APPENDIX B

HYDROGEOLOGY OF THE PERCHED GROUNDWATER ZONE AND ASSOCIATED SEEPS AND SPRINGS NEAR THE WHITE MESA URANIUM MILL

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BLANDING, UTAH

November 12, 2010

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1. INTRODUCTION

In response to Part I.H, Section 10 of the Utah Department of Environmental Quality (UDEQ) Ground Water Quality Discharge Permit UGW370004 (the "Permit), this report discusses the hydrogeology of seeps and springs at the margins of White Mesa in the vicinity of the White Mesa Uranium Mill, (the 'Mill' or the 'site') located south of Blanding, Utah, and the relationship of these seeps and springs to the hydrogeology of the site, in particular to the occurrence of a relatively shallow perched groundwater zone beneath the site. The addition of requirements at Part I.H.10 of the Permit is motivated by the construction of an additional tailing cell (Cell 4B). Figure 1A shows the location of Cell 4B (now under construction) and seeps and springs near the site. Figure 1B is a detail map showing the locations of perched monitoring wells at the site.

Specifically, UDEQ requests the following in Part I.H.10 of the Permit:

a. "additional field investigations to confirm elevation survey data for springs and seeps at the margin of White Mesa, including, but not limited to, Cottonwood Seep and/or Westwater Seep and Ruin Spring. The purpose of such studies will be to determine representative elevation of shallow groundwater and the upper geologic contact of the Brushy Basin Member of the Morrison Formation at these seeps and springs";

b. "written explanation and resolution of final survey data for seeps and Ruin Spring and shall use appropriate data points to construct a representative Bushy Basin/Burro Canyon geologic contact/surface map of White Mesa that includes, but is not limited to, areas west and southwest of the tailings management cell areas, including Cell 4B. The geologic contact surface map shall include data from all nearby monitoring wells, seeps, and springs";

c. A report submitted to the executive secretary for approval "that demonstrates compliance with the requirements described above. Said report shall be signed and certified (stamped) by a Utah Licensed Geologist or Professional Engineer, and shall: 1) resolve apparent uncertainties associated with local geologic structural directions/gradient of the Brushy Basin/Burro Canyon geologic contact of the local perched water system and its relationship to seeps located west and southwest of the tailings management cells and Ruin Spring, 2) identify the closest point(s) of surface discharge of groundwater from the White Mesa perched water system (point of exposure), and 3) estimate travel time for shallow groundwater to reach the nearest surface discharge point(s)."

Section 2 discusses the hydrogeology of the site and provides the framework for the seep and spring field investigation and findings. Section 3 provides the results of field examination of seeps and springs and discusses seep and spring hydrogeology in relation to the perched water system. Section 3.1.1 provides confirmation of seep and spring elevations (Part I.H.10 [a]) measured during surveys in December, 2009 and July, 2010. Section 4 addresses shallow (perched) groundwater elevations in relation to seeps and springs (Part I.H.10 [a] and [b]), Burro Canyon Formation/Brushy Basin Member contact elevations (Part I.H.10 [b]), and closest points of discharge (Part I.H.10 [c] item 2). Contour maps of the Burro Canyon Formation/Brushy Basin Member contact elevations and shallow groundwater elevations presented in Section 4 incorporate seep and spring data where appropriate based on the findings of the investigation. These contour maps (Figures 9 and 10) in conjunction with the findings presented in section 3 essentially "resolve apparent uncertainties associated with local geologic structural directions/gradient of the Brushy Basin/Burro Canyon geologic contact of the local perched water system and its relationship to seeps located west and southwest of the tailings management cells and Ruin Spring" (Part I.H.10 [c] item 1). Section 5 provides estimated times for shallow groundwater to travel from the tailings cells to the nearest discharge points (Part I.H.10 [c] items 2 and 3). For convenience, the above sections within the main body of the report also reference the particular element of Part I.H.10 that is addressed.

2. SITE HYDROGEOLOGY

TITAN (1994) provides a detailed description of site hydrogeology based on information available at that time. A brief summary of site hydrogeology that is based primarily on TITAN (1994), but includes the results of more recent site investigations, is provided below.

2.1 Geologic Setting

The White Mesa Uranium Mill is located within the Blanding Basin of the Colorado Plateau physiographic province. Typical of large portions of the Colorado Plateau province, the rocks underlying the site are relatively undeformed. The average elevation of the site is approximately 5,600 feet above mean sea level (ft amsl).

The site is underlain by unconsolidated alluvium and indurated sedimentary rocks consisting primarily of sandstone and shale. The indurated rocks are relatively flat lying with dips generally less than 3º. The alluvial materials consist mostly of aeolian silts and fine-grained aeolian sands with a thickness varying from a few feet to as much as 25 to 30 feet across the site. The alluvium is underlain by the Dakota Sandstone and Burro Canyon Formation, which are sandstones having a total thickness ranging from approximately 100 to 140 feet. In places, a few feet to as much as about 20 feet of Mancos Shale lies between the alluvium and the Dakota Sandstone.

Beneath the Burro Canyon Formation lies the Morrison Formation, consisting, in descending order, of the Brushy Basin Member, the Westwater Canyon Member, the Recapture Member, and the Salt Wash Member. Figure 2 is a photograph of the contact between the Burro Canyon Formation and the underlying Brushy Basin Member taken from a location along highway 95 immediately north of the Mill. This photograph illustrates the transition from the cliff-forming sandstone of the Burro Canyon Formation to the slope-forming Brushy Basin Member.

The Brushy Basin and Recapture Members of the Morrison Formation, classified as shales, are very fine-grained and have a very low permeability. The Brushy Basin Member is primarily composed of bentonitic mudstones, siltstones, and claystones. The Westwater Canyon and Salt Wash Members also have a low average vertical permeability due to the presence of interbedded shales.

Beneath the Morrison Formation lie the Summerville Formation, an argillaceous sandstone with interbedded shales, and the Entrada Sandstone. Beneath the Entrada lies the Navajo Sandstone. The Navajo and Entrada Sandstones constitute the primary aquifer in the area of the site. The

Entrada and Navajo Sandstones are separated from the Burro Canyon Formation by approximately 1,000 to 1,100 feet of materials having a low average vertical permeability. Groundwater within this system is under artesian pressure in the vicinity of the site, is of generally good quality, and is used as a secondary source of water at the site.

2.2 Hydrogeologic Setting

The site is located within a region that has a dry to arid continental climate, with an average annual precipitation of approximately 13.3 inches, and an average annual lake evaporation rate of approximately 47.6 inches. Recharge to aquifers occurs primarily along the mountain fronts (for example, the Henry, Abajo, and La Sal Mountains), and along the flanks of folds such as Comb Ridge Monocline.

Although the water quality and productivity of the Navajo/Entrada aquifer are generally good, the depth of the aquifer (approximately 1,200 feet below land surface [ft bls]) makes access difficult. The Navajo/Entrada aquifer is capable of yielding significant quantities of water to wells (hundreds of gallons per minute [gpm]). Water in wells completed across these units at the site rises approximately 800 feet above the base of the overlying Summerville Formation.

Perched groundwater in the Dakota Sandstone and Burro Canyon Formation is used on a limited basis to the north (upgradient) of the site because it is more easily accessible than the Navajo/Entrada aquifer. Water quality of the Dakota Sandstone and Burro Canyon Formation is generally poor due to high total dissolved solids (TDS) and is used primarily for stock watering and irrigation. The saturated thickness of the perched water zone generally increases to the north of the site, increasing the yield of the perched zone to wells installed north of the site.

2.3 Perched Zone Hydrogeology

Perched groundwater beneath the site occurs primarily within the Burro Canyon Formation. Perched groundwater at the site has a generally low quality due to high total TDS in the range of approximately 1,100 to 7,900 milligrams per liter (mg/L), and is used primarily for stock watering and irrigation in the areas upgradient (north) of the site. Perched water is supported within the Burro Canyon Formation by the underlying, fine-grained Brushy Basin Member. Figure 3 is a contour map showing the approximate elevation of the contact of the Burro Canyon Formation with the Brushy Basin Member, which essentially forms the base of the perched water zone at the site. Contact elevations between the Burro Canyon Formation and Brushy Basin Member in Figure 3 are based on perched monitoring well drilling and geophysical logs and surveyed land surface elevations. As indicated, the Burro Canyon Formation/Brushy Basin Member contact (although irregular because it represents an erosional surface) generally dips to the south/southwest beneath the site.

