. The RO facility will consist of a pre-engineered building (approximately 20 feet by 30 feet) on a slab and footings, three equalization tanks, and plumbing and connections to the discharge system. The treatment system will consist of one anthracite/greensand filter, an activated carbon filter, and one RO treatment skid. Other required site improvements will include a power drop to the building consisting of transformers, utility pole, and meter. Three storage tanks will be placed next to the building to provide equalization storage for the filtered well water, the treated water, and the rejected water.

Extracted groundwater from RW-1 and RW-2 will enter the treatment facility at a flow rate of approximately 16 gpm with a TDS concentration of greater than 10,000 mg/L. The TDS concentration was calculated from field conductivity measurements recorded during development of the recovery wells in November 2009. The extracted groundwater will be filtered by the anthracite/greensand filter to remove particulates and reduce dissolved iron and manganese. The filtered water will then be stored in a tank before being pumped through the activated carbon filters to reduce the levels of organics. Antiscalant will be injected after the activated carbon filters to protect the RO membranes from any residual silica or other fouling material. The water will then be sent to the RO membranes for final treatment.

The RO system will be designed to treat a flow of 16 gpm. The RO process typically removes more than 95 percent of TDS from the influent water. Of the total 16 gpm entering the treatment facility, 8.2 gpm will pass through the RO membranes and be stored in a treated water storage tank, and 7.8 gpm will be rejected by the membranes. The 7.8 gpm of rejected water, also known as concentrate, will be pumped to a holding tank for disposal by reinjection into the brine well. Treated water is expected to have a TDS concentration of about 525 mg/L. Water rejected by the reverse osmosis membranes is expected to have a concentration of approximately 42,000 mg/L (Appendix C).

The treated water will be adequate for construction, irrigation, or other non potable uses. If the water is disinfected and tested, it will be potable.

3.3 Pumping and Evaporation

The pumping and evaporation alternative will dispose of extracted groundwater through evaporation in a retention pond. Evaporation ponds are a common means of disposing of wastewater without contamination of groundwater or surface waters in semiarid regions such as New Mexico. Evaporation ponds are lined with an HDPE liner that allows for full evaporation of the wastewater. Successful use of evaporation for disposal requires that the net evaporation equal or exceed the total water input to the system, including precipitation. The net evaporation may be defined as the difference between the evaporation and precipitation during any time period.

Based on the monthly rainfall and pan evaporation rates from weather stations located in Hobbs and Clovis, New Mexico (WRCC, 2009; OCS, 2009), an approximate water surface area of 7.5 acres is required for the evaporation pond. The resulting pond dimensions are 3 to 4 feet in depth (including a freeboard of 2 feet) with a total footprint of approximately 8 acres (Appendix D). Assuming an expected duration of extraction system operation of approximately 5 years, there will not be a significant buildup of salt in the pond. Site improvements for the pond will include fencing and access roads.

Installation of the evaporation pond will require a discharge permit from the NMED GWQB. The permit will require installation of a leak detection system and groundwater monitoring wells and periodic monitoring of these components during the life of the project. Upon completion of the treatment, the pond will need to be closed according to the discharge permit requirements.

3.4 Pumping and Hauling for Off-Site Disposal

The pumping and hauling alternative will dispose of extracted groundwater at a licensed off-site facility. A daily production of approximately 550 barrels will be produced at a pumping rate of 16 gpm. Assuming 50 barrels per truck, 11 truck loads per day will be required for disposal. A truck filling station will be constructed at the brine pond area, including an appropriately sized holding tank and transfer pump and a properly designed loading pad. Other site improvements will include lighting and fencing.

4. Cost Comparison and Recommended Alternative

A budget level cost estimate was compiled for each conceptual treatment alternative for comparison purposes. A more accurate engineer's estimate of probable cost should be completed during the design process for the chosen alternative. Table 4 presents the capital and operations and maintenance (O&M) estimates for each alternative. Based on the modeling results, a 5-year operational period is used for the project duration.

Table 4. Treatment Alternatives Cost Comparison

Alternative	Common Components Capital Costs	Estimated Capital Costs	Estimated Annual O&M Costs	Capital plus 5 years of O&M
Reinjection	42,600	48,524	97,116	576,702
RO treatment	42,600	528,937	95,126	1,047,167
Evaporation pond	42,600	1,666,665	55,116	1,984,843
Hauling	42,600	15,490	601,937	3,067,775

The pumping and reinjection alternative is the least expensive option over the 5-year life of the project due to the small capital outlay and the low O&M costs. The pumping and treatment by RO alternative is the second least expensive, but entails more operational complexity and costs due to the increased electrical requirements and higher level of technology than the reinjection alternative. The pumping and evaporation pond alternative and the pumping and hauling alternative result in much higher costs over the life of the project, by $1,000,000 and $2,000,000, respectively. The cost spreadsheets for each of the alternatives are provided in Appendix E.

