Reid Gardner Generating Station
Inactive Coal Combustion Residual Surface Impoundments
Ponds 4B-1, 4B-2, 4B-3, and E-1

Closure Certification

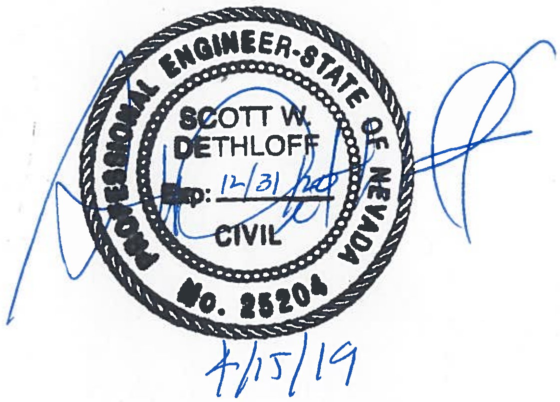
Final

April 2019

NV Energy, Inc.

Certification

This section contains the written certification by a qualified professional engineer required by §257.102 of the U.S. Environmental Protection Agency's Coal Combustion Residual Rule.



This closure certification meets the requirements of §257.102 of the Coal Combustion Residual Rule.

Contents

Figures

Appendixes

1. Introduction

This report presents the notification and certification for completion of closure of four inactive coal combustion residuals (CCR) surface impoundments at the former NV Energy Reid Gardner Generating Station (RGS, "Station"). These four inactive CCR surface impoundments[1] , identified as Ponds 4B-1, 4B-2, 4B-3, and E-1, were part of an evaporation pond complex that was constructed at the Station between about 1973 and 2008 for the management and disposal of waste process waters. The locations of individual evaporation ponds in the complex are presented in Figures 1, 2, and 3. This report discusses the relationships between the inactive CCR surface impoundments and other historic evaporation ponds in the area for the purpose of documenting closure of the CCR impoundments in accordance with requirements of the CCR rule.

1.1 Site Description and Background Information

The Station is a former electric power generation facility which historically produced approximately 600 megawatts (MW) of power from four coal-fired, power-generating units. Power generation began in 1965 and continued through 2017. Units 1-3 were permanently shut down on December 31, 2014. Unit 4 was permanently shut down on March 11, 2017. Demolition of the facility began in 2018 and is expected to continue through the first quarter of 2020.

Beginning in about 1974, NV Energy began construction of evaporation ponds to be used for management and disposal of process wastewaters from plant air emissions control systems and other operations. Table 1 provides a timeline of pond construction and usage. Essentially, there were two sets of ponds constructed at the station: original clay-lined or native soil-lined evaporation ponds, and more recently constructed evaporation ponds with engineered high-density polyethylene (HDPE) geomembrane liner systems. All of the original clay-lined and native soil-lined evaporation ponds were closed prior to the promulgation of the CCR Rule. Of the ponds with engineered geomembrane liner systems, only Ponds 4B-1, 4B-2, 4B-3, and E-1 are subject to regulation under the CCR Rule as inactive CCR surface impoundments.

All of the evaporation ponds constructed prior to about 2001, including former Ponds 4A, 4B, 4C, D, E, F, and G (see Figures 1 and 2), used compacted native soil and clay material in the bottom liners and berms which allowed water containing elevated concentrations of dissolved salts to migrate through the pond bottoms and into groundwater. Between 2001 and about 2010, a number of the former evaporation ponds were removed from service, pond solids were removed, and the ponds were replaced. The new ponds that replaced them (often within the same foot print) were designed, permitted and constructed in accordance with Nevada Division of Environmental Protection (NDEP) and Nevada Division of Water Resources (NDWR) requirements. These requirements included that the pond liner systems be constructed with two layers of HDPE geomembrane, and an interstitial drainage web and leak detection and collection system. These newly constructed ponds included the inactive CCR surface impoundments 4B-1, 4B-2, 4B-3 and E-1.

Regardless of the date constructed or associated engineering design, none of the liners for evaporation ponds at the Station meet the definition of a liner under the CCR rule, 40 CFR 257.70 to 40 CFR 257.72, which specifies a composite liner system consisting of a geomembrane and an underlying 2-foot layer of compacted soil. Under the CCR rule, the older compacted native-soil- or clay-lined former ponds at the Station, and the more recently operated and closed double-HDPE-lined ponds, are both considered "unlined" ponds despite their considerable differences in engineering design and expected performance.

In 2008 NV Energy and NDEP entered into an Administrative Order on Consent (AOC) to address soil and groundwater impacts associated with past facility operations, including the former clay-lined and native soil-

[1] These ponds meet the definition of "Inactive CCR surface impoundments" because: (a) they no longer received CCR on or after October 14, 2015; (b) they still contained both CCR and liquids on or after October 14, 2015 (all liquids and CCR were removed by December 2017); (c) a notification of intent to close was placed in the station operating record no later than December 17, 2015; (d) notification of the availability of the intent to initiate closure was provided to the State Director no later than January 19, 2016; and (e) the notification of the intent to initiate closure was placed on the publicly accessible CCR Web Site no later than January 19, 2016.

lined ponds. The AOC governs the performance and completion of environmental characterization, corrective action for soil and groundwater contamination at the site, and long-term operation and maintenance of NDEP approved corrective actions.

Environmental characterization and corrective actions at the Station are ongoing. To date this work has included extensive groundwater and soil investigations, development of a three-dimensional computer model to visualize and evaluate the geologic and groundwater data, preparation of a preliminary geochemical conceptual site model, and implementation of corrective actions that have resulted in the removal and disposal of over 2 million cubic yards of pond solids and soils from former evaporation ponds at the Station. Key AOC documents relevant to former ponds history and groundwater impacts include the Preliminary Source Area Identification and Characterization Report (Stanley 2013a), the Background Conditions Report (Stanley 2014), Preliminary Geochemical Conceptual Site Model (Stanley 2015), pond solids removal completion reports (e.g., Stanley 2011a to 2018b), and annual reports from Station-wide AOC groundwater monitoring (e.g., Stanley 2016a, 2018a).

1.2 Pond Nomenclature

Table 1 presents the ponds discussed in this report in chronological order of construction and are categorized within the general area in which they were built. An alphanumeric naming convention was used by NV Energy to identify the ponds for plant operating purposes, e.g. Pond 4A, Pond 4C, or Pond E, as shown in the table and Figures 1 to 3. The naming conventions were retained when the original ponds were subdivided and also when new HDPE lined ponds were constructed within the footprint of older native soil and clay lined ponds. For the sake of clarity, this report refers to the ponds in three general categories: (1) the original native soil-lined and clay-lined ponds, including Ponds 4A, 4B, 4C, D, E, F and G, as “former ponds”; (2) ponds constructed with geomembrane liner systems as “double HDPE lined ponds”; and (3)_the inactive CCR surface impoundments (which are a subset of the double HDPE lined ponds), as “Ponds 4B-1, 4B-2, 4B-3, and E-1.”

1.3 Purpose and Summary

The purpose of this report is to document the notification and completion of closure for inactive CCR surface impoundments Ponds 4B-1, 4B-2, 4B-3, and E-1. The information providing the basis for closure of these ponds is presented in this report as follows:

1) Section 2 provides documentation of NV Energy compliance with closure requirements of the CCR Rule for Ponds 4B-1, 4B-2, 4B-3, and E-1, following the pertinent sections of 40 CFR 257.100 (prior to its remand) and 40 CFR 257.102.

2) Section 3 provides supporting documentation that demonstrates that historical releases from native soil and clay lined former ponds are the most likely cause of groundwater impacts known to exist at and near Ponds 4B-1, 4B-2, 4B-3 and E-1. The construction, operation, and discovery of groundwater impacts from the former ponds predated the construction and operation of Ponds 4B-1, 4B-2, 4B-3, and E-1. This is based on the following information:

   a) Documented groundwater impacts and releases, including seepage, from former ponds (which were not subject to CCR regulations) that operated for a longer duration (between 16 to 27 years for the former ponds, compared to 8 to 12 years for the Ponds 4B-1, 4B-2, 4B-3 and E-1) at the same location, and over a larger footprint, prior to the effective date of the CCR rule.

   b) Analysis of historical groundwater data from 1996 to 2018, that suggests Ponds 4B-1, 4B-2, 4B-3, and E-1 did not contribute additional groundwater impacts to what existed before these ponds were constructed.

4) Section 4 demonstrates that the former clay-lined ponds would have leaked at much greater rates than the inactive CCR surface impoundment double HDPE-lined ponds by providing a comparison of model-simulated leakage rates from former ponds with clay liners to ponds with double-HDPE-liner systems. This section also describes a federal inspection of the double HDPE-lined ponds in 2011 which found them in satisfactory condition.

5) Section 5 describes the regulation of Ponds 4B-1, 4B-2, 4B-3, and E-1 under state programs, including those of the NDEP and the NDWR. These state programs regulated the construction and operation of Ponds 4B-1, 4B-2, 4B-3, and E-1 through permitting, monitoring, and reporting requirements. Additionally, prior to the CCR rule effective date, the NDEP and NV Energy had already entered into an Administrative Order on Consent (AOC) which requires NV Energy, under the direction of NDEP, to perform contaminant characterization activities and identify corrective action measures for soil and groundwater throughout the Station.

2. Compliance with Closure Requirements of the CCR Rule

This section documents compliance with the pond closure requirements of 40 CFR 257.102. Certain requirements were completed prior to the October 2016 remand rule and therefore reference sections of 40 CFR 257.100, which was later superseded by the remand. The following discussion is organized by regulatory requirements, with applicable text copied from the CCR Rule followed by summaries of actions by NV Energy in compliance with the Rule.

Timeframes for Certain Inactive CCR Surface Impoundments (§257.100(e)(6)(i)

> *The owner or operator of the inactive CCR surface impoundment must: (i) No later than April 17, 2018, prepare an initial written closure plan as set forth in § 257.102(b).*

The written closure plans for Ponds 4B-1, 4B-2, 4B-3, and E-1 were prepared in accordance with the provisions of 40 CFR 257.102(b) and placed in the operating record by NV Energy on April 16, 2018, before the April 17, 2018, deadline specified in 40 CFR 257.100(e)(6)(i).

Written Closure Plan §257.102(b)

> *The owner or operator of a CCR unit must prepare a written closure plan that describes the steps necessary to close the CCR unit at any point during the active life of the CCR unit consistent with recognized and generally accepted good engineering practices. The written closure plan must include, at a minimum, the information specified in paragraphs (b)(1)(i) through (vi) of this section.*

Because CCR units Ponds 4B-1, 4B-2, 4B-3, and E-1 are inactive surface impoundments, the written closure plans were prepared in accordance with the provisions of 40 CFR 257.102(b) and placed in the operating record by NV Energy on April 16, 2018, before the April 17, 2018, deadline specified in 40 CFR 257.100(e)(6)(i).

Closure by Removal of CCR (§257.102(c))

> *Closure by removal of CCR. An owner or operator may elect to close a CCR unit by removing and decontaminating all areas affected by releases from the CCR unit. CCR removal and decontamination of the CCR unit are complete when constituent concentrations throughout the CCR unit and any areas affected by releases from the CCR unit have been removed and groundwater monitoring concentrations do not exceed the groundwater protection standard established pursuant to §257.95(h) for constituents listed in appendix IV of this part.*

The first part of this closure requirement has been completed by removal of the CCR materials in Ponds 4B-1, 4B-2, 4B-3, and E-1 in 2017. CCR materials removed included pond solids, the pond liner systems, and underlying soils. The second part of the requirement (the portion related to constituent concentrations in groundwater) is addressed in more detail in Section 3 of this report. Section 3 identifies former compacted native-soil- or clay-lined ponds (that have since been removed) as the source of historical groundwater impacts present at the locations of Ponds 4B-1, 4B-2, 4B-3, and E-1. The historical groundwater impacts from these former ponds were documented well before the construction of Ponds 4B-1, 4B-2, 4B-3, and E-1, and the former ponds were removed prior to the effective date of the CCR Rule. These historic impacts complicate demonstrating compliance with the second part of 40 CFR 257.102(c) because groundwater is clearly impacted in the area. But, because the contribution of Ponds 4B-1, 4B-2, 4B-3, and E-1 to these impacts cannot be demonstrated, and because the former ponds and the groundwater impacts they caused are not regulated under the Rule, closure of the inactive CCR surface impoundments Ponds 4B-1, 4B-2, 4B-3, and E-1 in accordance with CCR Rule §257.102(c) is certified by this document.

It is important to note that the groundwater impacts at the location of Ponds 4B-1, 4B-2, 4B-3, and E-1 result from operation of the former ponds and these impacts are currently being addressed by the AOC under regulatory jurisdiction of the NDEP. The AOC requirements include, but are not limited to, evaluating groundwater impacts, performing groundwater monitoring and reporting, and planning and implementing corrective action and surface impoundment closure.

Closure Performance Standard When Leaving CCR in Place (§257.102(d))

Not applicable. Ponds 4B-1, 4B-2, 4B-3, and E-1 were closed in accordance with §257.102(c), and the requirements of this section do not apply.

Initiation of Closure Activities (§257.102(e))

> *Except as provided for in paragraph (e)(4) of this section and § 257.103, the owner or operator of a CCR unit must commence closure of the CCR unit no later than the applicable timeframes specified in either paragraph (e)(1) or (2) of this section. (1) The owner or operator must commence closure of the CCR unit no later than 30 days after the date on which the CCR unit either: (i) Receives the known final receipt of waste, either CCR or any non-CCR waste stream; or (ii) Removes the known final volume of CCR from the CCR unit for the purpose of beneficial use of CCR (2)(i) Except as provided by paragraph (e)(2)(ii) of this section, the owner or operator must commence closure of a CCR unit that has not received CCR or any non-CCR waste stream or is no longer removing CCR for the purpose of beneficial use within two years of the last receipt of waste or within two years of the last removal of CCR material for the purpose of beneficial use.*

Closure commenced when the notification of intent to initiate closure was placed in the Station’s operating record on December 15, 2015 and posted to the publicly accessible internet site by January 16, 2016. These notifications were prepared to satisfy the early-closure provisions in §257.100(c)(1) of the CCR Rule as it was originally promulgated and also satisfies the requirement of §257.102(e).

Completion of Closure Activities (§257.102(f)(1))

> *Completion of closure activities. (1) Except as provided for in paragraph (f)(2) of this section, the owner or operator must complete closure of the CCR unit: (i) For existing and new CCR landfills and any lateral expansion of a CCR landfill, within six months of commencing closure activities. (ii) For existing and new CCR surface impoundments and any lateral expansion of a CCR surface impoundment, within five years of commencing closure activities.*

This report documents the completion of closure activities with the removal of CCR from Ponds 4B-1, 4B-2, 4B-3, and E-1, the liner systems, and select underlying soil in December 2017 and demonstrates that contributions from Ponds 4B-1, 4B-2, 4B-3, and E-1 to the preexisting groundwater impacts in the area are negligible and cannot be distinguished, thus satisfying the two major components of 40 CFR 257.102(c). Closure activities have been completed in advance of the 5-year requirement established in 40 CFR 257.102(f)(1).

Extension of Closure Timeframes (§257.102(f)(2))

Not applicable. An extension for closure timeframes has not been requested.

Certification of Closure (§257.102(f)(3))

> *Upon completion, the owner or operator of the CCR unit must obtain a certification from a qualified professional engineer verifying that closure has been completed in accordance with the closure plan specified in paragraph (b) of this section and the requirements of this section.*

This document has been stamped by a professional engineer and certifies that closure has been completed in accordance with the written closure plan specified in §257.102(b).

Notification of Intent to Close Unit (§257.102(g))

> *No later than the date the owner or operator initiates closure of a CCR unit, the owner or operator must prepare a notification of intent to close a CCR unit. The notification must include the certification by a qualified professional engineer for the design of the final cover system as required by § 257.102(d)(3)(iii), if applicable. The owner or operator has completed the notification when it has been placed in the facility's operating record as required by § 257.105(i)(7).*

Because CCR units Ponds 4B-1, 4B-2, 4B-3, and E-1 are inactive surface impoundments, the notifications of intent to initiate closure were originally prepared in accordance with the provisions of §257.100(c)(1), prior to its remand, and placed in the facility operating record on December 15, 2015.

Notification of Closure of CCR (§257.102(h))

> *Within 30 days of completion of closure of the CCR unit, the owner or operator must prepare a notification of closure of a CCR unit. The notification must include the certification by a qualified professional engineer as required by § 257.102(f)(3). The owner or operator has completed the notification when it has been placed in the facility's operating record as required by § 257.105(i)(8).*

This report documents the completion of closure activities with the removal of CCR from Ponds 4B-1, 4B-2, 4B -3, and E-1, of liner systems, and of select underlying soil in December 2017 and demonstrates that any contributions from Ponds 4B-1, 4B-2, 4B-3, and E-1 to the preexisting groundwater impacts are negligible and cannot be distinguished. Thus, this report provides documentation of closure completion and serves as notification of that completion. As such, the document both begins and ends the 30-day time frame for notification of closure completion.

Deed Notations (§257.102(i)(1) and (4))

Not applicable. Per §257.102(i)(4), since Ponds 4B-1, 4B-2, 4B-3, and E-1 were closed in accordance with §257.102(c) they are not subject to the requirements of paragraph (§257.102(i)(1).

Closure Record Keeping Requirements (§257.102(j))

> *The owner or operator of the CCR unit must comply with the closure recordkeeping requirements specified in § 257.105(i), the closure notification requirements specified in § 257.106(i), and the closure Internet requirements specified in § 257.107(i)*

Compliance with the closure recordkeeping (§ 257.105(i)), notification (§ 257.106(i)), and internet (§ 257.107(i)) are summarized in Table 2.

Criteria to Retrofit an Existing CCR Surface Impoundment (§257.102(k))

Not applicable. Ponds 4B-1, 4B-2, 4B-3, and E-1 were closed in accordance with §257.102(c) and are not undergoing a retrofit; therefore, the requirements of this section do not apply.

3. Review of Pond Operations, Pond Construction, Historical Releases, and Groundwater Data

This section documents that leakage from the former ponds accounts for the groundwater impacts underlying the inactive CCR surface impoundments Ponds 4B-1, 4B-2, 4B-3, and E-1. Any contributions from Ponds 4B-1, 4B-2, 4B-3, and E-1 to the preexisting groundwater impacts are negligible and cannot be distinguished. The section reviews the operation of former ponds, summarizes historical accounts of seepage under the pond berms, and evaluates groundwater data before and during Ponds 4B-1, 4B-2, 4B-3, and E-1 operation.

3.1 Historical Operations in the Vicinity of Ponds 4B-1, 4B-2, 4B-3, and E-1

As discussed earlier, before construction of the Ponds 4B-1, 4B-2, 4B-3, and E-1, compacted native soil-lined and clay-lined ponds operated within and adjacent to their footprint (Intellus 1986, Nevada Power Company 1992 and 2002, Stanley 2002). In the Ponds 4B-1, 4B-2 and 4B-3 area, the older compacted native soil-lined and clay-lined ponds operated from 1983 to 2005. In the Pond E-1 area, these former ponds operated from 1974 to 2008.

Table 3 provides a detailed summary of pond operations, including name, duration of use, areal extent, and type of bottom liner. The table lists the older former native-soil-lined and clay-lined ponds to the left, and the more-recently constructed double-HDPE-lined ponds to the right. The regulated inactive CCR impoundments being certified for closure are distinguished from other double HDPE lined ponds in Table 3 using boldface type. Pond operations are discussed in more detail in the *Preliminary Source Area Identification and Characterization Report* prepared under the AOC (Stanley 2013a).

The transition from the older former ponds began in about May 1997 when the NDEP issued an order requiring NV Energy to submit a sitewide plan and schedule to eliminate the migration of contaminants into the groundwater (NDEP 1997). NV Energy submitted a plan and schedule committing to either line all evaporation ponds with double-synthetic-liner systems or remove the ponds from service before 2010. Between 2001 and 2008, former ponds 4B, 4C, E, and F were taken out of service and had pond solids removed. New ponds (identified in Table 3 as 4B-1, 4B-2, 4B-3, 4C-1, 4C-2, E-1, E-2, and F) were then constructed, some within the same footprint as the original ponds, with the required double HDPE geomembrane bottom liner system. Ponds 4A, D, and G were permanently taken out of service between 1999 and 2008, pond solids were later removed, and new evaporation ponds were not constructed to replace them.

3.2 Historical Groundwater Impacts at Ponds 4B-1, 4B-2, 4B-B-3, and E-1

Historical groundwater impacts in the area of Ponds 4B-1, 4B-2, 4B-3, and E-1 over the time frame of native-soil-lined and clay-lined former pond operations is well documented. This section describes groundwater impacts caused by seepage and leakage from former pond operations from 1974 through 2001 as documented by NV Energy and NDEP, before the construction of ponds with engineered double HDPE geomembrane liner systems. Figures 4 and 5 show monitoring well locations that are discussed below; Figure 4 also shows typical groundwater flow direction based on recent (2009–2017) monitoring reports, and Figure 5 shows features associated with historical groundwater impacts.

3.2.1 Seepage from Ponds D, E, F. and G

Seepage was noticed at Ponds D and E leading to geotechnical investigations as early as 1981 (Converse 1983, Nevada Power Company 2002, Stanley 2013a). Geotechnical investigations (Kleinfelder 1996) found that at some locations along the pond berms, seepage was occurring through more-permeable silt or sand zones between the pond bottoms and the clay cores of the pond berms. Figure 5 shows the general areas of seepage reported from Ponds D, E, F, and G.

Efforts to control seepage included slurry wall installation in segments of the berms of Ponds D and E in the 1980s at locations shown on Figure 5 (Converse 1983, Converse 1990, Kleinfelder 1996, Nevada

Power Company 2002). After further investigations, additional slurry walls and sheet piling were installed along portions of the south and west sides of Pond D and the south and east sides of Pond E between 1992 and 1997 to augment the clay berm core and slurry walls (Kleinfelder 1996, Stanley 2011a). Continued seepage from Ponds D and E was listed in the NDEP Finding of Alleged Violation (NDEP 1997). A groundwater interception trench, installed at the southeast and south sides of the berms for Ponds D and E in 2002, removed more than 2 million gallons of groundwater that was discharged into Pond E-1 for evaporation (Stanley 2011a, Stanley 2013a).

3.2.2 Historical Groundwater Impacts from Former Ponds D, E, F, and G

Groundwater impacts from former Ponds D and E are first detailed in the 1986 *Hydrogeologic Study of the Reid Gardner Power Plant Region* (Intellus 1986). This report describes historical pond groundwater impacts detected at surrounding monitoring wells by 1980 to 1984.

Groundwater impacts from former Ponds D, E, F and G were described in correspondence and reports between NV Energy and the NDEP. The corrective action plan for Ponds F and G (NV Energy, 2004) noted that, despite the clayey native soils or clay liners and assumed slow rate of seepage, "over a thirty-year period shallow water under the ponds became salt-impacted". Figures 4 and 5 present monitoring well locations discussed below.

The persistence of groundwater impacts in monitoring wells south (Locations P-5, P-6, P-7, P-8, and P-9) and east of Ponds D and E (Locations P-3 and P-4) were the reason for geotechnical investigations to understand the causes of elevated total dissolved solids (TDS) in monitoring wells and seepage outside the pond berms, and engineering efforts to reduce seepage from these ponds from the early 1980s through the 1990s. These efforts led to groundwater interceptor trench installation in 2002 and ultimately the removal from service, closure, and in some cases replacement of these ponds with double-HDPE-lined ponds.

3.2.3 Historical Groundwater Impacts from Former Ponds 4A, 4B, and 4C

Downgradient groundwater impacts from Ponds 4B and 4C at locations MW-2 and MW-3 were described in the 1986 *Hydrogeologic Study of the Reid Gardner Power Plant Region* (Intellus 1986), and further in a January 18, 1988, letter report from NV Energy to NDEP, "Results of December 1987 Groundwater Sampling at Reid Gardner Station" (Nevada Power Company 1988). Results reported from quarterly monitoring in December 1986 and March, June, and September 1987 were similar. Groundwater impacts from Ponds 4B and 4C at monitoring well MW-3 are listed in the NDEP 1997 Finding of Alleged Violation, where they were compared to lower concentrations at upgradient well MW-6. The NDEP later noted that in a 2001 inspection, Ponds 4B and 4C were estimated to be leaking at a rate of 50 acre-feet per year (Stanley 2013a). Figures 4 and 5 present monitoring well locations discussed below.

Groundwater impacts from Pond 4A were described over the same time frame as for Ponds 4B and 4C (Nevada Power Company 2002). Groundwater impacts from Pond 4A at downgradient well MW-1 are listed in the NDEP finding of alleged violation (NDEP 1997). The revised *Hydrogeologic Characterization Report for the Reid Gardner Station* (Nevada Power Company 2002) describes groundwater impacts beneath and downgradient from former Ponds 4A, 4B, 4C, D, E, F and G using data through 1999. In 2006 a groundwater interceptor trench was installed at Pond 4A.

The historical reports for the Station described above document that that groundwater impacts encompassed this vicinity before double-HDPE-lined, CCR-regulated Ponds 4B-1, 4B-2, 4B-B-3, and E-1 were constructed.

3.3 Analysis of Groundwater Data before and during Ponds 4B-1, 4B-2, 4B-3, and E-1 Operations

Historical groundwater monitoring data was reviewed to compare conditions during operation of the former native-soil-lined and clay-lined ponds with conditions during and after the subsequent operation of Ponds 4B-1, 4B-2, 4B-3, and E-1. The objectives of this review and statistical analysis were to evaluate if

Ponds 4B-1, 4B-2, 4B-3 and E-1 added to the pre-existing groundwater impacts created by prior operation of the former clay or native soil lined ponds.

The review consisted of preparing time series plots, histograms, and probability plots for visual inspection, and a basic statistical analysis and summary including testing for trends over time. For this review, five conservative (i.e., mobile) analytical constituents believed to be indicative of pond water were selected: boron, chloride, sodium, sulfate, and TDS. All except sodium are Appendix III constituents for CCR detection monitoring. The depth to water measured with each sampling event was also included on the time series plots.

Monitoring wells selected for this review are presented on Figure 4 and are listed in Tables 4 and 5. Table 4 provides information about monitoring well locations reviewed with Ponds 4B-1, 4B-2 and 4B-3, and Table 5 provides information about monitoring well locations reviewed with Pond E-1. Wells were selected for this review based on proximity to Ponds 4B-1, 4B-2, 4B-3 and E-1, and for the duration of the data set available for review. Some more recently installed wells were included to review the current spatial extent of groundwater impacts although their groundwater monitoring record did not extend back to the use of the former clay or native soil lined ponds. The data set used for this review extends as far back as 1996 and contains field-filtered groundwater monitoring data collected for the AOC, and for monitoring and reporting to NDEP that predated the AOC.

Some more recently installed wells were included to review the current spatial extent of groundwater impacts, although their groundwater monitoring record did not extend back to the use of native-soil-lined and clay-lined ponds. Data were combined for locations where a replacement well was installed at the same location as an original well (for example, MW-3, replaced by MW-3R and replaced again by MW-3RR). Refer to Figure 4 for well locations. While the replacement wells differed slightly in screened intervals from original wells (Tables 4 and 5); the data were combined because the original and replacement wells were co-located and monitor the uppermost aquifer.

3.3.1 Time-Series Plots

Appendix A presents time-series plots for data collected at each monitoring well. Appendices A-1 and A-2 provide the time-series plots for monitoring wells located upgradient or downgradient relative to Ponds 4B-1, 4B-2, and 4B-3, respectively. Appendixes A-3, A-4, and A-5 provide the time-series plots for monitoring wells located upgradient, downgradient, or side-gradient relative to Pond E-1. On the plots the laboratory results for boron, chloride, sodium, sulfate, and TDS are shown with a logarithmic vertical axis on the left for concentrations in milligrams per liter (mg/L, or parts per million [ppm]). TDS is considered representative for changes in all five of these constituents on the time series plots, and the following discussions focus on TDS unless calling out notable observations for other constituents. Depth-to-water measurements are shown as circles with a second vertical axis on the right and linear scale. Where replacement monitoring wells were installed, a vertical dashed line shows the change to a new well at the same location as a former well. Changes in measuring point elevation with replacement wells cause offsets in the depth to water plots. The timeframes over which a pond associated with a monitoring well were out of service are shown as grey-shaded vertical bars on the plots, and the ponds associated with each plot are labeled. All ponds were out of service as of October 15, 2015.

Monitoring well data from the area of Ponds 4B and 4C suggest that Ponds 4B-1, 4B-2, and 4B-3 did not add to preexisting groundwater impacts. During the use of double-HDPE-lined Ponds 4B-1, 4B-2, and 4B-3 from 2008 to 2015, TDS concentrations at downgradient well locations MW-2/2R and MW-3/3R/3RR (see Appendix A-2) appeared to be stable on the plots. Similar patterns are seen at P-13/P-13R and P-14/P-14R, which are more distant downgradient wells (P-14/P-14R may show impacts from former Pond D). Some locations plotted in Appendix A have shorter monitoring durations that are more useful for spatial comparisons of groundwater results instead of changes over time. For example, when newer wells MW-15 and MW-16S are considered with MW-2/2R and MW-3/3R/3RR, all of these downgradient wells have TDS concentrations that are approximately two to four times less than the TDS concentrations measured at newer upgradient wells MW-12S, MW-13, and MW-14 (see Appendix A-1) during monitoring since those wells were installed in 2013. While MW-11S, farther upgradient inside Pond C (Figures 4 and

5), is not plotted, it has concentrations similar to these three upgradient wells, confirming either prior operation of clay-lined former Ponds 4B or 4C as a source of the TDS groundwater impacts.