2.3.1 Lithologic and Hydraulic Properties

Although the Dakota Sandstone and Burro Canyon Formations are often described as a single unit due to their similarity, previous investigators at the site have distinguished between them. The Dakota Sandstone is a relatively hard to hard, generally fine-to-medium grained sandstone cemented by kaolinite clays. The Dakota Sandstone locally contains discontinuous interbeds of siltstone, shale, and conglomeratic materials. Porosity is primarily intergranular. The underlying Burro Canyon Formation hosts most of the perched groundwater at the site. The Burro Canyon Formation is similar to the Dakota Sandstone but is generally more poorly sorted, contains more conglomeratic materials, and becomes argillaceous near its contact with the underlying Brushy Basin Member. The permeabilities of the Dakota Sandstone and Burro Canyon Formation at the site are generally low.

No significant joints or fractures within the Dakota Sandstone or Burro Canyon Formation have been documented in any wells or borings installed across the site (Knight-Piésold, 1998). Any fractures observed in cores collected from site borings are typically cemented, showing no open space.

2.3.1.1 Dakota

Porosities of the Dakota Sandstone range from 13.4% to 26%, averaging 20%, and water saturations range from 3.7% to 27.2%, averaging 13.5%, based on samples collected during installation of wells MW-16 (abandoned) and MW-17 (Figure 1B). The average volumetric water content is approximately 3%. The hydraulic conductivity of the Dakota Sandstone based on packer tests in borings installed at the site ranges from approximately 2.7 x 10^{-6} centimeters per second (cm/s) to 9.1 x 10^{-4} cm/s, with a geometric average of 3.9 x 10^{-5} cm/s.

2.3.1.2 Burro Canyon

The average porosity of the Burro Canyon Formation is similar to that of the Dakota Sandstone. Porosity ranges from 2% to 29.1%, averaging 18.3%, and water saturations of unsaturated materials range from 0.6% to 77.2%, averaging 23.4%, based on samples collected from the

Burro Canyon Formation at MW-16 (abandoned), located immediately downgradient of tailings Cell #3. TITAN (1994) reported that the hydraulic conductivity of the Burro Canyon Formation ranges from 1.9 x 10^{-7} to 1.6 x 10^{-3} cm/s, with a geometric mean of 1.1 x 10^{-5} cm/s, based on the results of 12 pumping/recovery tests performed in monitoring wells and 30 packer tests performed in borings prior to 1994. Subsequent hydraulic testing of perched zone wells has yielded a range of 2 x 10^{-7} to 0.01 cm/s (HGC, 2009a).

In general, the highest permeabilities and well yields are in the area of the site immediately northeast and east (upgradient to cross gradient) of the tailings cells. A relatively continuous, higher permeability zone has been inferred to exist in this portion of the site. Analysis of drawdown data collected from this zone during long-term pumping of MW-4, MW-26 (TW4-15), and TW4-19 (Figure 1B) yielded estimates of hydraulic conductivity ranging from 4 x 10^{-5} to 1 x 10^{-3} cm/s (HGC, 2004). The decrease in perched zone permeability south to southwest of this area indicates that this higher permeability zone "pinches out" (HGC, 2007).

Permeabilities downgradient of the tailings cells are generally low. Hydraulic tests at wells located at the downgradient edge of the cells, and south and southwest of the cells yielded geometric average hydraulic conductivities of 2.3 x 10^{-5} and 4.3 x 10^{-5} cm/s depending on the testing and analytical methods. The low permeabilities and shallow hydraulic gradients downgradient of the tailings cells result in average perched groundwater pore velocity estimates that are among the lowest on site (approximately 1.7 ft/yr to 3.2 ft/yr based on calculations presented in HGC, 2009a).

2.3.2 Perched Groundwater Flow

Perched groundwater flow at the site has historically been to the south/southwest. Figure 4 is a perched groundwater elevation contour map for the second quarter of 2010. These contours are based on water levels measured in the perched groundwater monitoring wells shown in the figure. Local depression of the perched water table occurs near wells MW-4, TW4-4, TW4-19, TW4-20, and MW-26. These wells are pumped to reduce chloroform mass in the perched zone east and northeast of the tailings cells as discussed in HGC (2007).

A dry area to the southwest of Cell 4B is defined by the area where the kriged Brushy Basin contact elevation rises above the kriged perched water level elevation. The actual extent of the dry area shown in Figure 4 is uncertain because there are few data points to define it. The installation of wells along the southern and western margins of Cell 4B in August, 2010 indicate that the dry zone extends at least from the southwest central portion of Cell 4B to the southwest corner of Cell 4B. The continuity of the zone southwest of Cell 4B is inferred from the kriged contact elevations and perched water elevations.

Beneath and downgradient of the tailings cells, on the west side of the site, perched water flow is south-southwest to southwest. On the eastern side of the site perched water flow is more southerly. Because of mounding near wildlife ponds, flow direction ranges locally from westerly (west of the ponds) to easterly (east of the ponds). Perched zone hydraulic gradients currently range from a maximum of approximately 0.08 ft/ft east of tailings Cell #2 (near pumping well TW4-4) to approximately 0.01 ft/ft downgradient of the tailings cells.

Perched water discharges in springs and seeps along Westwater Creek Canyon and Cottonwood Canyon to the west-southwest of the site, and along Corral Canyon to the east of the site, where the Burro Canyon Formation outcrops. Based on the data presented in Figure 4, the discharge point located most directly downgradient of the tailings cells is Ruin Spring. This feature is located approximately 9,400 feet south-southwest of the tailings cell complex at the site (Figure 4).

2.3.3 Saturated Thickness

The saturated thickness of the perched zone as of the 2nd quarter of 2010 ranges from approximately 93 feet in the northeastern portion of the site to less than 6 feet in the southwest portion of the site (Figure 5). A saturated thickness of approximately 1 foot occurs in well MW-34 along the south dike of new tailings Cell 4B, and the perched zone is apparently dry at MW-33 located at the southwest corner of Cell 4B. Depths to water range from approximately 16 feet in the northeastern portion of the site (adjacent to the wildlife ponds) to approximately 117 feet at the southwest margin of tailings Cell #3 (Figure 6). The relatively large saturated thicknesses in the northeastern portion of the site are likely related to seepage from the wildlife ponds located northeast and east of the tailings cells.

Although sustainable yields of as much as 4 gpm have been achieved in wells intercepting the larger saturated thicknesses and higher permeability zones in the northeast portion of the site, perched zone well yields are typically low (<0.5 gpm) due to the generally low permeability of the perched zone. Sufficient productivity can generally be obtained only in areas where the saturated thickness is greater, which is the primary reason that the perched zone has been used on a limited basis as a water supply to the north (upgradient) of the site, but has not been used downgradient of the site.

2.4 Summary

Perched groundwater at the site is hosted primarily by the Burro Canyon Formation, which consists of a relatively hard to hard, fine- to medium-grained sandstone containing siltstone, shale and conglomeratic materials. The Burro Canyon Formation is separated from the underlying regional Navajo/Entrada aquifer by approximately 1,000 to 1,100 feet of Morrison Formation and Summerville Formation materials having a low average vertical permeability. The Brushy Basin Member of the Morrison Formation is a shale that lies immediately beneath the Burro Canyon Formation and forms the base of the perched water zone at the site. Figure 2 is a photograph of the contact between the Burro Canyon Formation and the underlying Brushy Basin Member taken from a location along highway 95 immediately north of the Mill. This photograph illustrates the transition from the cliff-forming sandstone of the Burro Canyon Formation to the slope-forming Brushy Basin Member. Based on hydraulic tests at perched zone monitoring wells, the hydraulic conductivity of the perched zone ranges from approximately 2 x 10^{-7} to 0.01 cm/s.

