Westinghouse

Westinghouse Electric Company LLC
Hematite Decommissioning Project
3300 State Road P
Festus, MO 63028
USA

ATTN: Document Control Desk
Director, Office of Federal and State Materials and Environmental Management Programs
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Direct tel: 314-810-3368
Direct fax: 636-937-6380
E-mail: hackmaek@westinghouse.com
Our ref: HEM-10-6
Date: January 20, 2010

Subject: Additional Information Concerning Alternate Waste Disposal (License No. SNM-00033, Docket No. 070-00036)

References:
1) Westinghouse (E. K. Hackmann) letter to Document Control Desk (NRC), HEM-09-146, dated December 29, 2009, "Response to Request for Additional Information – Alternate Waste Disposal"
2) NRC (J. J. Hayes) letter to Westinghouse (E. K. Hackmann), dated December 3, 2009, "Westinghouse Hematite 10CFR20.2002 Alternate Disposal Requests for Additional Information"

Reference 1 provided responses to the NRC Reference 2 request for additional information (RAI) concerning 10 CFR 20.2002 alternate waste disposal. This letter provides the Westinghouse response to RAI #2 under *Groundwater Pathway Parameters*. Reference 1 had communicated that a report answering the question would be forthcoming. The Attachment herein provides that report.

Please contact Gerard Couture, Licensing Manager of my staff at (803) 647-2045 should you have questions or need any additional information.

Sincerely,

E. Kurt Hackmann
Director, Hematite Decommissioning Project

Attachment: "Summary of Hydrogeologic Conditions and Groundwater Flow Model," Eric Lappala (Eagle Resources), Chuck Feast (Feast Geosciences) and Rex Hansen (American Geotechnics), for U.S. Ecology Idaho Facility, January 13, 2010

cc: J. J. Hayes, NRC/FSME/DWMEP/DURLD
J. W. Smetanka, Westinghouse, w/o attachment
W. G. Snell, NRC Region III/DNMS/DB, w/o attachment
R. Tadesse, NRC/FSME/DWMEP/DURLD, w/o attachment

ATTACHMENT

Summary of Hydrogeologic Conditions and Groundwater Flow Model

US Ecology Idaho Facility
Grand View, Idaho

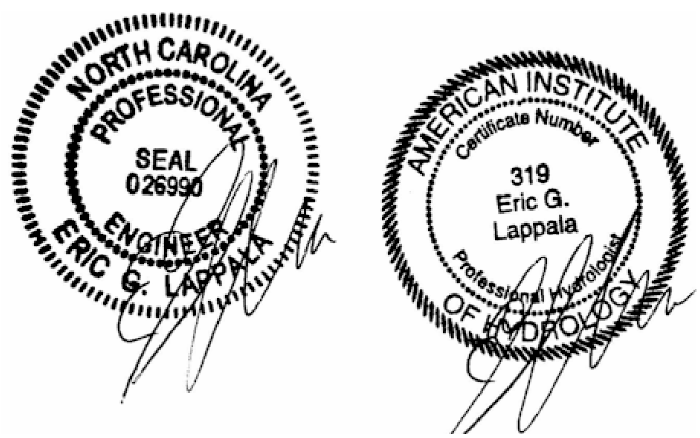
January 13, 2010

Summary of Hydrogeologic Conditions and Groundwater Flow Model

US Ecology Idaho Facility
Grand View, Idaho

January 13, 2010

Prepared by;



Eric G. Lappala, P.E., P.H.
Eagle Resources, P.A.

Chuck Feast, P.G.
Feast Geosciences, LLC

Rex Hansen, P.E.
American Geotechnics

Eagle Resources
Advocacy → Sound Science → Innovation → Solutions

Eagle Resources, P.A.
4005 Lake Springs Court
Raleigh, NC 27613-1525

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1 Introduction and Executive Summary

US Ecology Idaho (USEI) currently operates a RCRA Subtitle C and Toxic Substance Control Act (TSCA) Hazardous Waste Treatment, Storage and Disposal Facility (EPA ID No. DD073114654) located approximately 10 miles west of Grand View in Owyhee County, Idaho (Figure 1). The facility is located approximately in the middle of Section 19, T4S, R2E. The USEI facility was previously one of three Titan missile bases in southwestern Idaho constructed and later decommissioned in the early to mid-1960's. The US Air Force designated the three bases Sites A, B and C. The USEI Grand View facility is Site B.

The USEI facility is operated under the authority of the permit issued and monitored by the Idaho Department of Environmental Quality (IDEQ). USEI has submitted a siting license application (Application) to add Cell 16 as additional storage capacity at the site[1]. This siting license was subsequently approved by the IDEQ after the prescribed review and public process[2]. The Siting Application includes a comprehensive description of subsurface conditions at the site that is has been confirmed by over 25 years of investigations by USEI and previous site owners and operators and their environmental consultants.

Because the USEI facility is not licensed by the U.S. Nuclear Regulatory Agency (NRC) and because Idaho does not have authority as an Agreement State to implement NRC regulations for disposal of wastes from NRC regulated facilities exemptions are necessary from the requirements of 10 C.F.R. § 20 for disposal at USEI. Pursuant to this requirement, Westinghouse Electric Company, LLC (WEC) has requested an amendment to its NRC license and authorization under the provisions of 10 C.F.R. § 20.2002 to ship waste from its Hematite facility in Festus, Missouri to USEI for disposal ("WEC Request"). In response to this application, the NRC has asked questions about the USEI site geology and groundwater that are the subject of this report. This report also addresses seven specific contentions raised by one commenter (CCI) in formal comments to the NRC regarding the WEC request (Appendix B)[3].

As an aid in further demonstrating site hydrogeologic conditions at Site B, we have prepared the following: 1) Summary of hydrogeologic conditions; 2) Quantitative analysis of hydrologic conditions using three-dimensional illustrations, geotechnical engineering analysis, and numerical modeling of groundwater flow; and 3) Use of the quantitative analysis to address comments made by one commenter on this matter.

[1] American Geotechnics, June 30, 2006: Hazardous Waste Facility Siting License Application Cell 16 Grand View, Idaho

[2] Idaho Department of Environmental Quality siting license approval letter to US Ecology Idaho dated December 6, 2006

[3] Citizens for a Clean Idaho (CCI), an Idaho citizens group, raised seven specific contentions to the US Nuclear Regulatory Commission as part of its request for a public hearing on the Westinghouse proposal. The Atomic Safety Licensing Board subsequently denied the request for a hearing.

In summary, this report will demonstrate the following:

- Site geologic and hydrogeologic conditions are well understood based on decades of environmental study and reports prepared by environmental professionals and accepted by the IDEQ.

- The site is underlain by two, discrete, low yielding, water-bearing units referred to as the Upper and Lower Aquifers.

- Rising groundwater conditions in both aquifers at the site are well documented and have been investigated and the potential impacts on groundwater monitoring have been systematically evaluated since 1999.

- The materials that overlie the Upper Aquifer are sufficiently permeable to allow water entering them to drain to the north and east which will limit the elevations to which groundwater will rise.

- A three-dimensional model has been developed that uses site specific and regional data and information that quantitatively demonstrates that drainage function of the permeable materials above the present zone of saturation will prevent water levels from continuing to rise and will prevent the formation of new groundwater discharge to the surface via springs and seeps.

- The model was used to demonstrate the limits on water level rises and the lack of new groundwater discharge to the surface under the a hypothetical and extremely unlikely condition of increasing recharge from precipitation from the current value of zero to a value that would result from permanently quadrupling the annual precipitation in the region.

- As a result, under both expected and extremely unlikely, hypothetical scenarios, the parameters and assumptions used for the site's RESRAD model remain sound.

This report has been prepared by licensed and certified professional engineers and geologists at the request of USEI.

Mr. Eric Lappala, P.E., P.H, Eagle Resources, P.A., provided the overall report collation and preparation including assembling and completing the figures. In addition Mr. Lappala was the primary author of Section 3 including the development of the numerical groundwater flow model and associated simulations. Mr. Rex Hanson, P.E., American Geotechnics, Inc., provided the geotechnical evaluation and discussion of water level responses to soil loading at Site B found in Section 3.1. Mr. Charles Feast, P.G., Feast Geosciences, LLC, prepared Section 2 describing the Site Hydrogeology and Section 3.2 which discusses long term water level trends at the USEI site. Mr. Lappala also conducted the RESRAD modeling presented in Section 4.

It is our collective professional opinion that the data, information and analyses included in reports that have been prepared over the last 25 years and which are summarized in the Siting Application comprise an adequate technical basis to demonstrate understanding and description of the hydrogeologic conditions at Site B.

2 Summary of Site Hydrogeologic Conditions

USEI and previous owners of the facility have conducted extensive studies and characterization of the groundwater and unsaturated (vadose) zone beneath Site B over the last 25 years. This report provides a summary of the hydrogeologic conditions based upon those studies and uses site specific information as well as regional information to extend the understanding of these conditions to an area of approximately nine (9) square miles that is centered on the site (Figure 1).

2.1 Hydrogeologic Setting

The USEI Facility sits on a low flat topped knoll at an elevation of 2545 to 2600 feet (Figure 1). Surrounding surface elevations range from 2450 to 2475 feet on the west, north and southeast and 2500 feet on the south side. The Snake River, at elevation approximately 2,335 flows from east to west approximately three miles to the east and two miles to the north of the site. Two perennial streams, Castle and Catherine Creeks flow from south to north approximately 2,000 feet west of northwest corner of Section 19 and 4,000 feet west of the southwest corner of Section 19 (Figure 1). The two creeks join at the approximate northern edge of Section 19 and the combined creek, Castle Creek, continues to the north approximately two miles where it discharges into the Snake River.

Site studies based upon geologic cores, geophysical logs and hundreds of water quality samples from dozens of borings and wells have concluded that below a thick vadose zone there are two, independent, water-bearing zones within the upper 300 feet beneath the site. Out of convenience and convention to ease communication with the regulatory agencies (US EPA and IDEQ) these units have been designated the Upper and Lower Aquifers (Figure 2), although neither "aquifer" is capable of producing significant water. The aquifers and the clay unit that separates them beneath the Site dip downward to the north-northeast at 3 to 5 degrees.

Underlying the Lower Aquifer and extending to a depth of approximately 2400 feet are progressively indurated clays and shale that comprise the confining bed for a deep, geothermal, artesian aquifer present in basalt that was penetrated by a 3100 foot deep well installed by the US Air Force.

The general geologic history of the subsurface at USEI Site B, pertinent to this report begins with the placement of the Banbury Basalts in late Miocene time, approximately 5 to 6 million years ago (mya). Overlying the Banbury Basalt is the Glenns Ferry Formation of Pliocene age (approximately 5 to 2 mya). The Glenns Ferry Formation consists of a thick section of predominantly clay, silt and fine sand beds deposited in a series of large, regional lakes that formed behind temporary lava dams across the Snake River near the Idaho-Oregon border. The Glenns Ferry Formation beneath Site B consists of both lacustrine (lake deposits) and fluvial (flood plain) sediments. The sedimentary record at Site B reflects a general pattern of coarsening upward, as the large regional lakes filled in, dried up or drained. In general the deeper portions of the Glenns Ferry Formation is almost entirely thick, massive, lacustrine clay and silt but the upper parts, including the Upper and Lower Aquifers and much of overlying vadose sediments, represent a transition from lacustrine to fluvial sediments. This coarsening-upward sedimentary pattern is very significant to the understanding of the hydrogeology of Site B.

Above the Glenns Ferry Formation is the Pleistocene Bruneau Formation (less than 1.5 mya) that forms a mantle of fine to coarse sands and mixed sand and gravel. The Bruneau Formation was deposited, and subsequently reworked, by the Snake River after the regional lake forming conditions at the end of the Pliocene had ceased.

2.2 Hydrostratigraphic Units

To assist in presenting the hydrogeologic conditions documented by past studies and reports a three-dimensional cross-section that cuts from west to east through the Cell 14 of the USEI site is presented as Figure 2. Figure 3 provides a detailed north-south cross section along the east side of Site B. These sections have been prepared using the lithologic logs of wells and borings that were drilled to characterize the Upper and Lower Aquifers.

Six hydrostratigraphic units are important to understanding site hydrogeology and its ability to isolate disposed wastes. These units, beginning at ground surface and extending to a depth of about 3300 feet consist of the following: 1) Vadose Zone; 2) Upper Aquifer; 3) Upper Confining Clay; 4) Lower Aquifer; 5) Lower Confining Clay and Shale, and 6) the basalt artesian aquifer.

2.2.1 Vadose Zone

The vadose zone is the interval of unsaturated materials extending downward from the land surface to the top of the uppermost zone of permanent saturation (Upper Aquifer). At the USEI site, the vadose zone is 150 to 200 feet of thick. Locally a discontinuous, surficial gravel layer is present over parts of the site but large areas of these deposits were disturbed beginning with the construction of the missile base in the late 1950’s. The upper part of the vadose zone, below the surficial gravels (where present), consists of thick beds of dry, fine to medium, sand with thin beds of silt and clay. The lower part of the vadose zone consists of medium to thinly bedded fine silty sand, silt and clay. West of the site, along the east wall of the Castle Creek valley, the materials comprising the vadose zone beneath the site crop out and form relatively steep slopes as shown in Figures 1 and 2.

The grain size distribution, moisture content and hydraulic properties of the various stratigraphic units within the vadose zone have been characterized by extensive sampling, field testing, and laboratory testing[4]. Using these characteristics, a three dimensional,

[4] CH2MHill, 1986. Vadose Zone Characteristics at ESII Site B Grand View Idaho

Saturated-Unsaturated Transport (SUTRA[5]) model was used to evaluate movement of water through the vadose zone. This analysis concluded that the overall low moisture content and hydraulic contrast between the numerous discrete beds comprising the vadose zone at USEI Site B provide a high degree of protection against vertical movement of water from the surface to the Upper Aquifer. In addition the model results indicated that the vadose zone would retain more water than could reasonably be produced on the site if such water were to enter the vadose zone as a result of the failure of the disposal cell liner systems[6].