During operation of clay-lined Pond 4B from 1984 to 2005, TDS concentrations in available data from 1996 to 2007 increased or appeared stable at downgradient monitoring wells MW-2/2R and MW-3/3R/3RR. TDS concentrations are higher in MW-12S, MW-13 which are upgradient to Ponds 4B-1, 4B-2, and 4B-3 and downgradient of Pond 4C.

Similarly, the Pond E monitoring well data suggests that Pond E-1 also did not add to preexisting groundwater impacts. During the use of double-HDPE-lined Pond E-1 from 2003 to 2015, TDS concentrations at downgradient well locations P-3 and P-4 (Appendix A-5) decreased compared to concentrations from 1996 to 2002 during operation of the clay-lined former Pond E. More-recent monitoring results from wells P-23S/SR and P-24S (Appendix A-3) upgradient to Pond E-1, like those from P-8R, have higher concentrations than recent results from downgradient and side gradient monitoring wells P-3, P-4, and P-5R and seem to indicate that locations more central to the operation of the historic soil lined and clay lined ponds show the most impact.

The well locations along the south side of former Ponds D and E are along an area of historical seepage that occurred in the 1980s and 1990s. These wells are considered upgradient to the west (P-8 through P-10 next to former Pond D) and side-gradient to the east (P-5 through P-7 next to former Pond E). P-5R (Appendix A-4) is at the southeast corner of Pond E and almost downgradient, and P-5R shows a decreasing pattern like downgradient wells P-3 and P-4. Monitoring well P-8/P-8R, closest to the center of historical seepage where Pond D joins Pond E, has increasing TDS concentrations over time, and the highest concentrations in this east–west line of wells. P-8/P-8R is upgradient from Pond E-1, indicating a source for groundwater impacts other than Pond E-1.

3.3.2 Histograms and Probability Plots

The same monitoring data set used for trend plots was used to prepare histograms and probability plots for a visual comparison of the upgradient and downgradient (and for Pond E-1, side gradient) results for the five constituents. These plots are presented in Appendix B. Appendix B-1 provides the histogram and probability plots for inactive CCR surface impoundments 4B-1, 4B-2, and 4B-3. Appendix B-2 provides the same information for Pond E-1.

For each constituent, the histograms are shown on the left, and the probability plots, also known as quantile-quantile, or Q-Q plots, are shown on the right. In the histograms, the plots are ordered from top to bottom to show downgradient wells above and upgradient wells below. The count or number of sample results is the vertical axis, and the concentration for the constituent (in milligrams per liter) is the horizontal axis. The histograms give a visual feel for the range and distribution of the data set. For the plots of Ponds 4B-1, 4B-2, and 4B-3 in Appendix B-1, the histograms show that the highest concentrations are present in upgradient wells for all constituents, with results tailing off to the right at higher values along the concentration axis. Most wells in the upgradient set are upgradient from Ponds 4B-1, 4B-2, and 4B-3 but immediately downgradient from and affected by Pond 4C. In contrast, the downgradient results are clustered more densely in lower concentration ranges to the left.

The probability plots depict actual concentrations on the vertical axis and theoretical quantiles on the horizontal axis. The format is like a cumulative probability plot, and the quantiles (also called percentiles) are a theoretical normal distribution. A more-normal distribution of concentrations plots as more linear in appearance. The *y*-axis concentration at the center of the theoretical quantiles (zero on *x*-axis) is the median value. The medians for sodium, sulfate, and TDS are similar in upgradient wells (blue points) and downgradient wells (orange points) in the plots for Ponds 4B-1, 4B-2 and 4B-3, but for boron and chloride the downgradient median value is slightly greater than the upgradient median value. To the right along the probability plots, the values for upgradient wells increase above the downgradient values, showing the same higher range of concentration values in upgradient wells that appear as bars farther to the right in the histograms. This rise in the right-hand portion of the probability plots indicates that the upgradient data are skewed towards higher concentrations. Most wells in the upgradient set are upgradient from Ponds 4B-1, 4B-2, and 4B-3 but downgradient from and affected by Pond 4C. A few wells, such as KMW-

19, MW-25S, and MW-26S, are upgradient from both former Pond 4C and former Pond 4B, and account for the lowest concentrations in the upgradient data set, which depress the left side of the probability plot and appear to the far left in the histograms.

Both the histograms and the probability plots show higher concentrations in monitoring wells upgradient from Ponds 4B-1, 4B-2, and 4B-3 than in those downgradient, indicating a groundwater contamination source that is upgradient from Ponds 4B-1, 4B-2, and 4B-3.

Appendix B-2 presents similar plots for monitoring data around Pond E-1. These plots add side-gradient wells as the middle histogram plot between downgradient and upgradient wells, and as a green color on the probability plots with the blue points upgradient and the orange downgradient. The pattern seen for Pond E-1 monitoring results resembles the pattern for Ponds 4B-1, 4B-2, and 4B-3 discussed above.

The histograms show results most tightly clustered for downgradient wells, with a wider range of concentrations and higher maximum concentrations for upgradient and side-gradient wells, which have the highest concentrations extending toward the right. Sodium, sulfate, and TDS show this upper range for side-gradient and upgradient concentrations more than do boron and chloride. The higher concentrations measured in upgradient and side-gradient wells are seen as the blue and green plot lines rise above the orange downgradient well plot line in the right-hand portions of the probability plots.

Some of the lowest concentrations are from upgradient wells that are upgradient from both Pond E and Pond D, such as P-11 and P-12, and seen as results in the first bar at the left of the histograms and a reason for the blue plot of upgradient results to be plotted lower at the left side of the probability plots. In the probability plots the upgradient wells, and to a lesser extent the side-gradient wells, depart the most from the more-linear plot, indicating that the upgradient and side-gradient results are skewed toward higher values, away from a more normal distribution.

Both the histograms and the probability plots show higher concentrations in monitoring wells that are upgradient or side-gradient from Pond E-1 than in downgradient monitoring wells, indicating a groundwater contamination source that is upgradient and not associated with Pond E-1.

3.3.3 Summary Statistics and Trend Review

Tables 6A through 7C present a statistical review of the same data set used for the time series plots, histograms, and probability plots discussed above. Ponds 4B-1, 4B-2, and 4B-3 statistics are presented in Tables 6A and 6B and Pond E-1 statistics are presented in Tables 7A, 7B, and 7C.

The same five constituents were reviewed: boron, chloride, sodium, sulfate, and TDS. In all tables the rows are grouped by constituent and well. Viewing columns left to right across the tables, the count (number of samples) from each well is shown followed by the area (e.g. B-Ponds), type (e.g. DG for downgradient and UG for upgradient), and percent of samples for which the constituent was detected. In addition, the minimum, maximum, and mean constituent concentrations are shown, followed by the standard deviation and coefficient of variation. Finally, the last three columns show results from testing for trends in the data. Increasing trends are shown in bold font and decreasing trends are shown in italics. The trend analyses offer an independent check on visual assessment of the time series plots (Section 3.3.1). The trend analyses are subject to some caution where data has a count of less than 20 samples, and where conditions vary such as wells that were replaced with differences in screen depths between original and replacement wells (see Tables 4 and 5). The summary statistics allow for spatial assessment of groundwater impacts by comparison of the mean value for a constituent at several different well locations. The following discussion reviews mean values for TDS at wells up- and downgradient of Ponds 4B-1, 4B-2, 4B-3, and E-1.

Tables 6A and 6B provide summary statistics resulting from evaluating of monitoring well data upgradient and downgradient of the area of Ponds 4B-1, 4B-2, and 4B-3. The mean values support the interpretations of the plots discussed in preceding sections. For example, the downgradient mean values for TDS are approximately 15,000 to 29,000 mg/L. The upgradient mean values for TDS are approximately 5,000 to 127,000 mg/L. The lowest upgradient values for TDS are from wells located upgradient from both former Ponds 4B and 4C and presumably unaffected (or at least less affected) by any of the former pond operations. The mean TDS values for wells upgradient from Ponds 4B-1, 4B-2, and 4B-3 but downgradient from former Pond C range from approximately 59,000 to 127,000 mg/L, or two to four times the mean TDS concentration found at wells downgradient from Ponds 4B-1, 4B-2, and 4B-3.

This statistical review found higher concentrations of the five constituents at upgradient or side gradient monitoring wells compared to downgradient monitoring wells. The review supports an alternate, upgradient source for groundwater impacts at Ponds 4B-1, 4B-2, and 4B-3.

Tables 7A, 7B, and 7C provide summary statistics resulting from evaluation of the Pond E-1 area upgradient, side-gradient, and downgradient monitoring well data. The mean value for TDS in downgradient wells is approximately 63,000 mg/L. The mean TDS values range from 57,000 to 96,000 mg/L in side-gradient wells and from 5,000 to 171,000 mg/L in upgradient wells. The lowest upgradient values for TDS are from wells located upgradient from both former Ponds E and D and presumably are unaffected (or at least less affected) by any of the former pond operations in this area. The mean TDS values for wells upgradient from Pond E-1 but downgradient from former Pond D range from approximately 30,000 to 171,000 mg/L, or roughly two to three times greater than mean TDS concentration found at wells downgradient from Pond E-1. The statistical analysis found instances of increasing and decreasing trends for the upgradient and side-gradient wells. For downgradient wells P-3 and P-4 and side-gradient well P-5R located at the southeast corner of Pond E-1 closest to the downgradient wells, all trends observed for the five constituents were decreasing.

This statistical review found higher concentrations of the five constituents at upgradient or side-gradient monitoring wells than at downgradient monitoring wells. As with Ponds 4B-1, 4B-2, and 4B-3, this review supports an alternate, upgradient source for groundwater impacts at Pond E-1.

3.4 Conclusion of Historical Groundwater Data Review

The historical discussion of seepage, geotechnical investigations, and efforts to reduce lateral seepage from Ponds D, E, F, and G supports that some releases from the former compacted-native-soil and clay-lined ponds followed somewhat more permeable pathways under the berms and cut-off walls. The finer-grained materials underlying all the former ponds also generally became saturated with high-TDS water that was released to groundwater during these former pond operations. Groundwater impacts encompassed the footprint of former Ponds 4A, 4B, 4C, D, E, F, and G and nearby downgradient areas before construction of the double HDPE-lined inactive CCR surface impoundments Ponds 4B1-, 4B-2, 4B-3 and E-1.

Groundwater impacts and seepage from the former ponds were documented in the 1980s and 1990s, years before Ponds 4B-1, 4B-2, 4B-3, and E-1 were constructed. As discussed in Sections 3.2 and 3.3, groundwater monitoring results for monitoring wells downgradient from Ponds 4B-1, 4B-2, 4B-3, and E-1 had lower TDS concentrations than upgradient wells during and after operation of these CCR surface impoundments.

Seepage from the area of Ponds D, E, F, and G was the subject of ongoing investigation that led to corrective actions, including slurry walls intended to prevent seepage by sealing more permeable zones beneath the pond berms, sheet piling to augment the slurry walls in areas with continued seepage, and interceptor trenches. The compacted native clay soil bottoms may not have been continuous, with more permeable zones that offered preferred pathways for leakage of high-TDS wastewater from the ponds, and migration to reach monitoring wells outside the pond berms. These ponds were permanently removed from service and have had pond solids removed.

Any impacts contributed by the CCR-regulated, double-HDPE-lined Ponds 4B-1, 4B-2, 4B-3, and E-1 would be minimal compared to the documented historical groundwater releases from the compacted-native-soil-lined and clay-lined ponds that formerly operated in the area. These historical groundwater impacts are not subject to the CCR Rule but are regulated (including the entire area of former ponds 4A, 4B, 4C, D, E, F and G) for assessment, corrective action, and closure through the AOC under the jurisdiction of the NDEP.

4. Review of Pond Construction and Potential for Leakage

Beginning in 2003 and concluding in 2008, Ponds 4B-1, 4B-2, 4B-3, and E-1 were constructed with two layers of HDPE geomembrane with interstitial drainage net, leak detection, and collection systems. These ponds operated with the HDPE lining systems from 2003 until October 14, 2015, when the Station ceased discharging to these ponds, rendering them inactive. With this double-liner construction, the interstitial drain system removes leakage from the primary (upper) liner, resulting in negligible pressure head experienced by the secondary (lower) liner to drive leakage through it. The drainage net creates the interstitial space between the geomembranes and adds some shear resistance to prevent relative movement between the two membranes.

Before Ponds 4B-1, 4B-2, 4B-B-3, and E-1 were constructed with double HDPE liners, Ponds 4B, 4C, D, E, F, and G (Figures 1 through 3, Table 1) operated as native-soil-lined and clay-lined ponds within the same footprint and in a larger surrounding area. Those older ponds were constructed between 1973 and 1986 and taken out of service between 1999 and 2008. The older ponds relied on naturally occurring clay soil in the pond bottoms to serve as the low-permeability liner or were lined with clayey soil from local borrow sources. They were constructed with berms enclosing clay cores keyed into the native soil. In some older ponds, a clay blanket was placed on the inner face of the berm.

Heterogeneity in the native clay soil used as a pond bottom or a clay borrow source likely resulted in areas with permeability above the values of 10^{-7} centimeters per second (cm/s) (or, 0.02 foot/day, about 7×10^{-6} cm/s) mentioned as design objectives in correspondence with the NDEP through 1992. Occurrences of coarser native material found in subsequent geotechnical investigations presented pathways for migration of high-TDS groundwater to pass under the vertical barriers within the berms. The clay in the pond bottoms or in slurry wall vertical barriers in the cores of the berms may also have been susceptible to high-TDS water (sulfate) causing clay minerals to flocculate, leading to some increase in permeability over time (National Research Council 2007). Groundwater impacts at monitoring wells adjacent to these older ponds were detected in the 1980s, and ultimately demonstrate that areas of higher permeability were certainly present (Section 3.2).

4.1 Modeled Leakage Potential

To examine the operational effectiveness of former ponds with clay liners in comparison to ponds with double-HDPE liners, theoretical leakage rates were estimated using the Hydrologic Evaluation of Landfill Performance (HELP) model. The HELP model was developed for the EPA by the U.S. Army Corps of Engineers Waterways Experiment Station to evaluate closure designs of hazardous and nonhazardous land disposal facilities. The program estimates the water balance for a facility by modeling rainfall, runoff, infiltration, and other water pathways. Model inputs include vegetation, soil type, geosynthetic liner materials, moisture conditions, layer thickness, slopes, drain spacing, and liner placement. Based on these inputs, the model can be used to estimate stormwater runoff, evapotranspiration, drainage, leachate collection, and liner leakage quantities.

Two leakage scenarios were evaluated. One scenario evaluated was based on a double-HDPE-liner system with an interstitial drainage and leak detection system, similar to the double-HDPE lined Ponds 4B-1, 4B-2, 4B-B-3, and E-1. The second scenario was based on a clay-lined pond, similar to the former historical ponds that were constructed and operated at the Station.

4.1.1 HELP Input Parameters

The HELP program has a database of standard climatic data for several U.S. cities, including nearby Las Vegas, Nevada. This is the default that was used for this evaluation. Based on the National Oceanic and Atmospheric Administration's 100-year, 24-hour isopluvial map for the landfill area, the 100-year, 24-hour storm peak precipitation value is 2.55 inches. This value was a hard number entry (manual input) into the model. Average precipitation data for the site was input to HELP, and the model used data to create annual variation in precipitation over the duration specified for the model run.

Temperature, evapotranspiration, and solar radiation model inputs were also defined using Las Vegas standard data in the HELP database. Site-specific conditions were used to develop evapotranspiration inputs for the HELP model, including evaporative zone depth and vegetation quality.

HELP model design data were chosen as inputs representative of soil and geosynthetic layer properties, layer thickness, slopes, evaporative zone depth, and other parameters. Representative material properties were selected from the HELP model, which provides an extensive database of recommended typical soil properties cross referenced to U.S. Soil Conservation Service soil classifications. Other relevant HELP input data include slope steepness and drainage length. A slope steepness of 3 percent was used based on as-built drawings. The drainage length is the distance that the contact water needs to travel within the contact water collection layer to a collector line (or a point where the leachate will flow freely). Review of as-built drawings found drainage length was variable due to the orientation of collector lines and shape of pond perimeters, so 500 feet was used as an estimated overall average input for drainage length.

4.1.2 HELP Input for Double-HDPE-Lined Pond Scenario

In addition to HELP input parameters described common to both modeled scenarios, input specific to the double-HDPE-lined scenario is summarized in Table 8. The footnotes associated with the table specify the use of HELP model parameters or site-specific data. Classification/parameters most closely matching the anticipated or actual layer type were selected from the HELP model's soil matrix options. Site-specific information from review of as-built drawings and reports was the basis for user input of liner construction.

4.1.3 HELP Input for Clay-Lined Pond Scenario

In addition to HELP input parameters described common to both modeled scenarios, input specific to the clay-lined scenario is summarized in Table 9. The footnotes associated with the table specify the use of HELP model parameters or site-specific data. Classification/parameters most closely matching the anticipated or actual layer type were selected from the HELP model's soil matrix options. If site-specific information was available, then that specific property was incorporated directly into the model. Site-specific information from review of monitoring well boring logs was the basis for user input of saturated hydraulic conductivity for the clay layer.

4.1.4 Simulated Leakage Potential

A 20-year simulation was run for each of the scenarios described above (clay-lined and double-HDPE-lined), and the average annual leakage rates were compared. The HELP model output is presented in Appendix C.

Double-HDPE-lined pond: **96.6** cubic feet of leakage per acre per year
Clay-lined pond: **3,261** cubic feet of leakage per acre per year

The unit rate of leakage through the clay-lined scenario was 34 times the potential rate of leakage calculated through the HDPE-lined scenario; or the double-HDPE-lined pond leakage potential is only about 3 percent of that from the clay-lined pond.

4.2 Practical Leakage Comparison

The potential leakage rates per unit area simulated by HELP differed by a factor of 34 times; with the potential leakage rate from a pond with a double-HDPE geomembrane liner (like the inactive CCR surface impoundments Ponds 4B-1, 4B-2, 4B-3 and E-1) being 3 percent of the simulated leakage rate from a pond with a clay liner (like the former ponds 4A, 4B, 4C, D, E, F and G).

For a more practical comparison of pond leakage, the unit leakage rate calculated in HELP model can be considered with the total area and duration of operation for each type of liner. The duration of the operation of native-soil-lined and clay-lined ponds was twice the duration of the operations of the more-recent double-HDPE-lined ponds. The historical clay-lined pond operations also encompassed more than twice the area of the more recent Ponds 4B-1, 4B-2, 4B-3, and E-1 that are subject to the CCR Rule. See Table 3 for a summary of the surface area and operational lifetime of the former ponds and the inactive CCR surface impoundments.

The following discussion applies the unit leakage rate over the pond areas and duration of operation to put the unit rate into context.

The surface area of Ponds 4B-1, 4B-2 and 4B-3 was 38 acres while the surface area of former ponds 4B and 4C was 72 acres; therefore, the inactive CCR surface impoundment area was 53 percent of former pond area. The duration of operations of former ponds 4B and 4C was 16 to 22 years, compared to inactive CCR surface impoundment operation for 8 years; therefore, the duration of inactive CCR surface impoundment operation was 42 percent of former pond operation duration. When these factors of operational duration and pond surface area are considered, the relative leakage simulated from the double HDPE-lined surface impoundments 4B-1, 4B-2 and 4B-3 becomes **0.7 percent** of the leakage from the clay lined former ponds 4B and 4C (Table 10).

If Pond E-1 is considered, the inactive CCR surface impoundment area was 9 acres. The area of former ponds D and E was 43 acres; therefore, the inactive CCR surface impoundment area was 21 percent of former pond area. The duration of operations of former ponds 4B and 4C was 26 years, compared to inactive CCR surface impoundment operation for 12 years; therefore, the duration of inactive CCR surface impoundment operation was 46 percent of former pond operation duration. When these factors are considered the relative leakage simulated from the double HDPE-lined surface impoundment Pond E-1 becomes **0.3 percent** of the leakage from the clay lined former ponds D and E (Table 10).

Based on this practical comparison using the simulated leakage rates and the actual operational duration and surface area, the potential leakage contributed from the inactive CCR surface impounds Ponds 4B-1, 4B-2, 4B-3 and E-1 was less than 1 percent of the potential leakage contributed from the clay-lined former ponds 4B, 4C, D and E at the same location. Compared to a clay liner, the geosynthetic liner is expected to be less prone to lateral seepage, which was not considered in the use of the HELP model described in Section 4.1, or in this practical comparison of leakage potential (Table 10). Documented lateral seepage from the former clay and native soil-lined ponds further decreases the relative contribution of the double-HDPE lined inactive CCR surface impoundments to pre-existing groundwater impacts, compared to the contribution from the native soil- or clay-lined former ponds.

4.3 Pond Inspection

As a precursor to the CCR Rule, the Station impoundments were inspected by an EPA contractor in 2011 (GEI Consultants 2011), which inspected all the double-HDPE-lined ponds including Ponds 4B-1, 4B-2, 4B-3, and E-1. All were found to be in “fair” condition, defined as “acceptable performance under all required loading conditions.” The only findings or deficiencies in this assessment related to vegetation removal from one outside berm area, berm-top grading, and sealing of berm-top pipe penetrations used for interstitial pumping. Those were corrected, as confirmed by NV Energy and NDEP in October 2011.

4.4 Conclusion from Pond Construction Review and Leakage Model

The former clay-lined ponds were far more prone to leak and to leak at higher rates than the double-HDPE-lined ponds that followed them. As described in Section 3.2 and Table 1, the native-soil-lined and clay-lined ponds were in operation over a duration of 17 to 27 years, more than twice as long as the double-HDPE-lined pond operations. Furthermore, operation of the former compacted-native-soil-lined and clay-lined ponds was not limited to the footprints of Ponds 4B-1, 4B-2, 4B-B-3, and E-1, so the higher leakage rate from the former native-soil-lined and clay-lined pond operations was also present over a larger area (Section 3.2, Figures 1 through 3, Tables 1, 3 and 10).

HELP modeling found that the unit rate of leakage for the clay-lined scenario was 34 times the leakage rate from the double-HDPE-lined scenario on a per unit area basis. Based on the twice-longer duration of use and twice-larger area of older, compacted-native-soil-lined and clay-lined pond use (see Table 1, Table 3 and Section 3.2), the relative leakage from soil- or clay-lined ponds predating Ponds 4B-1, 4B-2, 4B-B-3, and E-1 is at least *two orders of magnitude* greater than estimated leakage from double-HDPE-lined Ponds 4B-1, 4B-2, 4B-B-3, and E-1 (Table 10). This is a conservative estimate, given that it does not include the lateral seepage described from the older clay-lined ponds (NPC 1992, NDEP 1997, NPC 2002, NV Energy 2004, Stanley 2011a).

Given this:

1) Documentation from 1983 through 2004 describes leakage in the form of groundwater impacts surrounding the historical ponds 4B, 4C, D, E, F, and G, and seepage from the historical ponds D, E, F, and G.
2) Inspections in 2011 found all double-HDPE-lined ponds, including Ponds 4B-1, 4B-2, 4B-3 and E-1, to be in acceptable condition.
3) Modeled leakage using HELP found a unit leakage rate from clay-lined construction 34 times greater than that of double-HDPE-lined construction (a likely underestimate of the actual difference in leakage rates).
4) When duration of use and pond area are considered, the potential leakage from the double-HDPE-lined Ponds 4B-1, 4B-2, 4B-3 and E-1 was less than 1 percent of the potential leakage from the native soil- or clay-lined former ponds.

It can be concluded that the contribution of any groundwater impacts from the inactive CCR surface impoundments was negligible (less than 1 percent) in comparison to the preexisting historical groundwater impacts at and surrounding the inactive CCR surface impoundments. The historical groundwater impacts resulted from 1974–2005 clay-lined former pond operations, which are not subject to the CCR Rule. Any contribution to those historical impacts from the inactive CCR surface impoundments was de minimis. It is not feasible to characterize or distinguish any groundwater impacts from Ponds 4B-1, 4B-2, 4B-3 and E-1 from the pre-existing impacts documented from former ponds 4B, 4C, D, E, F and G.

5. Regulation of Former Ponds 4B-1, 4B-2, 4B-3, and E-1 in Accordance with State Programs

Inactive CCR surface impoundments Ponds 4B-1, 4B-2, 4B-3, and E-1 were permitted, designed, constructed and operated before promulgation and effective date of the CCR Rule and were compliant with State of Nevada regulations for water pollution control and dam safety under the jurisdictions of NDEP and NDWR, respectively. The NDEP Bureau of Water Pollution Control issued the Station an Authority to Discharge permit (No. NEV91022). The permit was effective on June 25, 2010, and states, "once these ponds are removed from active service the closure requirements and oversight will pass to the NDEP Bureau of Corrective Actions (BCA) and become part of the Administrative Order of Consent (AOC) between NV Energy and the NDEP-BCA."

NV Energy and NDEP entered into the AOC on February 22, 2008. The AOC defines the general framework to proceed with identification, characterization, corrective action planning, corrective action implementation, and long-term operation and maintenance to address soil and groundwater environmental concerns at the Station. This work includes evaluating groundwater impacts in the former pond area, performing groundwater monitoring and reporting, and planning and implementing corrective action and surface impoundment closure as directed and agreed to with the NDEP-BCA.

The AOC governs the performance and/or completion of environmental contaminant characterization, the screening and selection of Corrective Action, and the implementation and long-term operation and maintenance of NDEP-BCA approved corrective action concerning pollution conditions at the site (including the areas of Ponds 4A, 4B, 4C, D, E, F and G). The AOC will continue to address the historical groundwater impacts from the former ponds with requirements for characterization, groundwater monitoring and reporting, corrective actions and surface impoundment closure.

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Tables

Table 1. Timeline of Pond Construction and Use

Year	Pond D Area	Pond E Area		Pond 4A Area	Pond 4B Area			Pond 4C Area			Pond F Area	Pond G Area
1965												
1966												
1967												
1968												
1969												
1970												
1971												
1972												
1973												
1974	Compacted native soil lined, with clay-cored berms Pond D	Compacted native soil lined, with clay-cored berms Pond E										
1975												
1976												
1977												
1978												
1979												
1980												
1981												
1982												
1983				Compacted native soil lined, with clay-cored berms Pond 4A	Clay lined, with clay-cored berms Pond 4B			Clay lined, with clay-cored berms Pond 4C				
1984												
1985												
1986											Clay lined, with clay-cored berms Pond F	Clay -lined, with clay-cored berms Pond G
1987					Pond 4B divided into 3 sub-ponds	Pond 4B divided into 3 sub-ponds	Pond 4B divided into 3 sub-ponds					
1988												
1989												
1990								Pond 4C divided into 3 ponds—early 1990s	Pond 4C divided into 3 ponds—early 1990s	Pond 4C divided into 3 ponds—early 1990s		
1991												
1992												
1993												
1994												
1995												
1996												
1997												
1998												
1999												
2000												
2001									Double-HDPE-lined with leak detection and collection Combined Pond 4C-2 includes the former 4C-2 and 4C-3 subdivisions of Pond C Pond 4C-2			
2002								Double-HDPE-lined with leak detection and collection Pond 4C-1				
2003		Double-HDPE-lined with leak detection and collection Former Pond E area split to Ponds E-1 and E-2 Pond E-1	Double-HDPE-lined with leak detection and collection Former Pond E area split to Ponds E-1 and E-2 Pond E-2									
2004												
2005												
2006												
2007							Double-HDPE-lined with leak detection and collection Pond 4B-3				Double-HDPE-lined with leak detection and collection Pond F	
2008					Double-HDPE-lined with leak detection and collection Pond 4B-1	Double-HDPE-lined with leak detection and collection Pond 4B-2						
2009												
2010												
2011												
2012												
2013												
2014												
2015												
2016 to 2019												

Notes:

(yellow)	= Clay-lined or native-soil-lined pond in operation; not subject to CCR regulation.
(green)	= Double-HDPE-lined pond in operation; not subject to CCR regulation.
(blue)	= CCR-regulated double-HDPE-lined pond in operation.

HDPE = high-density polyethylene

Table 2 Summary of Compliance with CCR Rule 40 CFR 257.105(i), 257.106(i), and 257.107(i)

Document	Date Placed in Operating Record, §257.105(i)	Date State Director Notification was Provided, §257.106(i)	Date Document was Posted to the CCR Web Site, §257.107(i)
(1) The notification of intent to initiate closure of the CCR unit as required by §257.100(c)(1).	Ponds 4B-1, 4B-2, and 4B-3—12/15/2015 Pond E-1—12/15/2015	Ponds B1, 4B-2, and 4B-3—1/8/2016 Pond E1—1/8/2016	Within 30 days of placement in operating record
(2) The annual progress reports of closure implementation as required by §257.100(c)(2)(i) and (ii).	Requirement was vacated by June 14, 2016, U.S. District Court of Appeals for the District Court of Columbia circuit and the direct final rule issued by EPA on August 5, 2016.		
(3) The notification of closure completion as required by §257.100(c)(3).	Requirement was vacated by June 14, 2016, US District Court of Appeals for the District Court of Columbia circuit and the direct final rule issued by EPA on August 5, 2016.		
(4) The written closure plan, and any amendment of the plan, as required by §257.102(b), except that only the most recent closure plan must be maintained in the facility's operating record irrespective of the time requirement specified in paragraph (b) of this section.	Pond 4B-1, 4B-2, and 4B-3—4/17/2018 Pond E1—4/17/2018	May 17, 2018	Within 30 days of placement in operating record
(5) The written demonstration(s), including the certification required by §257.102(e)(2)(iii), for a time extension for initiating closure as required by §257.102(e)(2)(ii).	Time extensions to initiate closure were not sought		
(6) The written demonstration(s), including the certification required by §257.102(f)(2)(iii), for a time extension for completing closure as required by §257.102(f)(2)(i).	Time extensions for completing closure were not sought		
(7) The notification of intent to close a CCR unit as required by §257.102(g).	Ponds 4B-1, 4B-2 and 4B-3—12/15/2015 Pond E1—12/15/2015	January 8, 2016	Within 30 days of placement in operating record
(8) The notification of completion of closure of a CCR unit as required by §257.102(h).	This document servers as the notification of completion of closure and will be placed in the operating record in accordance with §257.105(i)(8).	This document servers as the notification of completion of closure and the State Director will be notified within 30 days of placement in the operating record in accordance with §257.106(i)(8).	This document servers as the notification of completion of closure and the will be placed on the CCR web site within 30 days of placement in the operating record in accordance with §257.107(i)(8).
(9) The notification recording a notation on the deed as required by §257.102(i).	These ponds were closed in accordance with §257.102(c) and are therefore not subject to the requirements of paragraph §257.102(i)		
(10) The notification of intent to comply with the alternative closure requirements as required by §257.103(c)(1).	Alternative closure requirements were not sought		
(11) The annual progress reports under the alternative closure requirements as required by §257.103(c)(2).	Alternative closure requirements were not sought		
(12) The written post-closure plan, and any amendment of the plan, as required by §257.104(d), except that only the most recent closure plan must be maintained in the facility's operating record irrespective of the time requirement specified in paragraph (b) of this section.	Per §257.104(a)(2) An owner or operator of a CCR unit that elects to close a CCR unit by removing CCR as provided by §257.102(c) is not subject to the post-closure care criteria under this section.		
(13) The notification of completion of post-closure care period as required by §257.104(e).	Per §257.104(a)(2) An owner or operator of a CCR unit that elects to close a CCR unit by removing CCR as provided by §257.102(c) is not subject to the post-closure care criteria under this section.		