Perched water flow is generally from northeast to southwest across the site. Beneath and downgradient of the tailings cells, on the west side of the site, perched water flow is south-southwest to southwest. On the eastern side of the site perched water flow is more southerly. Because of mounding near wildlife ponds, flow direction ranges locally from westerly (west of the ponds) to easterly (east of the ponds). Perched water generally has a low quality, with total dissolved solids ranging from approximately 1,100 to 7,900 mg/L, and is used primarily for stock watering and irrigation north (upgradient) of the site.

Depths to perched water range from approximately 16 feet near the wildlife ponds in the northeastern portion of the site to approximately 117 feet at the southwestern margin of the tailings cells. Saturated thicknesses range from approximately 93 feet near the wildlife ponds to less than 6 feet in the southwest portion of the site, downgradient of the tailings cells. A saturated thickness of approximately 1 foot occurs in well MW-34 along the south dike of new tailings Cell 4B, and the perched zone is apparently dry at MW-33 located at the southwest corner of Cell 4B. Although sustainable yields of as much as 4 gpm have been achieved in wells penetrating higher transmissivity zones, well yields are typically low (<0.5 gpm) due to the generally low permeability of the perched zone.

Hydraulic testing of perched zone wells has yielded a range of approximately 2 x 10^{-7} to 0.01 cm/s. In general, the highest permeabilities and well yields are in the area of the site immediately northeast and east (upgradient to cross gradient) of the tailings cells. A relatively continuous, higher permeability zone has been inferred to exist in this portion of the site. Analysis of drawdown data collected from this zone during long-term pumping of MW-4, TW4-19, and MW-26 (TW4-15) yielded estimates of hydraulic conductivity ranging from 4 x 10^{-5} to 1 x 10^{-3} cm/s.

Permeabilities downgradient of the tailings cells are generally low. Hydraulic tests at wells located at the downgradient edge of the cells, and south and southwest of the cells yielded geometric average hydraulic conductivities of 2.3 x 10^{-5} and 4.3 x 10^{-5} cm/s depending on the testing and analytical method. The low permeabilities and shallow hydraulic gradients downgradient of the tailings cells result in average perched groundwater pore velocity estimates that are among the lowest on site.

3. SEEP AND SPRING OCURRENCE AND HYDROGEOLOGY

All seeps and springs examined as part of this investigation have associated cottonwood trees that suggest a relatively consistent source of water. Seeps and springs occurring at the margins of White Mesa are typically associated with sandstones of the Burro Canyon Formation. As discussed in Section 2, The Burro Canyon Formation hosts most of the perched groundwater at the site. Cottonwood Seep, located approximately 1,500 feet west of the mesa margin within the lower portion of the Brushy Basin Member of the Morrison Formation, is a notable exception.

The elevations of seeps and springs have been surveyed previously by a surveyor licensed by the State of Utah. The latest survey of all seeps and springs was performed in December 2009. One goal of the present investigation is to confirm the surveyed elevations of the seeps and springs (Part I.H.10 [a] of the Permit). This was accomplished by 1) plotting the December, 2009 surveyed (latitude-longitude) locations of seeps and springs on USGS topographic maps and comparing the surveyed elevations with the elevation contours shown on the maps, and 2) re-surveying Westwater Seep, Cottonwood Seep, and Ruin Spring, which are the primary focus of the investigation. The December, 2009 and July, 2010 surveys were conducted by the same State of Utah licensed surveyor. Another goal of the present investigation was to refine the elevation of the contact between the Burro Canyon Formation and Brushy Basin Member at the margins of White Mesa near seeps and springs (Part I.H.10 [a] and [b] of the Permit). This was accomplished at appropriate locations by using the confirmed elevations of those seeps and springs that arise at the contact. Although most of the seeps and springs were presumed to arise at or near the contact between the Burro Canyon Formation and Brushy Basin Member, the present investigation shows that many of the seeps and springs do not arise at this contact and are not appropriate for determining the contact elevation.

For example, Cottonwood Seep does not occur at the mesa margin nor is it associated with the Burro Canyon Formation. Cottonwood Seep is interpreted to occur within the lower third of the Brushy Basin Member, at a transition between a slope-forming and a bench-forming morphology. Cottonwood Seep is therefore interpreted to receive water from a source other than the perched groundwater hosted by the Burro Canyon Formation. Corral Canyon Seep, Entrance Spring, and Corral Springs on the east side of the site appear to originate within the Burro Canyon Formation but above the contact between the Burro Canyon Formation and Brushy Basin Member. Some of these features may receive water primarily from alluvium. These features will be discussed in more detail in Section 3.3 below.

3.1 Overview of Seep Locations, Elevations, and Hydrogeology

Figure 7 is a map showing the December, 2009 surveyed locations of seeps and springs and the Frog Pond on portions of USGS topographic 7.5 minute quads Black Mesa Butte, Blanding South, No Man's Island, and Big Bench, Utah. As shown, all springs and seeps are located within drainages and except for Cottonwood Seep, are located at the mesa margins. Table 1 provides surveyed locations and elevations of the seeps and springs and the Frog Pond. Included are the locations and elevations of all seeps and springs surveyed in December 2009, and the July 7, 2010 re-surveyed locations and elevations of Westwater Seep, Cottonwood Seep, and Ruin Spring.

3.1.1 Confirmation of Seep and Spring Elevations

As shown in Figure 7, the December, 2009 surveyed elevations for all seeps and springs agree well with the USGS elevation contours. For example, Ruin Spring has a surveyed elevation of 5,380 ft amsl and is located upon the 5,380 ft amsl contour line. Corral Canyon Seep has a surveyed elevation of 5,624 ft amsl and is located between the 5,620 ft amsl and 5,640 ft amsl contour lines, but closer to the 5,620 ft amsl contour. Similarly, Entrance Spring has a surveyed elevation of 5,560 ft amsl and is centered almost upon the 5,560 ft amsl contour line; Corral Springs has a surveyed elevation of 5,383 ft amsl and is located just above the 5,380 ft amsl contour line; Cottonwood Seep has a surveyed elevation of 5,234 ft amsl and is located between the 5,220 ft amsl and 5,240 ft amsl contour lines; and Westwater Seep has a surveyed elevation of 5,468 ft amsl and is located between the 5,460 ft amsl and 5,480 ft amsl contour lines. Resurveying of Cottonwood Seep, Westwater Seep, and Ruin Spring on July 7, 2010 yielded nearly identical locations and elevations as shown in Table 1. The concurrence between all December 2009 surveyed seep and spring elevations and the USGS elevation contours, and the nearly identical results obtained by re-surveying of Westwater Seep, Cottonwood Seep, and Ruin Spring in July 2010, confirms the elevations of the seeps and springs as requested in Part I.H.10 (a) of the Permit.

The December, 2009 seep and spring locations and elevations differ from previous survey data reported prior to December, 2009. The "2009 Annual Seeps and Springs Sampling Report" submitted by Denison Mines to UDEQ on November 30, 2009, tabulated the results of a previous survey and incorporated those data in constructing a groundwater elevation contour map. Subsequent to that report, perched water elevation or Burro Canyon Formation/Brushy Basin Member contact elevation maps either did not incorporate seep and spring elevations (because they were not yet confirmed), or were constructed using the December, 2009 data under the assumption that these were the best available. The appropriate December, 2009 survey data were used to construct Burro Canyon Formation/Brushy Basin Member contact elevations maps for a conference call between UDEQ, Denison Mines, URS, and HGC on February 18, 2010, and for a conference call between UDEQ, Denison Mines, and HGC on September 1, 2010.

The December, 2009 seep and spring survey data shown in Table 1 will be used in all future reporting where seep and spring locations and elevations are relevant.