2.2.2 Upper Aquifer

The Upper Aquifer is an unconfined or water-table aquifer. The top of the aquifer is defined by the current position of the water table. The lower part of the Upper Aquifer consists of fine sand and silt beds in a predominantly silty-clay matrix. The frequency and thickness of sand beds generally increase upwards within the Upper Aquifer and the uppermost portion of the Upper Aquifer is predominantly fine to medium sand. As a result of the north-northeast dip of the Upper Aquifer, the saturated thickness of the Upper Aquifer is wedge shaped with the greatest thickness along the northern boundary of the site. And as shown on Figure 3, the saturated thickness of the Upper Aquifer thins to the south. The southern extent of saturation in the Upper Aquifer crosses from northwest to southeast across the site approximately at the northern toe of Cell 14 as shown in Figure 4.

As a result of the combination of decreasing saturated thickness, and the fact that the lower part of the Upper Aquifer contains less sand, the well yields of the Upper Aquifer also decrease from north to south. Across the northern portion of the site where the aquifer is the thickest and contains the highest percentage of sands, well yields of 1 to 3 gallons per minute (gpm) can be maintained. Toward the southern extent of the aquifer where it is thinner and there are fewer and thinner saturated sand beds, well yields fall off to less than 0.5 gpm.

Water levels in the Upper Aquifer are generally 165 to 200 feet below ground level depending on the ground surface elevation at the well head. In the extreme northwest corner of the site in the vicinity of well U-4, the topography is the lowest and the depth to water in the Upper Aquifer is approximately 130 feet.

2.2.3 Upper Confining Unit

Underlying the Upper Aquifer is a thick, massive clay and silty clay 20 to 35 feet thick with sufficiently low permeability to hydraulically separate the Upper and Lower Aquifers. This material is similar to that being mined from the Ketterling source located 2 miles southeast of the site. The clays from this source are being used for the low permeability clay liners at the site and have a permeability of approximately 1.0×10^{-6}

[5] Voss, C.I., 1984 A Finite Element Simulation Model for Saturated-Unsaturated, Fluid-density-dependent Groundwater Flow with Energy Transport or Chemically-reactive Single-Species Solute Transport: U.S. Geological survey Water Resources Investigation Report 84-4369.

[6] CH2MHill, 1987. Computer modeling results for the Part B Permit Application, ESII Site B Grand View Idaho.

cm/sec (0.003 ft/day). The permeability of samples of the deep lacustrine clays determined during site characterization [7] ranged from 1.0 x 10^{-6} cm/sec to 1.0 x 10^{-7} cm/sec.

2.2.4 Lower Aquifer

The Lower Aquifer is a confined aquifer and is saturated beneath the entire site. The Lower Aquifer is bounded by upper and lower confining clays and consists of a “swarm” of thin lamina, partings, and thin beds of very fine sand with an aggregate thickness of approximately 3 feet that is embedded in approximately 30 feet of silty clay. The Lower Aquifer is an extremely low water yielding formation. None of the Lower Aquifer wells can be pumped continuously and estimates from observations of water level recovery rates indicate that even under extreme drawdown conditions the formation yields less than 0.01 gpm.

Beneath the southern edge of the Site the depth to water in the Lower Aquifer is typically 190 to 210 feet.

2.2.5 Deeper Hydrostratigraphic Units

Based upon the log of the 3,100 foot deep artesian supply well drilled on site by the U.S. Air Force, site, approximately 2285 feet of clay and shale underlie the Lower Aquifer and separate it from the Banbury Basalt and deeper basalt aquifers. The Banbury Basalt and deeper basalts are local and regional geothermal, artesian aquifer. The artesian well at Site B was plugged and abandoned in 1985 using oil field techniques and contractors[8].

2.3 Recharge, Movement, and Discharge of Groundwater

Understanding the operation of any hydrogeologic system requires knowing the location, timing, and magnitudes of water entering (recharge), flowing through, and leaving the system (discharge).

2.3.1 Groundwater Recharge

Four potential sources of groundwater recharge have been evaluated by past studies of the USEI site: deep percolation of precipitation, infiltration of ponded precipitation in uncompleted waste cells; streamflow losses from Castle and Catherine Creeks, and upward leakage from the geothermal artesian aquifer or from the abandoned artesian well. As shown in the following sections, recharge from the creeks is the only plausible and reasonable source of groundwater present in the Upper and Lower Aquifers.

2.3.1.1 Recharge from Precipitation

Previous studies conducted as part of the permitting of the USEI site have clearly demonstrated that the arid conditions and thick vadose zone at the site preclude measurable recharge to the saturated zone from infiltration of precipitation. The mean annual precipitation at the site is less than 7 inches per year based upon 47 years of

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[7] CH2MHill, 1986. Vadose Zone Characteristics at ESII Site B Grand View Idaho

[8] CH2M HILL, June 1986). Report on Plugging the Artesian Well at USEI Site B Near Grand View, ID. Boise, ID.

record at Grand View Idaho[9]. Records of precipitation and potential evapotranspiration (PET) for Grand View, Idaho from 1993 to the present show that average annual precipitation was 6.1 inches and average annual PET was 57.3 inches[10]. In addition site runoff is routed to lined evaporation basins and prevented from ponding and infiltrating. Consequently, all precipitation falling on the site is returned to the atmosphere by ET from the soil zone before it infiltrates deeper. The vadose zone characterization and SUTRA model results[6] confirmed that recharge from precipitation is insignificant at the USEI site.

2.3.1.2 Infiltration from Waste Cells

Liquid wastes are not accepted at the USEI facility as a condition of their operating permit with IDEQ. The liner and leachate collection systems for the waste cells at the USEI site are constructed to contain and remove any liquids that may accumulate as a result of an extreme rainfall event falling on the cells prior to closure. As part of previous permitting of the site, analyses were conducted to assess the fate of a release of water from a hypothetical liner failure. These studies have shown that water from such a failure would not reach the water table in the Upper Aquifer because it would be retained by capillarity in the thick vadose zone present at the site[4,5,11,12].

2.3.1.3 Lateral Recharge from Castle and Catherine Creeks

Catherine and Castle Creeks originate in the Owyhee Mountains south of the site and have a combined drainage area of 248 square miles[13]. Both of these streams are designated as perennial on the U.S. Geological Survey 7.5 topographic map of the area[14].

Site studies since 1999[15] have identified Castle Creek northwest and southwest of Site B as the probable recharge source for the Upper and Lower Aquifers. The strata containing the Upper and Lower Aquifers dip to the north-northeast at 3 to 5 degrees and the lateral trend of the strata, the strike, is southeast-northwest. Extending the strike of the Upper Aquifer sediments indicates the upper part of the aquifer probably underlies Castle Creek northwest of the northwest corner of Section 19. Projecting the Lower Aquifer up-dip to the southwest indicates that recharge to the Lower Aquifer probably occurs along the reach of Castle Creek lying south of approximately the north boundary of Section 24 (Figures 1 and 2).

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[9] http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?WWDI~StnSrch: National Climatic Data Center Station 103760, Grand View, ID.
[10] http://www.usbr.gov/pn/agrimet/wxdata.html : U.S. Bureau of Reclamation AGRIMET Station Grand View, ID
[11] CH2MHill, February 1986. ESII Site B Site Characterization and Groundwater Monitoring Program, Envirosafe Services of Idaho, Inc., Grand View, ID. U.S. EPA I.D. No. IDD073114654. Boise, ID.
[12] Eagle Resources, P.A. April 2005. Site-Specific RESRAD Water Pathway Parameters for the Contaminated Soil, Vadose Zone and Saturated Zone, US Ecology Grand View Idaho.
[13] http://www.idwr.idaho.gov/GeographicInfo/GISdata/watersheds.htm: Idaho Department of Water Resources online GIS Data.
[14] http://data.geocomm.com/catalog/US/61053/425/index.html: U.S. Geological Survey, Castle Butte 7.5 minute topographic map, digital version.
[15] CH2MHill, 1999 Rising Groundwater Study

2.3.1.4 Upward Leakage from the Geothermal Artesian Aquifer or from the Abandoned Artesian Well

Site studies since 1999[16] and data collected during each semi-annual groundwater sampling event have examined geochemistry, water level and temperature data in an effort to determine if the Lower Aquifer is being recharged by vertical movement either as diffuse flow through the thick lower confining strata beneath the Lower Aquifer, or as leakage up the well wellbore of the abandoned artesian well drilled by the U.S. Air Force. Based on these analyses there is no evidence that vertical leakage at the site is a significant source of recharge to the Lower Aquifer.

2.3.2 Groundwater Movement and Age Dating

The characterization of the movement of groundwater in the Upper and Lower Aquifers has been documented by using both water level elevation measurements in monitoring wells and age dating of water samples from the water wells.

2.3.2.1 Groundwater Flow Directions

Water level measurements in Upper Aquifer monitoring wells and Lower Aquifer monitoring wells that have been taken over the last 20+ years have been used to document the direction of groundwater movement and to infer the approximate rates of such movement. These data show that groundwater in the Upper Aquifer flows along strike from its recharge area along Castle Creek northwest of Section 19 and flows to the east-southeast (Figures 2 and 4). Groundwater in the Lower Aquifer moves down dip to the northeast from the apparent recharge area along Castle Creek drainage southwest of the site (Figures 2 and 5).

In addition to the lateral flow regimes described above there are vertical gradients between the aquifers. Based on previous studies[17], the confining clay between the aquifers has a hydraulic conductivity of 1.0×10^{-6} cm/sec to 1.0×10^{-7} cm/sec. Across the northern one-third of the site the water level in the Upper Aquifer is higher than the Lower Aquifer and thus there is a downward gradient and therefore under Darcy's law a calculable flow. However, the flux of water across the confining clay under these head conditions is not significant.

Across the south central part of the site, there is a zone where an upward gradient exists from the Lower to the Upper Aquifer. Based upon the difference in measured water levels in the Upper and Lower Aquifers in this zone and the low hydraulic conductivity of the clay that separates them, the leakage from Lower to Upper Aquifer is insignificant. The lack of significant exchange of water between the two aquifers has been clearly demonstrated by the distinct different water chemistry of the two aquifers.

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[16] CH2MHill, 1999 Rising Groundwater Study

[17] CH2MHill, 1986. Vadose Zone Characteristics at ESII Site B Grand View Idaho

2.3.2.2 Groundwater Age Dating

Age dating conducted in 1999[18] indicates that "new" 700-900 year old groundwater is coming in from the northwest in the higher permeable parts of the Upper Aquifer and is mixing with and displacing the older water in the less permeable parts of the Upper Aquifer across the eastern and south central portions of the site. The oldest Upper Aquifer water was dated at about 9,500 years old.

Water in the Lower Aquifer is moving very slowly to the northeast (down dip) from the projected recharge area along Castle Creek southwest of the site. Lower Aquifer water at Site B was dated at about 12,000 years old, about the same age as the samples collected from two artesian wells in the area. This suggests that while hydraulic head (pressure) and gradient (flow direction) are being influenced by the recharge area, modern recharge water has not reached Site B. The extreme sluggish movement of water in the Lower Aquifer makes it difficult to positively identify the source of water in the Lower Aquifer.

2.3.3 Discharge of Groundwater

As documented by the direction of groundwater flow based on contours of water levels shown in Figures 2, 4, and 5, both of the aquifers discharge through the north and east boundaries of the analysis area. Although there has been no specific aquifer characterization efforts conducted off site to the east and northeast the continuation of the aquifers is implied by the consistency and continuity of the water level contours and groundwater potential lines for both aquifers.

2.3.4 Water Level Trends, Causes and Effects

Beginning with the first sets of sequential water level measurements in test wells installed during the site characterization process in the mid 1980's it was observed that water levels were rising slowly in monitoring wells at USEI Site B. The upward trend in water levels at Site B is one of the major issues raised by CCI.

The issue of rising groundwater at the site has been evaluated by USEI and the previous site owners. The results of these studies have been presented in reports beginning with the primary report in 1999[19] and with subsequent updates in 2001, 2003 and 2006. In addition, beginning in 2006, each semi-annual groundwater sampling report contains an evaluation of water level trends updated with the most recent set of water level data.

2.3.4.1 Water Level Trends

Figure 6 provides examples of hydrographs for Upper and Lower Aquifer wells at Site B. The hydrograph for Upper Aquifer well U-7 along the northern boundary of the site shows that the rate of water level rise has flattened considerably since approximately 2000. Well U-26 at the extreme southern extent of the Upper Aquifer shows a longer, steeper trend but also a distinct flattening of the water level trend line beginning in about 2004.

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[18] CH2MHill, 1999 Rising Groundwater Study
[19] CH2MHill, 1999 Rising Groundwater Study

The hydrographs for Lower Aquifer wells shown on Figure 6 have similar water level trends to the Upper Aquifer wells. Well LP-13 in the extreme northeast corner of the site shows a flattening trend similar to adjacent well U-7. Well L-33 in the center of the site shows a flattening trend similar to well U-26.

The hydrograph for Lower Aquifer well L-38 is provided to illustrate the water level response to surface loading observed in this, and several other Lower Aquifer wells. One of CCI's issues was directly related to this hydrograph. As can be seen by this hydrograph, a large spike in the water level occurred in mid-1992. This spike correlates with the stock piling of soil excavated from Cell 14. Following this sudden increase, the water levels slowly declined in a smooth curve over the next 5 years as the hydrostatic conditions in the aquifer re-equilibrated. Other, smaller, changes in surface loading occurred as additional soil stockpiles were placed, or moved in the area (1997 and 2002). Since about 2005 water levels have remained fairly constant. Other Lower Aquifer wells around L-38 and adjacent to Cell 15 show the effects of loading from the stockpiling of soils associated with cell construction. The geotechnical assessment, presented in Section 3.1 provides a more detailed analysis of the affects of soil loading on water levels.

2.3.4.2 Causes of Rising Water Levels

The specific causes of rising water levels in each well at Site B are not known but can be reasonably attributed to several processes based on the known site history and hydrogeology. Both aquifers appear to be responding to some change of conditions which may include long term (thousands to tens of thousands of years) precipitation cycles. The sluggish response of both aquifers, especially the Lower Aquifer, makes it difficult to determine the lag time components of any changes due to variations in paleo-climates.