Notes:

§= Section

CCR = coal combustion residuals

EPA = U.S. Environmental Protection Agency

Table 3 Summary of Pond Construction, Size, and Operations

Compacted-Native-Soil-Lined or Clay-Lined Ponds		Double-HDPE-Lined Ponds (Replacing Native-Soil-Lined or Clay-Lined Ponds)	
Pond Name	**Area and Years of Operation; Comments**	**Pond Name**	**Area and Years of Operation; Comments**
Pond 4A	Operated 1983–1999 21-acre area single pond	Pond 4A was not replaced (Stanley 2017a)	
Pond 4B	Operated 1983–2005 40-acre single pond 1983–1987 Subdivided with interior berms in 1987–1988 into 3 sub ponds which were operated until 2000 to 2005	**Ponds 4B-1, 4B-2, and 4B-3**	4B-1 (15 acres) and 4B-2 (14 acres) operated 2007–2015 4B-3 (9 acres) operated 2008–2015 (Stanley 2019)
Pond 4C	Operated 1983–2000 32 acres in area as a single pond from 1983–2000 Subdivided with interior berms in 1990 into three sub ponds	Ponds 4C-1 and 4C-2	4C-1 (15 acres) and 4C-2 (13 acres) operated 2002–2008 (Stanley 2016a, 2017b)
Pond D West Pond	Operated 1974–2001 15-acre area single pond	Pond D was not replaced (Stanley 2011a)	
Pond E East Pond	Operated 1974–2001 28-acre area single pond	**Pond E-1** and Pond E-2	E-1 (9 acres) operated 2003–2015, and E-2 (17 acres) operated 2003–2014 (Stanley 2016b, 2018)
Pond F	Operated 1986–2003 4-acre area single pond	Pond F	Pond F (4 acres) operated 2007–2011 (Stanley 2013b)
Pond G	Operated 1986–2008 6-acre area single pond	Pond G was not replaced (Stanley 2011b)	
Duration of native-soil-lined and clay-lined pond operations: 1974 to 2008		Duration of double-HDPE-lined pond operations: 2002–2015	
Area and duration of operations of native-soil-lined and clay-lined Ponds 4B and 4C: 72 acres for 16 to 22 years Area and duration of operations of native-soil-lined and clay-lined Ponds D and E: 43 acres for 26 to 27 years		Area and duration of operations of **CCR-regulated Ponds 4B-1, 4B-2, 4B-3:** 38 acres for 8 years Area and duration of operations of **CCR-regulated Pond E-1:** 9 acres for 12 years	

Note:

Bold font indicates inactive CCR surface impoundments 4B-1, 4B-2, 4B-3, and E-1, for which this document certifies closure.

Table 4. Ponds 4B-1, 4B-2, and 4B-3 Area, Monitoring Wells Selected for Historical Data Review

Ponds 4B-1, 4B-2, and 4B-3—Selected Wells for Review						
Monitoring Well	**Pond Out-of-Use Interval (Appendix A)**	**Start of Data Set**	**Well Installation and Replacement**	**Location Relative to 4B-1, 4B-2, 4B-3 Ponds**	**Screened Interval (ft bgs)**	**Comments**
MW-2 MW-2R	2006–2007; 2016 onward (Pond 4B, Ponds 4B-1 to 4B-3)	1996	MW-2 installed 1999 and replaced by MWR-2R in 2007	Downgradient	MW-2: 13-23 MW-2R: 5-20	—
MW-3 MW-3R MW-3RR		1996	MW-3 installed 1999 and replaced by MW-3R in 2007 MW3R was replaced by MW3RR in 2011	Downgradient	MW-3: 5-10 MW-3R: 5-25 MW-3RR: 8-23	—
MW-12S MW-12SR	2001; 2016 onward (Pond 4C, Ponds 4C-1 and 4C-2)	2013	MW-12S installed 2013 and replaced by MW-12SR in 2018	Upgradient	MW-12S: 15-30 MW-12SR: 5-20	Between Pond 4B and Pond 4C
MW-13	2016 onward (Ponds 4B-1 to 4B-3 and Ponds 4C-1 and 4C-2)	2013	Installed 10-25	Upgradient	MW-13: 10-25	—
MW-14S MW-14SR		2013	MW-14S installed 2013 and replaced by MW-14SR in 2018	Upgradient	MW-14S: 15-35 MW-14SR: 5-20	MW-14 is within Pond 4B; between 4B-1 and 4B-2
MW-15		2013	Installed 2013	Downgradient	MW-15: 8-23	—
MW-16S		2013	Installed 2013	Downgradient	MW-16S: 8-20	—
MW-17S		2015	Installed 2015	Downgradient	MW-17S: 10-20	—
MW-25S		2015	Installed 2015	Upgradient	MW-25S: 8-18	—
MW-26S		2015	Installed 2015	Upgradient	MW-26S: 16-26	—
KMW-19	2006–2007; 2016 onward (Ponds 4B and 4B-1 to 4B-3)	2000	Installed 2000	Upgradient	KMW-19: 10-25	Hogan Wash (south of Pond 4B)
IMW-2SR	2016 onward (Ponds 4B-1 to 4B-3)	2011	Installed 2011	Upgradient	IMW-2SR:19-39	Hogan Wash
P-13 P-13R	2000–2007; 2016 onward (Ponds 4B-1 and 4B-2)	1996	P-13 installed 1988 and replaced by P-13R in 2007	Downgradient	P-13: 15-35 P-13R: 15-35	—
P-14 P-14R		1996	P-14 installed 1988 and replaced by P-14R in 2004	Downgradient	P-14: 18-28 P-14R: 10-35	—

Notes:
ft bgs = feet below ground surface
S = shallow well
R = replacement well
Depth to water measurements are shown on time series plots in Appendix A

Table 5. Ponds E-1 Area, Monitoring Wells Selected for Historical Data Review

Pond E-1—Selected Wells for Review						
Monitoring Well	Pond Out-of-Use Interval (Appendix A)	Start of Data Set	Well Installation and Replacement	Location Relative to Pond E-1	Screened Interval (Ft bgs)	Comments
P-3	2001–2002 2016 onward (Pond E and Pond E-1)	1996	Installed before 1986	Downgradient	P-3: 8-18	—
P-4		1996	Installed before 1986	Downgradient	P-4: 8-18	—
P-5 P-5R		1996	P-5 installed 1989 and replaced by P-5R in 2004	Side gradient	P-5: 9-19 P-5R: 8-33	—
P-6 P-6R		1996	P-6 installed 1988 and replaced by P-6R in 2004	Side gradient	P-6: 7-18 P-6R: 8-33	—
P-7 P-7R		1996	P-7 installed 1988 and replaced by P-7R in 2004	Side gradient	P-7: 8-19 P-7R: 8-33	Former seep area
P-8 P-8R	2001 onward (Pond D)	1996	P-8 installed 1988 and replaced by P-8R in 2004	Upgradient	P-8: 6-16 P-8R: 8-33	Former seep area at junction of Ponds E and D
P-9 P-9R		1996	P-9 installed 1988 and replaced by P-9R in 2004	Upgradient	P-9: 5-15 P-9R: 8-33	Former seep area
P-10		1996	Installed 1988	Upgradient	P-10: 4-14	—
P-11		1996	Installed 1993	Upgradient	P-11: 20-65	—
P-12		1996	Installed 1989	Upgradient	P-12: 67-82	—
P-23S P-23SR	2016 onward (Ponds E-1 and E-2)	2015	P-23S installed 2015 and replaced by P-23SR in 2018	Upgradient	P-23S: 15-35 P-23SR: 6-21	—
P-24S		2015	Installed 2015	Upgradient	P-24S: 25-35	—

Notes:
Depth to water measurements are shown on time series plots in Appendix A
R = replacement well
S = shallow well

Table 6A. Ponds B-1, B-2, B-3 Downgradient Wells Summary Statistics

LOCID	PARAM	UNITS	COUNT	AREA	TYPE	DET	PER.DET	MIN.DET	MAX.DET	MEAN	SD	CV	Trend Statistic	PVAL	TREND
MW-15	Boron	mg/L	12	B PONDS	DG	12	100	13.0	38.0	18.2	7.3	0.40	9	0.30	No Trend
MW-16S	Boron	mg/L	13	B PONDS	DG	13	100	12.0	20.0	15.7	2.2	0.14	44	0.00	**Increasing**
MW-17S	Boron	mg/L	6	B PONDS	DG	6	100	5.9	7.9	7.1	0.8	0.12	-1	0.50	No Trend
MW-2-2R	Boron	mg/L	58	B PONDS	DG	58	100	2.9	14.0	8.9	3.1	0.35	-333	0.01	***Decreasing***
MW-3-3R-3RR	Boron	mg/L	52	B PONDS	DG	52	100	0.3	47.0	32.5	6.4	0.20	-199	0.06	No Trend
P-13-13R	Boron	mg/L	57	B PONDS	DG	57	100	1.2	100.0	65.0	14.9	0.23	539	0.00	**Increasing**
P-14-14R	Boron	mg/L	54	B PONDS	DG	54	100	10.0	220.0	106.6	33.6	0.32	875	0.00	**Increasing**
MW-15	Chloride	mg/L	12	B PONDS	DG	12	100	1,500.0	2,100.0	1,766.7	192.3	0.11	-6	0.37	No Trend
MW-16S	Chloride	mg/L	13	B PONDS	DG	13	100	2,100.0	2,900.0	2,423.1	311.3	0.13	43	0.00	**Increasing**
MW-17S	Chloride	mg/L	5	B PONDS	DG	5	100	2,600.0	4,300.0	3,360.0	634.8	0.19	0	0.59	No Trend
MW-2-2R	Chloride	mg/L	70	B PONDS	DG	70	100	800.0	7,040.0	2,717.4	1,150.9	0.42	417	0.02	**Increasing**
MW-3-3R-3RR	Chloride	mg/L	60	B PONDS	DG	60	100	2,100.0	9,900.0	4,283.8	1,114.8	0.26	160	0.15	No Trend
P-13-13R	Chloride	mg/L	70	B PONDS	DG	70	100	540.0	7,200.0	3,315.1	987.6	0.30	229	0.12	No Trend
P-14-14R	Chloride	mg/L	67	B PONDS	DG	67	100	1,700.0	4,700.0	3,704.3	509.4	0.14	-586	0.00	***Decreasing***
MW-15	Sodium	mg/L	12	B PONDS	DG	12	100	2,300.0	11,000.0	4,075.0	2,929.8	0.72	-17	0.14	No Trend
MW-16S	Sodium	mg/L	13	B PONDS	DG	13	100	2,700.0	4,000.0	3,130.8	425.0	0.14	16	0.18	No Trend
MW-17S	Sodium	mg/L	5	B PONDS	DG	5	100	3,300.0	5,200.0	3,840.0	773.3	0.20	-1	0.50	No Trend
MW-2-2R	Sodium	mg/L	69	B PONDS	DG	69	100	760.0	6,200.0	3,510.6	1,305.9	0.37	-203	0.15	No Trend
MW-3-3R-3RR	Sodium	mg/L	60	B PONDS	DG	60	100	2,500.0	6,300.0	4,714.3	691.9	0.15	904	0.00	**Increasing**
P-13-13R	Sodium	mg/L	70	B PONDS	DG	70	100	145.0	10,000.0	5,642.4	1,713.1	0.30	447	0.01	**Increasing**
P-14-14R	Sodium	mg/L	67	B PONDS	DG	67	100	124.0	8,600.0	5,639.9	1,322.6	0.23	232	0.11	No Trend
MW-15	Sulfate	mg/L	12	B PONDS	DG	12	100	5,300.0	24,000.0	9,050.0	6,995.1	0.77	-10	0.27	No Trend
MW-16S	Sulfate	mg/L	13	B PONDS	DG	13	100	6,700.0	9,500.0	7,653.8	877.1	0.11	26	0.06	No Trend
MW-17S	Sulfate	mg/L	5	B PONDS	DG	5	100	6,800.0	12,000.0	8,700.0	1,987.5	0.23	2	0.41	No Trend
MW-2-2R	Sulfate	mg/L	70	B PONDS	DG	70	100	1,800.0	14,700.0	7,805.0	2,773.6	0.36	-157	0.21	No Trend
MW-3-3R-3RR	Sulfate	mg/L	60	B PONDS	DG	60	100	7,200.0	22,000.0	15,743.3	2,915.3	0.19	795	0.00	**Increasing**
P-13-13R	Sulfate	mg/L	70	B PONDS	DG	70	100	3,100.0	34,000.0	15,935.7	4,717.2	0.30	349	0.04	**Increasing**
P-14-14R	Sulfate	mg/L	67	B PONDS	DG	67	100	1,100.0	15,000.0	9,920.1	2,356.0	0.24	890	0.00	**Increasing**
MW-15	TDS	mg/L	13	B PONDS	DG	13	100	11,000.0	38,000.0	15,203.1	8,851.2	0.58	-39	0.01	***Decreasing***
MW-16S	TDS	mg/L	14	B PONDS	DG	14	100	13,710.0	19,840.0	15,846.4	2,002.7	0.13	19	0.17	No Trend
MW-17S	TDS	mg/L	6	B PONDS	DG	6	100	16,320.0	23,000.0	18,563.3	2,749.6	0.15	-4	0.30	No Trend
MW-2-2R	TDS	mg/L	71	B PONDS	DG	71	100	1,180.0	26,000.0	15,427.3	5,253.4	0.34	-99	0.31	No Trend
MW-3-3R-3RR	TDS	mg/L	61	B PONDS	DG	61	100	12,000.0	38,000.0	29,048.9	4,380.6	0.15	966	0.00	**Increasing**
P-13-13R	TDS	mg/L	71	B PONDS	DG	71	100	2,080.0	43,000.0	27,175.9	7,390.3	0.27	318	0.06	No Trend
P-14-14R	TDS	mg/L	68	B PONDS	DG	68	100	14,000.0	32,400.0	20,428.8	2,673.0	0.13	892	0.00	**Increasing**

Notes:

Mann-Kendall Trend Result

Bold = Increasing trend

Bold italic = decreasing trend

Table 6B. Ponds B-1, B-2, B-3 Upgradient Wells Summary Statistics

Upgradient Wells	PARAM	UNITS	COUNT	AREA	TYPE	DET	PER.DET	MIN.DET	MAX.DET	MEAN	SD	CV	Trend Statistic	PVAL	TREND
IMW-2SR	Boron	mg/L	12	B PONDS	UG	12	100	1.1	9.9	3.3	3.2	0.95	34	0.01	**Increasing**
KMW-19	Boron	mg/L	30	B PONDS	UG	30	100	3.7	33.0	13.5	7.4	0.55	-336	0.00	***Decreasing***
MW-12S-12SR	Boron	mg/L	13	B PONDS	UG	13	100	140.0	360.0	266.9	59.5	0.22	38	0.01	**Increasing**
MW-13	Boron	mg/L	11	B PONDS	UG	11	100	1.2	49.0	26.1	15.5	0.59	-21	0.06	No Trend
MW-14S-14SR	Boron	mg/L	14	B PONDS	UG	14	100	140.0	300.0	202.1	50.9	0.25	31	0.05	No Trend
MW-25S	Boron	mg/L	4	B PONDS	UG	4	100	0.6	1.3	0.9	0.3	0.35	2	0.38	No Trend
MW-26S	Boron	mg/L	4	B PONDS	UG	4	100	1.7	2.0	1.8	0.1	0.07	4	0.17	No Trend
IMW-2SR	Chloride	mg/L	12	B PONDS	UG	12	100	110.0	1,300.0	393.3	349.4	0.89	35	0.01	**Increasing**
KMW-19	Chloride	mg/L	30	B PONDS	UG	30	100	209.0	2,400.0	1,321.9	737.9	0.56	-297	0.00	***Decreasing***
MW-12S-12SR	Chloride	mg/L	13	B PONDS	UG	13	100	12,000.0	28,000.0	22,076.9	4,367.7	0.20	42	0.01	**Increasing**
MW-13	Chloride	mg/L	11	B PONDS	UG	11	100	360.0	2,900.0	1,885.5	838.4	0.44	-11	0.22	No Trend
MW-14S-14SR	Chloride	mg/L	13	B PONDS	UG	13	100	9,600.0	14,000.0	11,738.5	1,150.0	0.10	40	0.01	**Increasing**
MW-25S	Chloride	mg/L	4	B PONDS	UG	4	100	260.0	310.0	290.0	24.5	0.08	5	0.10	No Trend
MW-26S	Chloride	mg/L	4	B PONDS	UG	4	100	160.0	240.0	200.0	33.7	0.17	6	0.04	**Increasing**
IMW-2SR	Sodium	mg/L	12	B PONDS	UG	12	100	170.0	2,100.0	604.2	655.3	1.08	39	0.00	**Increasing**
KMW-19	Sodium	mg/L	30	B PONDS	UG	30	100	441.0	5,400.0	2,904.9	1,481.8	0.51	-243	0.00	***Decreasing***
MW-12S-12SR	Sodium	mg/L	13	B PONDS	UG	13	100	21,000.0	69,000.0	39,000.0	12,767.1	0.33	3	0.45	No Trend
MW-13	Sodium	mg/L	11	B PONDS	UG	11	100	560.0	29,000.0	16,693.6	10,499.7	0.63	-20	0.07	No Trend
MW-14S-14SR	Sodium	mg/L	13	B PONDS	UG	13	100	500.0	80,000.0	37,884.6	20,314.4	0.54	25	0.07	No Trend
MW-25S	Sodium	mg/L	4	B PONDS	UG	4	100	270.0	320.0	297.5	20.6	0.07	1	0.50	No Trend
MW-26S	Sodium	mg/L	4	B PONDS	UG	4	100	430.0	480.0	450.0	21.6	0.05	6	0.04	**Increasing**
IMW-2SR	Sulfate	mg/L	13	B PONDS	UG	13	100	1,500.0	9,200.0	3,400.0	2,240.2	0.66	42	0.01	**Increasing**
KMW-19	Sulfate	mg/L	30	B PONDS	UG	30	100	4,200.0	16,000.0	9,981.3	3,752.4	0.38	-311	0.00	***Decreasing***
MW-12S-12SR	Sulfate	mg/L	13	B PONDS	UG	13	100	37,000.0	140,000.0	67,230.8	32,049.8	0.48	-26	0.06	No Trend
MW-13	Sulfate	mg/L	11	B PONDS	UG	11	100	3,900.0	78,000.0	43,481.8	25,276.9	0.58	-16	0.13	No Trend
MW-14S-14SR	Sulfate	mg/L	13	B PONDS	UG	13	100	34,000.0	140,000.0	59,230.8	29,794.2	0.50	-40	0.01	***Decreasing***
MW-25S	Sulfate	mg/L	4	B PONDS	UG	4	100	3,300.0	3,600.0	3,475.0	150.0	0.04	5	0.10	No Trend
MW-26S	Sulfate	mg/L	4	B PONDS	UG	4	100	2,700.0	3,200.0	2,875.0	221.7	0.08	5	0.10	No Trend
IMW-2SR	TDS	mg/L	13	B PONDS	UG	13	100	2,652.0	16,280.0	5,728.5	3,914.8	0.68	42	0.01	**Increasing**
KMW-19	TDS	mg/L	30	B PONDS	UG	30	100	4,800.0	26,800.0	15,705.5	6,569.6	0.42	-273	0.00	***Decreasing***
MW-12S-12SR	TDS	mg/L	12	B PONDS	UG	12	100	93,800.0	220,000.0	127,366.7	41,889.6	0.33	34	0.01	**Increasing**
MW-13	TDS	mg/L	12	B PONDS	UG	12	100	6,784.0	114,000.0	59,345.3	36,299.1	0.61	-20	0.10	No Trend
MW-14S-14SR	TDS	mg/L	14	B PONDS	UG	14	100	66,800.0	190,000.0	98,692.9	35,722.0	0.36	17	0.19	No Trend
MW-25S	TDS	mg/L	5	B PONDS	UG	5	100	5,200.0	5,628.0	5,425.6	186.2	0.03	2	0.41	No Trend
MW-26S	TDS	mg/L	5	B PONDS	UG	5	100	4,320.0	4,800.0	4,469.6	189.1	0.04	5	0.18	No Trend

Notes:

Mann-Kendall Trend Result

Bold = Increasing trend

Bold italic = decreasing trend

Table 7A. Pond E-1 Upgradient Wells Summary Statistics

LOCID	PARAM	UNITS	COUNT	AREA	TYPE	DET	PER.DET	MIN.DET	MAX.DET	MEAN	SD	CV	Trend Statistic	PVAL	TREND
P-10	Boron	mg/L	59	E1 POND	UG	59	100	25	170	64	22	0.34	347	0.01	**Increasing**
P-11	Boron	mg/L	59	E1 POND	UG	59	100	4	9	6	1	0.15	127	0.20	No Trend
P-12	Boron	mg/L	57	E1 POND	UG	57	100	4	11	5	1	0.20	63	0.33	No Trend
P-23S-23SR	Boron	mg/L	6	E1 POND	UG	6	100	1,800	2,500	2,050	259	0.13	6	0.19	No Trend
P-24S	Boron	mg/L	6	E1 POND	UG	6	100	650	1,600	1,163	359	0.31	6	0.19	No Trend
P-8-8R	Boron	mg/L	52	E1 POND	UG	52	100	17	1,000	520	210	0.40	248	0.03	**Increasing**
P-9-9R	Boron	mg/L	57	E1 POND	UG	57	100	5	680	132	150	1.14	-455	0.00	***Decreasing***
P-10	Chloride	mg/L	67	E1 POND	UG	67	100	2,000	6,200	3,850	998	0.26	479	0.00	**Increasing**
P-11	Chloride	mg/L	67	E1 POND	UG	67	100	436	2,600	563	261	0.46	-689	0.00	***Decreasing***
P-12	Chloride	mg/L	69	E1 POND	UG	69	100	330	880	475	77	0.16	464	0.01	**Increasing**
P-23S-23SR	Chloride	mg/L	6	E1 POND	UG	6	100	25,000	36,000	29,500	3,987	0.14	-1	0.50	No Trend
P-24S	Chloride	mg/L	5	E1 POND	UG	5	100	6,000	16,000	11,300	4,502	0.40	3	0.33	No Trend
P-8-8R	Chloride	mg/L	61	E1 POND	UG	61	100	720	11,000	6,427	1,658	0.26	100	0.27	No Trend
P-9-9R	Chloride	mg/L	69	E1 POND	UG	69	100	1,000	6,000	2,880	1,582	0.55	-994	0.00	***Decreasing***
P-10	Sodium	mg/L	67	E1 POND	UG	67	100	2,400	13,000	6,640	1,849	0.28	435	0.01	**Increasing**
P-11	Sodium	mg/L	67	E1 POND	UG	67	100	490	1,600	685	129	0.19	71	0.35	No Trend
P-12	Sodium	mg/L	69	E1 POND	UG	69	100	410	1,300	963	226	0.23	725	0.00	**Increasing**
P-23S-23SR	Sodium	mg/L	6	E1 POND	UG	6	100	33,000	81,000	54,167	17,360	0.32	-5	0.24	No Trend
P-24S	Sodium	mg/L	5	E1 POND	UG	5	100	32,000	59,000	47,400	13,649	0.29	8	0.04	**Increasing**
P-8-8R	Sodium	mg/L	61	E1 POND	UG	61	100	2,060	50,000	29,493	10,286	0.35	156	0.17	No Trend
P-9-9R	Sodium	mg/L	69	E1 POND	UG	69	100	1,900	32,000	11,337	9,251	0.82	-1120	0.00	***Decreasing***
P-10	Sulfate	mg/L	67	E1 POND	UG	67	100	7,600	35,000	16,346	4,616	0.28	550	0.00	**Increasing**
P-11	Sulfate	mg/L	67	E1 POND	UG	67	100	1,317	3,600	2,653	299	0.11	205	0.13	No Trend
P-12	Sulfate	mg/L	69	E1 POND	UG	69	100	469	6,100	3,312	707	0.21	280	0.07	No Trend
P-23S-23SR	Sulfate	mg/L	6	E1 POND	UG	6	100	46,000	150,000	93,667	44,778	0.48	-5	0.24	No Trend
P-24S	Sulfate	mg/L	5	E1 POND	UG	5	100	53,000	160,000	99,000	48,826	0.49	0	0.59	No Trend
P-8-8R	Sulfate	mg/L	61	E1 POND	UG	61	100	18,000	120,000	61,836	21,618	0.35	472	0.00	**Increasing**
P-9-9R	Sulfate	mg/L	69	E1 POND	UG	69	100	4,700	55,000	24,820	20,322	0.82	-1094	0.00	***Decreasing***
P-10	TDS	mg/L	68	E1 POND	UG	68	100	14,400	57,000	30,166	8,286	0.27	610	0.00	**Increasing**
P-11	TDS	mg/L	68	E1 POND	UG	68	100	3,400	5,720	4,652	300	0.06	-207	0.14	No Trend
P-12	TDS	mg/L	70	E1 POND	UG	70	100	3,770	20,900	5,830	1,961	0.34	223	0.13	No Trend
P-23S-23SR	TDS	mg/L	6	E1 POND	UG	6	100	118,400	200,000	171,467	34,158	0.20	0	0.58	No Trend
P-24S	TDS	mg/L	6	E1 POND	UG	6	100	87,000	210,000	161,317	53,313	0.33	1	0.50	No Trend
P-8-8R	TDS	mg/L	61	E1 POND	UG	61	100	10,000	169,200	100,051	34,106	0.34	462	0.00	**Increasing**
P-9-9R	TDS	mg/L	70	E1 POND	UG	70	100	7,700	97,000	39,745	30,775	0.77	-1044	0.00	***Decreasing***

Notes:

Mann-Kendall Trend Result

Bold = Increasing trend

Bold italic = decreasing trend

Table 7B. Pond E-1 Side-Gradient Wells Summary Statistics

LOCID	PARAM	UNITS	COUNT	AREA	TYPE	DET	PER.DET	MIN.DET	MAX.DET	MEAN	SD	CV	Trend Statistic	PVAL	TREND
P-5-5R	Boron	mg/L	55	E1 POND	SG	54	98.18	25	180	58	36	0.62	-1018	0.00	***Decreasing***
P-6-6R	Boron	mg/L	47	E1 POND	SG	47	100	43	340	221	62	0.28	212	0.03	**Increasing**
P-7-7R	Boron	mg/L	58	E1 POND	SG	58	100	69	710	370	164	0.44	807	0.00	**Increasing**
P-5-5R	Chloride	mg/L	68	E1 POND	SG	68	100	4,800	9,300	7,122	1,136	0.16	-466	0.01	***Decreasing***
P-6-6R	Chloride	mg/L	56	E1 POND	SG	56	100	3,000	7,200	5,559	793	0.14	-366	0.00	***Decreasing***
P-7-7R	Chloride	mg/L	70	E1 POND	SG	70	100	1,400	7,600	4,865	1,447	0.30	-143	0.24	No Trend
P-5-5R	Sodium	mg/L	68	E1 POND	SG	68	100	5,600	80,000	17,493	11,395	0.65	-1126	0.00	***Decreasing***
P-6-6R	Sodium	mg/L	56	E1 POND	SG	56	100	5,900	37,000	25,498	7,149	0.28	276	0.03	**Increasing**
P-7-7R	Sodium	mg/L	70	E1 POND	SG	70	100	8,100	62,000	28,491	11,395	0.40	541	0.00	**Increasing**
P-5-5R	Sulfate	mg/L	68	E1 POND	SG	68	100	16,000	110,000	34,591	16,192	0.47	-1319	0.00	***Decreasing***
P-6-6R	Sulfate	mg/L	56	E1 POND	SG	56	100	4,900	84,000	61,513	15,399	0.25	207	0.07	No Trend
P-7-7R	Sulfate	mg/L	70	E1 POND	SG	70	100	19,000	130,000	63,036	25,122	0.40	442	0.01	**Increasing**
P-5-5R	TDS	mg/L	69	E1 POND	SG	69	100	28,000	121,000	57,303	18,713	0.33	-1210	0.00	***Decreasing***
P-6-6R	TDS	mg/L	55	E1 POND	SG	55	100	40,000	133,000	95,802	20,824	0.22	178	0.10	No Trend
P-7-7R	TDS	mg/L	71	E1 POND	SG	71	100	10,000	174,000	95,685	32,653	0.34	799	0.00	**Increasing**

Notes:

Mann-Kendall Trend Result

Bold = Increasing trend

Bold italic = decreasing trend

Table 7C. Pond E-1 Downgradient Wells Summary Statistics

LOCID	PARAM	UNITS	COUNT	AREA	TYPE	DET	PER.DET	MIN.DET	MAX.DET	MEAN	SD	CV	Trend Statistic	PVAL	TREND
P-3	Boron	mg/L	33	E1 POND	DG	33	100	130.0	320.0	205.6	51.2	0.25	-336	0.00	***Decreasing***
P-4	Boron	mg/L	56	E1 POND	DG	56	100	93.0	280.0	158.2	37.4	0.24	164	0.12	No Trend
P-3	Chloride	mg/L	43	E1 POND	DG	43	100	3,900.0	6,600.0	5,007.0	583.3	0.12	5	0.48	No Trend
P-4	Chloride	mg/L	69	E1 POND	DG	69	100	3,100.0	7,700.0	5,935.8	744.7	0.13	161	0.20	No Trend
P-3	Sodium	mg/L	43	E1 POND	DG	43	100	11,000.0	26,000.0	17,469.8	3,835.8	0.22	-457	0.00	***Decreasing***
P-4	Sodium	mg/L	69	E1 POND	DG	69	100	7,900.0	40,000.0	17,088.4	4,363.5	0.26	-594	0.00	***Decreasing***
P-3	Sulfate	mg/L	43	E1 POND	DG	43	100	1,205.0	59,000.0	38,632.7	10,196.5	0.26	-510	0.00	***Decreasing***
P-4	Sulfate	mg/L	69	E1 POND	DG	69	100	23,000.0	53,000.0	38,202.9	6,020.6	0.16	-496	0.01	***Decreasing***
P-3	TDS	mg/L	43	E1 POND	DG	43	100	36,000.0	86,000.0	62,688.4	11,693.4	0.19	-551	0.00	***Decreasing***
P-4	TDS	mg/L	70	E1 POND	DG	70	100	40,000.0	85,300.0	62,768.6	8,509.9	0.14	-596	0.00	***Decreasing***

Notes:

Mann-Kendall Trend Result

Bold = Increasing trend

Bold italic = decreasing trend

Table 8. HELP Modeling Parameters Summary (Double-HDPE-Lined Pond)

HELP Modeling Parameters Summary (Double-HDPE-Lined Pond)							
Layer Description	Thickness (Inches)	Classification		Total Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated Hydraulic Conductivity (cm/s)
		Soil Texture #[a]	Layer Type[b]				
Operations Layer	6	4[c]	1	0.437	0.105	0.047	1.0×10^{-4}
HDPE Geomembrane	0.06	35	4	---	---	---	2.0×10^{-13}
Drainage Net	0.24	34	2	---	---	---	33
HDPE Geomembrane	0.04	35	4	---	---	---	2.0×10^{-13}

[a] HELP soil texture number for standard soil and geosynthetic material characteristics. HDPE geomembrane = 35, operations layer = 4, and drainage net = 34 (with user inputs as described in Note c).