3.1.2 Seep and Spring Locations in Relation to Perched Water Levels Measured in Perched Zone Wells

Figure 4 shows second quarter, 2010 perched water level contours and the locations of seeps and springs on an aerial photographic base. These contours are based on water levels measured in the perched groundwater monitoring wells shown in the figure. As noted above, all springs and seeps are located within drainages and except for Cottonwood Seep, are located at the mesa margins. Based on Figure 4, Corral Canyon Seep is located upgradient of the tailing cells, and Entrance Spring and Corral Springs are located cross gradient of the tailings cells. Both Entrance Spring and Corral Springs are separated from the tailings cells by a groundwater divide. This groundwater divide likely results from mounding associated with the wildlife ponds. Ruin Spring is located downgradient of the tailings cells, and Westwater Seep appears to be cross gradient of the tailings cells. Cottonwood Seep is neither cross gradient nor downgradient of the tailings cells because it is interpreted to receive water from a source other than the perched groundwater system hosted by the Burro Canyon Formation. A dry area, defined by the area where the kriged Brushy Basin contact elevation rises above the kriged perched water level elevation, occurs to the southwest of Cell 4B. As discussed in Section 2.3.2, the actual extent of the dry area shown in Figure 4 is uncertain because there are few data points to define it. The installation of wells along the southern and western margins of Cell 4B in August 2010 indicates that the zone extends at least from the southwest central portion of Cell 4B to the southwest corner of Cell 4B. The continuity of the zone southwest of Cell 4B is inferred from the kriged elevations. If this feature is actually as continuous and extensive as depicted in Figure 4, it would result in a barrier to the southerly movement of perched groundwater west of the tailings cells.

Because Corral Canyon Seep, Entrance Spring and Corral Spring are cross gradient of the tailings cells, and are separated from the tailings cells by a groundwater divide, they are considered less important than springs and seeps located on the west side of the mesa. Although all seeps and spring were examined, the field investigation focused primarily on the seeps and springs on the west side of the mesa (Westwater Seep, Cottonwood Seep, and Ruin Spring).

3.1.3 Seep and Spring Locations in Relation to White Mesa Geology

The relationships between seeps and springs and the geology of White Mesa are shown in Figure 8. The geology in Figure 8 is based on Kirby (2008), and Hintze et al (2000), and has been modified locally by field reconnaissance. Because of the difficulty in distinguishing the Burro Canyon Formation from the Dakota Sandstone, the two formations are undifferentiated on the geologic map.

As shown, all springs and seeps except Cottonwood Seep are associated with outcrops of the Burro Canyon Formation (and/or Dakota Sandstone). Some are also associated with mixed eolian and alluvial deposits (alluvium) stratigraphically above the Burro Canyon Formation and/or Dakota Sandstone. Ruin Spring and Westwater Seep are located at the contact between the Burro Canyon Formation and underlying Brushy Basin Member. Although too small in extent to be shown on the map, the drainages associated with these features contain alluvium. Westwater Seep (where typically sampled) occurs within alluvium at the Burro Canyon Formation/Brushy Basin Member contact whereas Ruin spring occurs at the contact but above the alluvium in the associated drainage. Corral Canyon Seep, Entrance Spring and Corral Springs occur within alluvium near the contact of the alluvium with the Burro Canyon Formation, but at an elevation above the contact between the Burro Canyon Formation and Brushy Basin Member. In contrast, Cottonwood Seep is mapped within the Brushy Basin Member, approximately 1,500 feet west of the contact of the Burro Canyon Formation and Brushy Basin Member, and stratigraphically approximately 200 feet below the contact. The Burro Canyon Formation does not exist at Cottonwood Seep because it has been eroded. Cottonwood Seep is interpreted to receive water from a source stratigraphically below the Burro Canyon Formation and from a hydrogeologic system other than the perched water system at the site. As discussed below, Westwater Seep, Corral Canyon Seep, Entrance Spring, and Corral Canyon Seep may receive water from both alluvial and bedrock (perched water) sources. Corral Springs, located immediately downgradient of a stock pond, may receive water primarily from alluvium recharged from the stock pond.

Springs occurring within alluvium deposited within drainages cutting the Burro Canyon Formation may or may not receive a contribution from perched water. Except for Ruin Spring (and "2nd Seep" near Cottonwood Seep, discussed in Section 3.3 below), each spring and seep occurs in alluvial materials within a drainage that will supply surface water during wet periods and help to recharge any alluvial materials within the drainage as well as bedrock near the drainage. Any alluvial materials within the drainage or marginal bedrock that are recharged during precipitation events will likely, at least temporarily, yield water to the seeps. Ruin Spring and Westwater Seep, located at the contact of Burro Canyon Formation with the Brushy Basin Member, likely receive most of their flow from perched water, although Westwater Seep may receive some contribution from alluvium. Corral Canyon Seep, Entrance Spring, and Corral Springs, located at the contact of the Burro Canyon Formation with overlying alluvium, may receive little or no perched water. The presence of cottonwoods at all these features suggests, however, that a continuous source of water, likely perched water, is available. Corral Springs is likely recharged by a stock pond located immediately upgradient of this feature. Furthermore, direct recharge of Dakota Sandstone and Burro Canyon Formation exposed at the margins of the mesa in the vicinity of all features except Cottonwood Seep is expected to temporarily enhance their flow after precipitation events. This expectation is consistent with reported temporary increases in flow at all springs and seeps after precipitation events. As shown in Figure 8, the potential for direct recharge of Dakota Sandstone and Burro Canyon Formation exists around the entire perimeter of the mesa margin where bedrock is exposed.

3.2 Westwater Seep and Ruin Spring

As shown in Figure 4, Ruin Spring is located downgradient of the tailings cells, and Westwater Seep appears to be cross gradient of the tailings cells. Both are interpreted to occur at the contact between the Burro Canyon Formation and the Brushy Basin Member and to receive water from the perched zone. Figures A.1 and A.2 are photographs of Westwater Seep and Figures A.3 and A.4 are photographs of Ruin Spring.

Figure A.1 shows the location where Westwater Seep is typically sampled, and Figure A.2 shows the contact between the Burro Canyon Formation and Brushy Basin Member immediately downgradient of the sampling location. As shown in the photographs, Westwater Seep was producing very little water on July 7, the day the photograph was taken.

Figure A.3 shows Ruin Spring and a short pipe that is used to channel water from a small dam at the base of the spring into a now unusable watering trough. Figure A.4 shows the outcrop of Burro Canyon Formation immediately above the spring (and above the contact with the Brushy Basin Member). The Burro Canyon Formation is conglomeratic at this location which is typical for the lower portion of the Formation. Alluvium at the base of the drainage generally covers up the Brushy Basin Member at this location. As discussed above, the alluvium is at an elevation below the point of discharge of Ruin Spring.

3.3 Cottonwood Seep

Unlike Westwater Seep and Ruin Spring, Cottonwood Seep is interpreted to receive water from a source other than the perched groundwater system hosted by the Burro Canyon Formation. As shown in Figures 1A, 7, and 8, Cottonwood Seep is located approximately 1,500 feet west of the mesa rim in an area where the Dakota Sandstone and Burro Canyon Formation (which hosts the perched water system) are absent due to erosion. Cottonwood Seep is neither cross gradient nor downgradient of the tailings cells with respect to the perched water system.

Figure A.5 is a photograph showing the area of Cottonwood Seep typically sampled, which is a small grassy area near a large cottonwood tree. Figure A.6 is a photograph of the cottonwood tree located immediately downgradient of Cottonwood Seep. The small grassy area typically sampled and the nearby cottonwoods are located within a drainage. In the background (approximately 1,500 feet to the east), the approximate contact between the Burro Canyon Formation and Brushy Basin Member on the mesa rim is illustrated.