The age dating study briefly discussed in Section 2.3.2.2 suggests both the Upper and Lower Aquifer originally had similarly-aged water of around 12,000 years old. Currently the oldest water in the Upper Aquifer is about 9,500 years old but as shown by this study it appears that younger water is entering the aquifer from the northwest and displacing and mixing with the original water. Therefore, in the case of the Upper Aquifer the rising water levels appear to be associated with post-ice age climate change and/or changes in streambed geometry in Castle Creek within the last 10,000 to 12,000 years.

The Lower Aquifer is confined across Site B and therefore rising water level measurements indicate increasing pressure and not an actual increase in the saturated thickness of the aquifer. Pressure or potentiometric responses in confined aquifers can be transmitted rapidly over relatively long distances. As was discussed in the previous section, changes in surface loading can quickly affect the potentiometric surface in Lower Aquifer wells. Increases in the hydraulic head in the recharge area of the Lower Aquifer could also cause water levels to rise in the Lower Aquifer wells. Therefore water level rises in the Lower Aquifer may be caused by both local affects and longer term climatic changes possibly complicated by the anthropomorphic changes in the Castle Creek and Catherine Creek drainage areas. These changes include the relatively recent drilling and incomplete abandonment of uncontrolled flowing wells, use of storage reservoirs to capture spring runoff and land use changes including irrigation in the general implied recharge area for the Lower Aquifer southwest of Site B.

Surface loading (and unloading) has been nearly continuous at Site B since the mid-1950s when the U.S. Air Force began construction of the missile base. To construct the subsurface structures and inter-connecting tunnels the upper 80 feet of sediments was splayed back across large swaths of the site and three excavations approximately 60 feet in diameter and 170 feet deep were made for the silos. This excavated soil was stockpiled over large areas of the site. Following decommissioning of the missile base the site has been in almost continual use for hazardous waste storage which has also involved excavation and stockpiling soils.

While there has been no correlative cause and effect of short term water level fluctuations associated with surface loading observed in the Upper Aquifer wells it is important to note that all of the significant construction activity at Site B since the mid-1980s has been over the southern portion of the site which overlies the Lower Aquifer. The Lower Aquifer water levels are clearly impacted by surface loading and compaction, the affects of which can operate over periods at least as long as 10 years for the relatively small surface loading near L-38 (Figure 6).

Rising groundwater levels in the Upper Aquifer are also increasing the hydraulic load on the Lower Aquifer where the Upper Aquifer directly overlies the Lower Aquifer across the northern half of the site (wells U-7 and LP-13, Figure 6). This hydraulic loading probably also affects water levels in the Lower Aquifer under the southern half of the site by the flattening the gradient and causing water to “back up”.

Therefore, it is likely that the rising water levels observed in the wells at USEI Site B are due to multiple causes including long term, complex changes in the recharge of both aquifers, localized surface loading, and hydraulic loading.

2.3.4.3 Effects of Rising Water Levels

As the water level in the Upper Aquifer rises it causes the southern extent of saturation move to the south (because of the NE dip), about 20 feet south for every 1 foot of rise. Since the Upper Aquifer is unconfined, water level rises represent increasing saturated thickness. The cross section provided in Figure 3 illustrates how the southern extent of saturation in the Upper Aquifer will move in response to water level changes.

As water levels rise in the Upper Aquifer rise, additional sand beds and higher permeability sediments will be encountered because of the coarsening upward characteristic of this formation. As more of these transmissive sediments become saturated water will flow more freely to the east and northeast and the rate of water level rise across the northern portion of the site will decline. This flattening of the water level trend is present in all the Upper Aquifer wells across the northern side of the site as illustrated in Figure 6 by the hydrograph for well U-7. In general this trend of flattening hydrographs should progressively advance from north to south across the site to include additional Upper Aquifer wells.

Potentiometric pressure rises in the Lower Aquifer, beneath the southern portion of the site, are increasing the gradient across the confining clay and into the overlying Upper Aquifer sediments. As the gradient increases the upward flux of water will also increase. However, the low permeability of the confining clay restricts this leakage to insignificant amounts. Currently under the southern one-third of the site the Upper Aquifer sediments are not saturated and the minor quantity of leakage that does cross the confining bed will gradually move down dip to the northeast where it will be incorporated into the flow dynamics of the Upper Aquifer and subsequently will flow to the east. Where leakage occurs into an area where the Upper Aquifer is currently saturated the water will simply flow with the Upper Aquifer. The small amount of water moving into the Upper Aquifer from the Lower Aquifer will not affect the flow patterns in the Upper Aquifer because of the relatively higher permeability and transmissivity of the Upper Aquifer.

The overall affect of rising groundwater at Site B is minimal: over the 25 years of monitoring, water levels have risen and average of 6 to 7 feet in both aquifers. Gradients and flow directions within and between both aquifers have remained relatively stable. The affects of water level rises over longer terms and under hypothetical recharge conditions is discussed in Section 3 of this report.

3 Quantitative Analysis of Hydrogeologic Conditions

To demonstrate clearly that the hydrogeologic conditions beneath and in the vicinity of the USEI site are adequately understood, to provide an explanation of the likely source of rising water levels in monitoring wells, and to provide a tool to demonstrate the fate of groundwater rising into the permeable sands, we present the following three analyses:

1. A geotechnical analysis that provides an explanation of fluctuations in water levels in Lower Aquifer monitoring wells around Cell 15;

2. An explanation for the long term trends of water levels in the Upper and Lower Aquifers; and

3. A groundwater flow model analysis that demonstrates that the hydrogeologic conditions described in the previous section can be quantified and that quantitatively demonstrates the fate of water rising above the top of the Upper Aquifer, independent of the reason for the rising levels.

3.1 Geotechnical Analysis of Fluctuating Water Levels in the Lower Aquifer Around Cell 15

Several of CCI's comments imply that the pattern of water level responses in Lower Aquifer monitoring well L-38 cannot be reasonably well explained and that therefore the site is too complex to adequately characterize. However an evaluation of the effects of loading by site operations (stockpiling excavated material from a cell and refilling the cell with waste and backfill) by a licensed professional geotechnical engineer has shown that this such loading is a plausible explanation for both the sudden changes in water level elevations as a result of increased overburden pressure, consolidation of clays within the aquifers and confining layer, and migration to sand and silt stringers.

3.1.1 Effects of Cell Construction

Stockpiling sand adjacent to the cells and waste placement in the cells has caused the underlying soil stratums to consolidate. Geotechnical analysis performed prior to the construction of Cell 15 indicates the underlying stratums were expected to experience approximately 3 feet of consolidation, with approximately one-half of the consolidation occurring within the saturated soil layers.

The quantity of water that is squeezed or displaced from the underlying saturated stratum related to the construction of Cell 15 and the adjacent stockpile is estimated below:
Displaced volume of water = Footprint of Cell 15 and sand stockpile * Consolidation

$$= [(39 \text{ acres} + 13 \text{ acres}) * (43{,}560 \text{ ft}^2/\text{acre})] * (1.5 \text{ ft})$$

$$= 3.4 \times 10^6 \text{ ft}^3 * 7.48 \text{ gallons/ft}^3$$

$$= 25 \times 10^6 \text{ gallons.}$$

Thus, the volume of groundwater that is ultimately squeezed out of the Glenns Ferry Formation as a result of Cell 15 construction is very substantial (approximately 25 million gallons).

The driving force displacing this volume of water is also considerable. If the ultimate load from the waste placed in Cell 15 and the sand stockpiles placed adjacent to Cell 15 were applied instantaneously, the driving force displacing groundwater from the saturated soil stratums would be approximately 50 psi (based upon an average net loading of 60 feet of material with a typical density of 120 pcf). The loading induced by cell construction at the site is not applied instantaneously. However, we expect that accelerated loading would result in displacement pressures approaching the upper limit of 50 psi and that slower loading would result in a lower displacement pressure, approaching the lower limit of 0 psi.

Ultimately, when waste placement and cell construction is completed at the site, the additional pressure head caused by these activities is expected to dissipate as the displaced water escapes the soil layers at the site. In evaluating a consolidation curve for the site conditions, the underlying soil stratums are expected to achieve 90 percent of ultimate consolidation within 25 years of complete loading. In the interim period, an increased pressure head will exist with a variable magnitude.

These observed changes of the water surface within the monitor wells (5 to 10 feet) are indicative of approximately an additional 2.2 to 4.4 psi of pressure head in the Lower Aquifer. These values are well below the maximum additional pressure head of 50 psi and are much closer to the lower limit of 0 psi.

3.1.2 Conclusions Regarding Lower Aquifer Water Level Fluctuations

During the last 8 years, landfill cell construction and waste placement has accelerated resulting in increased pressure within the site soils across the southern portion of the site. This increase in pressure causes water from the underlying strata to be manifested in water level rises in wells that are connected to the zones undergoing consolidation. As discussed in Section 2.3.4.2 surface loading is a component of the rising water levels in the lower aquifer, especially across the southern portion of the site.

3.2 Long Term Trends in Water Levels

The ultimate upper limit of water levels in the upper and lower aquifer is controlled by three factors: the elevation head of the recharge, the aquifer transmissvity or ability to transmit the incoming water to point(s) of discharge, and the surface elevations on the down-gradient side of the site.

With regard to the Upper Aquifer, the apparent recharge source is Castle Creek northwest of the site at an elevation of approximately 2425 to 2450 feet. The ultimate possible water level in the Upper Aquifer is therefore 2425 to 2450 feet. Currently the water level in the Upper Aquifer ranges from 2373 to about 2400 feet. Water level data indicate this recharge water is moving into and across the site and is discharging east of the site. Since there is apparently an established discharge area for Upper Aquifer, the maximum water level will be lower than the recharge elevation.

In addition, as discussed previously, as the saturated thickness of the Upper Aquifer increases the transmissivity of the aquifer also increases, and under conditions of constant recharge the resultant water levels will reach a point of equilibration. As illustrated by the hydrograph for U-7 shown on Figure 6, the Upper Aquifer wells along the northern portion of the site may be reaching this equilibration point. The water level in well U-7 is currently at elevation 2376 feet and has been stable at this elevation since 2000.

The apparent recharge area (or pressure head source) affecting the Lower Aquifer in the Castle Creek drainage southwest of the site is at an approximate elevation of 2500 feet. For the same reasons discussed above, since there is a flow-discharge pattern established in the Lower Aquifer, the ultimate water level will be somewhat less than 2500 feet. The current water levels in the Lower Aquifer range from 2370 to 2446 feet. However, it is important to note that the Lower Aquifer is confined and these are elevation or pressure heads measured in wells and they do not represent the top of the zone of saturation.

There are two discharge regimes that will affect the ultimate pressure head in the Lower Aquifer, the lateral discharge area off site to the northeast, and vertical leakage into the overlying Upper Aquifer sediments as discussed in section 2.3.4.2. Under the current pressure heads there is insignificant leakage, however, if the pressure heads continue to increase there may be a self limiting increase in leakage into the Upper Aquifer. Since the Upper Aquifer is much more permeable than the Lower Aquifer any increased leakage will be quickly assimilated and discharged with the Upper Aquifer flow.

The ultimate water level elevation in the Upper Aquifer, and any component of Lower Aquifer water entering the Upper Aquifer, will be the surface elevations east of the site. If water levels in the Upper Aquifer rise to this level springs and surface discharges will develop. The Snake River, elevation approximately 2355 is the ultimate base level for the groundwater in this area. Between the Snake River and Site B the surface terrain rises to a bench at 2400. Ground surface gradually rise to 2500 feet northeast of the site. There are smaller drainages due east of the northern boundary of Section 19 at elevation 2450 that would probably develop surface flow if regional groundwater levels rose to this elevation. However, as discussed in Section 3, even under hypothetical conditions of climate change that would increase the regional groundwater recharge from the present value of zero to 4 inches/year, groundwater levels will not rise to the land surface to produce spring discharge east of Site B.

In summary, the elevations of the recharge areas for both aquifers provide one general sense of the maximum water level elevation if water levels continue to rise. Aquifer properties and flow-discharge dynamics however will provide a self limiting water levels that are lower than the recharge elevations. Topography and existing drainages east of the site provide additional controls limiting the maximum water levels at Site B. To address some of the issues associated with long term water levels trends under current and hypothetical future conditions, USEI has conducted additional groundwater modeling. These modeling efforts and results are discussed in the following section.

3.3 Groundwater Flow Model Analysis

Numerical models of groundwater flow are commonly used to evaluate and demonstrate the operation of hydrogeologic systems. These models provide the ability to represent complex conditions such as the presence and three-dimensional geometries of multiple aquifers and confining zones, complex recharge areas connected to different aquifers at different locations, and conditions that would result from factors such as those causing water levels to rise at the site.

A three-dimensional numerical model of groundwater flow has been built based upon the information and data in the Application, and regional topographic and geologic information available in the public domain. This model is a mathematical representation of the three-dimensional system illustrated in Figure 2.

3.3.1 Model Construction

The groundwater model was constructed using a 100-ft x 100-ft square grid of computational cells that cover the analysis area shown in Figure 1 that is centered on the site. All horizontal coordinates used to construct the model are in feet based on the Idaho West State Plane system. All vertical coordinates are in feet based on the NAVD88 Datum.

Figure 2 illustrates the geometry of the five layers that represent hydrostratigraphic units used to construct the model. Each of the units described above is included with the exception of the deep artesian fractured basalt aquifers. The thickness and low permeability of the clays and shales separating this unit from the Lower Aquifer preclude any significant effect on the units above it caused by conditions within the artesian basalt aquifer.

Note that because the model uses hydrostratigraphic units to define layers, they may or may not be saturated. The top of the zone of saturation or watertable is computed as part of the model output, and is not specified a-priori. Measures of how well the model represents the modeled system are the degree of fit between the computed elevation of the watertable and the lateral extent of the zone of saturation of the upper aquifer which dips to the north and east at 3 to 5 degrees.

3.3.1.1 Layer 1: Bruneau Formation

The top of the uppermost layer (Layer 1) which represents the Bruneau Formation was taken as the elevation of the land surface. The elevation of the land surface was downloaded from the U.S. Geological Survey National Elevation Dataset (NED) in on a 10 meter x 10 meter grid for the analysis area shown in Figure 1. The elevation of the land surface for each of the 100 ft x 100 ft model cells was interpolated from the NED grid using the ArcInfo(tm) GIS program. The bottom of Layer 1 in the model is the top of the Upper Aquifer.