[b] HELP layer type and function: (1) vertical percolation layer, (2) lateral drainage layer, (3) barrier soils, and (4) geomembrane liners.

[c] A HELP standard soil texture number of 4 was used with user input of saturated hydraulic conductivity, based on general specified properties. This value is based on a theoretical estimate for the hydraulic conductivity of the material.

Notes:

cm/s = centimeters per second

vol/vol = volume per volume

Table 9. HELP Modeling Parameters Summary (Clay-Lined Pond)

HELP Modeling Parameters Summary (Clay-Lined Pond)							
Layer Description	Thickness (Inches)	Classification		Total Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated Hydraulic Conductivity (cm/s)
		Soil Texture #[a]	Layer Type[b]				
Operations Layer	24	21	1	0.397	0.032	0.013	0.3
Clay Liner	24	4[c]	1	0.437	0.105	0.047	3.0×10^{-6}

[a] HELP soil texture number for standard soil and geosynthetic material characteristics. HDPE geomembrane = 35, operations layer = 4, granular material = 21, and drainage net = 34 (with user inputs as described in Note c).

[b] HELP layer type and function: (1) vertical percolation layer, (2) lateral drainage layer, (3) barrier soils, and (4) geomembrane liners.

[c] A HELP standard soil texture number of 4 was used with user input of saturated hydraulic conductivity, based on general specified properties. This value is based on analysis of well logs in the area.

Notes:

= number

HELP = Hydrologic Evaluation of Landfill Performance

Table 10. Summary of Pond Areas, Years of Use, and Relative Leakage Potential

Pond Area	Clay-lined Duration of Operations	Double HDPE-lined Duration of Operations	Relative Duration of HDPE-lined vs. Clay-lined Operations	Clay-lined former Pond Area	Double HDPE-lined Pond Area	Relative area of HDPE-lined vs. clay-lined ponds	Relative HDPE-lined vs. Clay-lined unit rate leakage potential (3%)* with duration of use and area also considered
Ponds 4B-1, 4B-2, 4B-3; former ponds 4B, 4C	19 years	8 years	42%	72 acres	38 acres	53%	3% leakage × 42% duration × 53% area = **0.67%**
Pond E-1; former ponds D and E	26 years	12 years	46%	43 acres	9 acres	21%	3% leakage × 46% duration × 21% area = **0.29%**

* The unit leakage rate modeled for the double HDPE-lined pond scenario was 96.6 cubic feet per acre per year, or 3% of the unit leakage rate of 3,261 cubic feet per acre per year modeled for the clay-lined pond scenario.

Note:

% = percent

Figures

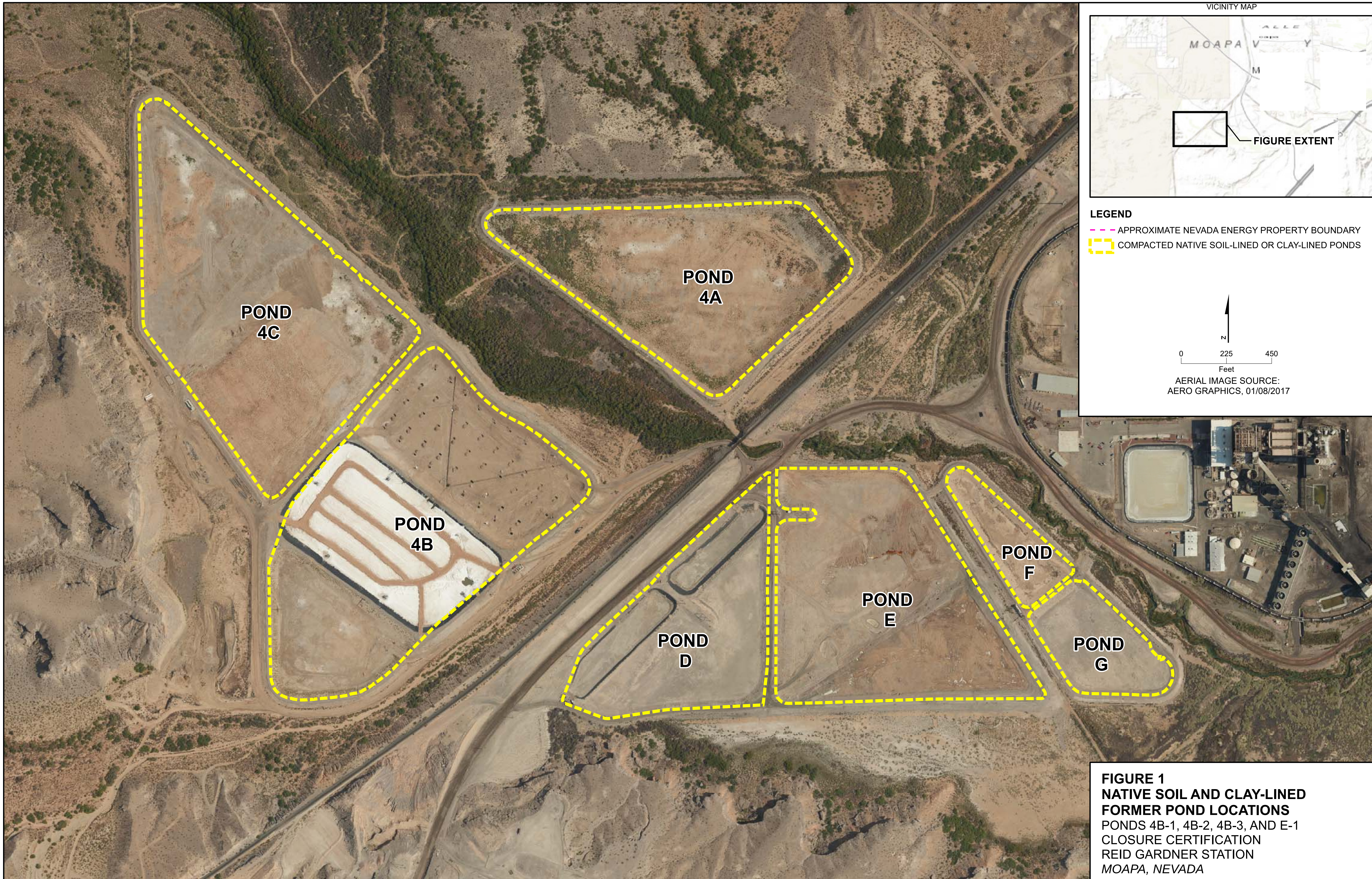

FIGURE 1
NATIVE SOIL AND CLAY-LINED FORMER POND LOCATIONS
PONDS 4B-1, 4B-2, 4B-3, AND E-1
CLOSURE CERTIFICATION
REID GARDNER STATION
MOAPA, NEVADA

ch2m:

FIGURE 2
1984 AERIAL VIEW OF FORMER PONDS
PONDS 4B-1, 4B-2, 4B-3, AND E-1
CLOSURE CERTIFICATION
REID GARDNER STATION
MOAPA, NEVADA

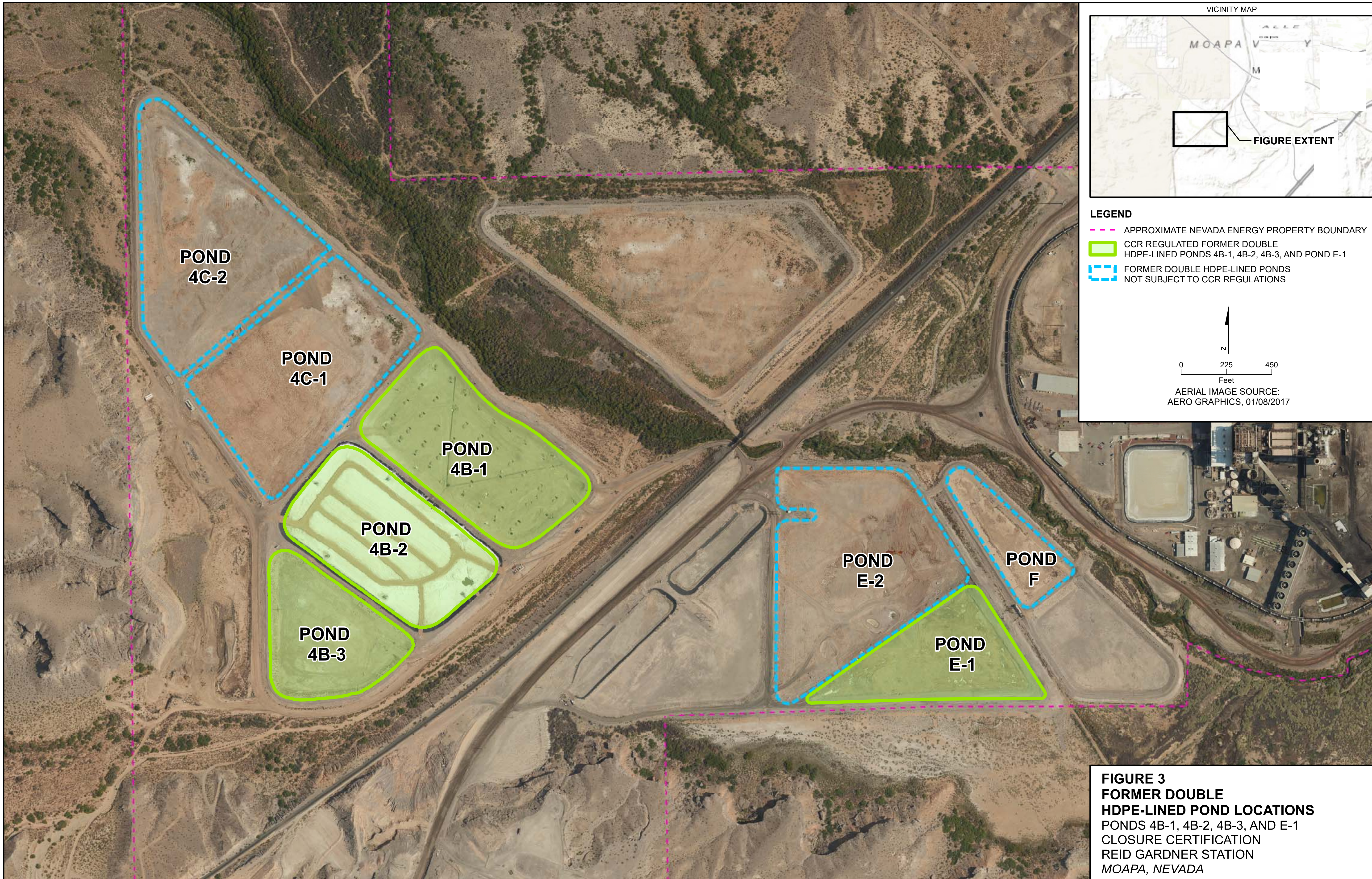

FIGURE 3
FORMER DOUBLE
HDPE-LINED POND LOCATIONS
PONDS 4B-1, 4B-2, 4B-3, AND E-1
CLOSURE CERTIFICATION
REID GARDNER STATION
MOAPA, NEVADA

ch2m.

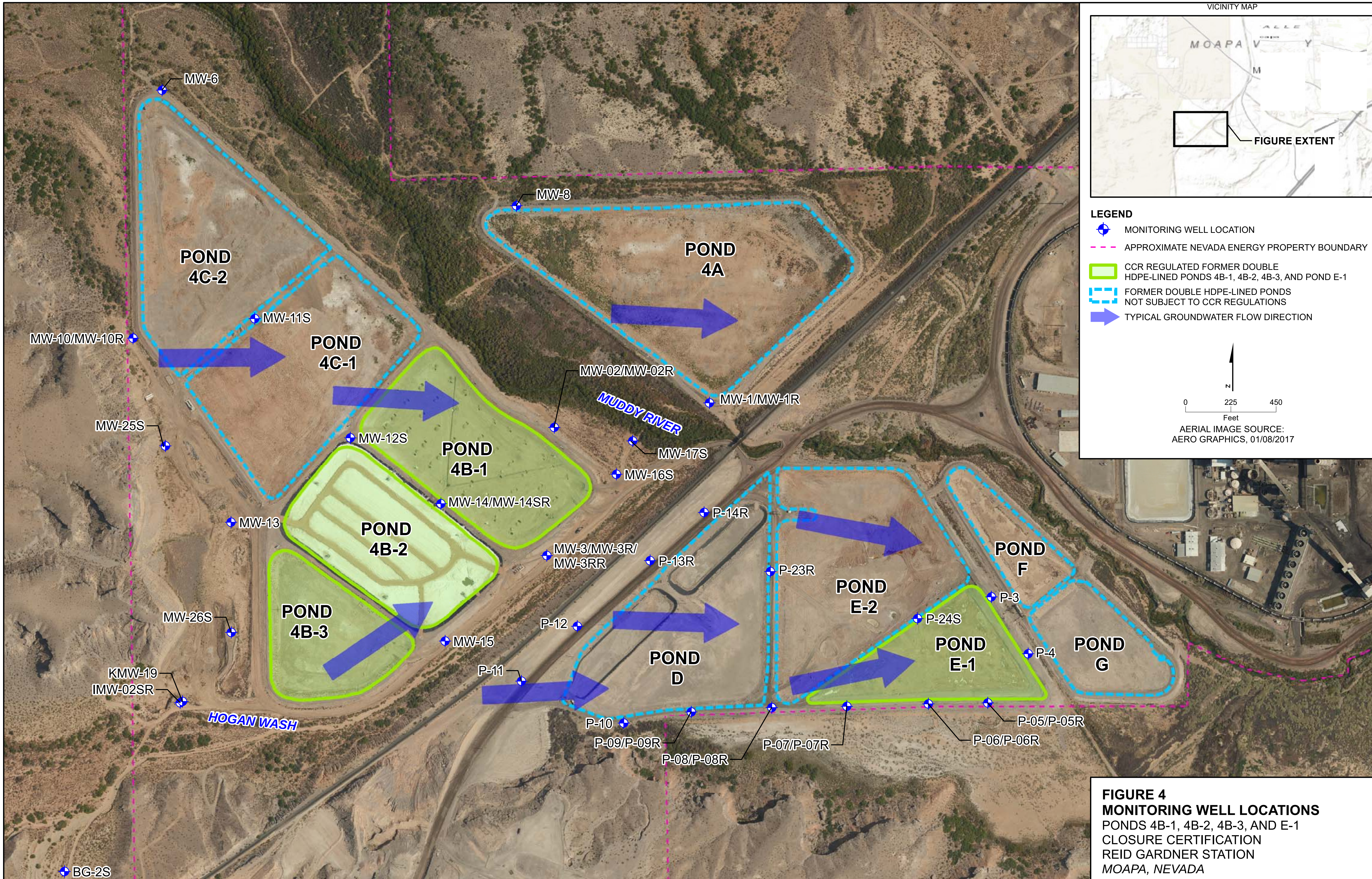

FIGURE 4
MONITORING WELL LOCATIONS
PONDS 4B-1, 4B-2, 4B-3, AND E-1
CLOSURE CERTIFICATION
REID GARDNER STATION
MOAPA, NEVADA

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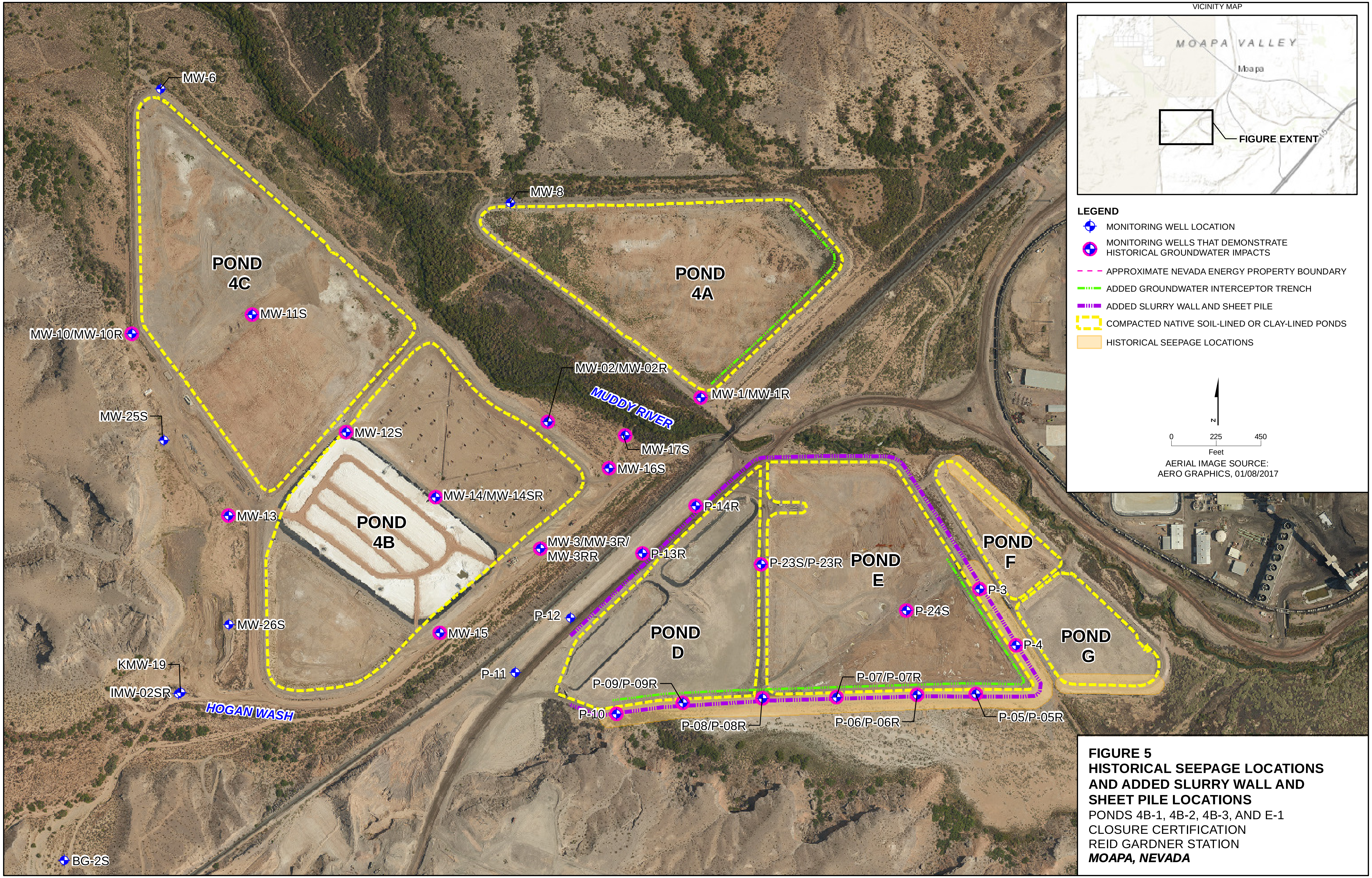

FIGURE 5
HISTORICAL SEEPAGE LOCATIONS AND ADDED SLURRY WALL AND SHEET PILE LOCATIONS
PONDS 4B-1, 4B-2, 4B-3, AND E-1
CLOSURE CERTIFICATION
REID GARDNER STATION
MOAPA, NEVADA

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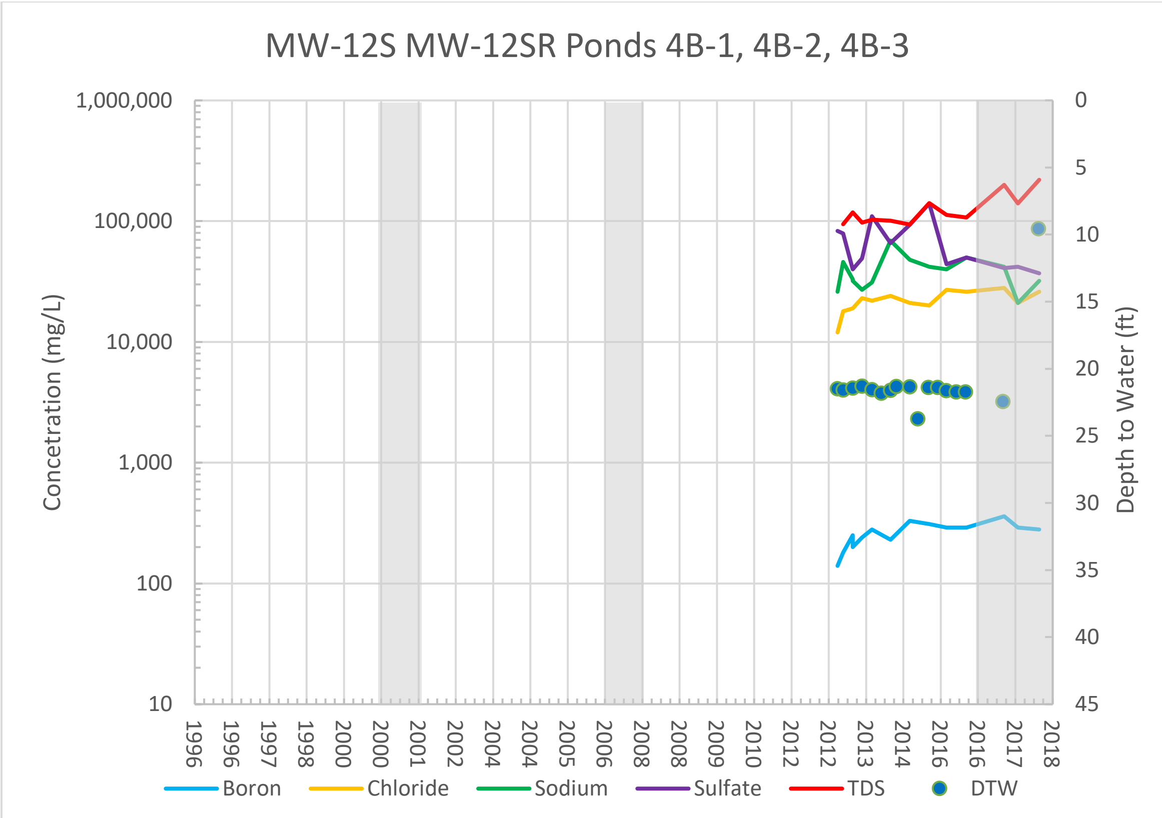
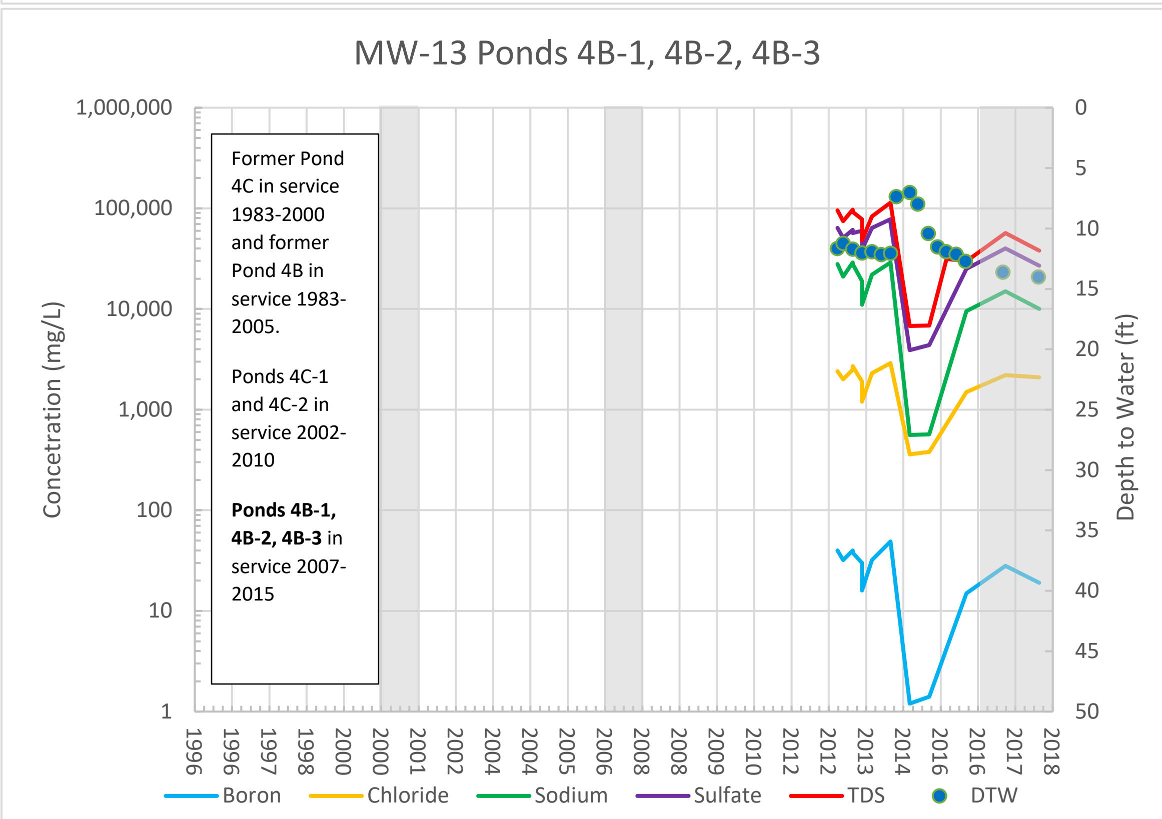
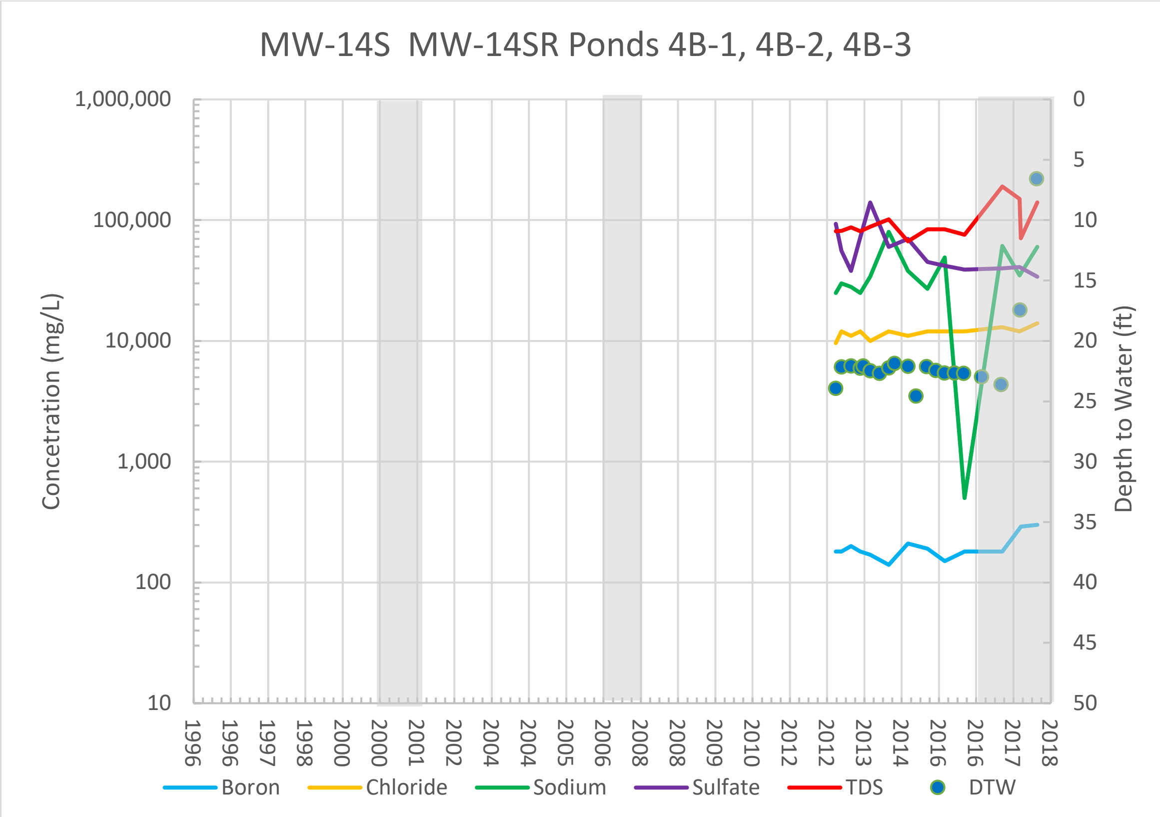
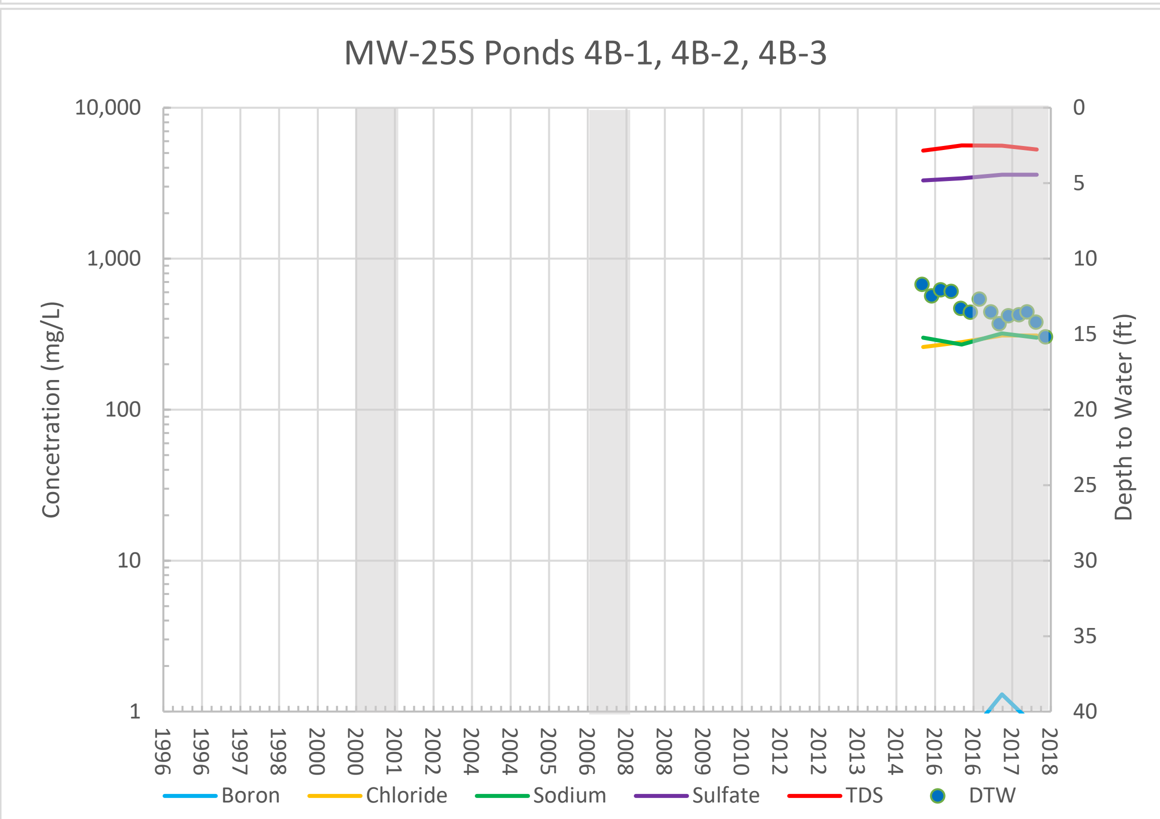
Appendix A
Groundwater Data Time Series Plots