Field investigation of the area near Cottonwood Seep reveals that a second seep, also defined by a small grassy area with associated cottonwoods, exists immediately to the north. This feature, hereafter referred to as "2nd Seep" is present on the aerial photograph (dark area immediately north of Cottonwood Seep on Figure 1A) and is marked by a seep symbol on the USGS topographic map for Black Mesa Butte. Figure A.7 is a photograph of the small grassy area at 2nd Seep, and Figure A.8 is a photograph taken from a location at the northern margin of 2nd Seep looking south toward Cottonwood Seep, and showing two cottonwoods in the foreground (at the southern margin of 2nd Seep) and the larger cottonwoods located immediately downgradient of Cottonwood Seep. Unlike Cottonwood Seep, which is located within a drainage, 2nd Seep is located on a relatively flat surface near the transition between slope-forming and bench-forming portions of the Brushy Basin Member. The approximate contact between Burro Canyon Formation and Brushy Basin Member along the mesa rim in the distance is illustrated on Figure A.8.

North of 2nd Seep is a third area referred to as "Dry Seep" that is located on relatively flat bench-like terrain, and is defined by a grassy (but dry) area and cottonwoods immediately to the east of the grassy area at the transition from slope-forming to bench-forming morphology. Dry Seep was not wet when examined on July 7. Figure A.9 is a photograph looking north from 2nd Seep toward the grassy area at Dry Seep, Figure A.10 is a photograph of the cottonwoods immediately east of Dry Seep at the transition between slope-forming and bench-forming terrain, and Figure A.11 is a photograph looking south from the grassy, bench-like area at Dry Seep toward 2nd Seep and Cottonwood Seep. The approximate contact between Burro Canyon Formation and Brushy

Basin Member along the mesa rim in the distance is illustrated on Figures A.9 and A.11. The close proximity of Cottonwood Seep, 2nd Seep, and Dry Seep suggest they are related.

An outcrop of greenish to grayish cliff-forming sandstone occurs to the west of Cottonwood Seep at the western margin of the bench-like terrain that underlies Cottonwood Seep, 2nd Seep, and Dry Seep. This sandstone is interpreted as the Westwater Canyon Member of the Morrison Formation. The Recapture Member of the Morrison Formation is presumed to underlie this sandstone. Figure A.12 is a photograph taken from the west side of Cottonwood Canyon, looking east toward this outcrop, with Cottonwood Seep, 2nd Seep, and Dry Seep indicated on the bench-like area above this outcrop, and with the rim of White Mesa in the distance. The approximate contact between the Burro Canyon and Brushy Basin Member on the mesa rim, and the approximate upper and lower contacts of the sandstone presumed to be Westwater Canyon Member in the foreground, are illustrated. The approximate elevations of the Burro Canyon/Brushy Basin contact, of the upper contact of (presumed)Westwater Canyon Member, and of Cottonwood and 2nd Seep are provided. The seeps are approximately 200 feet lower in elevation than the Burro Canyon/Brushy Basin contact, and approximately 80 feet above the (presumed) Westwater Canyon Member.

Figure A.13 is a photograph of the west side of Cottonwood Canyon, looking west from the east side of the canyon, taken while standing on the outcrop presumed to be Westwater Canyon Member. The approximate Burro Canyon/Brushy Basin contact on the mesa rim in the distance is illustrated, as are the upper and lower contacts of the (presumed) Westwater Canyon Member. Figure A.14 is a photograph taken from the east side of Cottonwood Canyon, looking south, and illustrating the lithology as in the previous figures.

Overall, the investigation indicates that Cottonwood Seep and associated 2nd Seep are disconnected hydrogeologically from the perched water zone hosted by the Burro Canyon Formation. These seeps occur within the lower third of the Brushy Basin Member near the transition between a slope-forming and bench-forming morphology. The western edge of this bench-like feature coincides with the outcrop of a cliff-forming sandstone interpreted to be the Westwater Canyon Member of the Morrison Formation. These seeps may receive water in part from sandier, more coarse-grained facies that may exist in the lower portion of the Brushy Basin Member near the seeps and that transition into the sands of the presumed Westwater Canyon Member.

3.4 Corral Canyon Seep, Entrance Spring, and Corral Springs

As shown in Figure 4, Corral Canyon Seep, Entrance Spring, and Corral Springs are located on the east side of the mesa, upgradient to cross gradient of the tailings cells. Entrance and Corral Springs are separated from the tailings cells by a perched groundwater divide. All are interpreted to occur near the contact between alluvium and the Burro Canyon Formation and may or may not receive water from the perched zone. Figures B.1 through B.11 are photographs of Corral Canyon Seep and vicinity (including the Frog Pond); Figures B.12 through B.15 are photographs of Entrance Spring and vicinity; and Figures B.16 through B.19 are photographs of Corral Spring and vicinity. Corral Canyon Seep was only damp, and Corral Springs was dry at the time the photographs were taken.

Figures B.1 and B.2 show the cottonwoods near Corral Canyon Seep, and Figures B.3, B.4, and B.5 the outcrops of conglomeratic Burro Canyon Formation near the Seep. Figures B.12 and B.13 are of Entrance Spring, showing cottonwoods and outcrops of conglomeratic Burro Canyon Formation, and Figures B.14 and B.15 are of the geology immediately downgradient of Entrance Spring at the location of a sharp drop in elevation. Figures B.16 through B.18 show Corral Springs and associated cottonwoods and conglomeratic Burro Canyon Formation outcrops. Figure B.19 is of the stock pond immediately upgradient of Corral Spring (which was dry).

As shown in Figures B.2 though B.5, and B.12 though B.18, conglomeratic sandstone within the Burro Canyon Formation outcrops near all three of the seeps and springs on the east side of the mesa. Corral Canyon Seep originates at an elevation above the contact between the Burro Canyon Formation and Brushy Basin Member. The Burro Canyon Formation is conglomeratic near its contact with the underlying Brushy Basin Member at this location. Entrance Spring and Corral Springs are associated with conglomeratic material in the Burro Canyon Formation that occurs above the Brushy Basin Member contact. Figures B.14 and B.15 illustrate the difference in elevation between the base of conglomeratic material in the Burro Canyon Formation and the interpreted contact with the Brushy Basin Member in the vicinity of Entrance Spring.

Figure B.6 is a photograph of the Frog Pond, located immediately east and downgradient of Corral Canyon Seep. The Frog Pond is separated from the drainage hosting Corral Canyon Seep by a ridge of conglomeratic Burro Canyon Formation (Figure B.7). Figure B.6 shows the tops of cottonwoods near Corral Canyon Seep in the background. The elevation of the Frog Pond is lower than that of Corral Canyon Seep. The Frog Pond is interpreted to be located at the contact between the Burro Canyon Formation and Brushy Basin Member, and to be separated from the Brushy Basin Member by a veneer of alluvium. The Frog Pond may transmit water laterally into the Burro Canyon Formation to a greater or lesser degree depending on fluctuations in elevation of the pond surface.

Figures B.8 through B.11 are photographs illustrating the contact between the Burro Canyon Formation and the Brushy Basin Member along Corral Canyon south of the Frog Pond. Figures B.8 and B.9 (representing the east and west sides of Corral Canyon, respectively) are from a vantage point approximately 75 feet south of the Frog Pond; Figure B.10 is from a location on the east side of Corral Canyon a few hundred feet south of the Frog Pond; and Figure B.11 is of the east side of Corral Canyon from a location on the west side approximately 1,500 feet south of the Frog Pond. Figure B.11 shows the irregularity of the Burro Canyon/Brushy Basin contact, which dives downward on the right (east) side of the photograph. This irregularity is consistent with drilling on the east and northeast portions of the site within the areas of the perched zone affected by elevated chloroform and nitrate concentrations.

4. ADDITION OF SEEPS TO PERCHED ZONE WATER LEVEL AND BRUSHY BASIN SURFACE MAPS

The results of the investigation show that only Ruin Spring and Westwater Seep originate at the contact between Burro Canyon Formation and underlying Brushy Basin Member, that Ruin Spring receives its flow predominantly from perched water, and that Westwater Seep likely receives a significant portion of its flow from perched water. The surveyed elevations of these features are considered representative of both the Burro Canyon Formation/Brushy Basin Member contact elevation and the perched water elevation at these locations.