As shown in Figure 2, the bottom of Layer 1 or the Bruneau Formation occurs at the toe of the steep slopes extending into the valley of Castle Creek from the plateau upon which the site is located. The model truncated layer one at this boundary.

Based upon lithologic descriptions and previous studies[6,7], the hydraulic conductivity of Layer 1 was modeled using a value representative for a fine sand of 10 ft/day (4.0×10^{-3} cm/sec).

3.3.1.2 Layer 2: Upper Aquifer

Layer 2 in the model represents the hydrostratigraphic unit that includes the saturated Upper Aquifer and materials above the zone of saturation. The term Upper Aquifer is used for the purposes of this report to refer to this entire hydrostratigraphic unit. The top of this unit was determined using the cross sections shown as 6 and 7 in the Siting Application (Figure 3 in this report) as well as lithologic logs of wells and borings that were drilled to characterize the Upper and Lower Aquifer. This information was used to prepare a hand-drawn contour map of the top of the Upper Aquifer. The contours were drawn to honor the observed dip from south-southwest to north-north east discussed in previous site investigations. Where these contours intersected the land surface, the land surface elevation was used as the top of layer. This results in the correct modeling of thinning of the Upper Aquifer in the lower parts of the valley of Castle Creek south of the north boundary of Section 24 as illustrated in Figure 2. The contours were interpolated to the model grid cells using ArcInfo.

Based on the sections in the Application and lithologic logs of borings and wells, the Upper Aquifer was assumed to have a constant average thickness of 45 feet. The bottom elevation of Layer 2 was therefore assigned by subtracting this value from the top elevation for each model grid cell.

Based upon information in the Application and site studies the hydraulic conductivity of the Upper Aquifer was modeled using a value representative of a sandy silt of 1 ft/day (4 x 10^{-4} cm/sec). This value was used as a generalization of the value of 0. 6 ft/day that is reported in the studies used to permit the site.

3.3.1.3 Layer 3: Upper Confining Clay

Layer 3 in the model represents the upper confining clay. Based upon the sections in Figures 6 and 7 of the Siting Application and logs of wells and borings on the site, this layer was assumed to have a constant average thickness of 38 feet and therefore the elevation of the bottom of this layer was determined by subtracting this value from the top elevation at each model grid cell.

Based upon information in the application and other site studies, the hydraulic conductivity of Layer 3 was modeled using a value representative of the clay from the Kettering Source of or 1 x 10^{-6} cm/sec (0.003 ft/day). This value is at the upper (more permeable) end of the range of 1 x 10^{-7} to 1 x 10^{-6} cm/sec for the upper confining clay based upon laboratory testing of core samples of the deep lacustrine clays in the Glenns Ferry Formation[7].

3.3.1.4 Layer 4: Lower Aquifer

Layer 4 in the model represents the Lower Aquifer. Based upon the sections in Figures 6 and 7 of the Siting Application and logs of wells and borings on the site, this layer was assumed to have a constant average thickness of 30 feet and therefore the elevation of the bottom of this layer was determined by subtracting this value from the top elevation at each model grid cell.

Based upon information in the application and other site studies, the hydraulic conductivity of Layer 3 was modeled using a value representative of a clayey to sandy silt of 0.1 ft/day (4 x 10^{-5} cm/sec). This is a generalization of the value of 0.29 ft/day for the hydraulic conductivity of the Lower Aquifer. Recent tests of the new Lower Aquifer wells show that the average hydraulic conductivity is lower than the value in the permit and hence the value used in the model is reasonable.

3.3.1.5 Layer 5: Artesian Aquifer Confining Layer

Layer 5 in the model represents the upper portion of the over 2000 feet of clay and shale that overly the deep artesian basalt aquifer. The bottom of Layer 5 was set an arbitrary constant elevation of 2,100 feet. The hydraulic conductivity of this layer was set to the same value of 1 x 10^{-6} cm/sec (0.003 ft/day) used for the upper confining clay.

3.3.2 Boundary Conditions

All model boundary conditions assumed steady state (time-invariant) to represent the conditions of dynamic equilibrium between recharge and discharge to the modeled system. Boundary conditions were specified to define inflow and outflow at the model boundaries as well as to represent the hydraulic connection between the system and Castle and Catherine Creeks.

3.3.2.1 Castle and Catherine Creeks

Because site studies concluded that these creeks are the source of recharge to the Upper and Lower Aquifer, they were included in the model to see if such a conclusion was reasonable. Both creeks were modeled using a River boundary condition that requires the specification of the elevation of the water surface in the creeks, the elevation of the streambed, and a hydraulic conductance per unit area of bottom sediments in the creeks. The cells representing the creeks were assigned by interpolating the locations digitized from the U.S. G.S topographic maps to the nearest grid cell. The elevations of the water surface were assigned to be the land surface elevation for the cells representing the creek, and the streambed elevation was assigned as being one (1) foot lower. The conductance of the streambed was assigned a value of 10 ft/day to represent a high degree of hydraulic connection.

3.3.2.2 Lateral Boundaries

Based upon an evaluation of the general topography, the northwest and southeast model boundaries extending approximately one mile from the respective corners of the model were assigned a no-flow boundary condition in Layers 2, 3, and 4 to model regional groundwater flow paths. The entire lateral boundaries of Layer 1(Bruneau) and Layer 5 (Lower Confining Clay) were modeled as no flow boundaries.

To model regional flow into the model across the southern half analysis boundary a General Head Boundary (GHB) was used for layers 2, 3, and 4 with a driving head elevation varying linearly from 2,510 feet at the southwest analysis corner to 2,590 feet at the southeast analysis corner and a conductance of 0.01ft/day.

To model regional flow out of the model that discharges to the north and east analysis boundaries, a General Head Boundary was used for layers 2,3, and 4 with a driving head equal to the average elevation of the Snake River from the U.S.G.S. topographic maps and a conductance of 0.01 ft/day. The conductance value was reduced from an initial value of 0.1 to achieve a reasonable match between modeled and measured water level contours at the site as discussed below.

3.3.3 Sources and Sinks

As discussed above, previous studies have concluded that there is no measureable recharge from precipitation at the site - ET exceeds precipitation by 7 times. Consequently, for the analysis used to simulate present and expected future conditions a recharge rate of zero was assigned to the entire top of the model (land surface).

Simulation of the potential discharge from springs that may form in the case that the modeled watertable rises to intersect the land surface is accomplished using a Drain boundary condition assigned to the top surface of the model. Based upon site studies U.S.G.S topographic maps, there are no springs that emanate from the modeled units within the modeled area. Consequently for modeling present and expected future conditions no drain boundaries were modeled. However, as discussed subsequently, this condition was used to assess the potential for springs to develop under the hypothetical extreme climatic change analysis used to force water levels to rise into Layer 1 of the model beneath the site.

Although there are wells that apparently pump from the modeled units within the analysis boundary, they are all located west of Castle Creek and therefore the River boundary condition used for the creek would preclude any modeled effects of pumping from these wells on modeled heads east of Castle Creek. Consequently no wells were included in the model.

3.3.4 Comparison of Modeled and Measured Water Levels

To assess the reasonableness of the numerical model contours of modeled water levels were compared to those in Figures 4 and 5 of the Siting Application. Figures 7 and 8 show this comparison and the areas where the model shows the Upper Aquifer to be unsaturated. The only model parameter adjusted to achieve this degree of fit was the conductance of the General Head Boundary used to represent the discharge to north and east portions of the model boundary (eventual discharge to the Snake River alluvium). Based upon professional judgment and over 40 years of applying groundwater flow models, this fit is acceptable for the purposes of using the model to understand the flow system and to test the conclusion stated above regarding the limiting effect on rising water levels provided by the permeable materials lying above the Upper Aquifer.

3.3.5 Model Analyses of Rising Water Levels

Because the model reasonably well reproduces observed water levels in the Upper and Lower Aquifers and the portion of the Upper Aquifer that is unsaturated, it comprises a reasonable tool to evaluate the consequences of rising water levels at the site. In particular it was used to evaluate the effect that the higher permeability materials of the Bruneau Formation have in serving to drain water to the north and east and therefore to prevent water levels from rising more than a few feet above the current top of the zone of saturation.

As has been documented by other studies[6,7] and described elsewhere in this report, the arid climate and thick vadose zone preclude recharge from infiltration of precipitation. However, to force water levels to rise into the upper part of the Upper Aquifer and the overlying Bruneau Formation, a hypothetical recharge rate of four inches per year was applied to the entire model analysis area. This rate is hypothetical but would correspond to an average annual precipitation of greater than 40 inches per year based upon a commonly used recharge rate of 10% of this rate in temperate areas of the U.S.

Figure 7 and 8 show the modeled increases in water levels and the changes on flow patterns that resulted from application of the hypothetical increased recharge. The modeled recharge applied to the analysis area causes water levels to rise under the topographically high areas east of Castle Creek, including under the site. These rises are sufficient to saturate the Upper Aquifer beneath all of these areas. However, as shown in Figure 8, the high permeability materials of the Bruneau Formation limit the rise to a few feet into this unit.

3.3.6 Conclusions from model construction and analyses

A representative quantitative model has been constructed using site specific information that has been developed from over 20 years of investigations and measurements at the site. The model incorporates the geometry and hydraulic properties of the five hydrostratigraphic units occurring below the site. The model includes recharge from Castle and Catherine Creeks and accounts for regional inflow from the south and west and for regional outflow to the north and east that eventually discharges to the alluvium of the Snake River.

The agreement between modeled water levels and gradients and those interpreted by hand from water level measurements in wells screened in both the Upper and Lower Aquifer is adequate to have confidence that the model is a reasonable representation of the hydrogeologic conditions beneath and in the vicinity of the site.

The model was used to clearly demonstrate that even under the hypothetical climate change conditions evaluated with the groundwater model that the recharge of 4 inches per year from this hypothetical and extremely unlikely condition is not sufficient to reverse the gradient and produce flow from the site towards any reach of Castle Creek. Furthermore this analysis shows that there is no potential to develop new surface water discharge to the north and east of the site because the high permeability of the materials occurring above the Upper Aquifer drain any water that rises into them and precludes the watertable from rising to the land surface, even in topographically low areas.

4 Assessment of the Site B RESRAD Model

USEI currently uses a RESRAD model to assess the potential dose from materials that are proposed to be disposed at Site B. The current RESRAD model for the site uses site-specific parameters to characterize the vadose and saturated zones that were developed and documented by Eagle Resources in 2005[20]. The site-specific parameters were developed using the same studies and reports cited in the present report regarding the degree of protection afforded by the thick vadose zone and the arid climate[6,15].

The saturated zone included in the site-specific RESRAD model corresponds to the Upper Aquifer discussed in this report. The site RESRAD model simulated the adjective (non-dispersion or ND) mode that assumes that the intruder water supply well is located at the down-gradient edge of the waste disposal facility.

RESRAD is a screening model that uses bounding conditions to define transport pathways, including flow in the saturated zone to the intruder well. As such, RESRAD does not explicitly simulate the regional effects of recharge from Castle Creek and discharge to the north and east. RESRAD also assumes that the lithologic unit comprising the saturated zone is horizontal and uniform in thickness. One of the purposes of constructing and applying the three-dimensional model described in Section 3.3 of this report was to assess the combined effects of the regional recharge and discharge with the

[20] Eagle Resources, April 2005: Site-Specific RESRAD Water Pathway Parameters for the Contaminated Soil, Vadose Zone, and Saturated Zone, US Ecology Grand View Idaho.

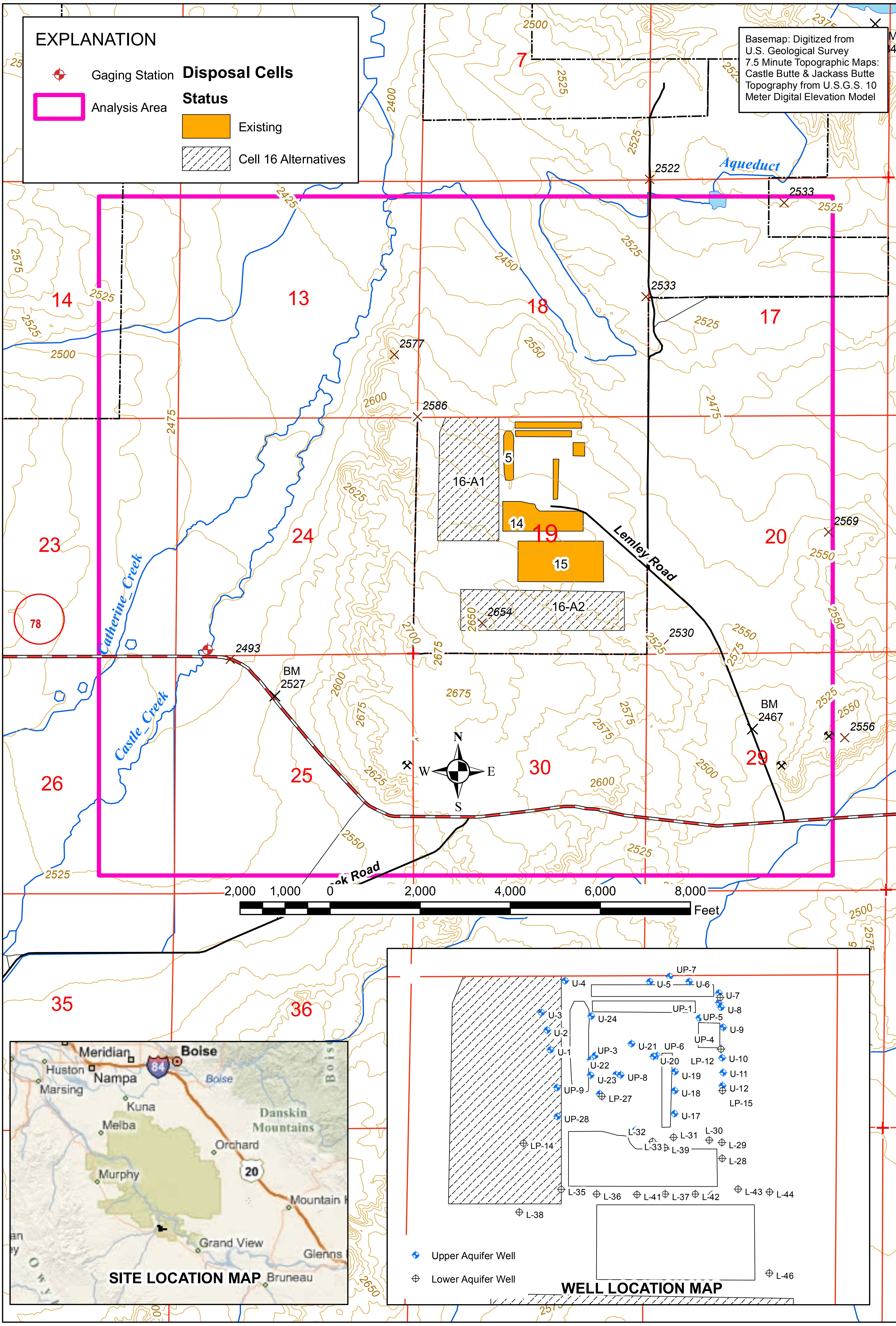
known dip to the northeast of the hydrostratigraphic unit that includes the Upper Aquifer as well as the units that correspond to the Lower Aquifer and the confining unit that separates the Upper and Lower Aquifers.