Appendix A-1
Ponds 4B-1, 4B-2, and 4B-3
Upgradient Wells


MW-12S MW-12SR Ponds 4B-1, 4B-2, 4B-3
Concetration (mg/L)
Depth to Water (ft)
1,000,000
100,000
10,000
1,000
100
10
0
5
10
15
20
25
30
35
40
45
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW


MW-13 Ponds 4B-1, 4B-2, 4B-3
Former Pond 4C in service 1983-2000 and former Pond 4B in service 1983-2005.
Ponds 4C-1 and 4C-2 in service 2002-2010
Ponds 4B-1, 4B-2, 4B-3 in service 2007-2015
Concetration (mg/L)
Depth to Water (ft)
1,000,000
100,000
10,000
1,000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW


MW-14S MW-14SR Ponds 4B-1, 4B-2, 4B-3
Concetration (mg/L)
Depth to Water (ft)
1,000,000
100,000
10,000
1,000
100
10
0
5
10
15
20
25
30
35
40
45
50
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW


MW-25S Ponds 4B-1, 4B-2, 4B-3
Concetration (mg/L)
Depth to Water (ft)
10,000
1,000
100
10
1
0
5
10
15
20
25
30
35
40
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
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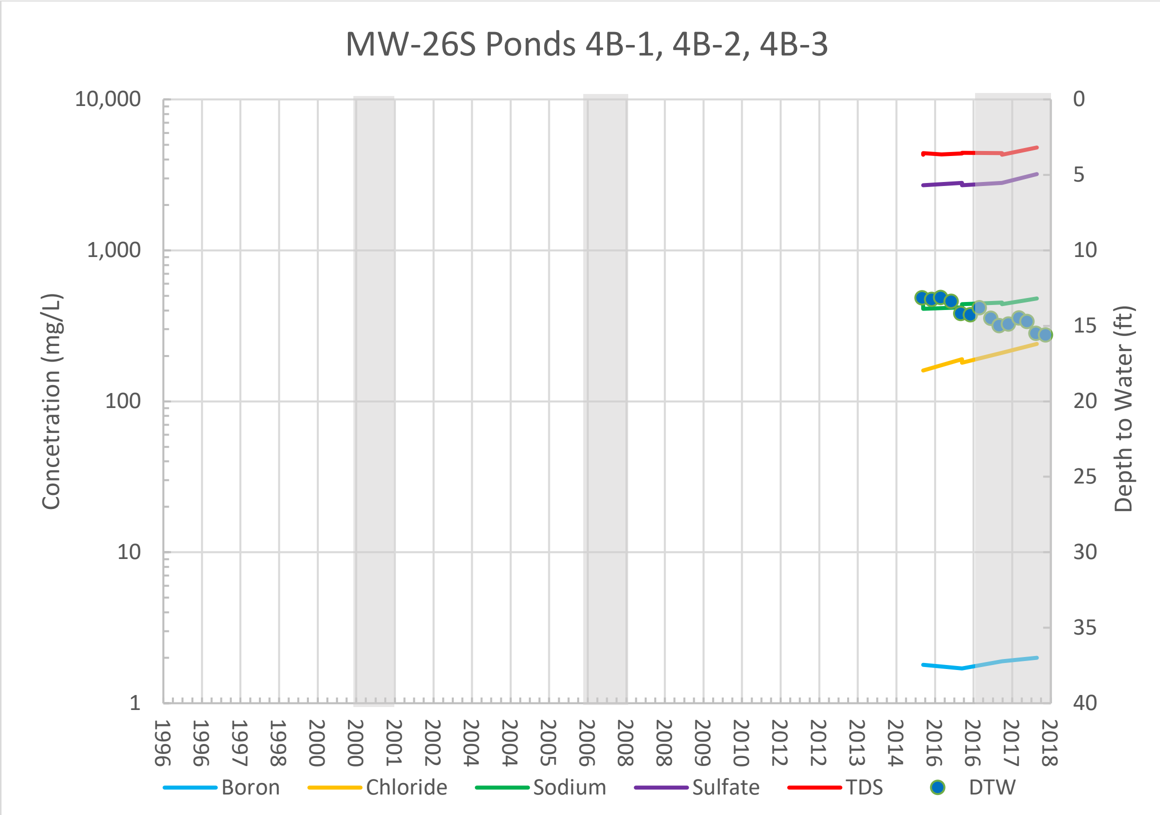
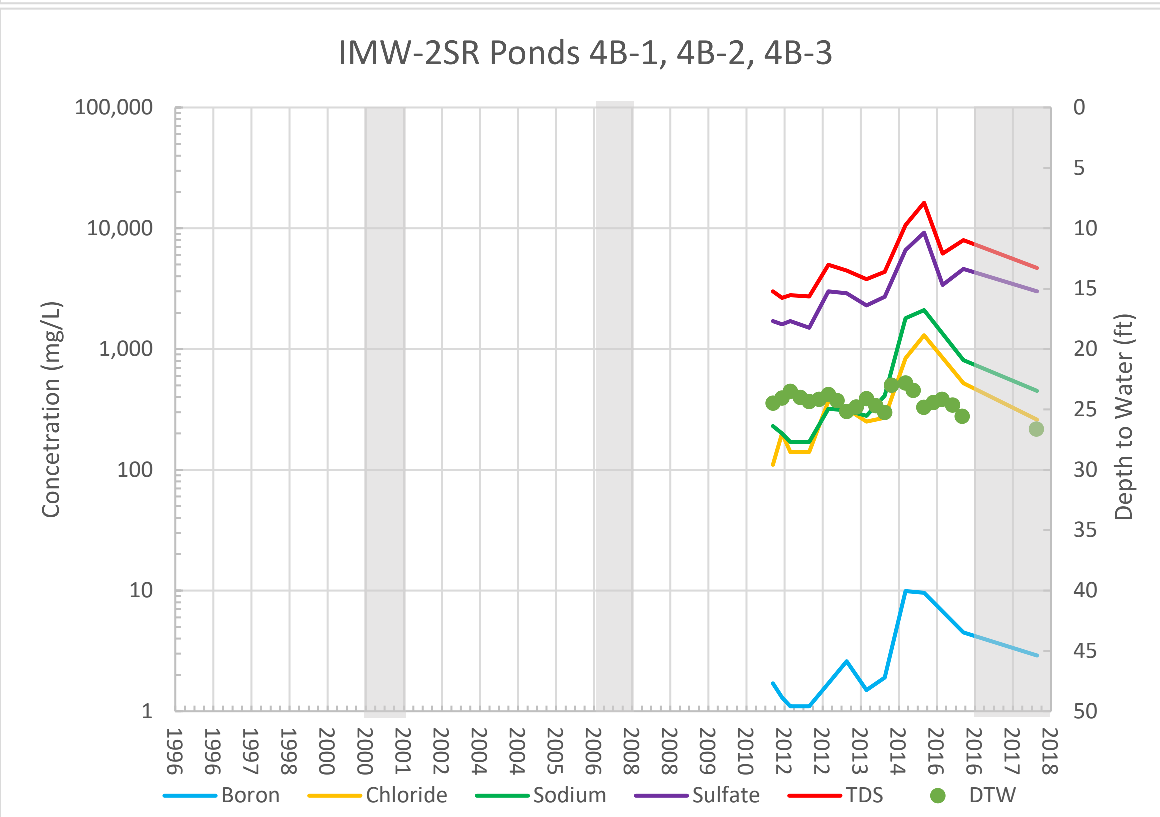
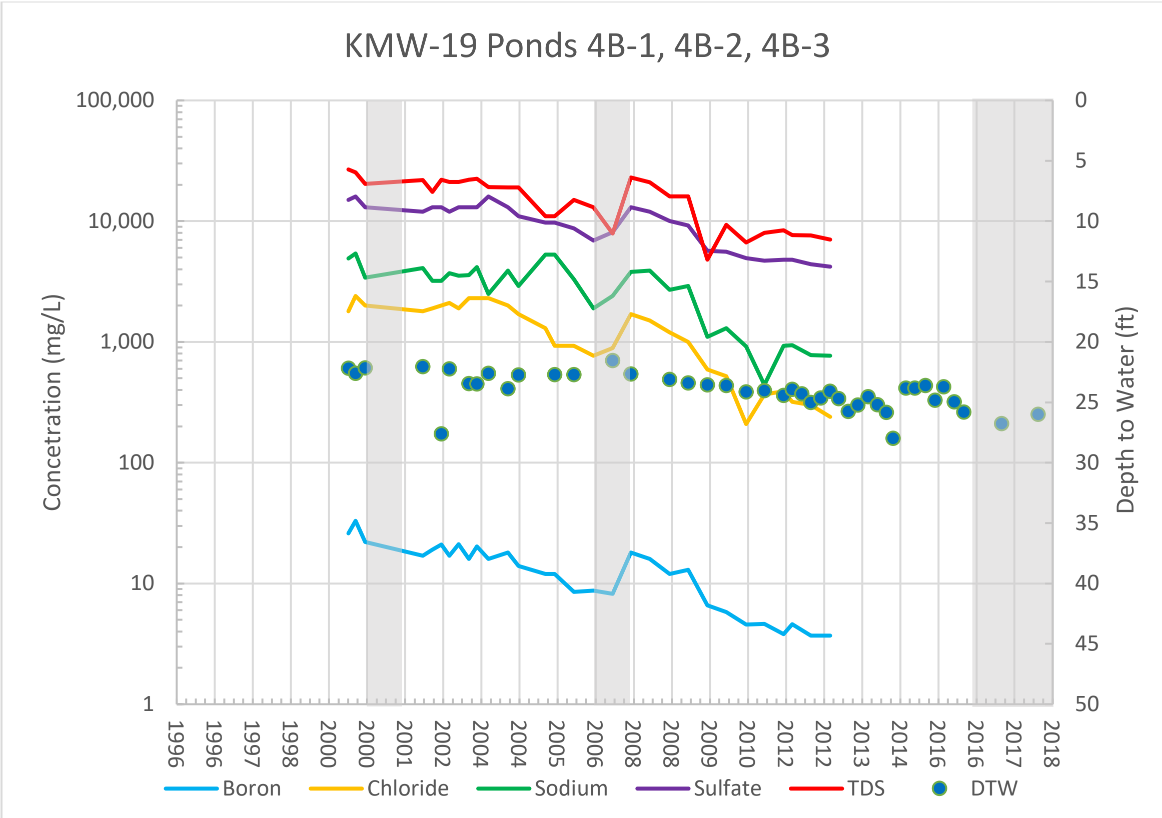
Sodium
Sulfate
TDS
DTW

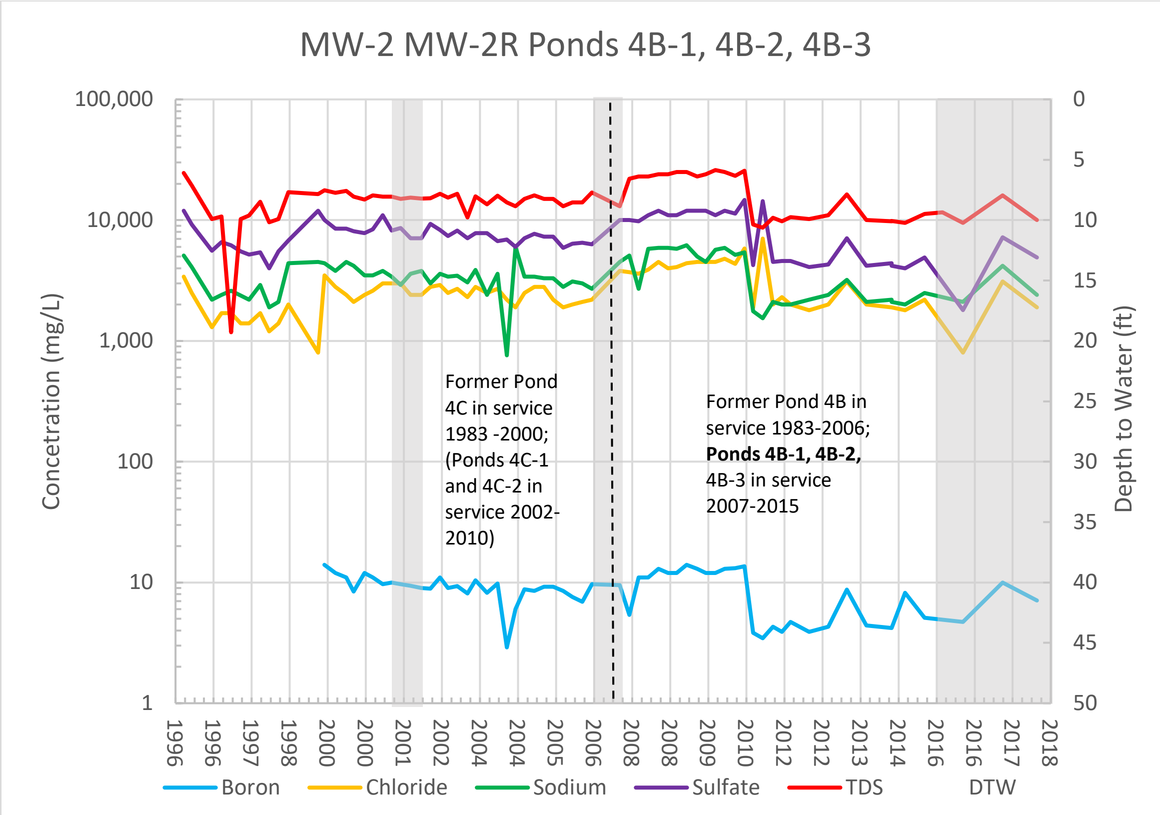

MW-26S Ponds 4B-1, 4B-2, 4B-3
Concetration (mg/L)
Depth to Water (ft)
10,000
1,000
100
10
1
0
5
10
15
20
25
30
35
40
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

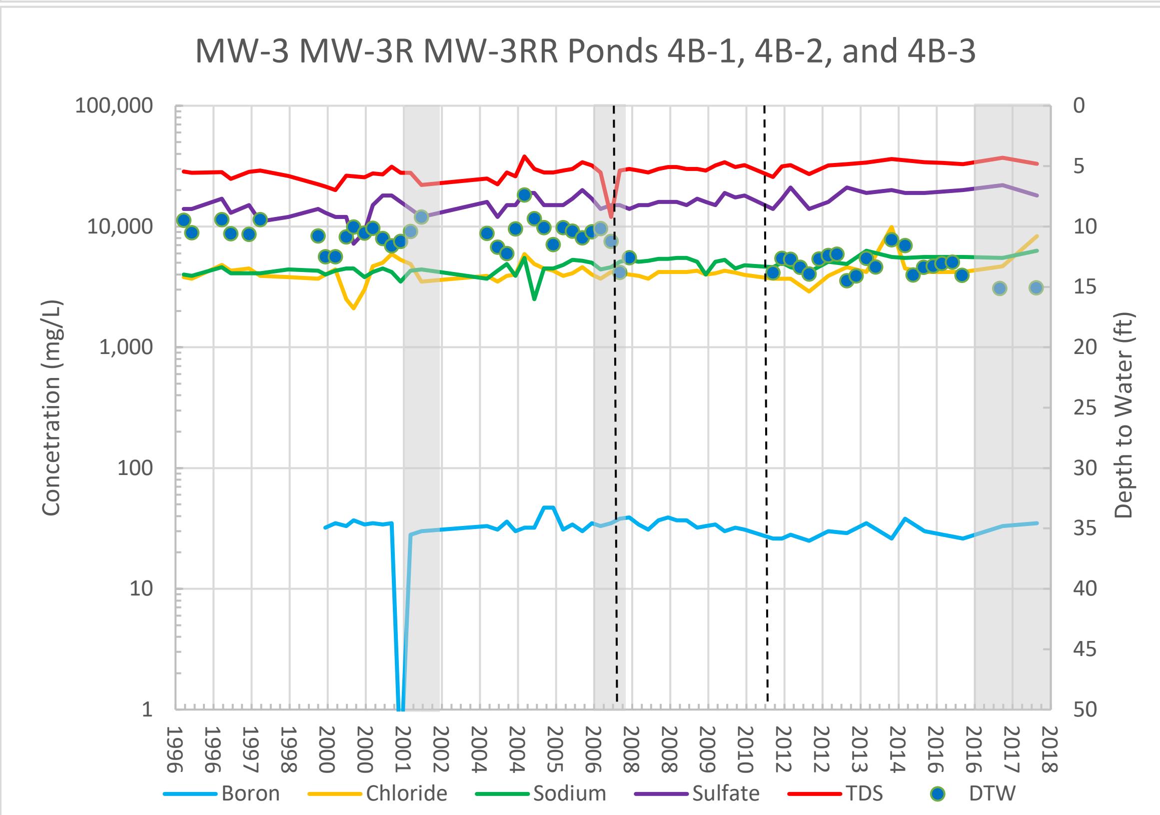

IMW-2SR Ponds 4B-1, 4B-2, 4B-3
Concetration (mg/L)
Depth to Water (ft)
100,000
10,000
1,000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

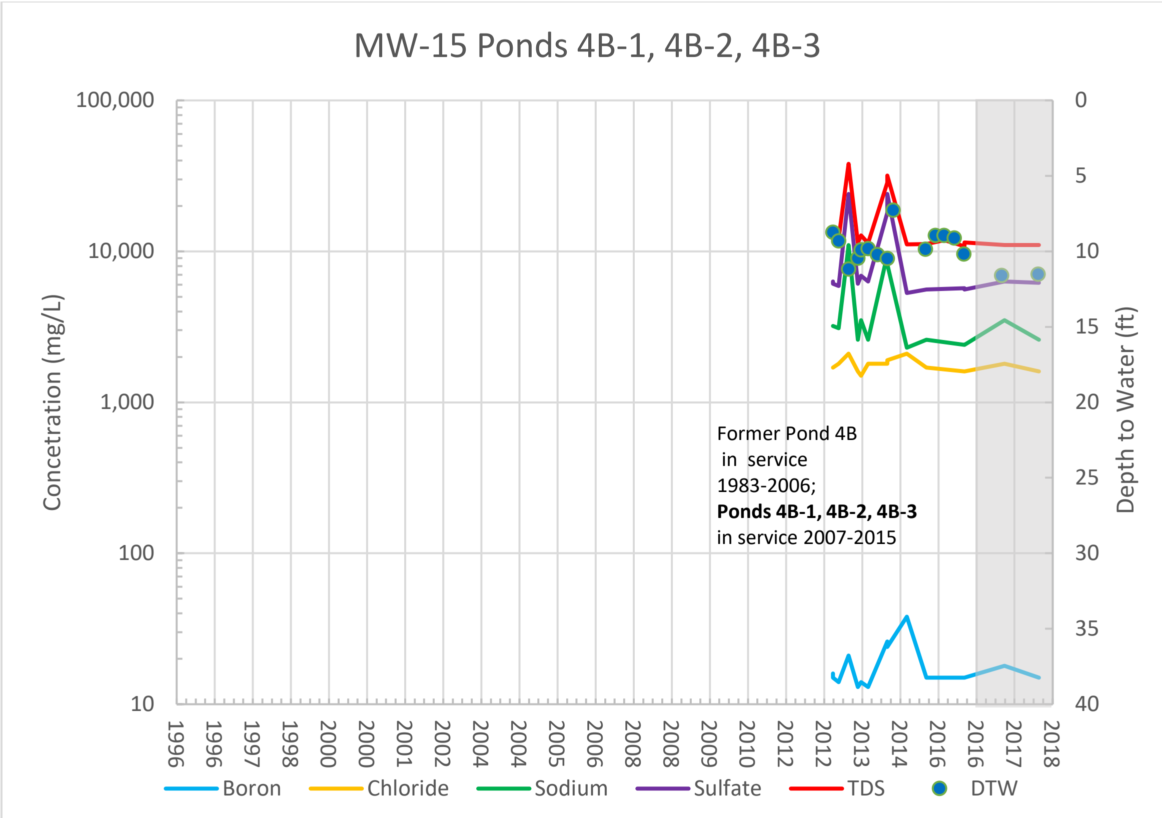


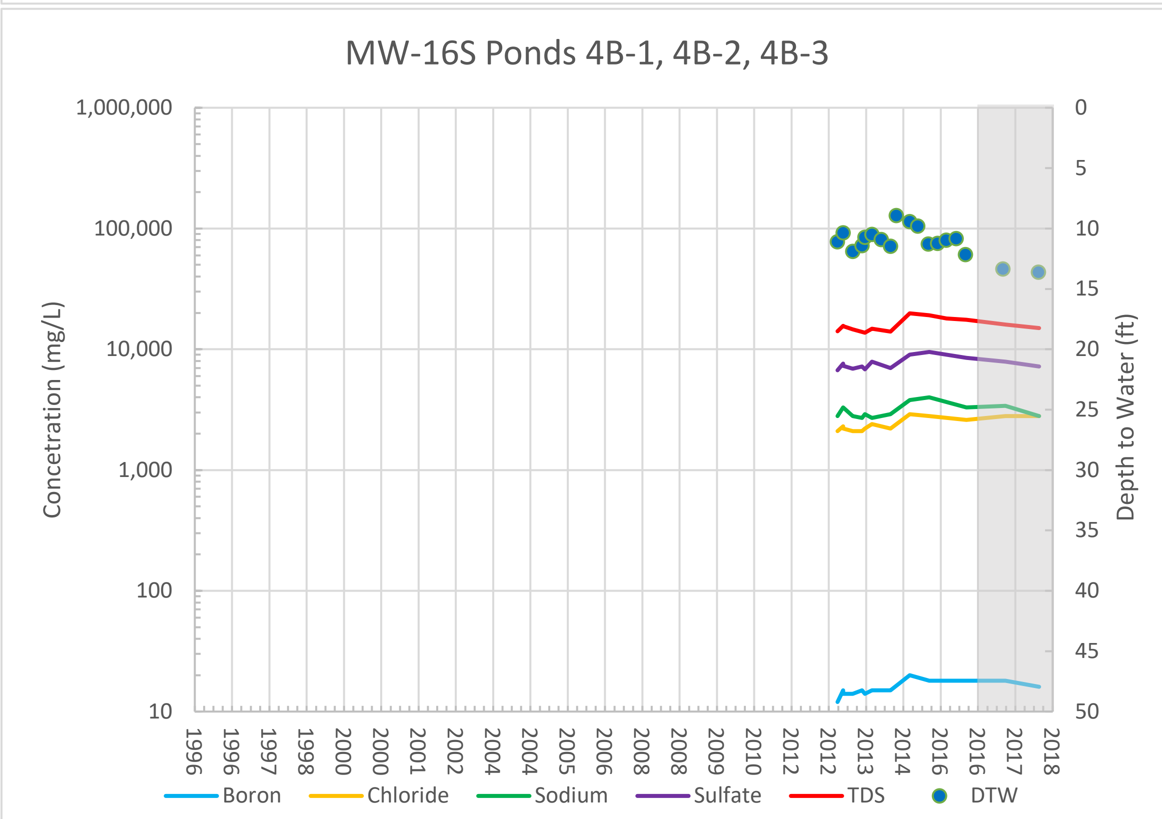
KMW-19 Ponds 4B-1, 4B-2, 4B-3
Concetration (mg/L)
Depth to Water (ft)
100,000
10,000
1,000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

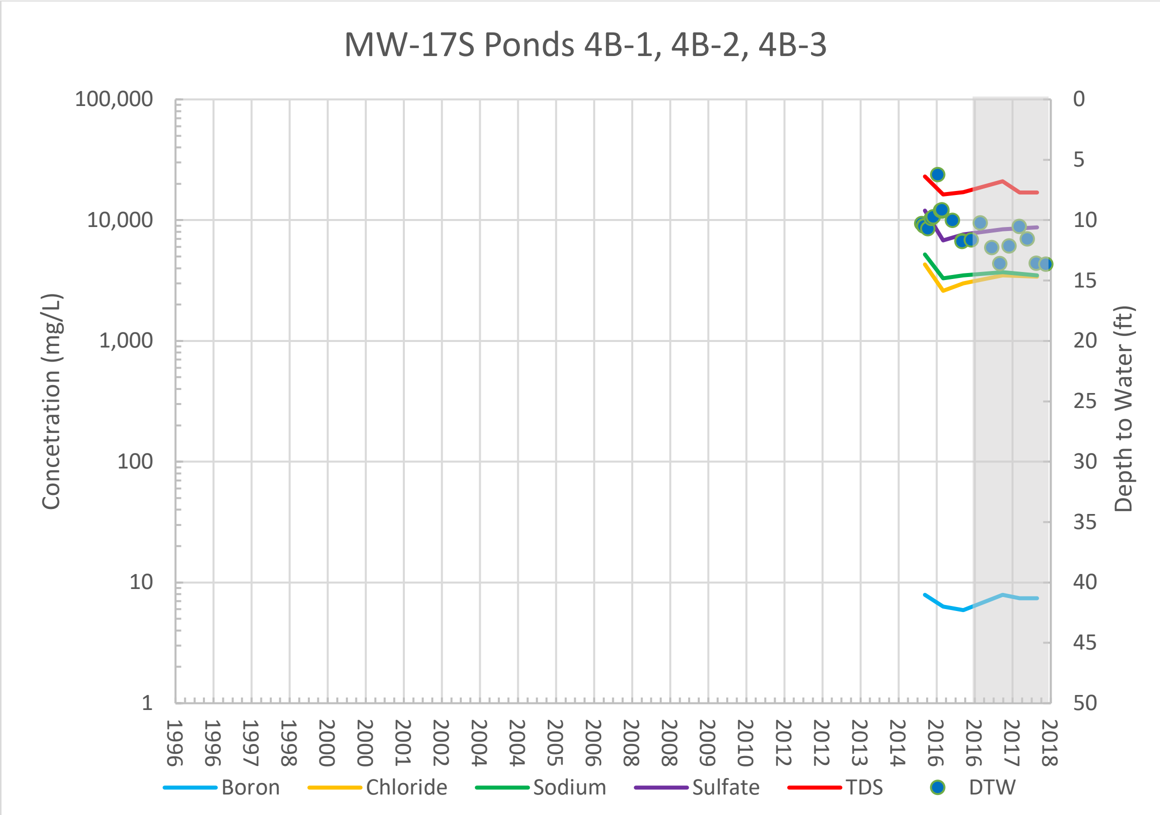
Appendix A-2
Ponds 4B-1, 4B-2, and 4B-3
Downgradient Wells