Corral Canyon Seep, Entrance Spring, and Corral Springs occur within alluvium in drainages cutting Burro Canyon Formation at elevations above the contact between the Burro Canyon Formation and the Brushy Basin Member. The surveyed elevations of these features are therefore not representative of the contact elevation. Each of these features is also interpreted to receive some contribution of flow from perched water. Although the proportion of perched water flow is indeterminate, the presence of cottonwood trees suggests a relatively continuous source of water consistent with a perched water source.

Figure 9 is a contour map of the Burro Canyon Formation/Brushy Basin Member contact generated from the same data used to generate Figure 3 but including the location and elevation data from Westwater Seep and Ruin Spring. Figure 9 was generated assuming that only Westwater Seep and Ruin Spring are located at the contact between Burro Canyon Formation and the Brushy Basin Member. Figure 10 is a contour map of perched water elevations generated from the same data used to generate Figure 4 but including the location and elevation data from all seeps and springs except Cottonwood Seep. Figure 10 was generated assuming that each feature (except Cottonwood Seep) receives some contribution of flow from perched water and that the elevation of the seep or spring is representative of the elevation of perched water at that location. As in Figure 4, a dry area is interpreted to occur southwest of Cell 4B.

The data and contoured surfaces presented in Figures 9 and 10 provide the "upper geologic contact of the Brushy Basin Shale Member of the Morrison Formation" and the "representative elevation of shallow groundwater", respectively, as requested in Part I.H.10 (a) of the Permit. Figure 9 also provides the "representative Brushy Basin/Burro Canyon geologic contact surface map of White Mesa" requested in Part I.H.10 (b) of the Permit. The findings presented in Section 3 that are incorporated in Figures 9 and 10 address Part I.H.10 (c) item 1 of the Permit and to the extent possible "resolve apparent uncertainties associated with local geologic structural directions/gradient of the Brushy Basin/Burro Canyon geologic contact of the local perched water system and its relationship to seeps located west and southwest of the tailings management cells and Ruin Spring”. Caveats associated with the data and contoured surfaces presented in Figure 10 are discussed below.

The assumption that the seep or spring elevation is representative of the perched water elevation is likely to be correct only in cases where the feature receives most or all of its flow from perched water and where the supply is relatively continuous (for example at Ruin Spring). The perched water elevation at the location of a seep or spring that receives a significant proportion of water from a source other than perched water may be different from the elevation of the seep or spring. The elevations of seeps that are dry for at least part of the year will not be representative of the perched water elevation when dry. The uncertainty that results from including seeps and springs in the contouring of perched water levels must be considered when interpreting Figure 10.

Assuming that the above uncertainties are small, including the data from the seeps and springs in the perched water elevation contour map produces very little change with regard to perched water flow directions except in the area west of the tailings cells and near Entrance Spring. West of the tailings cells, incorporation of Westwater Seep creates a more westerly gradient in the perched water contours. Whereas Westwater Seep appears to be cross gradient to the entire tailings cell complex in Figure 4, the feature appears nearly downgradient of the western portion of the cell complex in Figure 10. Ruin Spring is downgradient of the entire cell complex in Figure 4 and is downgradient of the eastern portion of the cell complex in Figure 10. The data presented in Figure 10 imply that Westwater Seep is the closest discharge point west of the tailings cells and Ruin Spring is the closest discharge point south-southwest of the tailings cells. The identification of Westwater Seep and Ruin Spring as the closest discharge points downgradient of the tailing cells satisfies Part I.H.10 (c) item 2 of the Permit which requests identification of “the closest point(s) of surface discharge of groundwater for the White Mesa perched water system (point of exposure)”.

The incorporation of Entrance Spring on the east side of the site creates a more easterly gradient in the perched water contours. Comparing Figures 4 and 10, Entrance Spring appears more directly downgradient of the northern wildlife ponds in Figure 10 than in Figure 4. In both Figures 4 and 10, seeps and springs on the east side of the mesa are either cross gradient of the tailings cells or are separated from the tailings cells by a groundwater divide.

Although there are uncertainties associated with incorporation of seep and spring elevations into maps depicting perched water elevations or maps depicting the Burro Canyon Formation/Brushy Basin Member contact elevations, future perched water elevation maps will incorporate seep and spring elevations, and future contact elevation maps will incorporate Westwater Seep and Ruin Spring elevations.

5. PERCHED WATER TRAVEL TIMES

As discussed in Section 2.3.1.2 perched water pore velocities southwest of the tailings cells were calculated to range from approximately 1.7 ft/yr to 3.2 ft/yr based on data presented in HGC (2009a). These estimates are representative of the rate of movement of a conservative solute assuming no dispersion

Using the same methodology presented in HGC (2009a), perched water pore velocities and travel times between the tailings cells and Ruin Spring and between the tailings cells and Westwater Seep have been calculated using 2nd Quarter, 2010 water levels. These calculations satisfy Part I.H.10 (c) item 3 of the Permit. The pathlines used in the calculations are shown in Figure 11. Water level contours in Figure 11 are the same as presented in Figure 10, and include elevations of seeps and springs (except Cottonwood). Pathline 1 extends from the southeastern corner of Cell 4B to Ruin Spring and pathline 2 from the southwestern corner of Cell #1 to Westwater Seep. In each case the tailings cell location and the discharge point are on lines approximately parallel to perched water flow as implied by the water level contours.

The average hydraulic gradient along pathline 1 is approximately 0.012 ft/ft based on the water level at MW-15 (5,494 ft amsl), the surveyed elevation of Ruin Spring (5,380 ft amsl), and the path length of approximately 9,350 ft. Using the estimates presented in HGC (2009a), the geometric average hydraulic conductivity south-southwest of the tailings cells ranges from 2.3 x 10^{-5} to 4.3 x 10^{-5} cm/s (0.064 ft/day to 0.120 ft/day). Assuming a porosity of 0.18, the perched water pore velocity is estimated to range from 1.6 ft/yr to 2.9 ft/yr. These estimates imply total travel times along path 1 ranging from approximately 3,225 to 5,850 years.

The average hydraulic gradient along pathline 2 is approximately 0.014 ft/ft based on the water level at MW-24 (5,507 ft amsl), the surveyed elevation of Westwater Seep (5,468 ft amsl), and the path length of approximately 2,800 ft. Using the hydraulic conductivities estimated from automatically logged data at MW-23, MW-24, and MW-35 as presented in HGC (2005), HGC (2009b), and HGC (2010), and calculating geometric average hydraulic conductivities in the same manner as HGC (2009a), the geometric average hydraulic conductivity west of the tailings cells ranges from approximately 1.2 x 10^{-5} cm/s (0.034 ft/day) to 1.5 x 10^{-5} cm/s (0.042 ft/day). Assuming a porosity of 0.18, the perched water pore velocity is estimated to range from 0.97 ft/yr to 1.2 ft/yr. These estimates imply total travel times along path 2 of approximately 2,330 to 2,890 years.

6. CONCLUSIONS

The December 2009 surveyed elevations of seeps and springs in Table 1 have been confirmed based on the positions of these features relative to elevation contour lines provided on USGS topographic maps. The elevations of Westwater Seep, Cottonwood Seep and Ruin Spring have been additionally verified by resurveying of these features in July 2010. The concurrence between all December 2009 surveyed seep and spring elevations and the USGS elevation contours, and the nearly identical results obtained by re-surveying of Westwater Seep, Cottonwood Seep, and Ruin Spring in July 2010, confirms the elevations of the seeps and springs as requested in Part I.H.10 (a) of the Permit.

Of the seeps and springs examined as part of this investigation, only Ruin Spring appears to receive a predominant and relatively consistent proportion of its flow from perched water. Ruin Spring originates from conglomeratic Burro Canyon Formation sandstone where it contacts the underlying Brushy Basin Member of the Morrison Formation, at an elevation above the alluvium in the associated drainage. Westwater Seep, which also originates at the contact between the Burro Canyon Formation and the Brushy Basin Member, likely receives a significant contribution from perched water. All seeps and springs other than Ruin Spring and "2nd Seep" (near Cottonwood Seep) are located within alluvium occupying the basal portions of small drainages and canyons. The relative contribution of flow to these features from bedrock and from alluvium is indeterminate. Cottonwood Seep and "2nd Seep" are interpreted to originate from coarser-grained materials within the lower portion of the Brushy Basin Member and are therefore not part of the perched water system at the site.