The hydraulic gradient used in the RESRAD model to compute the rate at which water would migrate from below the waste zones to the intruder well located at the edge of the disposal site was 0.011. The computed hydraulic gradient across Site B with the three-dimensional model discussed in Section 3.3 of this report was 0.012. The agreement between these values of the hydraulic gradient shows that the RESRAD model correctly incorporates the effects of regional discharge and discharge across the site.

The value of hydraulic conductivity of the Upper Aquifer for the model described in Section 3.3 was 1 ft/day. The hydraulic conductivity used in the RESRAD well intruder scenario to compute the advective flow in the saturated zone to the well was 25 meters/year (0.23 ft/day). The lower hydraulic conductivity used by the RESRAD model is conservative (more protective) because it results in a smaller volumetric rate of clean water entering the intruder well from that portion of the well's cone of depression that is outside the site boundary than would be the case using the value used for the model described in Section 3.3 of this report. This results in a higher computed dose from the intruder well with the parameters used in the RESRAD model than would be the case if the value of 1 ft/day from the current model were used.

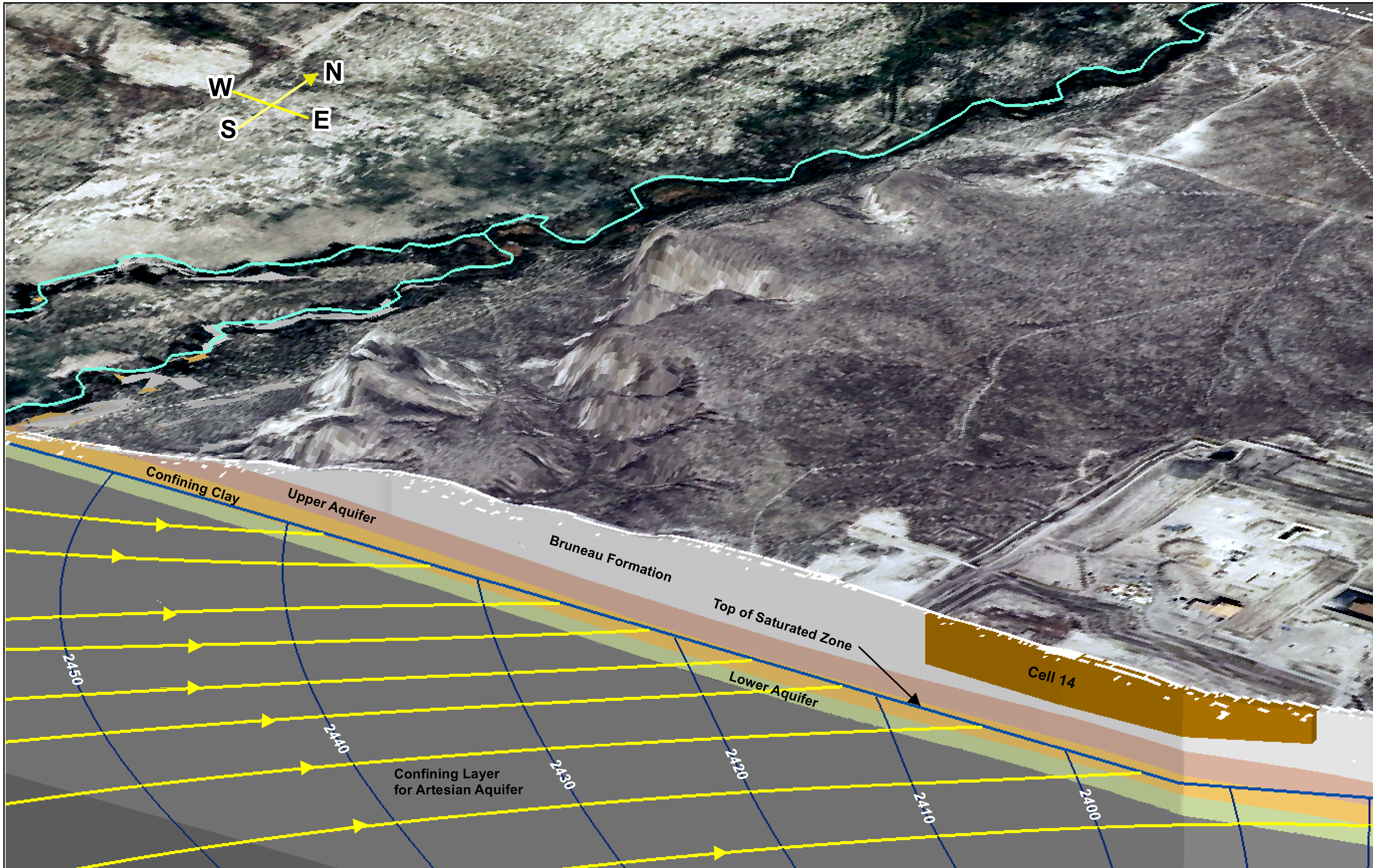
In conclusion, the analyses presented in this report are consistent with the assumptions and parameters used in the Site B RESRAD model for the water pathway involving the intruder well scenario. The RESRAD model correctly represents the regional hydraulic gradient across the site, and the hydraulic conductivity used results in a conservative higher dose from the water pathway than would be the case if the value used in the model developed for this report had been used.

5 APPENDIX A: Figures



Eagle Resources 4005 Lake Springs Court Raleigh, NC 27613 919.345.1013 www.eagleresources.com	US Ecology Idaho	Project No. 20019.1 Approved: EGL Date: 12/17/09	**Summary of Hydrogeologic Conditions and Groundwater Flow Model** **Location and Site Features of the USEI Facility**

Figure 1



Basemap: National Agricultural Inventory Program 2009 Orthophoto

Vertical Exaggeragion: 2.5X

EXPLANATION

Contour on Surface of Zone of Saturation
Under Present and Expected Future Conditions;
Contours on Top of Saturation Zone (Elevation Datum: NAVD88);
and Directions of Groundwater Flow.

Eagle Resources
4005 Lake Springs Court
Raleigh, NC 27613
919.345.1013
www.eagleresources.com

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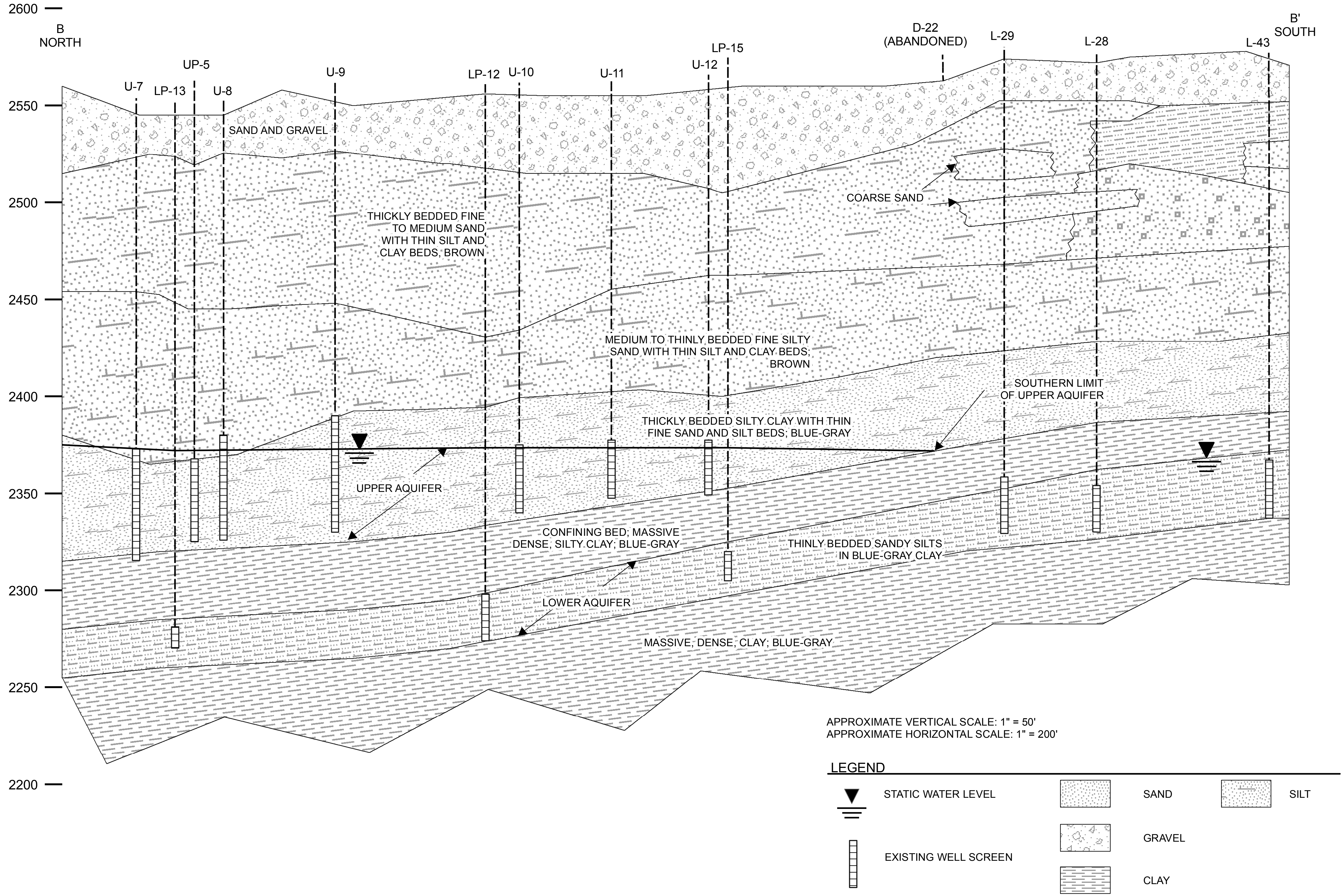
Date

Summary of Hydrogeologic Conditions and Groundwater Flow Model

Three-dimensional section through the USEI site showing hydrostratigraphic units and present and expected future water level conditions.

Figure 2



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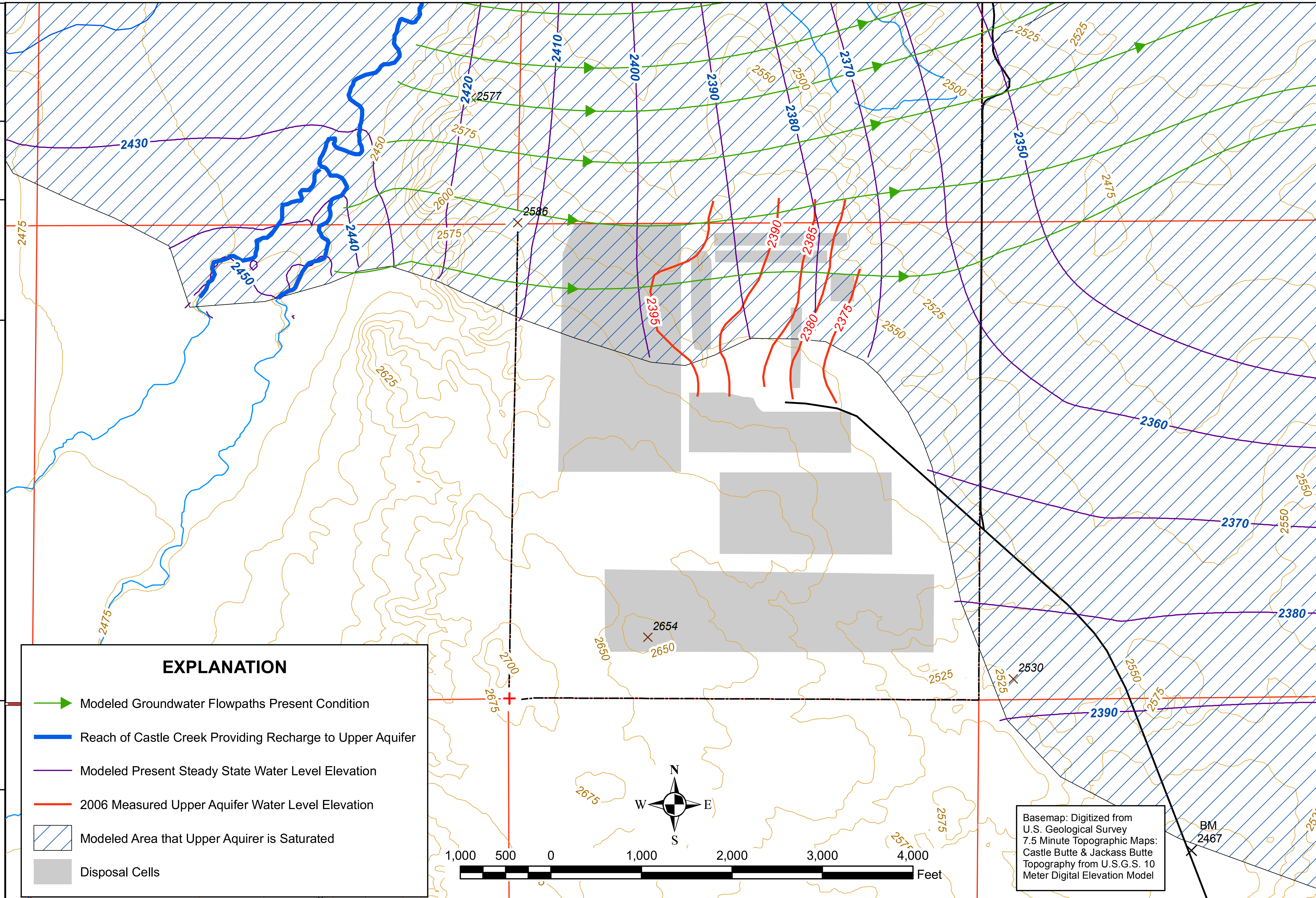
Summary of Hydrogeologic Conditions and Groundwater Flow Model