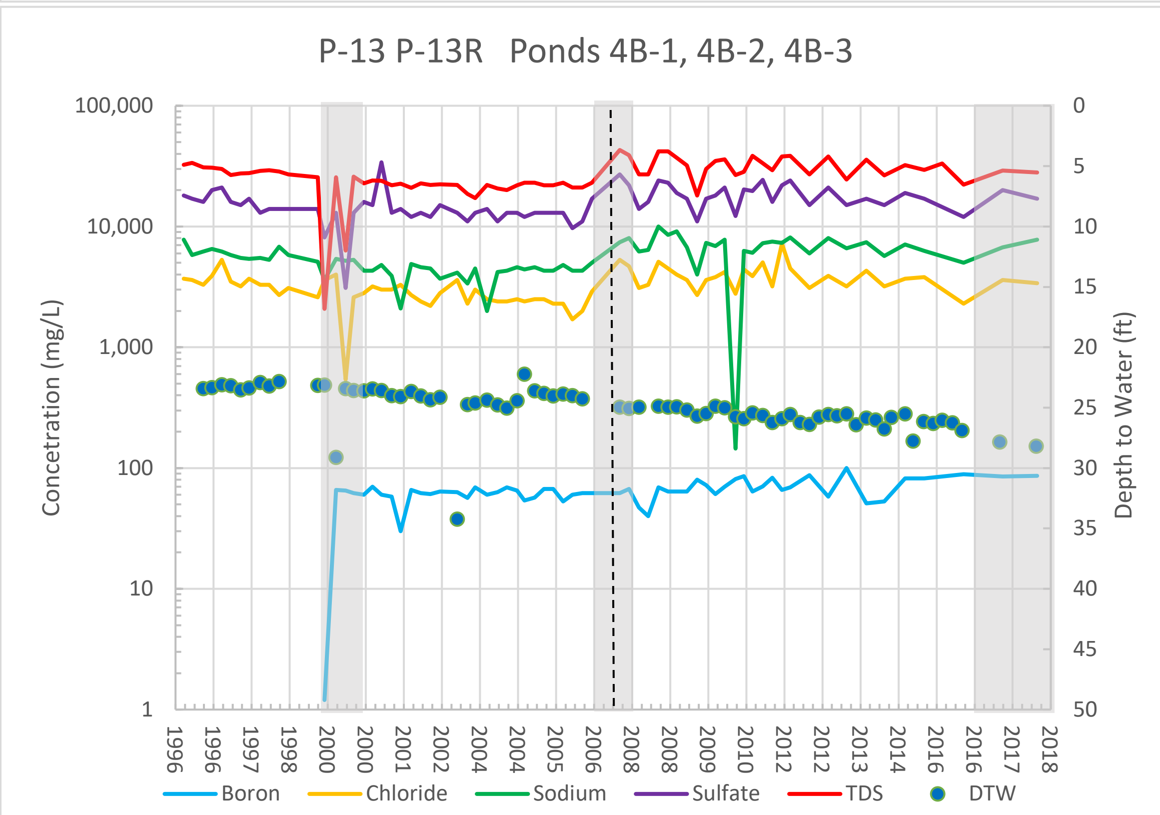

MW-2 MW-2R Ponds 4B-1, 4B-2, 4B-3
100,000
10,000
1,000
100
10
1
Concetration (mg/L)
0
5
10
15
20
25
30
35
40
45
50
Depth to Water (ft)
Former Pond 4C in service 1983 -2000; (Ponds 4C-1 and 4C-2 in service 2002-2010)
Former Pond 4B in service 1983-2006; **Ponds 4B-1, 4B-2,** 4B-3 in service 2007-2015
1996 1996 1997 1998 2000 2000 2001 2002 2004 2004 2005 2006 2008 2008 2009 2010 2012 2012 2013 2014 2016 2016 2017 2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

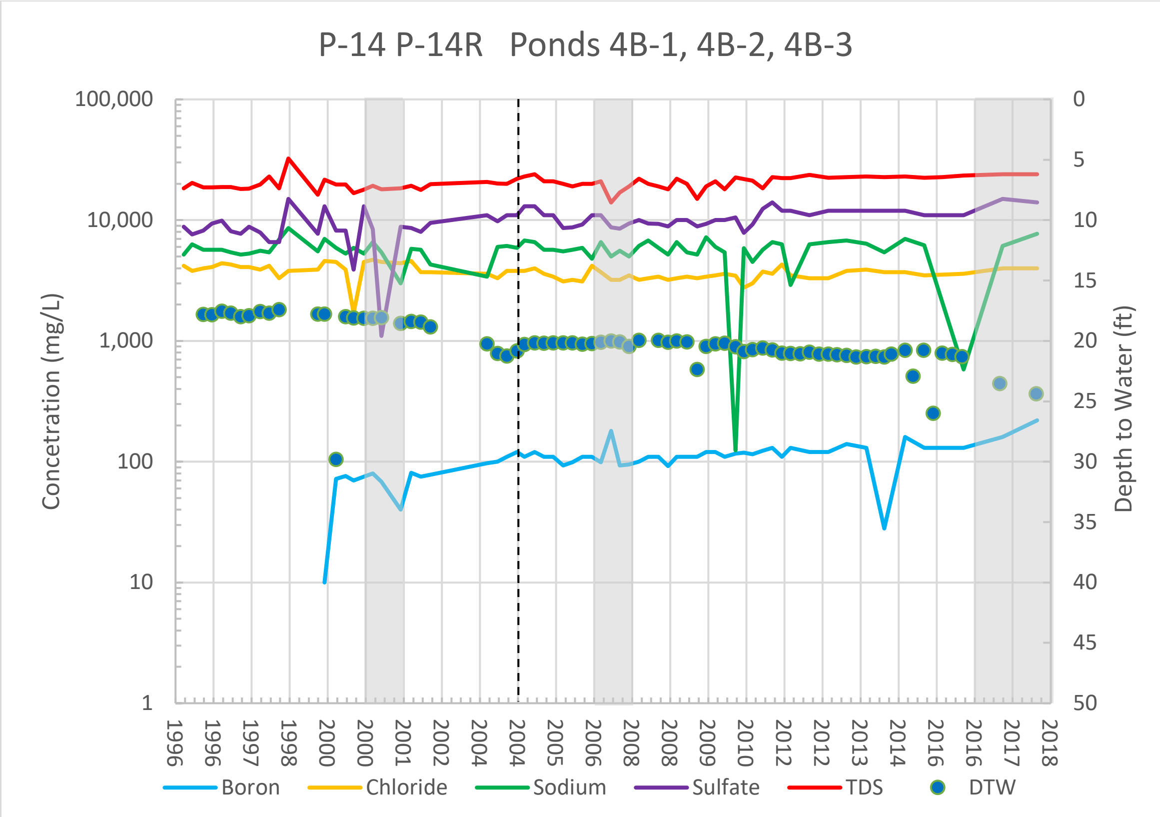

MW-3 MW-3R MW-3RR Ponds 4B-1, 4B-2, and 4B-3
100,000
10,000
1,000
100
10
1
Concetration (mg/L)
0
5
10
15
20
25
30
35
40
45
50
Depth to Water (ft)
1996 1996 1997 1998 2000 2000 2001 2002 2004 2004 2005 2006 2008 2008 2009 2010 2012 2012 2013 2014 2016 2016 2017 2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW


MW-15 Ponds 4B-1, 4B-2, 4B-3
Concetration (mg/L)
Depth to Water (ft)
100,000
10,000
1,000
100
10
0
5
10
15
20
25
30
35
40
Former Pond 4B
in service
1983-2006;
Ponds 4B-1, 4B-2, 4B-3
in service 2007-2015
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW


MW-16S Ponds 4B-1, 4B-2, 4B-3
Concetration (mg/L)
Depth to Water (ft)
1,000,000
100,000
10,000
1,000
100
10
0
5
10
15
20
25
30
35
40
45
50
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

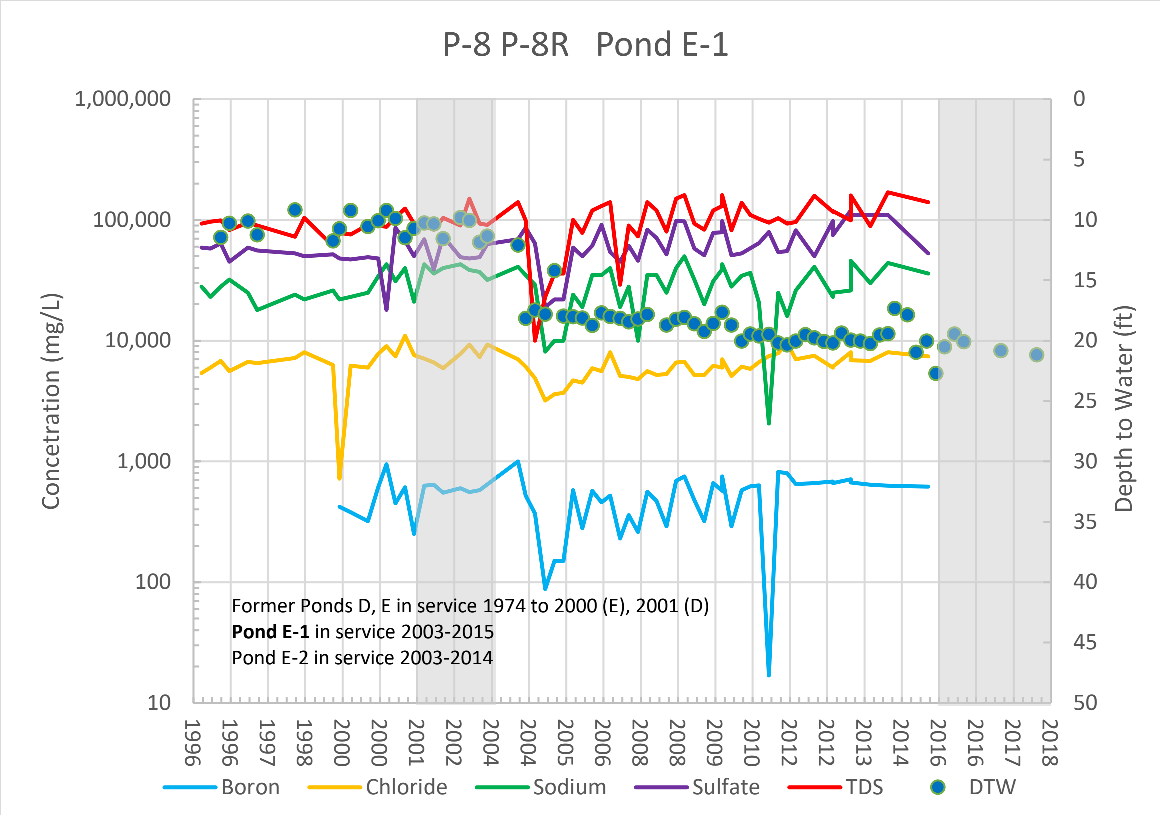

MW-17S Ponds 4B-1, 4B-2, 4B-3
Concetration (mg/L)
Depth to Water (ft)
100,000
10,000
1,000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

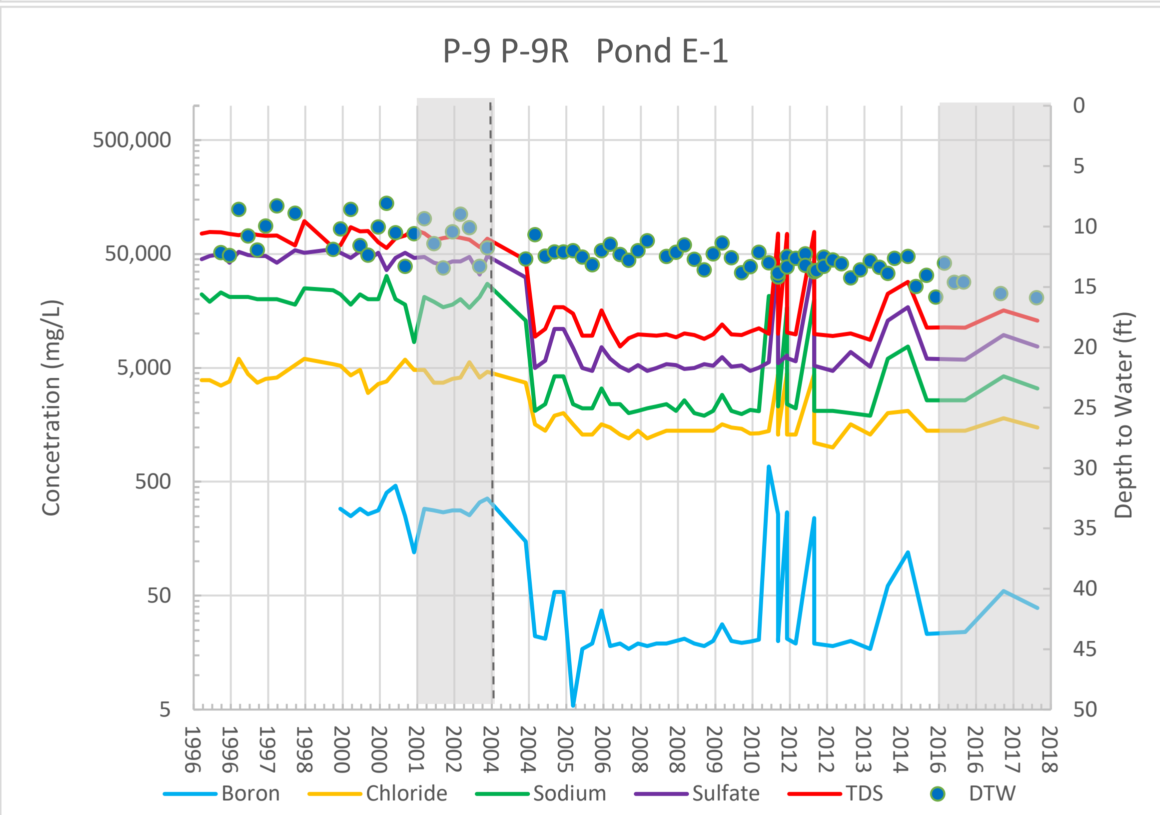

P-13 P-13R Ponds 4B-1, 4B-2, 4B-3
Concetration (mg/L)
Depth to Water (ft)
100,000
10,000
1,000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

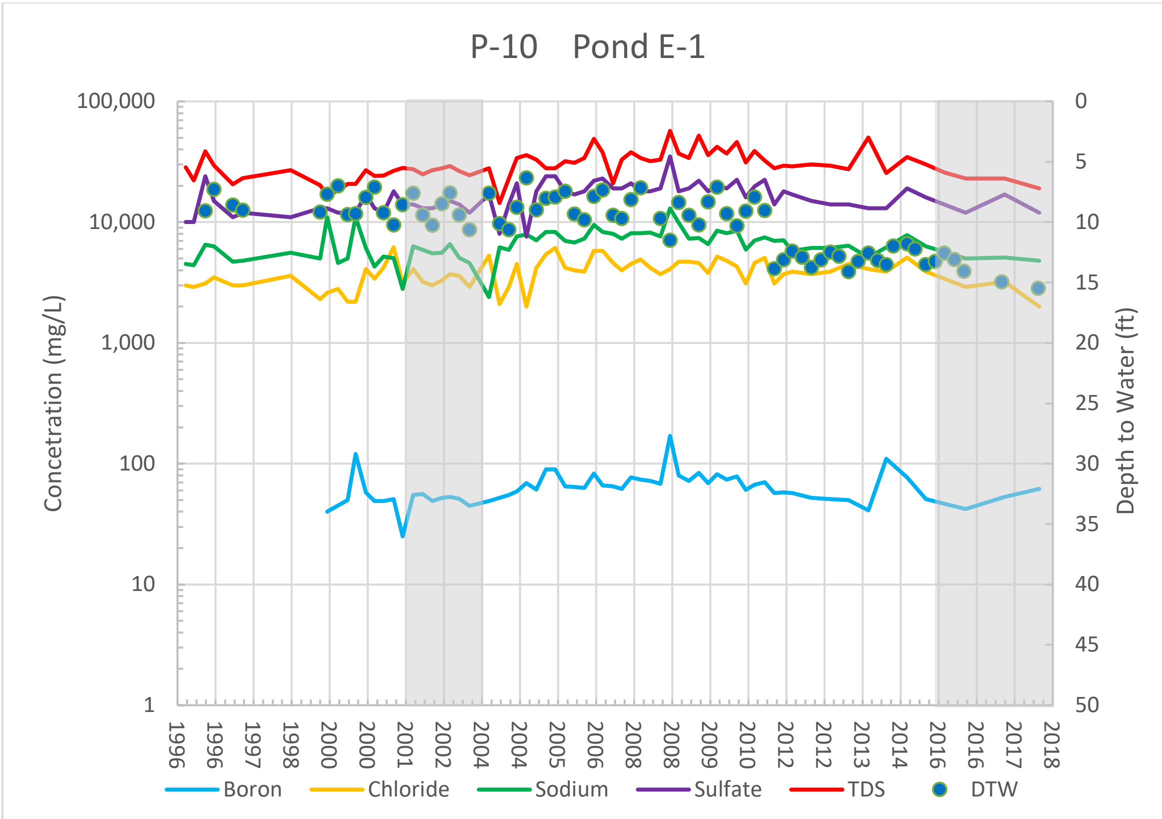


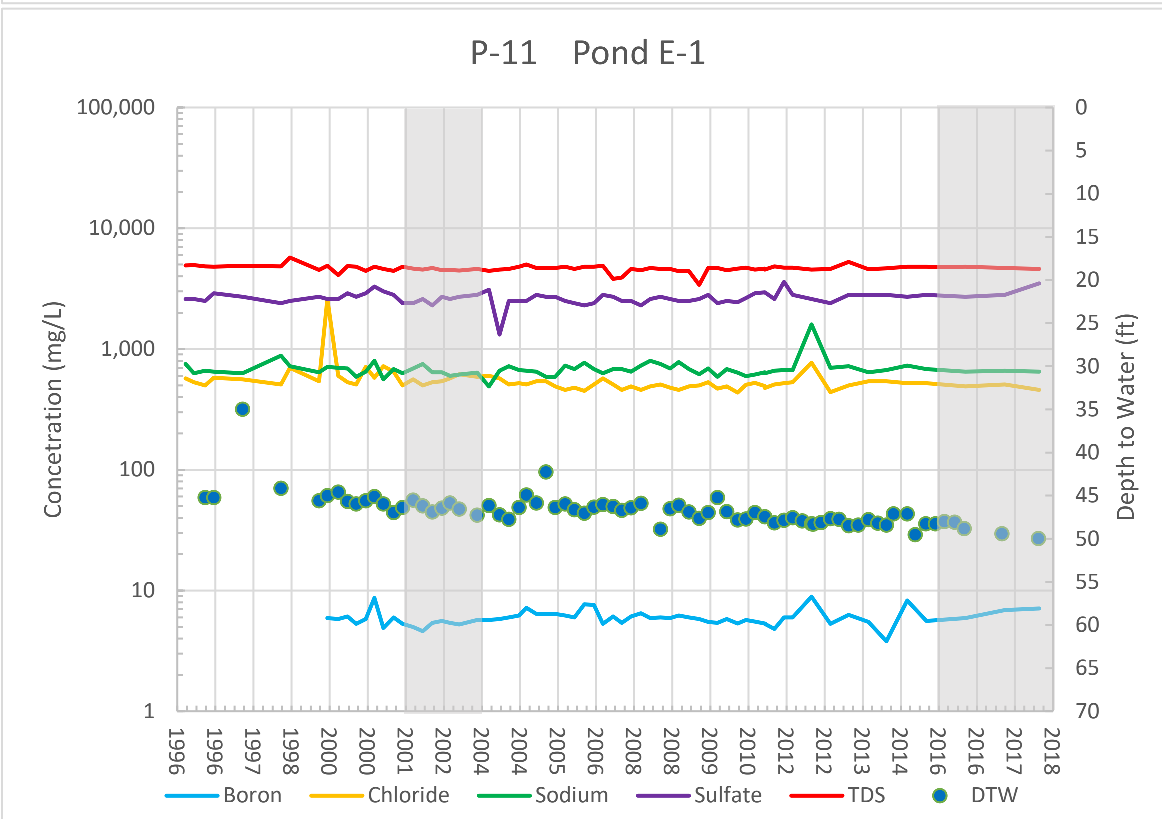
P-14 P-14R Ponds 4B-1, 4B-2, 4B-3
100,000
10,000
1,000
100
10
1
Concetration (mg/L)
0
5
10
15
20
25
30
35
40
45
50
Depth to Water (ft)
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

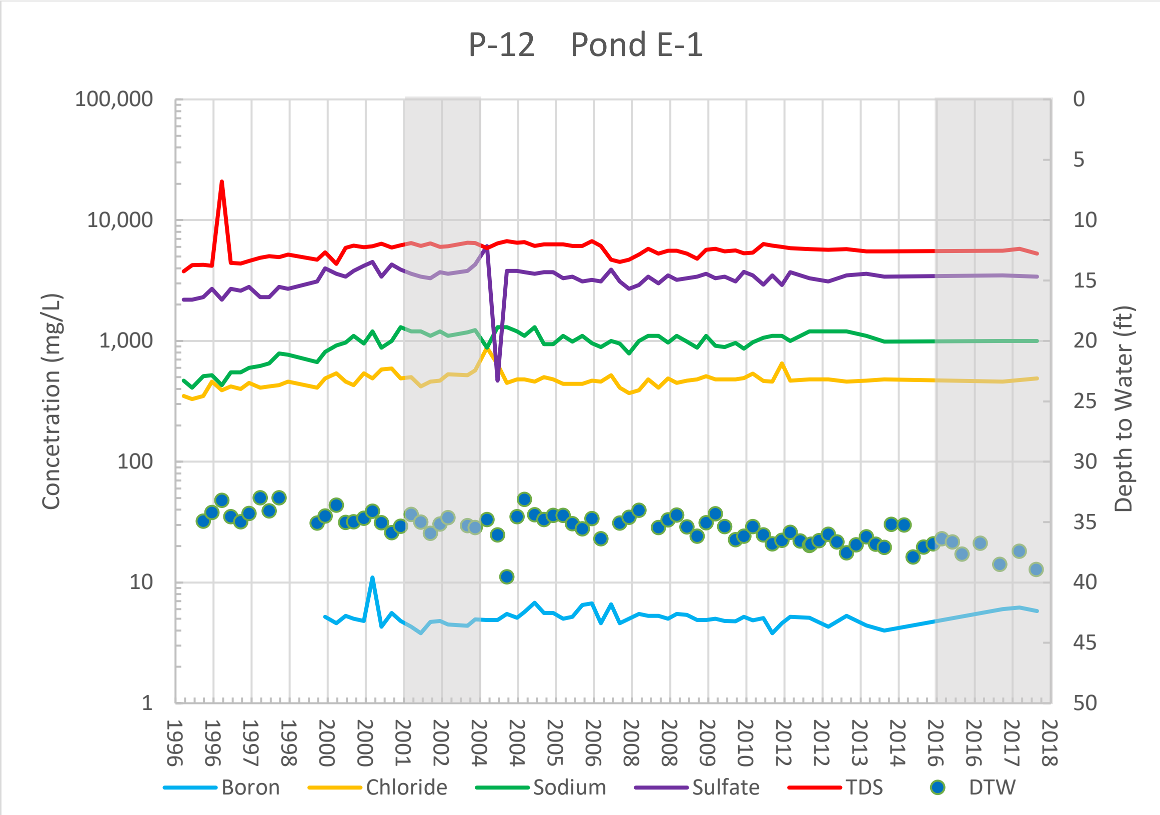
Appendix A-3
Pond E-1 Upgradient Wells

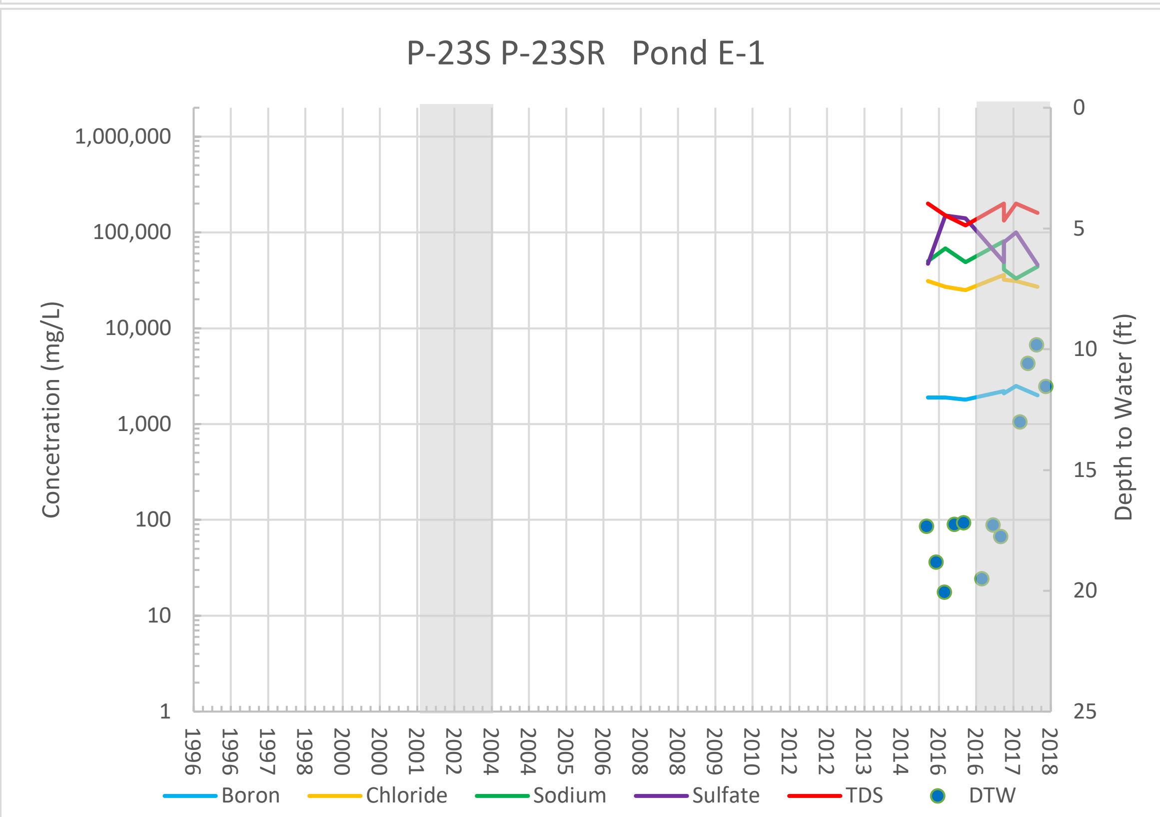

P-8 P-8R Pond E-1
Concetration (mg/L)
Depth to Water (ft)
1,000,000
100,000
10,000
1,000
100
10
0
5
10
15
20
25
30
35
40
45
50
Former Ponds D, E in service 1974 to 2000 (E), 2001 (D)
Pond E-1 in service 2003-2015
Pond E-2 in service 2003-2014
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