All seeps and springs are reported to have enhanced flow during wet periods. For seeps and springs associated with alluvium, this behavior is consistent with an alluvial contribution to flow. Enhanced flow during wet periods at Ruin Spring, which originates from bedrock above the level of the alluvium, likely results from direct recharge of Burro Canyon Formation and Dakota Sandstone outcropping near the mesa margin in the vicinity of Ruin Spring. This recharge would be expected to temporarily increase the flow at Ruin Spring (as well as other seeps and springs where associated bedrock is directly recharged) after precipitation events.

As discussed above, Ruin Spring and Westwater Seep are interpreted to occur at the contact between the Burro Canyon Formation and the Brushy Basin Member of the Morrison Formation. Corral Canyon Seep, Entrance Spring, and Corral Springs are interpreted to occur at elevations within the Burro Canyon Formation at their respective locations but above the contact with the Brushy Basin Member. All seeps and springs (except Cottonwood Seep) are associated with conglomeratic portions of the Burro Canyon Formation. The more conglomeratic portions of the Burro Canyon Formation are likely to have higher permeabilities and the ability to transmit water more readily than finer-grained portions. This behavior would be consistent with on-site drilling and hydraulic test data that associates higher permeability with the conglomeratic horizons detected east and northeast of the tailing cells as discussed in Section 2.3.1.2.

Figures 3 and 9 provide the approximate elevation of the Burro Canyon Formation/Brushy Basin Member contact. Figure 3 is based on site well data only and Figure 9 is based on site well data and seep and spring elevations where appropriate. Figures 4 and 10 provide site perched water elevations. Figure 4 is based on site well data only and Figure 10 is based on site well data and seep and spring elevations where appropriate. A dry area interpreted to occur southwest of Cell 4B appears on both figures. The data and contoured surfaces presented in Figures 9 and 10 provide the "upper geologic contact of the Brushy Basin Shale Member of the Morrison Formation" and the "representative elevation of shallow groundwater", respectively, as requested in Part I.H.10 (a) of the Permit. Figure 9 also provides the "representative Brushy Basin/Burro Canyon geologic contact surface map of White Mesa" requested in Part I.H.10 (b) of the Permit.

Including the data from the seeps and springs in the perched water elevation contour map (compare Figures 4 and 10) produces little change with regard to perched water flow directions except in the area west of the tailings cells and near Entrance Spring. West of the tailings cells, incorporation of Westwater Seep creates a more westerly gradient in the perched water contours. Whereas Westwater Seep appears to be cross gradient to the entire tailings cell complex in Figure 4, the feature appears nearly downgradient of the western portion of the cell complex in Figure 10. Ruin Spring is downgradient of the entire cell complex in Figure 4 and is downgradient of the eastern portion of the cell complex in Figure 10. The data presented in Figure 10 imply that Westwater Seep is the closest discharge point west of the tailings cells and Ruin Spring is the closest discharge point south-southwest of the tailings cells. The identification of Westwater Seep and Ruin Spring as the closest discharge points downgradient of the tailing cells satisfies Part I.H.10 (c) item 2 of the Permit which requests identification of "the closest point(s) of surface discharge of groundwater for the White Mesa perched water system (point of exposure)".

The incorporation of Entrance Spring on the east side of the site creates a more easterly gradient in the perched water contours. Comparing Figures 4 and 10, Entrance Spring appears more directly downgradient of the northern wildlife ponds in Figure 10 than in Figure 4. In both Figures 4 and 10, seeps and springs on the east side of the mesa are either cross gradient of the tailings cells or are separated from the tailings cells by a groundwater divide.

The findings of the investigation (presented in Section 3) that are incorporated in Figures 9 and 10 address Part I.H.10 (c) item 1 of the Permit and to the extent possible "resolve apparent uncertainties associated with local geologic structural directions/gradient of the Brushy Basin/Burro Canyon geologic contact of the local perched water system and its relationship to seeps located west and southwest of the tailings management cells and Ruin Spring". Caveats associated with the data and contoured surfaces presented in Figure 10 are discussed below.

The assumption that the seep or spring elevation is representative of the perched water elevation is likely to be correct only in cases where the feature receives most or all of its flow from perched water and where the supply is relatively continuous (for example at Ruin Spring). The perched water elevation at the location of a seep or spring that receives a significant proportion of water from a source other than perched water may be different from the elevation of the seep or spring. The elevations of seeps that are dry for at least part of the year will not be representative of the perched water elevation when dry. The uncertainty that results from including seeps and springs in the contouring of perched water levels must be considered when interpreting Figure 10. Although there are uncertainties associated with incorporation of seep and spring elevations into maps depicting perched water elevations or maps depicting the Burro Canyon Formation/Brushy Basin Member contact elevations, future perched water elevation maps will incorporate seep and spring elevations, and future contact elevation maps will incorporate Westwater Seep and Ruin Spring elevations.

Perched water pore velocities and travel times between the tailings cells and Ruin Spring and between the tailings cells and Westwater Seep have been calculated using 2nd Quarter, 2010 water levels. These calculations satisfy Part I.H.10 (c) item 3 of the Permit. The pathlines used in the calculations are shown in Figure 11. Estimates of perched water pore velocity between the southern margin of the tailings cells and Ruin Spring range from 1.6 ft/yr to 2.9 ft/yr. These estimates imply total travel times along path 1 ranging from approximately 3,225 to 5,850 years. Estimates of perched water pore velocity between the western margin of the tailings cells and Westwater Seep range from 0.97 ft/yr to 1.2 ft/yr. These estimates imply total travel times along path 2 ranging from approximately 2,330 to 2,890 years.