Considerations for each alternative include:

- The pumping and reinjection alternative requires the least amount of new construction, and the O&M requirements are minimal for the wells, pumps, and tanks.

- The pumping and treatment by RO alternative is the only alternative producing potable water; however, the capital costs are high and O&M requirements are greatest of the four alternatives. The RO system also produces a waste stream that will require disposal, either by reinjection or hauling.

- The pumping and evaporation pond capital costs are highest of the four alternatives due to the pond size and required HDPE liner. O&M requirements for this option are the lowest of the four alternatives.

- The pumping and hauling alternative requires moderate capital and O&M costs for the loading pad and fill station, and high costs for the ongoing trucking and off-site disposal. The requirement for full-time truck drivers results in much higher labor costs than for the part-time operators needed for the other three alternatives.

Based on the costs and the minimal construction and O&M requirements, DBS&A recommends the pumping and reinjection alternative for the remediation of the chloride plumes at the brine pond and brine well areas.

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Appendix A

Capture Zone and Extracted Groundwater Volume Calculations

Project Name Salty Dog Inc. Number ES08.0118.01 Date 12/8/09
Subject Estimation of Well Capture Zone Width and Well Spacing
By J. Ayarbe Calculation No. 01

Purpose:

Calculate a well capture zone width for extraction well RW-01 at the PAB Salty Dog Site, Lea County, New Mexico. Capture zone width is calculated from a transmissivity value determined from a pumping test performed at well RW-01 in November 2009.

Extraction wells will be used to remove brine impacted groundwater caused by a release from a former brine pond.

Given:

$$W = \frac{Q}{T \cdot \Delta h}$$ modified from Fetter (1994). *Applied Hydrogeology*. page 502

W = capture zone width, *Q* = pumping rate, *T* = aquifer transmissivity; *Δh* = hydraulic gradient

Potential pumping rate (Q):

$$Q := 0.5\text{gpm}$$

Hydraulic gradient (Δh) determined from a April 2009 groundwater elevation map (DBS&A [2009]. *Monitoring Well Installation and Groundwater Monitoring Report Lea County, New Mexico.* Figure 8. September 18, 2009):

$$\Delta h := 0.004$$

Transmissivity values from Theis analysis of RW-01 recovery data (DBS&A [2009]. *Recovery Well Installation and Pump Test Report Salty Dog Brine Station, Lea County, New Mexico.* page 18. November 20, 2009):

$$\text{Trans} := 23\,\frac{\text{ft}^2}{\text{day}}$$

Solution:

Capture zone width (CZW) for a single pumping well:

$$\text{CZW} := \frac{Q}{\text{Trans} \cdot \Delta h}$$

$$\text{CZW} = 1046 \cdot \text{ft}$$

Assuming only 50% of pumping is from upper (more cemented) zone, RW-01 partially penetrating:

$$\text{Spacing} := \text{CZW}\cdot 0.5$$

$$\text{Spacing} = 523\cdot\text{ft}$$

Potential number of wells needed to intercept impacted groundwater:

$\text{Width} := 200\text{ft}$ Estimated plume width perpendicular to groundwater flow direction

$$\text{Wells} := \frac{\text{Width}}{\text{Spacing}}$$

$$\text{Wells} = 0.38$$

Project Name Salty Dog Inc. Number ES08.0118.01 Date 12/8/09
Subject Estimation of Well Capture Zone Width and Well Spacing
By J. Ayarbe Calculation No. 02

Purpose:

Calculate a well capture zone width for extraction well RW-02 at the PAB Salty Dog Site, Lea County, New Mexico. Capture zone width is calculated from a transmissivity value determined from a pumping test performed at well RW-02 in November 2009.

Extraction wells will be used to remove brine impacted groundwater caused by a release from brine well.

Given:

$W = \frac{Q}{T \cdot \Delta h}$ modified from Fetter (1994). *Applied Hydrogeology*. page 502

W = capture zone width, *Q* = pumping rate, *T* = aquifer transmissivity; Δh = hydraulic gradient

Potential pumping rate (Q):

$$Q := 12\text{gpm}$$

Hydraulic gradient (Δh) determined from a April 2009 groundwater elevation map (DBS&A [2009]. *Monitoring Well Installation and Groundwater Monitoring Report Lea County, New Mexico.* Figure 8. September 18, 2009):

$$\Delta h := 0.004$$

Transmissivity value from Theis analysis of RW-02 pumping test data (DBS&A [2009]. *Recovery Well Installation and Pump Test Report Salty Dog Brine Station, Lea County, New Mexico.* page 18. November 20, 2009):

$$\text{Trans} := 690 \frac{\text{ft}^2}{\text{day}}$$

Solution:

Capture zone width (CZW) for a single pumping well:

$$\text{CZW} := \frac{Q}{\text{Trans} \cdot \Delta h}$$

$$\text{CZW} = 837 \cdot \text{ft}$$

Assuming a 20% margin of safety:

$$Spacing := CZW \cdot 0.8$$

$$Spacing = 670 \cdot ft$$

Number of wells needed to intercept impacted groundwater:

$Length := 663ft$ projected distance between DBS-8 and MW-6 measured perpendicular to hydraulic gradient

$$Wells := \frac{Length}{Spacing}$$

$$Wells = 0.99$$

Project Name Salty Dog Inc. Number ES08.0118.01 Date 12/21/09
Subject Estimation of captured groundwater volumes and pumping duration
By J. Ayarbe Calculation No. 03

Purpose:

Calculate the area of groundwater impacts intercepted by pumping at RW-01 at the PAB Salty Dog Site, Lea County, New Mexico. Then estimate the time required to remove impacted groundwater at a pumping rate determined from WinFlow modeling.