North-South Geological Section - East Side of Section 19. (From Figure 7 in Siting Application) Original Prepared by Feast Geosciences,

Figure 3



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Raleigh, NC 27613
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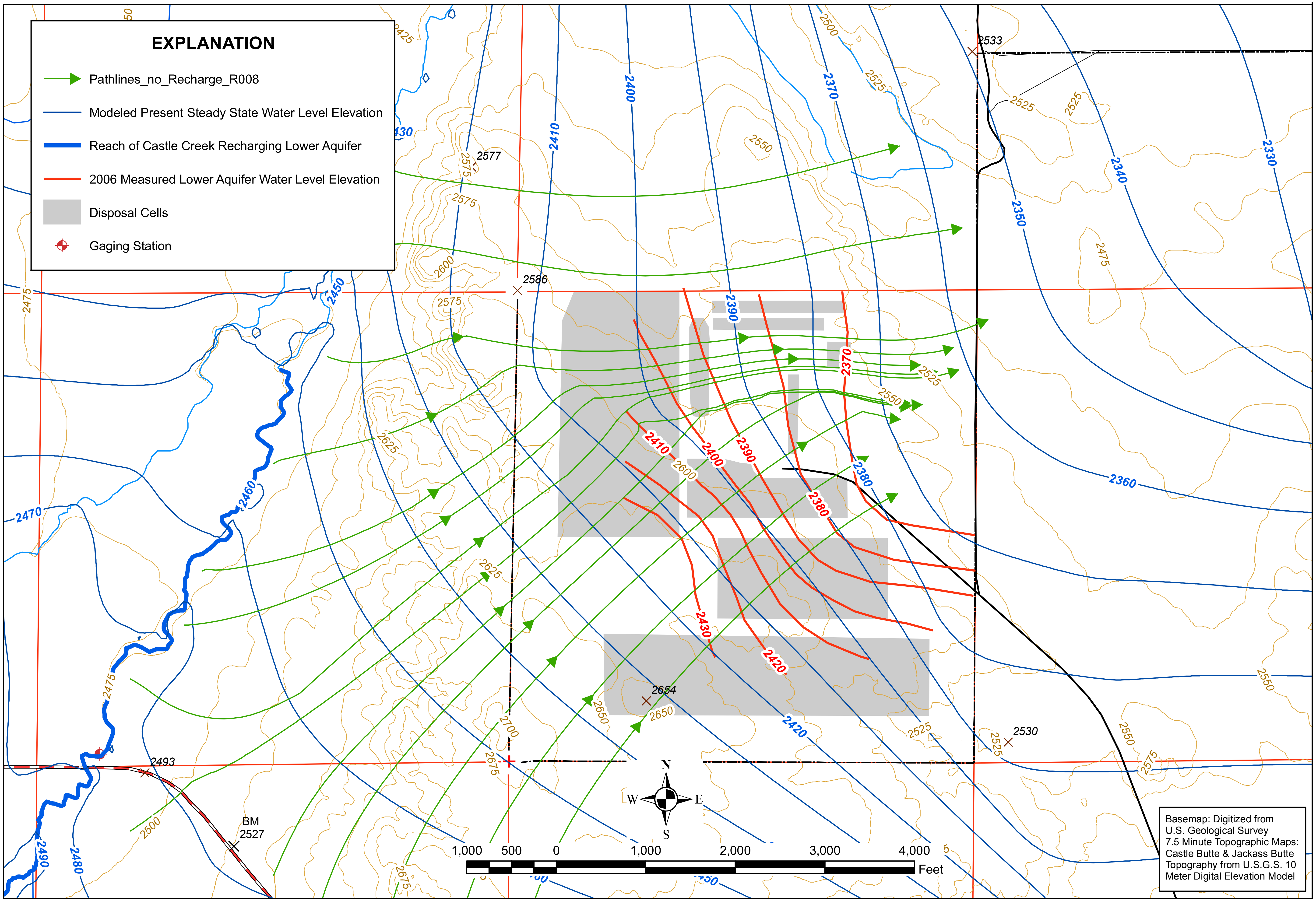
Summary of Hydrogeologic Conditions and Groundwater Flow Model

Plan view of hydrogeologic conditions in the Upper Aquifer under present and expected future conditions.

Figure 4



Eagle Resources
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Raleigh, NC 27613
919.345.1013
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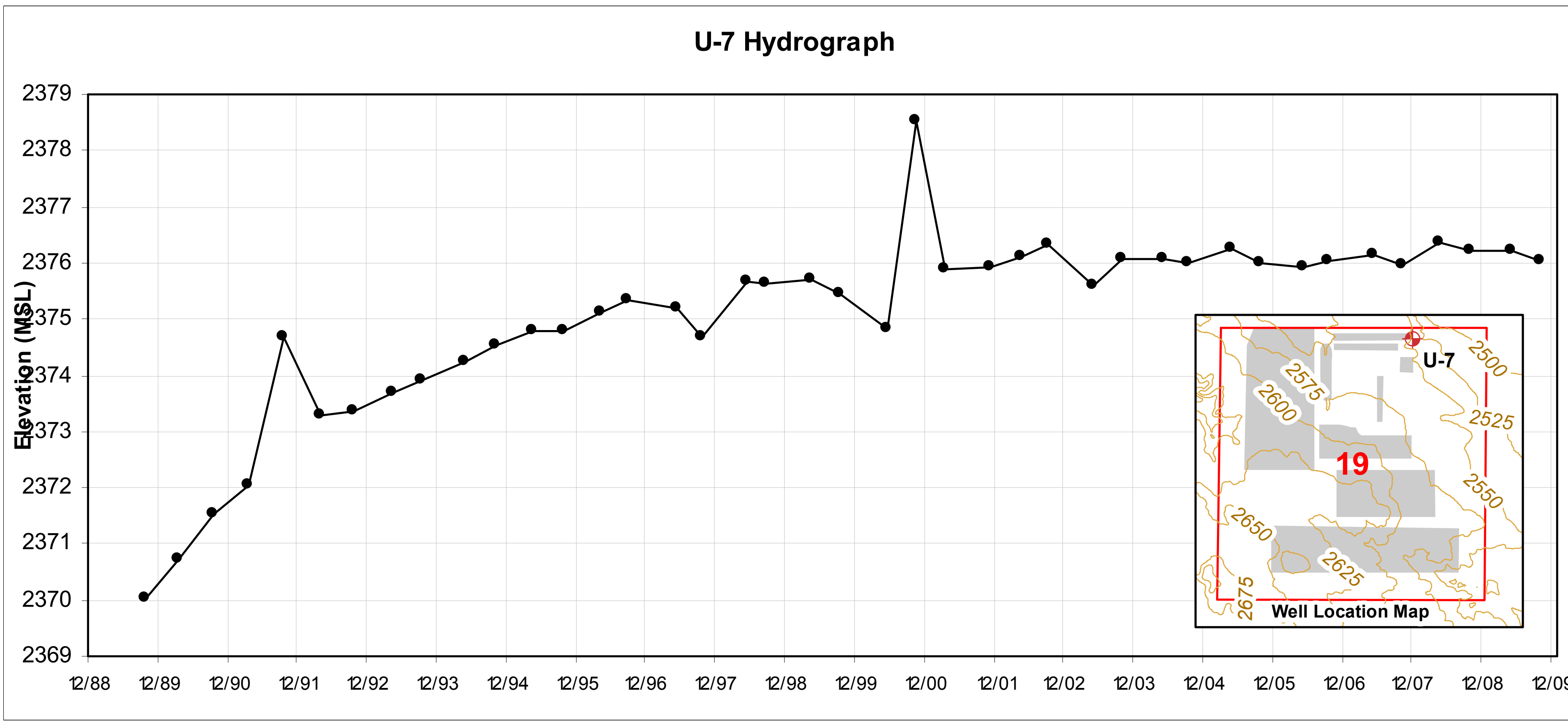
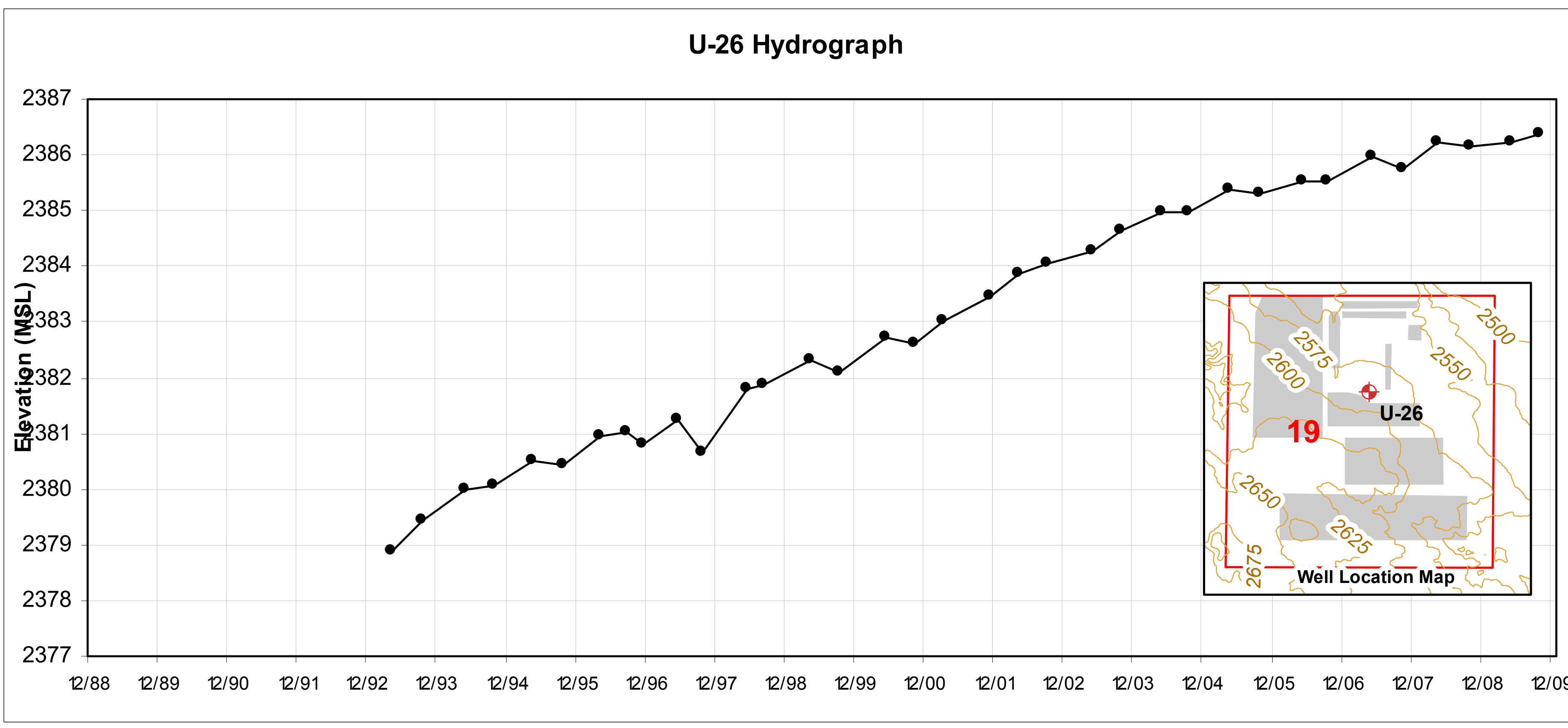
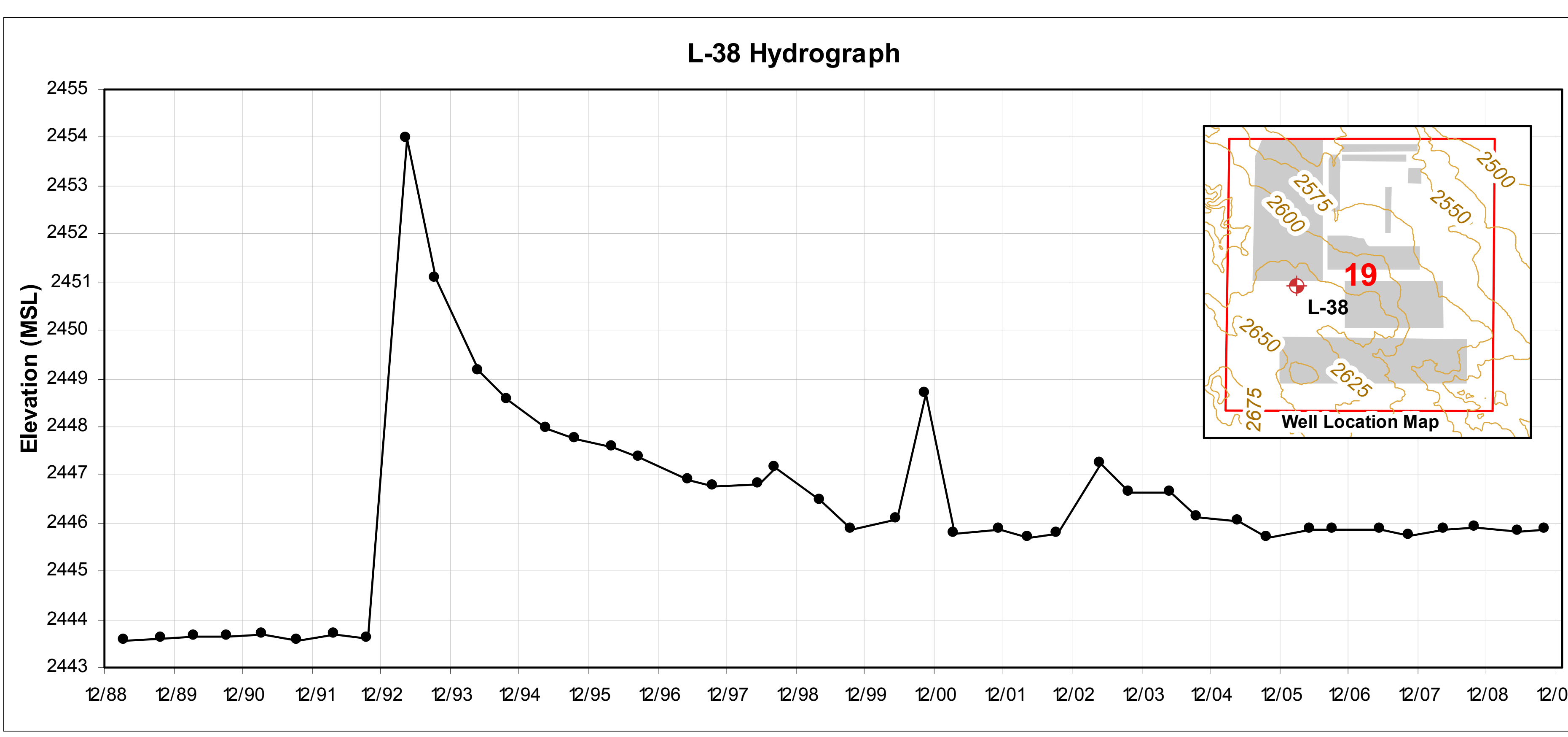
Summary of Hydrogeologic Conditions and Groundwater Flow Model

Plan view of hydrogeologic conditions in the Lower Aquifer under present and expected future conditions.