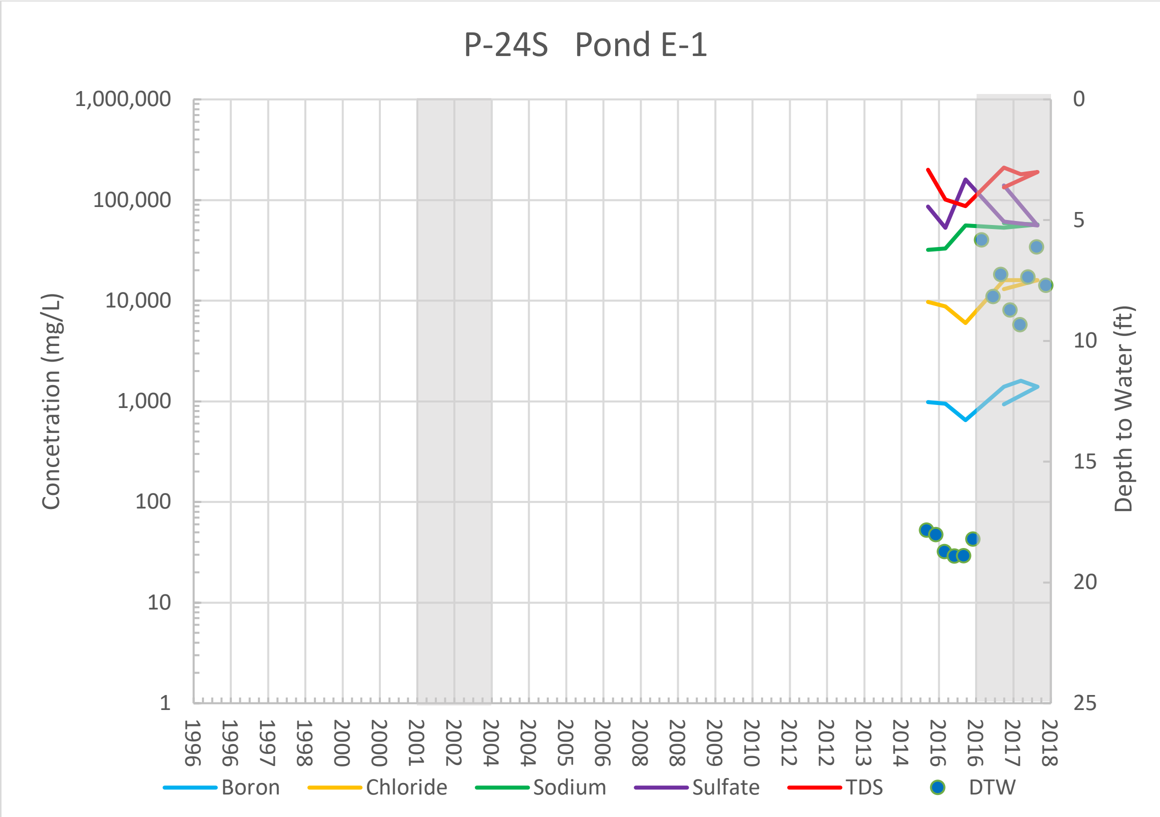

P-9 P-9R Pond E-1
Concetration (mg/L)
Depth to Water (ft)
500,000
50,000
5,000
500
50
5
0
5
10
15
20
25
30
35
40
45
50
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW


P-10 Pond E-1
Concetration (mg/L)
Depth to Water (ft)
100,000
10,000
1,000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW


P-11 Pond E-1
Concetration (mg/L)
Depth to Water (ft)
100,000
10,000
1,000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

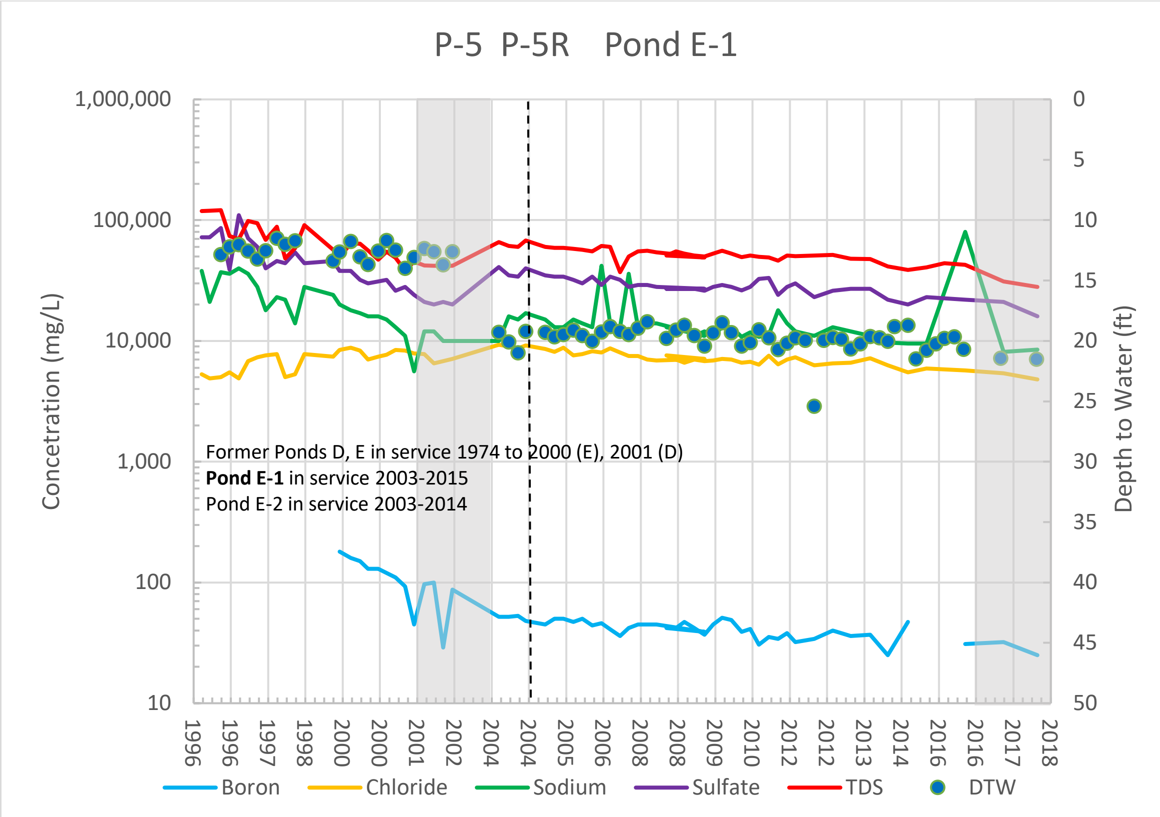

P-12 Pond E-1
Concetration (mg/L)
Depth to Water (ft)
100,000
10,000
1,000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
1996 1996 1997 1998 2000 2000 2001 2002 2004 2004 2005 2006 2008 2008 2009 2010 2012 2012 2013 2014 2016 2016 2017 2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

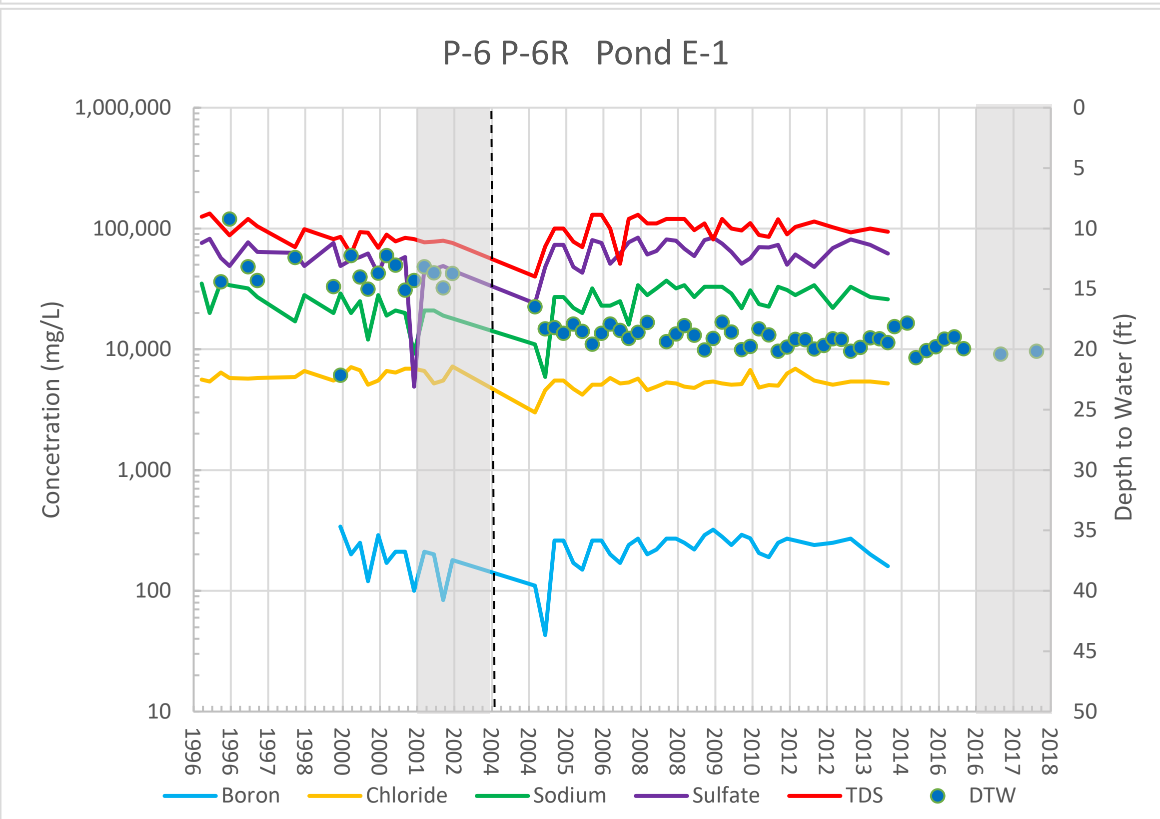

P-23S P-23SR Pond E-1
Concetration (mg/L)
Depth to Water (ft)
1,000,000
100,000
10,000
1,000
100
10
1
0
5
10
15
20
25
1996 1996 1997 1998 2000 2000 2001 2002 2004 2004 2005 2006 2008 2008 2009 2010 2012 2012 2013 2014 2016 2016 2017 2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

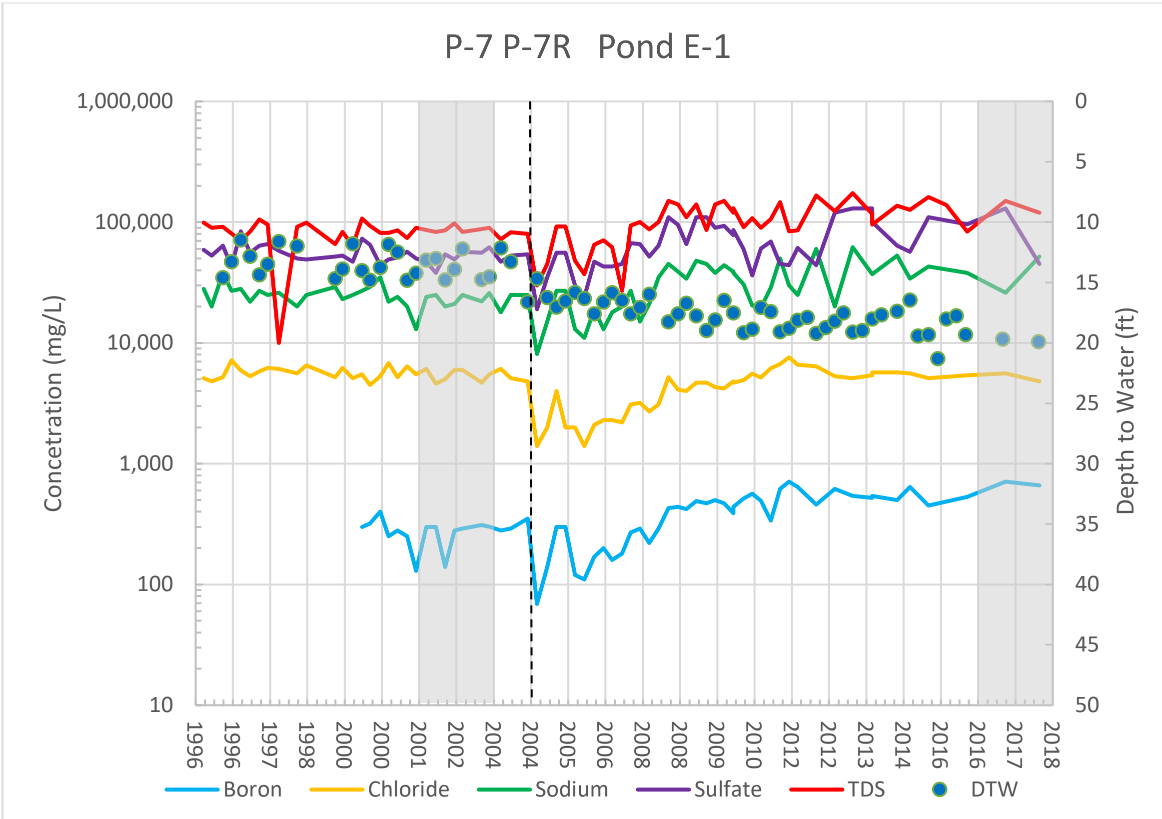


P-24S Pond E-1
1,000,000
100,000
10,000
1,000
100
10
1
Concetration (mg/L)
0
5
10
15
20
25
Depth to Water (ft)
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

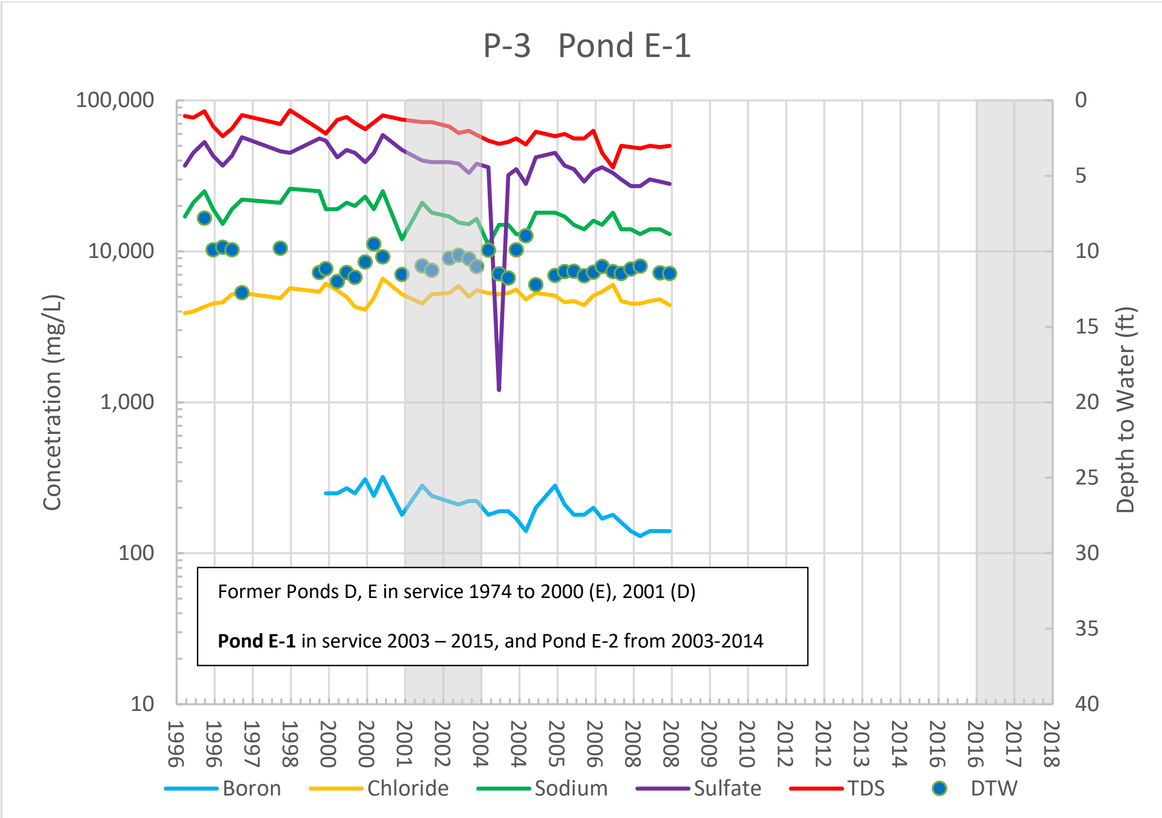
Appendix A-4
Pond E-1 Side-Gradient Wells

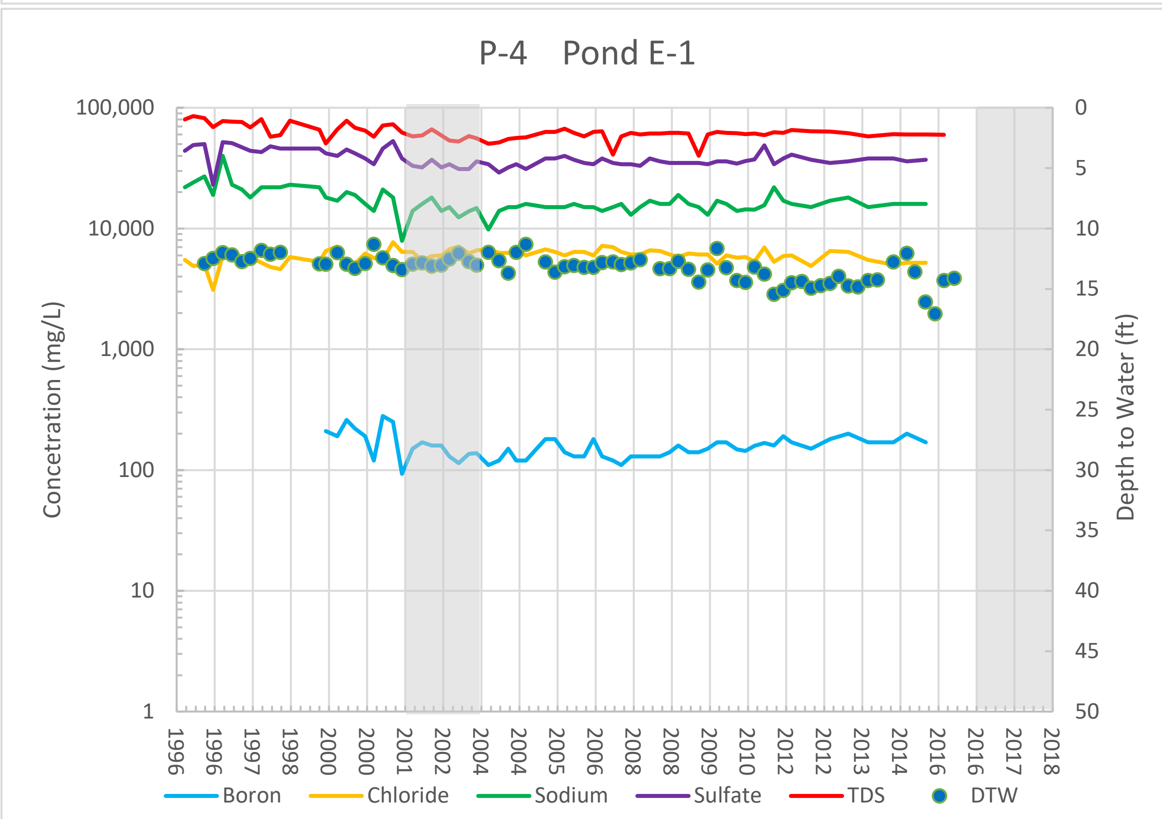

P-5 P-5R Pond E-1
Concetration (mg/L)
Depth to Water (ft)
1,000,000
100,000
10,000
1,000
100
10
0
5
10
15
20
25
30
35
40
45
50
Former Ponds D, E in service 1974 to 2000 (E), 2001 (D)
Pond E-1 in service 2003-2015
Pond E-2 in service 2003-2014
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW


P-6 P-6R Pond E-1
Concetration (mg/L)
Depth to Water (ft)
1,000,000
100,000
10,000
1,000
100
10
0
5
10
15
20
25
30
35
40
45
50
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW


P-7 P-7R   Pond E-1
Concetration (mg/L)
Depth to Water (ft)
1,000,000
100,000
10,000
1,000
100
10
0
5
10
15
20
25
30
35
40
45
50
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

Appendix A-5
Pond E-1 Downgradient Wells

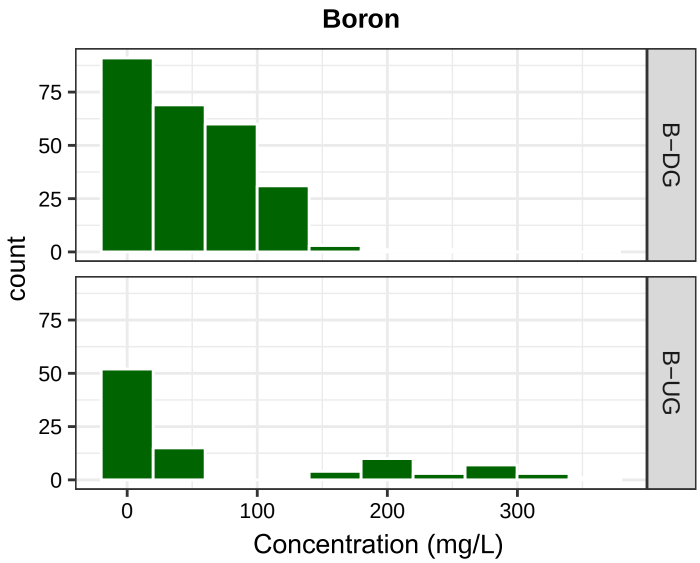

P-3 Pond E-1
Concetration (mg/L)
Depth to Water (ft)
100,000
10,000
1,000
100
10
0
5
10
15
20
25
30
35
40
Former Ponds D, E in service 1974 to 2000 (E), 2001 (D)
Pond E-1 in service 2003 – 2015, and Pond E-2 from 2003-2014
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

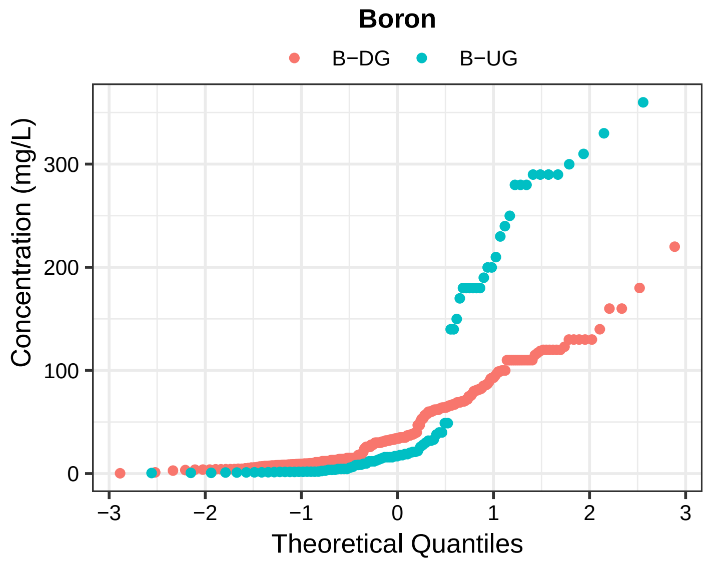

P-4 Pond E-1
Concetration (mg/L)
Depth to Water (ft)
100,000
10,000
1,000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
1996
1996
1997
1998
2000
2000
2001
2002
2004
2004
2005
2006
2008
2008
2009
2010
2012
2012
2013
2014
2016
2016
2017
2018
Boron
Chloride
Sodium
Sulfate
TDS
DTW

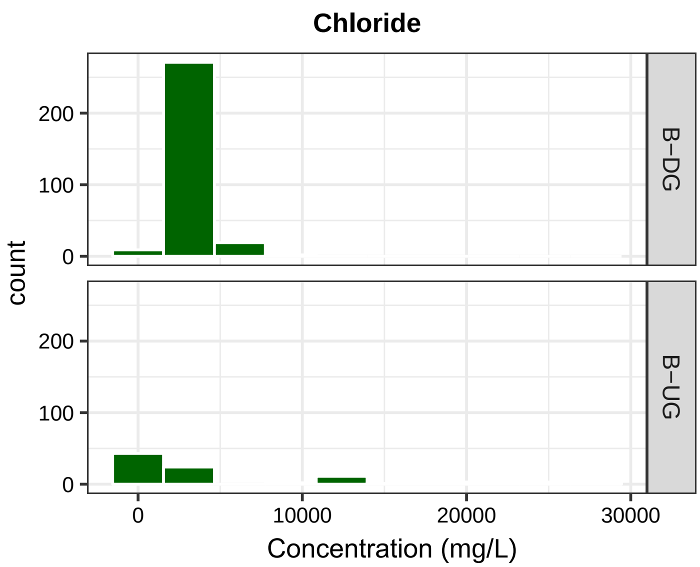
Appendix B
Groundwater Data Histogram and Probability Plots

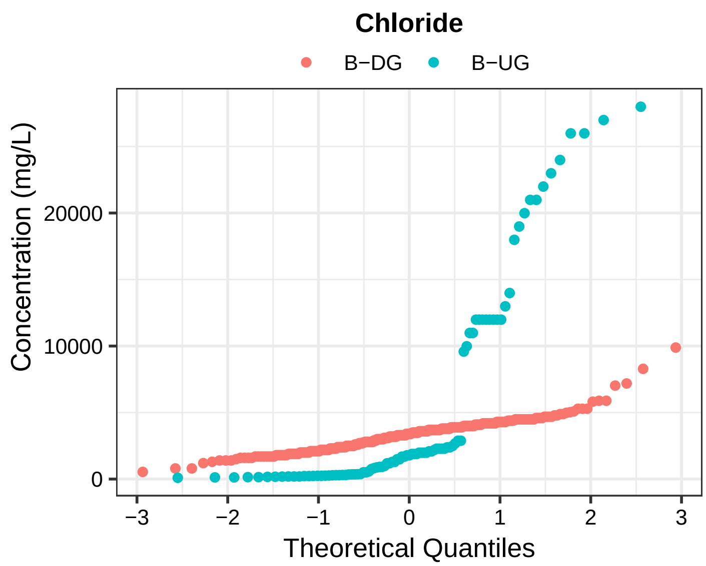
Appendix B-1
Ponds 4B-1, 4B-2, and 4B-3 Wells

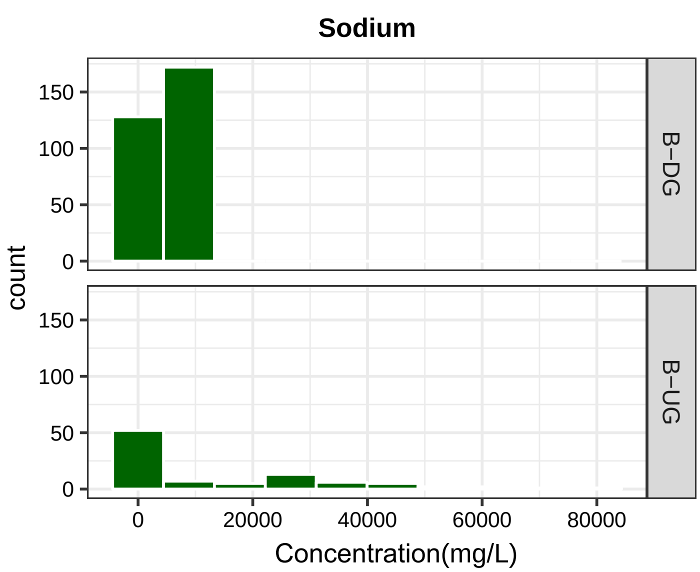
Histograms and Q−Q Plots
(nondetects shown as detection limit)
Page 1 of 2