Given:

$$V = A \cdot b \cdot n_e$$

V = groundwater volume, *A* = captured area of impacts, *b* = aquifer or zone thickness; n_e = effective porosity

Area of impacts (A) determined in GIS by overlapping extent of chloride impacts and WinFlow reverse-particle tracks (see attached figure):

$$A := 0.75\text{acre}$$

Thickness (b) estimated to be two times the saturated length of the RW-01 well screen. RW-01 is partially penetrating with 15 feet of screen below the static water table. Thickness doubled to account for possibility of groundwater contributions from deeper depths:

$$b := 30\text{ft}$$

Effective porosity (n_e) (based on information in Blandford et al. [2008]; Native and Smith [1987]):

$$n_e := 0.15$$

$$t = \frac{V}{Q}$$

t = pumping duration, *V* = groundwater volume, *Q* = pumping rate

Pumping rate (Q) determined from WinFlow modeling:

$$Q := 0.5\text{gpm}$$

Solution:

Volume (V) of impacted groundwater captured by RW-1:

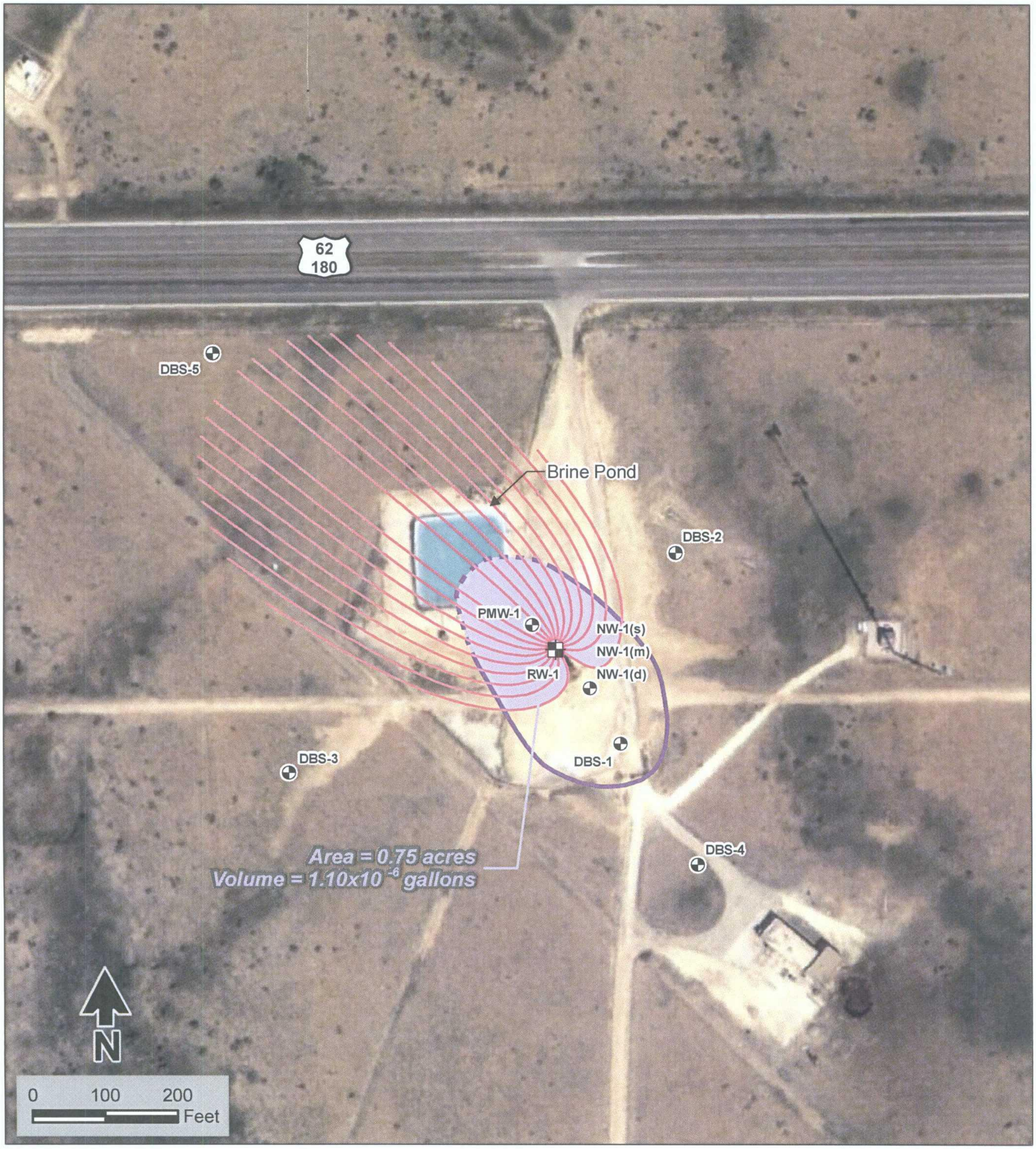
$$V := A \cdot b \cdot n_e$$

$$V = 1.10 \times 10^6 \cdot gal$$

Estimated time needed to completely pump impacted groundwater:

$$t := \frac{V}{Q}$$

$$t = 4.2 \cdot yr$$



Explanation

DBS-1 Well designation

Monitor well location

Extraction well location

Extent of Chloride impacts in April 2009

Reverse particle path

Captured impacted area

Source: Google Earth aerial photograph dated September 2002

Note: Reverse particle paths and simulated water levels created using WinFlow

SALTY DOG BRINE STATION

Brine Pond Area

Captured Impacted Groundwater

Daniel B. Stephens & Associates, Inc.

12/22/2009

JN ES08.0118.01

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Project Name Salty Dog Inc. Number ES08.0118.01 Date 12/21/09
Subject Estimation of captured groundwater volumes and pumping duration
By J. Ayarbe Calculation No. 04

Purpose:

Calculate the area of groundwater impacts intercepted by pumping at RW-02 at the PAB Salty Dog Site, Lea County, New Mexico. Then estimate the time required to remove impacted groundwater at a pumping rate determined from WinFlow modeling.

Given:

$$V = A \cdot b \cdot n_e$$

V = groundwater volume, *A* = captured area of impacts, *b* = aquifer or zone thickness; n_e = effective porosity

Area of impacts (A) determined in GIS by overlapping extent of chloride impacts and WinFlow reverse-particle tracks (see attached figure):

$$A := 6.6\text{acre}$$

Aquifer thickness (b) at RW-2. RW-2 fully penetrates the Ogallala aquifer:

$$b := 90\text{ft}$$

Effective porosity (n_e) (based on information in Blandford et al. [2008]; Native and Smith [1987]):

$$n_e := 0.15$$

$$t = \frac{V}{Q}$$

t = pumping duration, *V* = groundwater volume, *Q* = pumping rate

Pumping rate (Q) determined from WinFlow modeling:

$$Q := 15\text{gpm}$$

Solution:

Volume (V) of impacted groundwater captured by RW-2:

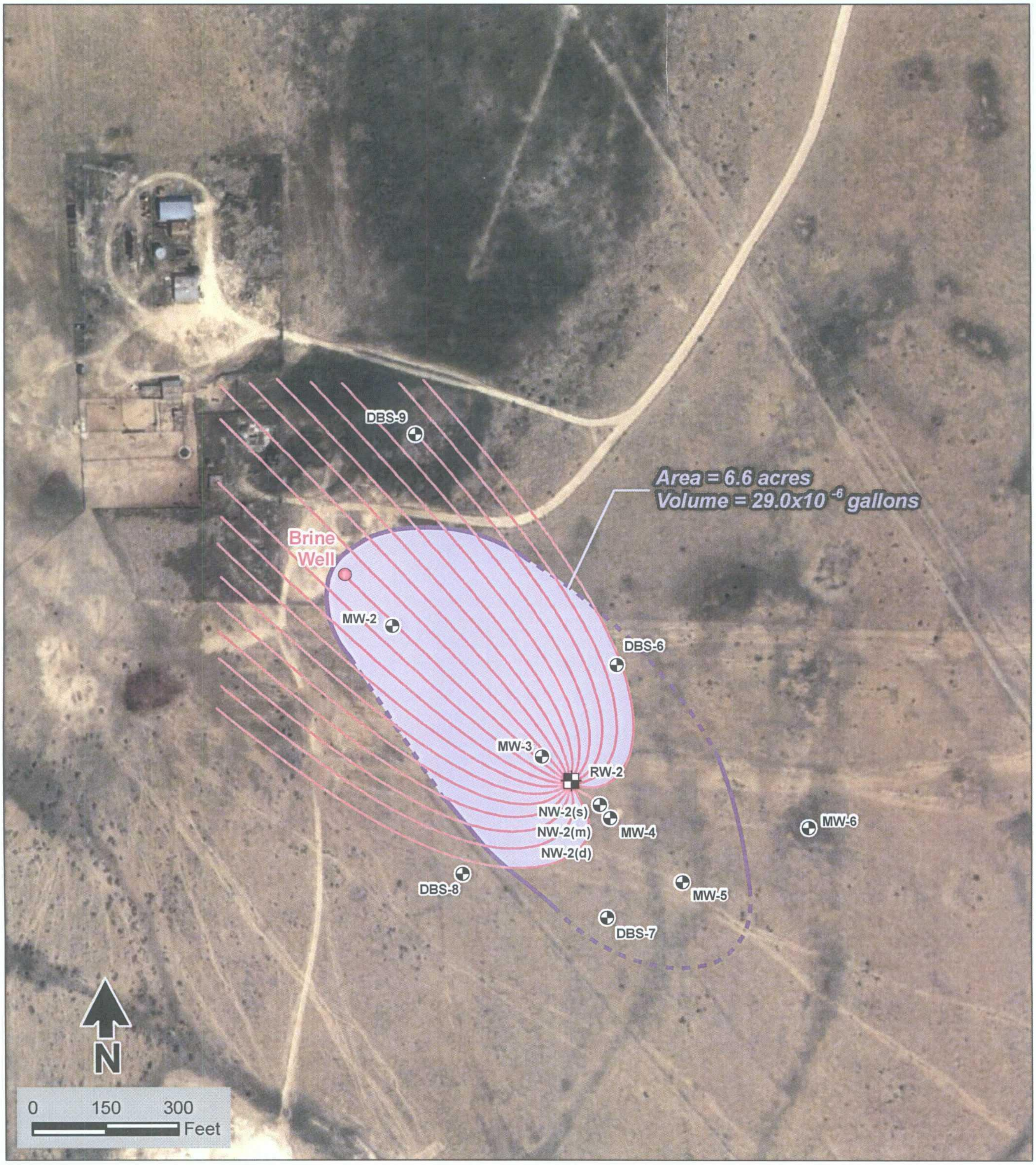
$$V := A \cdot b \cdot n_e$$

$$V = 2.90 \times 10^{7} \cdot gal$$

Estimated time needed to completely pump impacted groundwater:

$$t := \frac{V}{Q}$$

$$t = 3.7 \cdot yr$$



Explanation

- MW-2 Well designation
- Monitor well location
- Extraction well location
- Extent of chloride impacts in April 2009
- Reverse particle path
- Captured impacted area

Source: Google Earth aerial photograph dated September 2002

Note: Reverse particle paths and simulated water levels created using WinFlow

SALTY DOG BRINE STATION
Brine Well Area
Captured Impacted Groundwater

Daniel B. Stephens & Associates, Inc.
12/22/2009 JN ES08.0118.01

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Appendix B

WinFlow Files

Appendix C

Reverse Osmosis Flows

Salty Dog Reverse Osmosis Flows

Well ID	Flow rate (gpm)	Flow rate (L/min)	Date of Sampling	CL- (mg/L)	TDS* (mg/L)
RW-1	1	4		5000	6700
RW-2	15	57		15000	10720
Totals	16	61			

$(C_1V_1 + C_2V_2 + C_3V_3 + C_4V_4) / V_T = C_T$

Chloride C_T = 14,375 mg/L (using measured values for all)

TDS C_T = 10,469 mg/L (using measured values for all)

Run time (hours/day)	Feed rate (gpm)	Recovery Rate (% P/F)	Run time (mins/day)	Rejection Rate