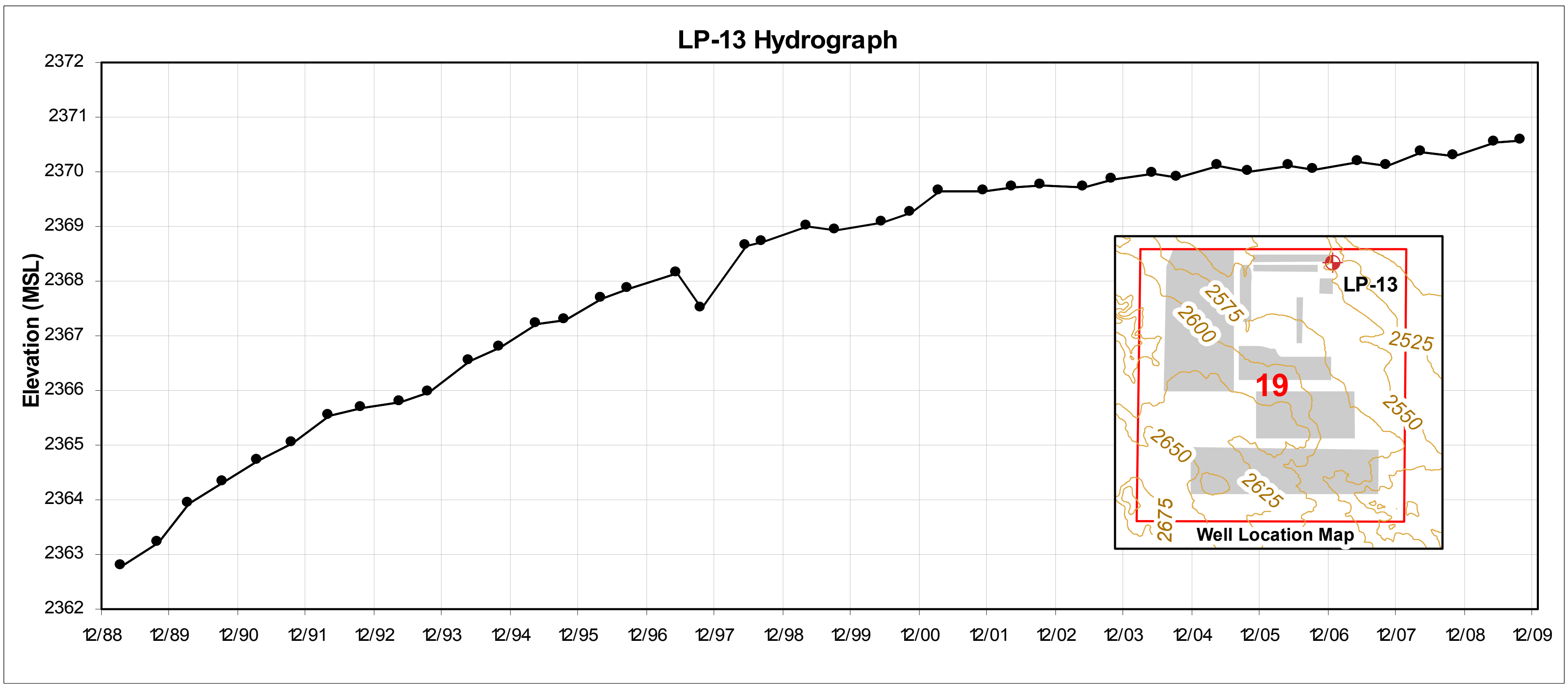
Figure 5

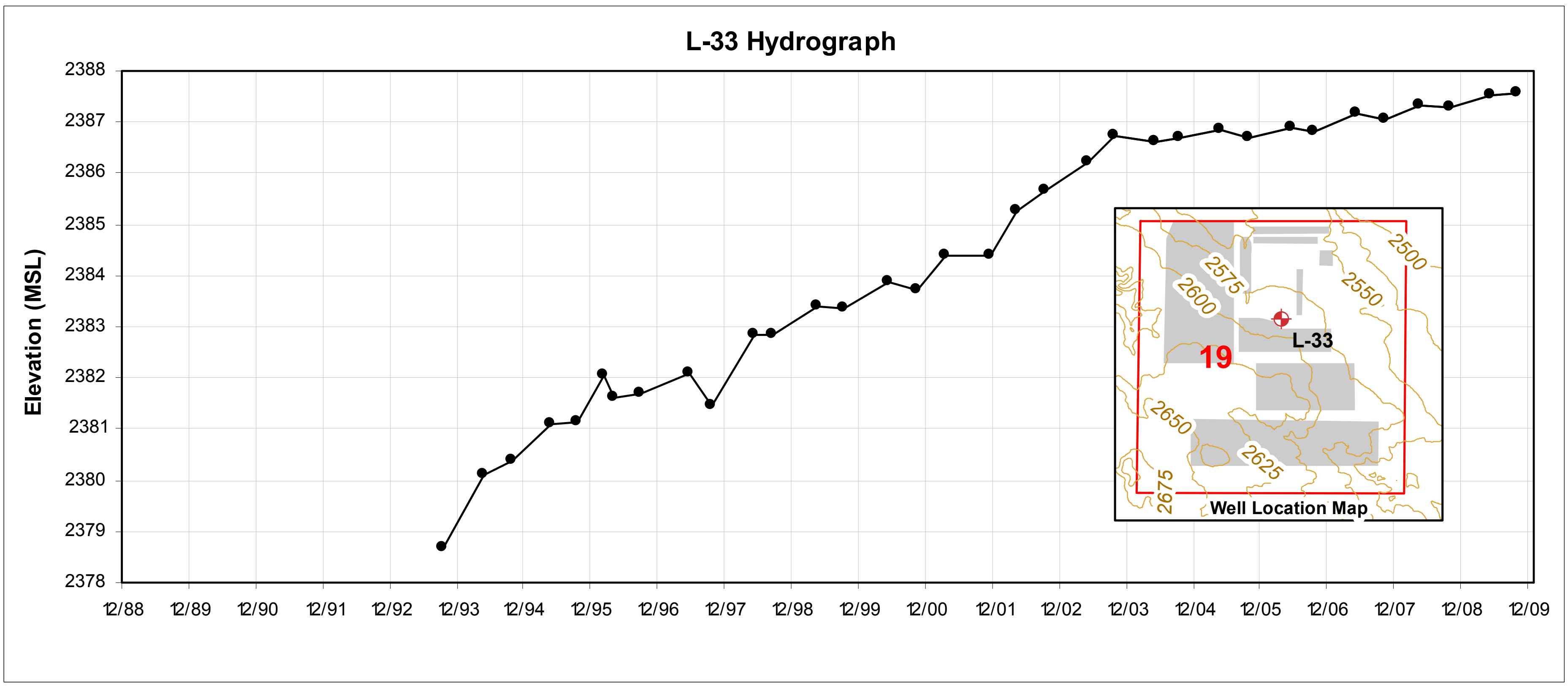




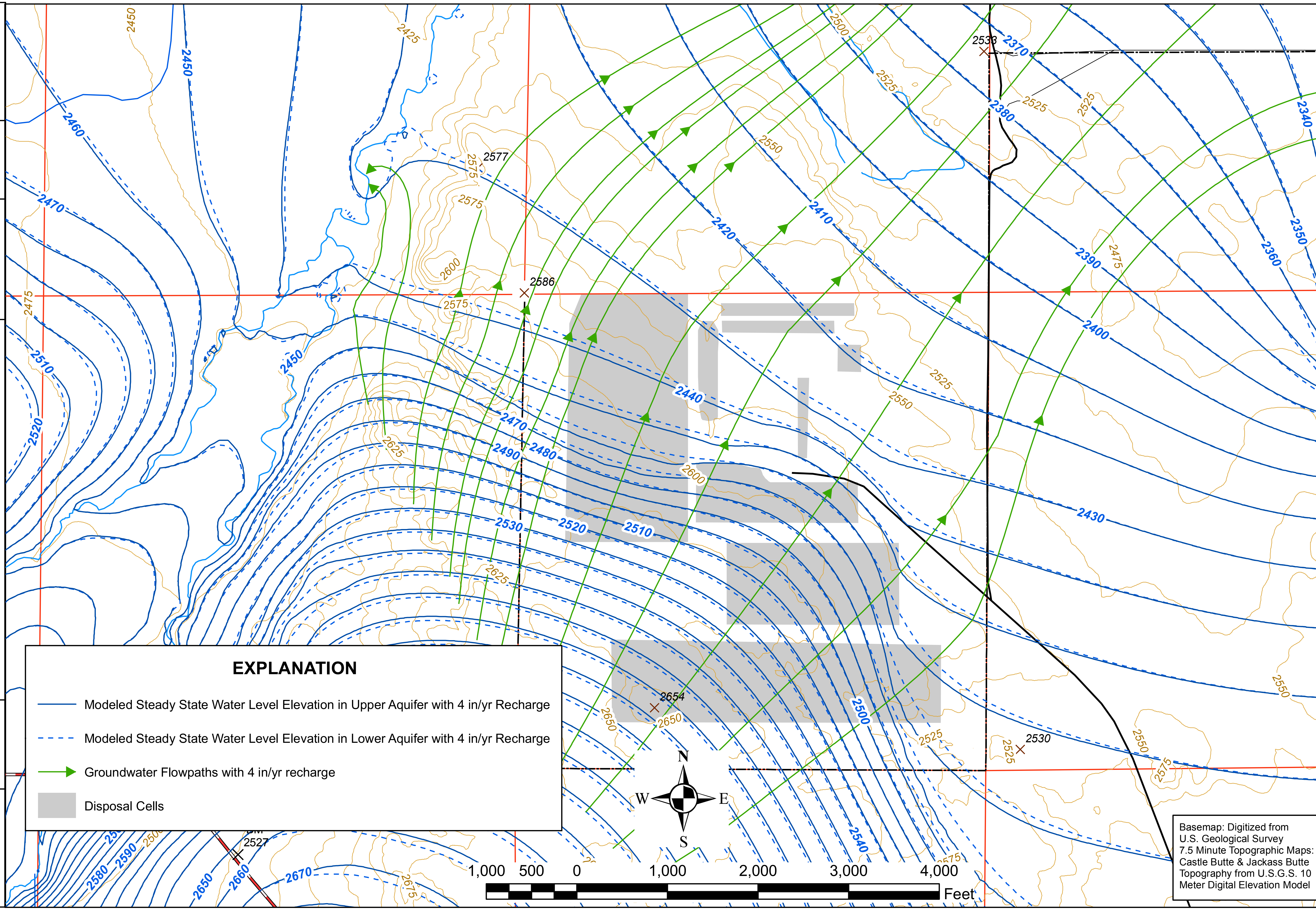


Eagle Resources 4005 Lake Springs Court Raleigh, NC 27613 919.345.1013 www.eagleresources.com	US Ecology Idaho	Project No. 20019.1 Approved: EGL Date: 12/17/09	Summary of Hydrogeologic Conditions and Groundwater Flow Model Example Hydrographs of Water Level Elevation in Upper and Lower Aquifer Wells.	Figure 6





Eagle Resources 4005 Lake Springs Court Raleigh, NC 27613 919.345.1013 www.eagleresources.com	US Ecology Idaho	Project No. 20019.1 Approved: EGL Date: 12/17/09	**Summary of Hydrogeologic Conditions and Groundwater Flow Model** **Example Hydrographs of Water Level Elevation in Upper and Lower Aquifer Wells.**	**Figure** **6a**



Eagle Resources
4005 Lake Springs Court
Raleigh, NC 27613
919.345.1013
www.eagleresources.com

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Approved

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Summary of Hydrogeologic Conditions and Groundwater Flow Model

Plan view of hypothetical hydrogeologic conditions in the Upper and Lower Aquifers in the event of a climate change producing annual precipitation of 40 inches and a regional recharge rate of 4 inches per year.