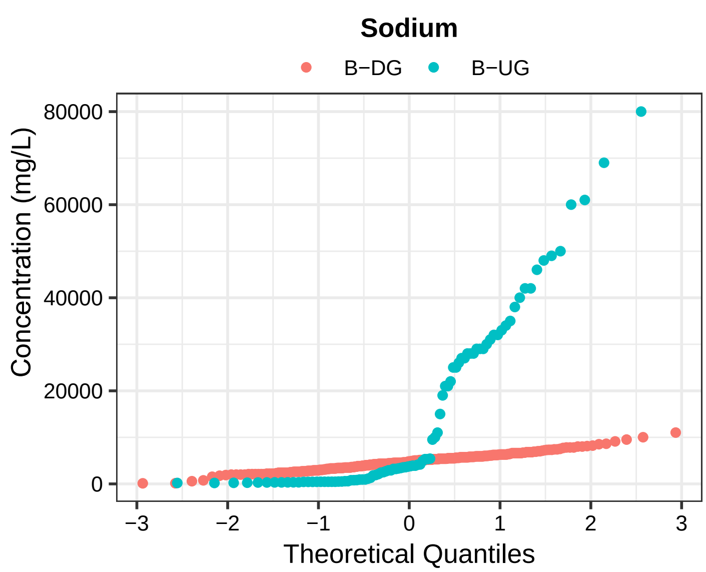




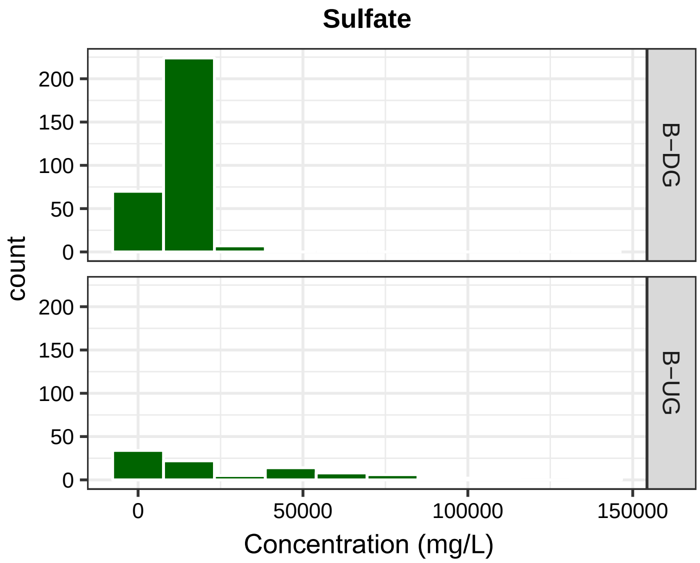


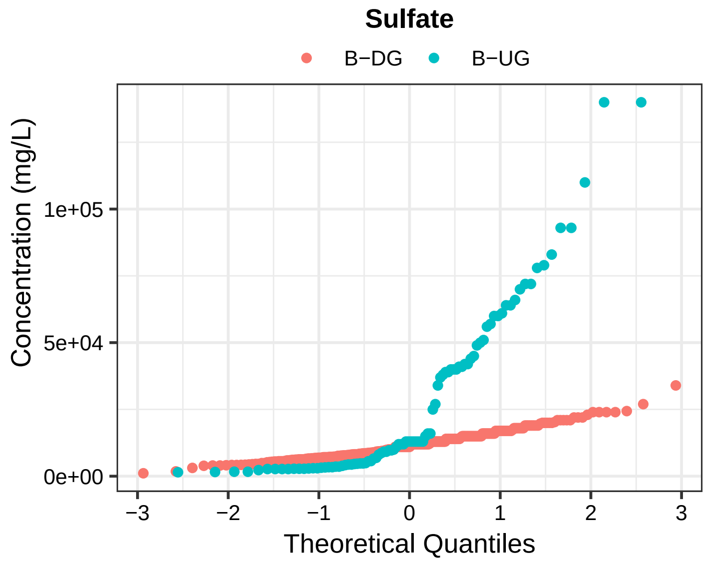


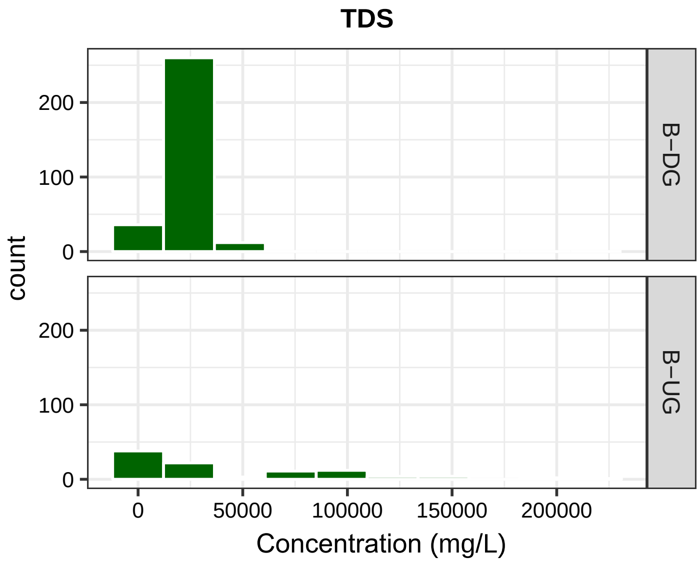


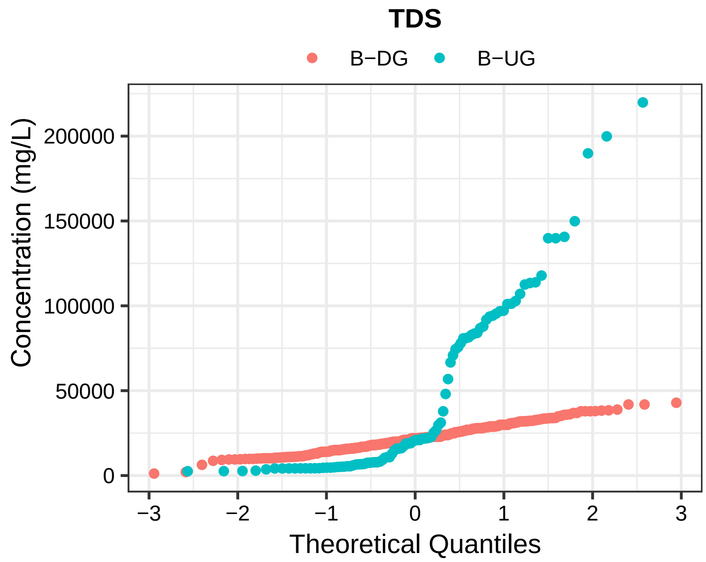


Histograms and Q−Q Plots
(nondetects shown as detection limit)
Page 2 of 2



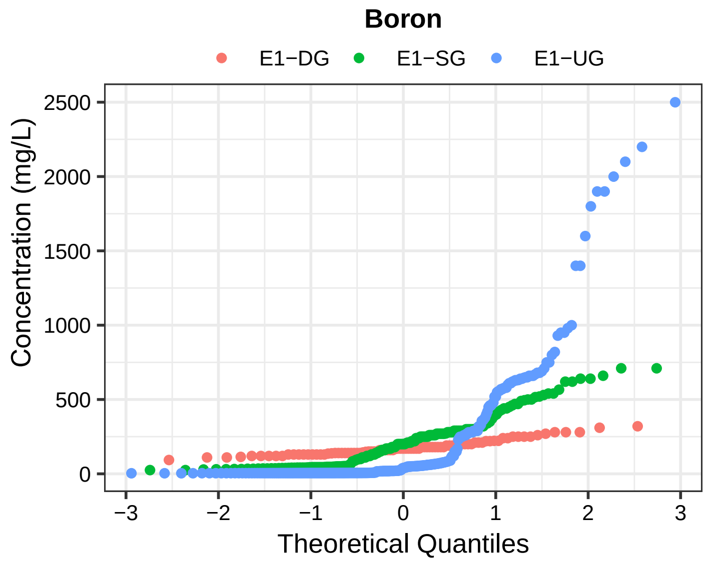


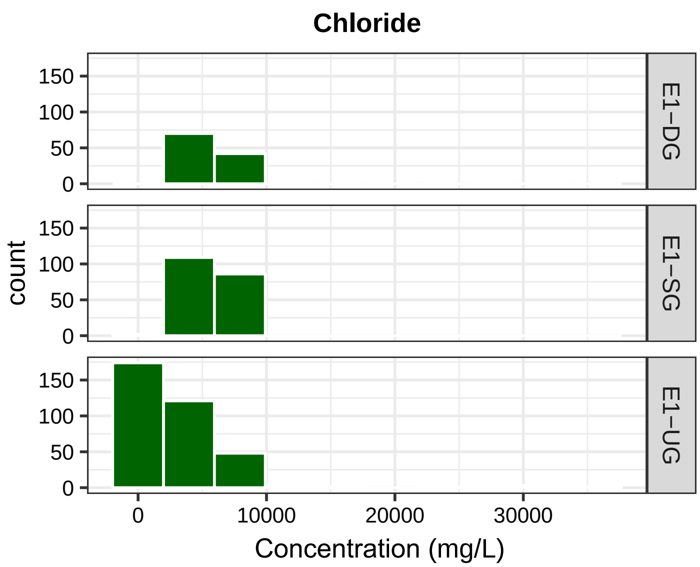


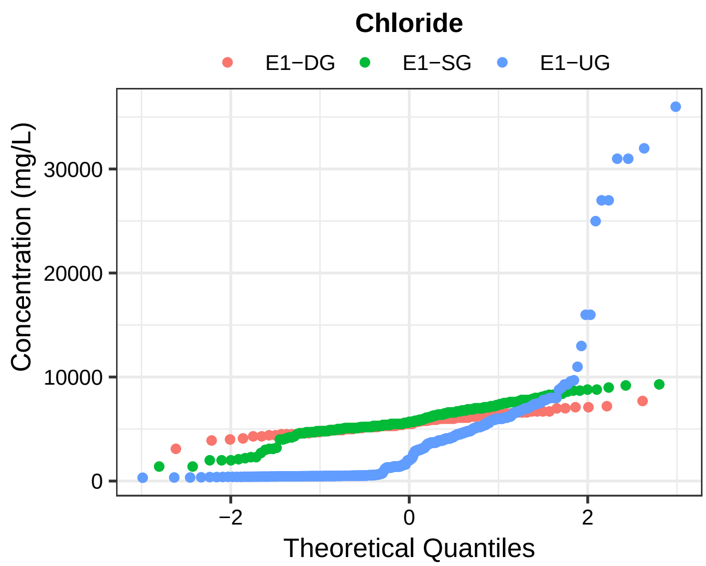


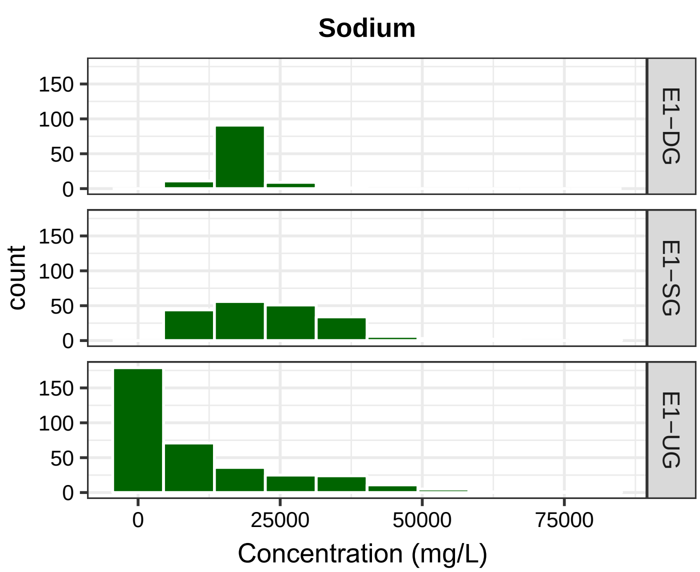
Appendix B-2
Pond E-1 Wells

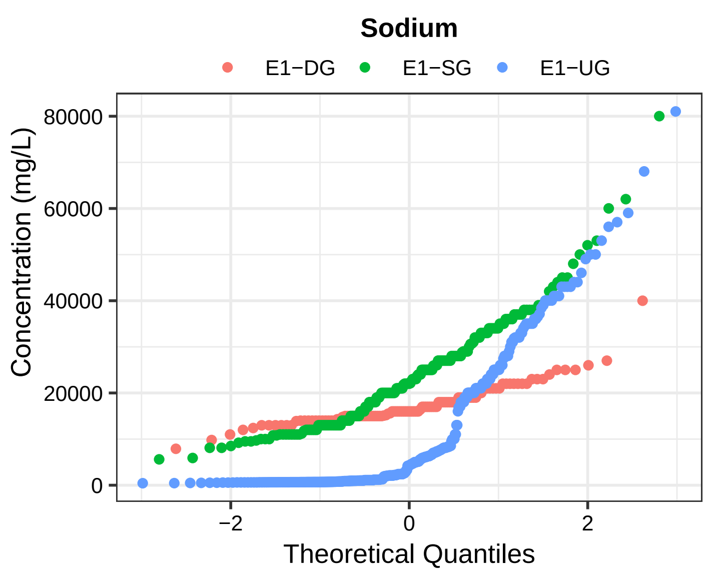
Histograms and Q−Q Plots
(nondetects shown as detection limit)
Page 1 of 2



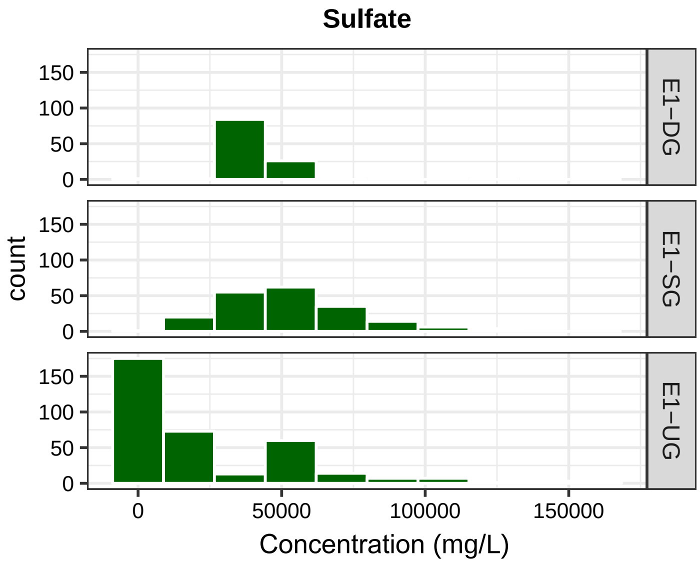


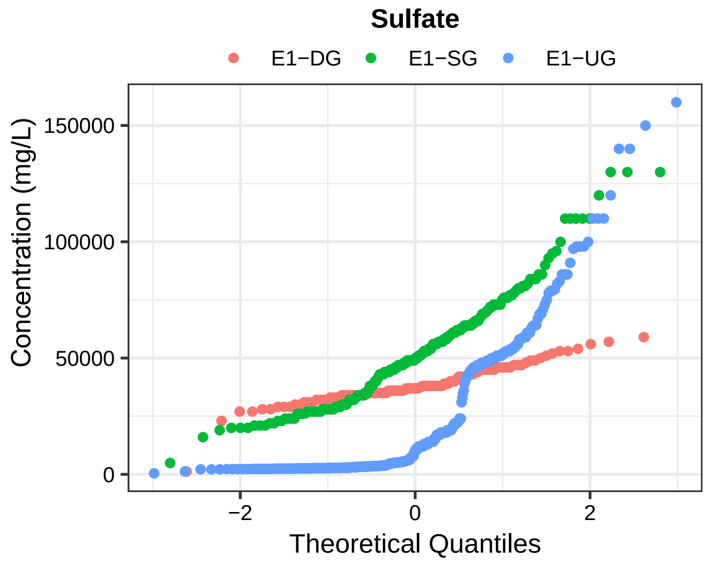


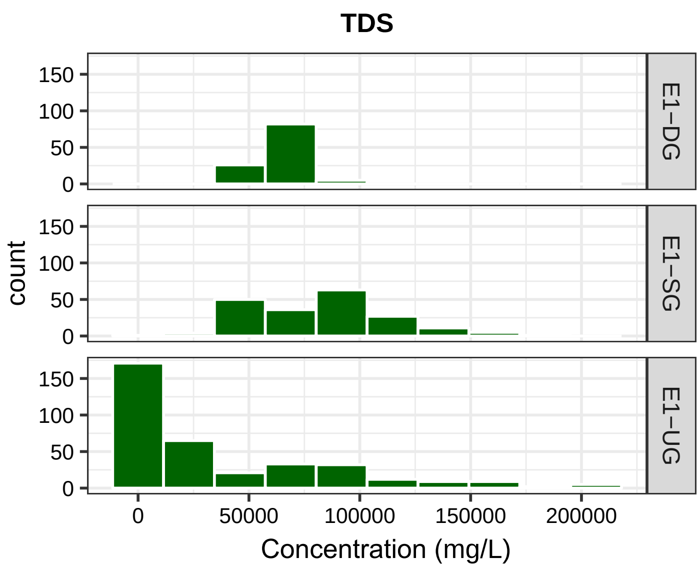


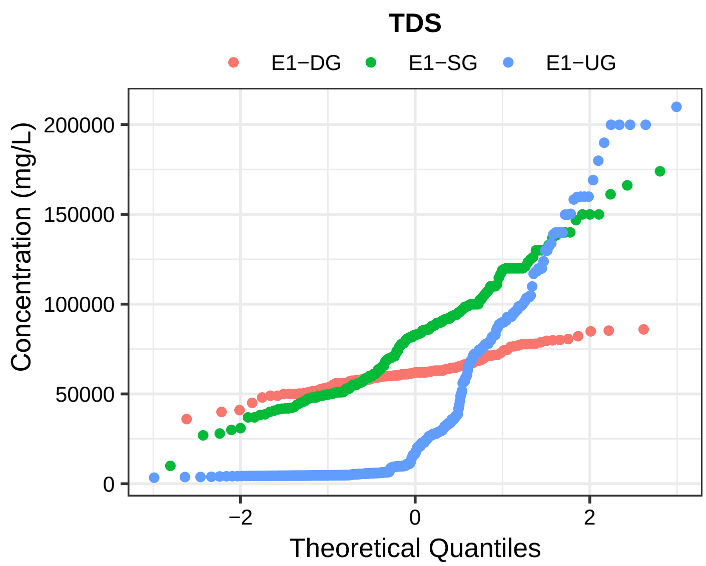


Histograms and Q−Q Plots
(nondetects shown as detection limit)
Page 2 of 2









Appendix C
HELP Model Output for Clay-Lined and Double-HDPE-Lined Ponds

Appendix C-1
HELP Model Output for Clay-Lined Pond Scenario

Clay-Lined Pond Scenario HELP Output

```
******************************************************************************
 ******************************************************************************
 **                                                                          **
 **                                                                          **
 **              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
 **                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
 **                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
 **                    USAE WATERWAYS EXPERIMENT STATION                     **
 **             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
 **                                                                          **
 **                                                                          **
 ******************************************************************************
 ******************************************************************************


 PRECIPITATION DATA FILE:     C:\nevada\p1.D4
 TEMPERATURE DATA FILE:       C:\nevada\t1.D7
 SOLAR RADIATION DATA FILE:   C:\nevada\sr1.D13
 EVAPOTRANSPIRATION DATA:     C:\nevada\e1.D11
 SOIL AND DESIGN DATA FILE:   C:\nevada\soilpond.D10
 OUTPUT DATA FILE:            C:\nevada\soilpond.OUT


 TIME:  63:26     DATE:   1/11/2019


 ******************************************************************************

      TITLE:  Nevada Energy Pond No Liner

 ******************************************************************************


      NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
               COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  21
            THICKNESS                  =     24.00   INCHES
            POROSITY                   =      0.3970 VOL/VOL
            FIELD CAPACITY             =      0.0320 VOL/VOL
            WILTING POINT              =      0.0130 VOL/VOL
            INITIAL SOIL WATER CONTENT =      0.0410 VOL/VOL
            EFFECTIVE SAT. HYD. COND.  =  0.300000012000     CM/SEC


                                   LAYER  2
                                   --------
```

```
                 TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER   0
   THICKNESS                     =     24.00   INCHES
   POROSITY                      =      0.4370 VOL/VOL
   FIELD CAPACITY                =      0.1050 VOL/VOL
   WILTING POINT                 =      0.0470 VOL/VOL
   INITIAL SOIL WATER CONTENT    =      0.4370 VOL/VOL
   EFFECTIVE SAT. HYD. COND.     =  0.300000011000E-05 CM/SEC


           GENERAL DESIGN AND EVAPORATIVE ZONE DATA
           ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-
           SPECIFIED CURVE NUMBER OF 97.0, A SURFACE SLOPE
           OF  1.% AND A SLOPE LENGTH OF  700. FEET.

  SCS RUNOFF CURVE NUMBER              =     96.90
  FRACTION OF AREA ALLOWING RUNOFF     =      0.0    PERCENT
  AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
  EVAPORATIVE ZONE DEPTH               =     18.0    INCHES
  INITIAL WATER IN EVAPORATIVE ZONE    =      0.792  INCHES
  UPPER LIMIT OF EVAPORATIVE STORAGE   =      7.146  INCHES
  LOWER LIMIT OF EVAPORATIVE STORAGE   =      0.234  INCHES
  INITIAL SNOW WATER                   =      0.000  INCHES
  INITIAL WATER IN LAYER MATERIALS     =     11.473  INCHES
  TOTAL INITIAL WATER                  =     11.473  INCHES
  TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

  NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
           LAS VEGAS             NEVADA

       STATION LATITUDE                          =  36.08 DEGREES
       MAXIMUM LEAF AREA INDEX                   =   0.00
       START OF GROWING SEASON (JULIAN DATE)     =     62
       END OF GROWING SEASON (JULIAN DATE)       =    321
       EVAPORATIVE ZONE DEPTH                    =  18.0  INCHES
       AVERAGE ANNUAL WIND SPEED                 =   9.10 MPH
       AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  39.00 %
       AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  21.00 %
       AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  24.00 %
       AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  36.00 %


  NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    LAS VEGAS           NEVADA

           NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL      FEB/AUG      MAR/SEP      APR/OCT      MAY/NOV      JUN/DEC
-------      -------      -------      -------      -------      -------
  0.50         0.58         0.46         0.21         0.15         0.07
  0.44         0.45         0.33         0.26         0.37         0.39
```

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.60	50.10	55.30	63.50	73.30	83.60
90.30	88.00	80.10	67.60	53.60	45.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.33	0.57	0.37	0.25	0.22	0.06
	0.50	0.43	0.38	0.18	0.43	0.34
STD. DEVIATIONS	0.37	0.62	0.39	0.23	0.25	0.10
	0.71	0.34	0.70	0.17	0.43	0.26
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.299	0.421	0.288	0.267	0.189	0.100
	0.281	0.235	0.274	0.161	0.321	0.338
STD. DEVIATIONS	0.368	0.447	0.277	0.286	0.226	0.049
	0.576	0.169	0.303	0.104	0.365	0.288
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0606	0.1321	0.1131	0.0507	0.0282	0.0212
	0.0851	0.0793	0.1677	0.0356	0.0871	0.0379
STD. DEVIATIONS	0.1063	0.1930	0.1487	0.0587	0.0242	0.0135
	0.1235	0.1133	0.5282	0.0301	0.1356	0.0528

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	0.0023	0.0099	0.0058	0.0009	0.0003	0.0002
	0.0022	0.0012	0.0998	0.0004	0.0015	0.0006
STD. DEVIATIONS	0.0082	0.0277	0.0135	0.0023	0.0003	0.0001
	0.0047	0.0027	0.4440	0.0003	0.0036	0.0009

***

***

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES	CU. FEET	PERCENT
PRECIPITATION	4.05 (1.688)	14714.2	100.00
RUNOFF	0.000 (0.0000)	0.00	0.000
EVAPOTRANSPIRATION	3.175 (1.1272)	11526.94	78.339
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.89840 (0.68338)	3261.182	22.16350
AVERAGE HEAD ON TOP OF LAYER 2	0.010 (0.037)		
CHANGE IN WATER STORAGE	-0.020 (0.3648)	-73.91	-0.502

***

```
*******************************************************************************

            PEAK DAILY VALUES FOR YEARS     1 THROUGH   20
   ------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------   -------------
      PRECIPITATION                            2.55          9256.500

      RUNOFF                                   0.000            0.0000

      PERCOLATION/LEAKAGE THROUGH LAYER  2     0.126072       457.64203

      AVERAGE HEAD ON TOP OF LAYER  2          5.651

      SNOW WATER                               0.74          2687.3430


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                0.1811

      MINIMUM VEG. SOIL WATER (VOL/VOL)                0.0130

*******************************************************************************
```

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	0.5777	0.0241
2	10.4880	0.4370
SNOW WATER	0.000	

****
****

Appendix C-2
HELP Model Output for
Double HDPE-Lined Pond Scenario

HDPE Dual-Lined Pond Scenario HELP Output

```
******************************************************************************
 ******************************************************************************
 **                                                                          **
 **                                                                          **
 **              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
 **                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
 **                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
 **                    USAE WATERWAYS EXPERIMENT STATION                     **
 **             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
 **                                                                          **
 **                                                                          **
 ******************************************************************************
 ******************************************************************************


 PRECIPITATION DATA FILE:     C:\nevada\p1.D4
 TEMPERATURE DATA FILE:       C:\nevada\t1.D7
 SOLAR RADIATION DATA FILE:  C:\nevada\sr1.D13
 EVAPOTRANSPIRATION DATA:     C:\nevada\e1.D11
 SOIL AND DESIGN DATA FILE:  C:\nevada\linepond.D10
 OUTPUT DATA FILE:            C:\nevada\linepond.OUT


 TIME:  63:21     DATE:   1/11/2019


 ******************************************************************************

      TITLE:  Nevada Energy Pond Double Liner

 ******************************************************************************


      NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
               COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
            THICKNESS                    =      6.00   INCHES
            POROSITY                     =      0.4370 VOL/VOL
            FIELD CAPACITY               =      0.1050 VOL/VOL
            WILTING POINT                =      0.0470 VOL/VOL
            INITIAL SOIL WATER CONTENT   =      0.2687 VOL/VOL
            EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC


                                   LAYER  2
                                   --------
```

```
              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =      2.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      2.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                          LAYER  3
                          --------

              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER  34
THICKNESS                    =      0.24   INCHES
POROSITY                     =      0.8500 VOL/VOL
FIELD CAPACITY               =      0.0100 VOL/VOL
WILTING POINT                =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   33.0000000000     CM/SEC
SLOPE                        =      3.00   PERCENT
DRAINAGE LENGTH              =    200.0    FEET


                          LAYER  4
                          --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
THICKNESS                    =      0.04   INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =      2.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      2.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD



          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-
           SPECIFIED CURVE NUMBER OF 97.0, A SURFACE SLOPE
           OF  1.% AND A SLOPE LENGTH OF  700. FEET.

SCS RUNOFF CURVE NUMBER               =     96.90
FRACTION OF AREA ALLOWING RUNOFF      =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE    =      1.000  ACRES
EVAPORATIVE ZONE DEPTH                =      6.0    INCHES
```

```
INITIAL WATER IN EVAPORATIVE ZONE    =       1.612  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =       2.622  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =       0.282  INCHES
INITIAL SNOW WATER                   =       0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =       1.615  INCHES
TOTAL INITIAL WATER                  =       1.615  INCHES
TOTAL SUBSURFACE INFLOW              =       0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          LAS VEGAS             NEVADA

     STATION LATITUDE                         =  36.08 DEGREES
     MAXIMUM LEAF AREA INDEX                  =   0.00
     START OF GROWING SEASON (JULIAN DATE)    =     62
     END OF GROWING SEASON (JULIAN DATE)      =    321
     EVAPORATIVE ZONE DEPTH                   =   6.0  INCHES
     AVERAGE ANNUAL WIND SPEED                =   9.10 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  39.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  21.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  24.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  36.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR     LAS VEGAS           NEVADA

          NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
  0.50        0.58        0.46        0.21        0.15        0.07
  0.44        0.45        0.33        0.26        0.37        0.39


 NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR     LAS VEGAS           NEVADA

     NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
-------     -------     -------     -------     -------     -------
 44.60       50.10       55.30       63.50       73.30       83.60
 90.30       88.00       80.10       67.60       53.60       45.40


 NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR     LAS VEGAS           NEVADA
            AND STATION LATITUDE  =  36.08 DEGREES
```

```
******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     1 THROUGH   20
------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 0.33     0.57     0.37     0.25     0.22     0.06
                           0.50     0.43     0.38     0.18     0.43     0.34

    STD. DEVIATIONS        0.37     0.62     0.39     0.23     0.25     0.10
                           0.71     0.34     0.70     0.17     0.43     0.26

  RUNOFF
  ------
    TOTALS                 0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

    STD. DEVIATIONS        0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 0.314    0.479    0.376    0.366    0.241    0.162
                           0.375    0.266    0.355    0.199    0.402    0.401

    STD. DEVIATIONS        0.330    0.454    0.283    0.327    0.124    0.051
                           0.621    0.211    0.570    0.143    0.403    0.341

  PERCOLATION/LEAKAGE THROUGH LAYER  2
  ------------------------------------
    TOTALS                 0.0126   0.0124   0.0145   0.0135   0.0122   0.0108
                           0.0111   0.0114   0.0126   0.0132   0.0136   0.0133

    STD. DEVIATIONS        0.0073   0.0056   0.0049   0.0043   0.0047   0.0054
                           0.0074   0.0075   0.0074   0.0073   0.0073   0.0072

  LATERAL DRAINAGE COLLECTED FROM LAYER  3
  ----------------------------------------
    TOTALS                 0.0104   0.0103   0.0120   0.0111   0.0099   0.0087
                           0.0091   0.0094   0.0104   0.0109   0.0113   0.0110

    STD. DEVIATIONS        0.0064   0.0049   0.0044   0.0038   0.0041   0.0047
                           0.0064   0.0065   0.0065   0.0063   0.0064   0.0063

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    TOTALS                 0.0022   0.0022   0.0025   0.0024   0.0023   0.0020
                           0.0020   0.0020   0.0022   0.0023   0.0023   0.0023

    STD. DEVIATIONS        0.0010   0.0007   0.0005   0.0004   0.0005   0.0007
                           0.0011   0.0011   0.0009   0.0010   0.0010   0.0009


------------------------------------------------------------------------------
              AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  2
  -------------------------------------
```

```
   AVERAGES                1.3123   1.4251   1.5190   1.4516   1.2522   1.1392
                           1.1556   1.1912   1.3617   1.3821   1.4775   1.3885

   STD. DEVIATIONS         0.8151   0.6924   0.5628   0.5062   0.5350   0.6260
                           0.8151   0.8254   0.8382   0.8058   0.8338   0.8036

 DAILY AVERAGE HEAD ON TOP OF LAYER  4
 -------------------------------------
   AVERAGES                0.0001   0.0001   0.0001   0.0001   0.0001   0.0001
                           0.0001   0.0001   0.0001   0.0001   0.0001   0.0001

   STD. DEVIATIONS         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*******************************************************************************


*******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   20
-------------------------------------------------------------------------------
                                      INCHES           CU. FEET       PERCENT
                                -------------------   -------------   ---------
 PRECIPITATION                    4.05     (   1.688)     14714.2     100.00

 RUNOFF                           0.000    (  0.0000)        0.00       0.000

 EVAPOTRANSPIRATION               3.935    (  1.5135)     14284.65     97.081

 PERCOLATION/LEAKAGE THROUGH      0.15105 (  0.04992)       548.295     3.72630
   LAYER  2

 AVERAGE HEAD ON TOP              1.338 (    0.471)
   OF LAYER  2

 LATERAL DRAINAGE COLLECTED       0.12443 (  0.04375)       451.670    3.06962
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH      0.02662 (  0.00638)        96.625     0.65668
   LAYER  4

 AVERAGE HEAD ON TOP              0.000 (    0.000)
   OF LAYER  4

 CHANGE IN WATER STORAGE         -0.033    (  0.5772)      -118.74     -0.807

*******************************************************************************
```

```
******************************************************************************

               PEAK DAILY VALUES FOR YEARS    1 THROUGH   20
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                               2.55         9256.500

      RUNOFF                                      0.000           0.0000

      PERCOLATION/LEAKAGE THROUGH LAYER  2        0.001864        6.76751

      AVERAGE HEAD ON TOP OF LAYER  2             6.000

      DRAINAGE COLLECTED FROM LAYER  3            0.00168         6.10718

      PERCOLATION/LEAKAGE THROUGH LAYER  4        0.000182        0.66033

      AVERAGE HEAD ON TOP OF LAYER  4             0.000

      MAXIMUM HEAD ON TOP OF LAYER  4             0.003

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)                 0.0 FEET

      SNOW WATER                                  0.74         2687.3430


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.4370

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.0470

       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
```

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	0.9580	0.1597
2	0.0000	0.0000
3	0.0024	0.0100
4	0.0000	0.0000
SNOW WATER	0.000	

****
****