24	16	55%	1440	95%

Treated water		Reject water			Blended Water		Daily Production	
TDS (mg/L)	Flow (gpm)	Reject Flow	TDS (mg/L)	Flow (gpm)	TDS (mg/L)	Flow (gpm)	Treated and Blended (gpd)	Reject (gpd)
523	8.8	7.2	41875	0.00	523	8.8	12,672	10,368

Blue text are inputs

*TDS calculated from field specific conductivity (11/08/09) with SpC(uS/cm)/0.66=TDS (mg/L)

Appendix D

Climate Data and Pond Design Spreadsheets

Pan Evapration Station Clovis 13N
Precipitation Station Hobbs Airport

Month	Avg Precip (in)	Cumm. Precip (in)	Pan Evap (in)	Estimated Pond Evap (in)	Estimated Cum Pond Evap (in)
Jan	0.44	0.44	3.83	2.55	2.55
Feb	0.44	0.88	4.12	2.75	5.30
Mar	0.56	1.44	6.63	4.42	9.72
Apr	0.79	2.23	8.72	5.81	15.53
May	1.99	4.22	10.15	6.77	22.30
Jun	1.88	6.10	11.45	7.63	29.93
Jul	2.10	8.20	11.65	7.77	37.70
Aug	2.42	10.62	9.55	6.37	44.07
Sep	2.62	13.24	7.64	5.09	49.16
Oct	1.59	14.83	5.78	3.85	53.01
Nov	0.57	15.40	3.95	2.63	55.65
Dec	0.56	15.96	3.21	2.14	57.79
Annual	15.96		86.68	57.79	

Pan Evaporation (inches)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period
Clovis	3.83	4.12	6.63	8.72	10.15	11.45	11.65	9.55	7.64	5.78	3.95	3.21	86.68	1929-2005