Figure 7

Eagle Resources
4005 Lake Springs Court
Raleigh, NC 27613
919.345.1013
www.eagleresources.com

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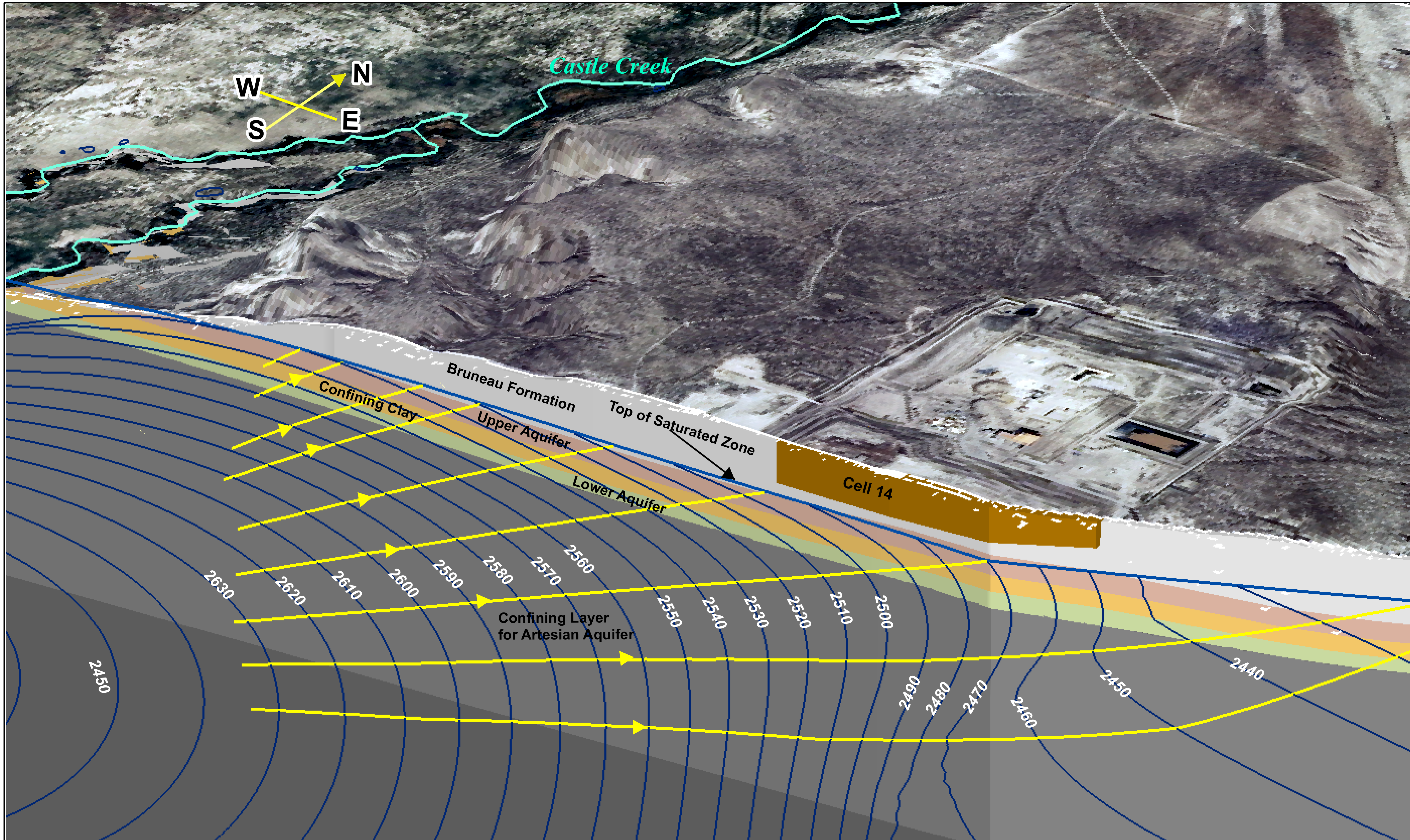
Summary of Hydrogeologic Conditions and Groundwater Flow Model

Three-dimensional section through the USEI Site showing hydrostratigraphic units and water levels resulting from a climate change that produces annual precipitation of 40 inches/year.



Basemap: National Agricultural Inventory Program 2009 Orthophoto

Vertical Exaggeragion: 2.5X

EXPLANATION

Contour on Surface of Zone of Saturation Under Present and Expected Future Conditions; Contours on Top of Saturation Zone (Elevation Datum: NAVD88); and Directions of Groundwater Flow.

Figure 8

6 APPENDIX B: Response to CCI Issues

The following presents our response to the seven (7) issues that Mr. Gililan as the commenter for CCI raises to the WEC application.

Issue 1: *Contrary to the stated conclusion in the application, the applicant conclusively demonstrates that there is a direct hydrologic connection between Castle Creek and all the underlying aquifers at Site B, which is typically the opposite conclusion one hopes to arrive at with regard to hazardous waste storage sites.*

RESPONSE:
The author's statement that it is necessary to have no connection between surface water and groundwater is not a requirement for a site to be protective. In the case such as is with the USEI site, when surface water serves as a recharge source rather than a discharge source, such connection needs to be understood, but is not a restriction on site protectiveness. Site studies and the modeling analysis presented in this response show that Castle Creek is the up-gradient recharge source for the groundwater beneath the site. Groundwater flow directions in both aquifers are away from Castle Creek to the east and northeast and not toward it as the author seems to imply by the oft repeated concern that the groundwater and surface water systems are connected.

Even under the hypothetical climate change conditions evaluated with the groundwater model Castle Creek continues to be a recharge source to the Upper and Lower Aquifers. The modeled recharge of 4 inches per year from this hypothetical and extremely unlikely condition is not sufficient to reverse the gradient and produce flow from the site towards any reach of Castle Creek.

Furthermore this analysis shows that there is no potential to develop new surface water discharge to the north and east of the site because the high permeability of the materials occurring above the Upper Aquifer drain any water that rises into them and precludes the watertable from rising to the land surface, even in topographically low areas.

Issue 2: *The applicant's study indicates that the local hydraulic head associated with the underlying artesian aquifer is significant and geologically impressive while simultaneously documenting through site well data that the area groundwater table is rising. In ideal storage siting, the applicant typically wants to demonstrate a very deep below ground, static and or receding groundwater table. The applicant has documented the opposite condition*.

RESPONSE:
The presence of a deep artesian basalt aquifer beneath the site Basalt is a statement of fact and the Application includes the log of the properly abandoned and sealed well on site that was completed in this aquifer. We are not aware of any statements in the Application or other reports on site hydrogeologic conditions that conclude that there is any effect either by the artesian aquifer on the units above its confining unit or any

potential effect on this aquifer that is or could be imposed by the units above its confining layer.

The wording in Mr. Gililan's comment implies that the artesian aquifer is somehow the source of groundwater in the Upper and Lower Aquifer and consequently the cause of the rising water levels at the site. The 1999 Rising Groundwater Study concluded that there was no indication of leakage from the deep artesian aquifer via either the confining bed or the well bore. Sections 2.3 and 3.2 of this report discuss the potential causes for rising water levels and as clearly demonstrated in Section 3.1 of this response, the shorter term fluctuations in water levels in wells near Cell 15 are adequately explained by variations in loading at the surface during cell construction, filling, and completion.

We are not aware of state or federal requirements for site suitability that require demonstration of deep and or receding watertable conditions.

Issue 3: *The applicant's analysis largely considers the risk of downward contaminant leakage to the underlying Upper and Lower Aquifers which are connected to Castle Creek. However, given the documented groundwater rise, the more likely pathway for contaminants leaving the site is through dispersal in a saturated near surface water table which also includes and permits significant lateral contaminant movement.*

RESPONSE:
It is true that previous studies by CH2M Hill and Eagle Resources[4,6,7,8] have shown that not only is there no discernable recharge from precipitation due to the arid climate and thickness of the vadose zone. These studies have also demonstrated that a release of water from extreme precipitation events that might collect in uncompleted cells and be released via a total liner failure would be retained in the vadose zone and not recharge the Upper Aquifer. The CH2M Hill Study used three-dimensional unsaturated transport computer simulations that used extreme, hypothetical releases of water to try to get something to reach the groundwater. After 10,000 simulated years the release faded into background soil moisture levels and effectively stopped moving.

Quantitative analysis with the model presented in this report demonstrate that if, water levels rise into the increasingly permeable materials in the upper part of the Upper Aquifer that they will conduct such water to the north and east. This limiting condition on water levels is functional even under hypothetical conditions of extreme climatic change that would permanently increase rainfall at the site sufficient to increase recharge from zero to 4 inches per year. These analyses demonstrate that there is no potential for new surface water discharge to springs and seeps by a rising water table around the site and along groundwater flow paths to the north and east.

Issue 4: *The applicant's data and analysis suggests a highly unusual and dynamic relationship between surface ground pressure at Site B and the underlying aquifers such that simple excavation of trenches and stockpiling overburden on the site dramatically and rapidly alters the elevation of the underlying groundwater.*

RESPONSE:
See Section 3.1 of this response document and responses to Issues 1, 2, and 3. Furthermore, the rise in the potentiometric surface at well L-38 in 1992 was in direct response to the geologically sudden increase in surface loading as the spoils from the excavation of trench 14 were stockpiled adjacent to this well. For the next 10 years water levels slowly recovered (declined) as the aquifer reached a new equilibrium with this loading. In 2002 additional spoils were moved into the area causing another small increase with a commensurate gradual decline for about 3 years. Since 2005 water levels in this well have been approximately constant. Other Lower Aquifer wells in the vicinity of Cells 14 and 15 also show rapid water level variations apparently related stockpiling and moving of spoils and the excavating and filling of trenches. Lower Aquifer wells more distant from the construction activity do not show these variations. The author should review the concept of hydraulic soil loading and effective stress on confined aquifer systems.

Issue 5: *The applicant clearly states that well log data analysis from UP-28 and U-29 indicate anomalies in expected potentiometric surfaces based on other well data onsite, and that these anomalies can be explained by upward leakage from the Lower Aquifer to the Upper Aquifer.*

RESPONSE:
The water levels in these two wells are not consistent with the expected water level for Upper Aquifer wells. During construction the boreholes at both wells were advanced into the Lower Aquifer to allow borehole geophysics to be used to positively identify the top of the Lower Aquifer and bottom of the Upper Aquifer. After logging the bottom portion of the boreholes were plugged back with bentonite grout. There are three possibilities for the higher than expected water levels in these wells: the water levels are real and reflect a recharge pathway or higher transmissivity zone in the Upper Aquifer; the water levels are an indication that the bottom seal in the borehole was not complete or sufficient to prevent the higher heads in the Lower Aquifer from dominating the water levels in the wells; or there is significant leakage of water through the confining bed at this location. The geologic and geophysical logs for these wells indicate the confining bed is present, intact, and similar to the confining bed encountered beneath the site at other wells. Consequently the most likely cause of these high water levels is leakage up the well bore or lateral movement of water from recharge areas at higher elevations along Castle Creek. Regardless of the cause of these water levels they have no affect on the groundwater monitoring at the Site.

Issue 6: *Based on the applicant's acknowledgment of complex site stratigraphy, communication between the Upper, Lower, Artesian, and Castle Creek shallow alluvial aquifer, and that time trends on this data show rapidly changing conditions, discussions concerning groundwater flux and velocity can be considered no more than speculative exercises.*

RESPONSE:

The author needs to read and study the many reports issued on the hydrogeology of Site B. There are no data that suggest the deep regional geothermal artesian aquifer is affecting or communicating with the upper or Lower Aquifers at Site B. The 1999 Rising Groundwater report addressed this issue directly and concluded there was no evidence from head, temperature or chemistry that the artesian well, plugged in 1985, on site was leaking. This conclusion has been confirmed by water level, temperature and chemistry data collected in the 20 years since the 1999 report was issued.

The "rapidly" changing conditions referenced by the author are apparently directed at the water level response in several of the Lower Aquifer wells across the southern portion of the site. These pressure heads in these wells, notably wells L-38 and LP-14, reacted to rapidly changing surface loads as cells 14 and 15 were excavated, the spoils stock piled and the cells backfilled up to and above original grade. With the exception of the Upper Aquifer across the northern portion of the site the groundwater systems at Site B have very low permeability, are internally complexly inter-bedded with thin, laterally discontinuous beds and lamina of fine sands, silts and clay and are therefore too sluggish or "hydraulically retarded" to have the "rapidly changing" conditions the author cites in his concern. With the exception of the few Lower Aquifer wells mentioned above, water levels while rising gradually have maintained inter-well and inter-aquifer gradients and consequently flow directions have been remarkably consistent over the 25 years the site has been monitored.

Groundwater flux evaluations were presented during the site characterization process as a way to account for water movement through the subsurface at Site B. Certain simplifying and generalizations assumptions are required because of the natural variation in aquifer properties, variations in head and head relationships within and between geologic units. A vertical flux from the Upper Aquifer into the Lower Aquifer across the northern portion of the site was addressed because the fundamental law addressing groundwater flow, Darcy's Law, mathematically does not allow "no" flow when there is permeability and a gradient. In actuality there are recognized lower limits of flux in natural systems and while Darcy's Law indicates the potential for flux between the aquifers, water chemistry separation between the upper and Lower Aquifers indicates any flux, if occurring, is minimal.

Issue 7*: The applicant clearly states a significant trend in groundwater rise beneath the site that is not related to any measurable change in the contributing areas precipitation or surface distribution of water related to agriculture or water storage facilities. Therefore, the observed rise in water table has to be related to a change in conditions in the overall hydrogeographic watershed.*

RESPOSE:
The use of the term ".. hydrogeographic watershed.." illustrates that at best Mr. Gillian's familiarity is with the elements of surface water hydrology which are defined by topographic basins or watersheds. There is no definition of hydrogeographic in any of the hydrogeologic literature. In fact, it is at best misleading because hydrogeologic units are defined by the presence and interconnection of hydrostratigraphic units, or subsurface features that exhibit similar hydraulic properties over connected zones or regions.

The analyses in this report show that there are reasonable and supportable explanations for the water level rises and further more that geometry and permeability of the sands that occur in the upper part of and above the Upper Aquifer place limits on future rises. This limiting function of these permeable materials on water level rises has been further demonstrated for a hypothetical and extremely unlikely condition that would increase recharge to the Upper Aquifer from zero to four (4) inches per year.