Precipitation Source: http://www.wrcc.dri.edu/summary/Climsmaz.html

Pan data source: http://www.ocs.orst.edu/page_links/comparative_climate/new_mexico/new_mexico.html

Site Name	Salty Dog Evaporation Pond	
Calcs by:	Gwinn Hall	
Date:	12/21/09	
Design Flow (gpm)	16	
Design Lifetime (yrs)	5	
Annual Influent Flow (gal)	8,409,600	
Annual Influent Flow (ft3)	1,124,278	
Lifetime Influent Flow (gal)	42,048,000	
Lifetime Influent Flow (ft3)	5,621,390	
Mean Annual Precip (in)	15.97	Hobbs, NM data from WRCC website
Mean Annual Precip (mm)	405.6	
Pan Evap Rate (in/yr)	80.57	Clovis, NM from WRCC website
Pan Coefficient (Ep/Eo)	1.5	Linacre, 2002, www-das.uwyo.edu
Est Pond Evap Rate (in/yr)	54	Clovis, NM from WRCC website

Evap Pond Dimensions:

Avg. Width at waterline (ft)	500
Avg. Length at waterline (ft)	650
Area (ft2)	325,000
Area (m2)	30,204
Area (acre)	7.46
Water Height (ft)	2
Storage Volume (ft3)	636,296
Storage Volume (m3)	18,020
Storage Volume (gal)	4,759,494

Water Balance Calculations:

Month	**Inflow (gal)**	**Direct Precip (gal)**	**Total Inflow (gal)**	**Evap (gal)**	**Vol Chg (gal)**	**Pond Volume (gal)**	**Water Depth (ft)**
Jan	700,416	89,137	789,553	517,263	272,290	272,290	0.1
Feb	700,416	89,137	789,553	556,429	233,124	505,414	0.2
Mar	700,416	113,447	813,863	895,418	-81,556	423,858	0.2
Apr	700,416	160,041	860,457	1,177,684	-317,228	106,630	0.0
May	700,416	403,141	1,103,557	1,370,814	-267,257	0	0.0
Jun	700,416	380,857	1,081,273	1,546,386	-465,113	0	0.0
Jul	700,416	425,425	1,125,841	1,573,397	-447,556	0	0.0
Aug	700,416	490,252	1,190,668	1,289,781	-99,113	0	0.0
Sep	700,416	530,768	1,231,184	1,031,824	199,360	199,360	0.1
Oct	700,416	322,108	1,022,524	780,621	241,902	441,262	0.2
Nov	700,416	115,473	815,889	533,469	282,419	723,681	0.3
Dec	700,416	113,447	813,863	433,528	380,334	1,104,016	0.5
Annual	**8,404,992**	**3,233,230**	**11,638,222**	**11,706,616**	**-68,394**		

Salty Dog Evaporation Pond

Inputs:

Width at waterline (ft)	500
Length at waterline (ft)	650
Sideslope:1 (below waterline)	3
Depth (ft) below waterline	2
Anchor Trench Runout (ft)	1
Sideslope:1 (above waterline)	3
Berm Height Above Waterline (ft)	2
Top of berm width (ft)	4

Outputs:

Width of pond base (ft) =	488
Length of pond base (ft) =	638
Volume of prismoid below waterline (cf) =	636,296
Volume of prismoid below waterline (cy) =	23,567
Volume of prismoid below waterline (gal) =	4,760,130
Approximate surface area of side slopes below waterline (sf =	14,395
Approximate surface area base (sf) =	311,344
Total liner area below water level (sf) =	**325,739**
Total liner area above water level (sf) =	**2,348**
Total airspace volume (cf) =	**1,272,592**
Total airspace volume (cy) =	**47,133**
Total pond capacity (gal) =	**9,520,261**
Approximate total surface area (sf) =	**325,739**
Approximate total liner surface area (sf) =	**328,087**
Pond + Berm volume (cy) =	**25,312**

Footprint area (acres) with berm =	8.2
Footprint area (acres) at top at inside of berm =	7.78
Footprint area (acres) at waterline =	7.46
Width of top at inside of berm (ft) =	512
Length of top at inside of berm (ft) =	662
Volume of prismoid above waterline (cf) =	636,296
Volume of prismoid above waterline (cy) =	23,567
Volume of prismoid above waterline (gal) =	4,760,130
Approximate surface area of side slopes above waterline (sf) =	0
Approximate liner runout area, side slopes (sf) =	2,348
Berm dimensions:	
Base (ft) =	16
Top Width (ft) =	4
Height (ft) =	2
X-Sect Area (sf) =	20
Perimeter (ft) =	2,356
Volume of berm around pond (cy) =	1,745

Notes:
This spreadsheet assumes waterline is at grade.
Therefore below waterline is cut, and above waterline (ie the berm) is fill.
The liner is calculated to run up to the top of the berm and then into an anchor trench.
The berm is calculated as symmetrical above the waterline.

Appendix E

Treatment Alternatives Cost Spreadsheets

Summary Table

Alternative	Common Components Costs	Estimated Capital Costs	Estimated Annual O&M Costs	Capital plus 5 years of O&M
Direct Injection	$ 42,600	$ 48,524	$ 97,116	$ 576,702
RO Treatment	$ 42,600	$ 528,937	$ 123,662	$ 1,189,847
Evaporation Pond	$ 42,600	$ 1,666,665	$ 55,116	$ 1,984,843
Hauling	$ 42,600	$ 16,075	$ 601,937	$ 3,068,361

Salty Dog
Remediation Alternative Evaluation

Extraction pump sizing (after Driscoll, pg 585)	Depth to Water	Flow (gpm)	HP
RW-1	65.80	0.5	0.03
RW-2	60.32	15	0.65

GW extraction electrical costs

hours of pump operation per day	24.0
hp	0.68
w/hp	750
System kWHrs/day	12
$/kwHr	0.1
$/month	$ 37.75
$/yr	**$ 452.97**

Pipeline and Well Pump Installation

Item	*Unit*	*Quantity*	*Unit Cost*	*Total*
1.5-inch PVC, DR-26 water line, common trenching, bedding, select backfill, testing and compaction, complete in place	LF	2600	$8	$ 20,800
Fittings (estimated at 10% of total pipe cost)	LS	1	$2,080	$ 2,080
Water meter 1.5-inch, installed	EA	1	$2,750	$ 2,750
RW-1 pump installation (0.125 HP)	EA	1	$ 2,800	$ 2,800
RW-2 pump installation (0.5 HP)	EA	1	$ 3,600	$ 3,600
Subtotal (excluding mobilization & demob)				$32,030
Mobilization/Demobilization (10%)				$ 3,203
Construction Staking (2.5%)				$ 801
Survey (3%)				$ 961
Engineering Services for Design and Construction (18%)				$ -
Construction Permitting (2.5%)				$ 801
Contingency (15%)				$ 4,805
			Total =	$ 42,600

Alternative - Water Hauling (Costs per personal communication with Gandy-Marley, Inc.)

<u>**Hauling and Disposal**</u>

	23040	gallons per day
Using	2100	gallons per load
	11	loads per day
Assume a one year cost period		
Yields	365	days of hauling
Therefore	4015	loads per year
Using $120 transport and $0.60/barrel disposal costs	$ 1,649	per day
Yields	**$ 601,937**	**per year for disposal**

<u>**Fill Station Capital Costs**</u>

Item	*Unit*	*Quantity*	*Unit Price*	*Total Price*
Transfer pump installation (pump, pad, plumbing)	Lump sum	1	$ 4,500	$ 4,500
Power from existing transformer	Lump sum	1	$ 3,000	$ 3,000
Fencing, chain link, 6' high, w/ double 8-foot gates, 3 strand barbed wire	LF	80	$ 26.00	$ 2,080
Clear and grub	AC	0.2	$ 4,475.00	$ 895
Truck Pad				
Concrete pad	SY	40	$ 140.00	$ 5,600
Fill stations and road improvements capital cost is =				**$ 16,075**

Salty Dog Reverse Osmosis Treatment Facility
Engineer's Estimate of Probable Cost

Item No.	Item	Quantity	Unit	Unit Cost	Total Price
1	Mobilization/Demobilization	1	LS	$31,815.00	$31,815
2	Construction staking by the contractor	1	LS	$2,500.00	$2,500
3	Clearing and grubbing land	1.0	AC	$1,500.00	$1,500
4	Geotech soil borings, testing, and reporting, for foundation data	1.0	LS	$4,600.00	$6,600
5	Testing soils, compaction, concrete	1	LS	$2,500.00	$2,500
6	Bollards, 4-inch diameter steel, concrete filled, cip	2	EA	$400.00	$800
7	Fencing, 6' high, w/ double 8-foot gates, 1 strand barbed wire	220	LF	$26.00	$5,720
8	**General Site work**			**Subtotal**	**$51,435**
9	1.5-inch PE, SDR-26 water line, common trenching, bedding, select backfill, testing and compaction, cip	1,500	LF	$12.50	$18,750
10	Fittings, valves for water lines (estimated at 10% of total pipe cost)	1	LS	$1,875.00	$1,875
11	Heat tape, insulation, and pipe jacketing for all exterior above ground piping, cip	60	LF	$35.00	$2,100
12	**Exterior Piping**			**Subtotal**	**$22,725**
13	Slab and footings, reinforced, cip	20	CY	$195.00	$3,900
14	Pre-Engineered building (40' X 40'), w/ interior walls, doors, and safety equipment, cip	600	SF	$29.50	$17,700
15	5,000 gal storage tanks (pre-RO and post-RO), tank, gravel ring w/ gravel, tank placement, plumbing, level controls, cip	3	EA	$9,500.00	$28,500
16	Electrical utility connection for RO plant	1	LS	$25,000.00	$25,000
17	HVAC, installation, ductwork, complete in place	1	LS	$8,500.00	$8,500
18	RO System (Siemens Skid Model M83R006 or EQ. plus pretreatment and peripheral equipment, and startup assistance)	1	LS	$145,000.00	$145,000
19	RO System Installation Labor and Materials, (Plumbing, electrical, mechanical)	1	LS	$94,250.00	$94,250
20	Plumbing, valves, and appurtenances	1	LS	$14,000.00	$14,000
21	RO Concentrate transfer pumps Grundfos CRN 10-2 or equivalent, cip	2	LS	$3,500.00	$7,000
22	Multimedia filter backwash pump Grundfos 15-2 or equivalent, cip	1	LS	$4,500.00	$4,500
23	Filtered water transfer pumps, Grundfos 10-3 or equivalent, cip	2	LS	$3,500.00	$7,000
	RO Facility			**Subtotal**	**$355,350**

Subtotal (excluding mobilization)	**$397,695**
Subtotal of Base Bid	**$429,510**
Contingency @ 15%	**$64,427**
Permitting	**$35,000**
Total	**$528,937**

Salty Dog RO System
Estimation of Monthly Expenses

Flows/Hours of operation

Input to skid	16	gpm
Total daily output	23040	gallons
Minutes of operation to get 30000 gallons	1440	minutes
hrs/day operation	24.0	hrs/day

Electricity

hours	24.0
hp	25
w/hp	750
System kWHrs/day	450
HVAC kWHrs/day	63
$/kwHr	0.1
$/month	$ 1,590.30

Parts/Supplies (monthly estimate)

Disinfection	$ -
Antiscalant	$ 250.00
Membranes	$ 400.00
Cartridge Filters	$ 50.00
Sampling/Testing	$ 450.00
Maint/Parts	$ 250.00
	$ 1,400.00

Total Electricity/Supplies/Parts($/month)	$ 2,990.30
Monthly Labor (@$65.0/hr, 4 hrs/day/ 7 days/wk)	$ 7,280.00
RO System monthly operation estimate	$10,270.30

Well pump power costs

24.0	hours
1	hp
750	w/hp
11	kWHrs/day
0.1	$/kwHr
34.88	$/month

Direct Injection Capital Costs						
10,000 Tank	LS	1	$	12,000.00	$	12,000
Injection Pump Installation	LS	1	$	1,500.00	$	1,500
Site Improvements	SY	1	$	23.82	$	24
Permitting	LS	1	$	35,000.00	$	35,000
Fill station and road improvements capital cost					**$**	**48,524**

Direction Injection O&M Costs	
Total Electricity/Supplies/Parts($/month)	$ 952.97
Monthly Labor (@$65.0/hr, 2 hrs/day/ 7 days/wk)	$ 3,640.00
Well Rehabilitation	$ 3,500.00
Direction Injection System monthly operation estimate (onsite only - no hauling)	**$ 8,092.97**

Salty Dog Brine Waste Disposal Ponds
Preliminary Cost Estimate

Item No.	Description	Quantity	Units	Unit Cost	Total Cost
Brine Waste Disposal System					
1	Mob/demob/grubbing/clean-up	1	ls	$28,000	$28,000
2	Pond excavation/preparation (8 acres)	25,000	cy	$3	$75,000
3	Berm preparation	0	cy	$12	$0
4	40 mil secondary HDPE pond liner	328,000	sf	$1.45	$475,600
5	Geonet between liner layers	0	sf	$0.50	$0
6	Leak detection & collection system	1	ea	$12,500	$12,500
7	Leak detection sump pumping equipment	2	ls	$18,000	$36,000
8	60 mil primary HDPE pond liner	328,000	sf	$1.65	$541,200
9	Seeding, erosion control fabric, and outside slope armoring with site gravel	1,000	sy	$1.25	$1,250
10	3" dia. brine waste discharge piping from entrance gate to pond, valving, flow control	1	ls	$7,500	$7,500
11	Site Perimeter Fencing (5' mesh), signage	2,600	lf	$26	$67,600
12	Perimeter drainage control	1	ls	$5,000	$5,000
14	Groundwater monitor wells	3	ea	$15,000	$45,000
				Disposal System Subtotal	***$1,294,650***
Support Services					
1	Construction surveying/staking/testing	8	acre	$7,000	$56,000
2	Construction oversight/inspection/admin	1	ls	$65,000	$65,000
3	Liner integrity QA/QC testing	8	acre	$7,000	$56,000
4	Record drawings	1	ls	$8,500	$8,500
5	Permitting	1	ls	$35,000	$35,000
				Support Services Subtotal	**$220,500**
				CONSTRUCTION SUBTOTAL	**$1,515,150**
				Contingency 10.0%	**$151,515**
				CONSTRUCTION TOTAL	**$1,666,665**

QA/QC = Quality Assurance/Quality Control
ls = lump sum, cy = cubic feet, sf = square feet, ea = each