7. REFERENCES

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8. LIMITATIONS STATEMENT

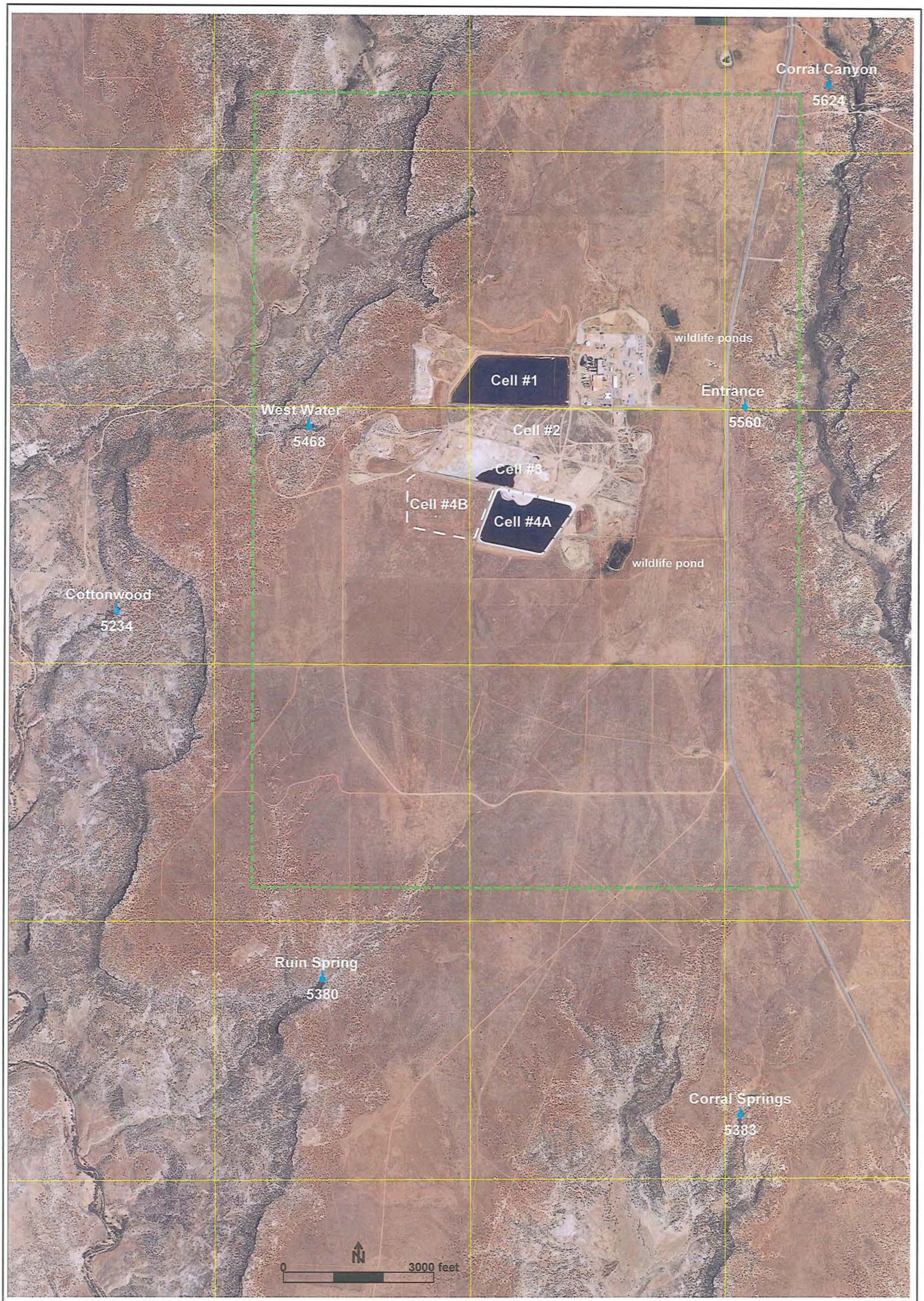
The opinions and recommendations presented in this report are based upon the scope of services and information obtained through the performance of the services, as agreed upon by HGC and the party for whom this report was originally prepared. Results of any investigations, tests, or findings presented in this report apply solely to conditions existing at the time HGC's investigative work was performed and are inherently based on and limited to the available data and the extent of the investigation activities. No representation, warranty, or guarantee, express or implied, is intended or given. HGC makes no representation as to the accuracy or completeness of any information provided by other parties not under contract to HGC to the extent that HGC relied upon that information. This report is expressly for the sole and exclusive use of the party for whom this report was originally prepared and for the particular purpose that it was intended. Reuse of this report, or any portion thereof, for other than its intended purpose, or if modified, or if used by third parties, shall be at the sole risk of the user.

TABLE

TABLE 1
Surveyed Locations and Elevations of Seeps and Springs and the Frog Pond
(December 2009)

Location	Latitude (N)	Longitude (W)	Elevation
FROG POND	37°33'03.5358"	109°29'04.9552"	5589.56
CORRAL CANYON	37°33'07.1392"	109°29'12.3907"	5623.97
ENTRANCE	37°32'01.6487"	109°29'33.7005"	5559.71
CORRAL SPRINGS	37°29'37.9192"	109°29'35.8201"	5383.35
RUIN SPRING	37°30'06.0448"	109°31'23.4300"	5380.03
COTTONWOOD	37°31'21.7002"	109°32'14.7923"	5234.33
WEST WATER	37°31'58.5020"	109°31'25.7345"	5468.23
Re-Surveyed July 2010			
RUIN SPRING	37°30'06.0456"	109°31'23.4181"	5380.01
COTTONWOOD	37°31'21.6987"	109°32'14.7927"	5234.27
WEST WATER	37°31'58.5013"	109°31'25.7357"	5468.32

FIGURES



EXPLANATION

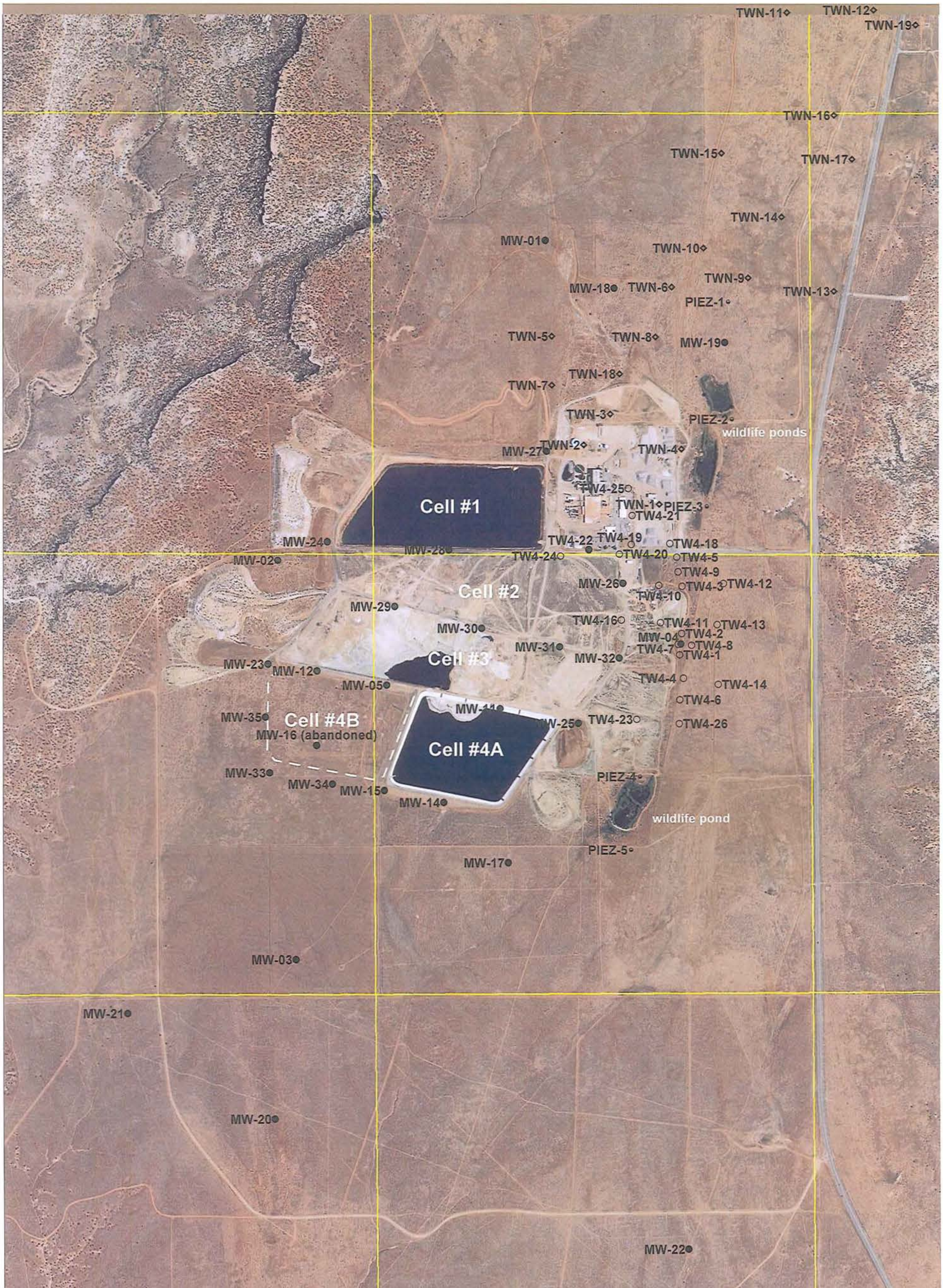
Ruin Spring 5380 — Seep or Spring Showing Elevation in Feet amsl

Area of Detail Map (Figure 1B)

HYDRO GEO CHEM, INC.

LOCATION OF CELL 4B AND SEEPS AND SPRINGS AROUND THE MESA MARGIN WHITE MESA SITE

APPROVED	DATE	REFERENCE	FIGURE
SJS		H:/718000/ cell4bjuly2010/springsQ2/springs.srf	1A



EXPLANATION

- ● perched monitoring well
- ○ TW4- series temporary perched minitoring well
- ◇ TWN- series temporary perched minitoring well
- ⊖ perched piezometer

HYDRO GEO CHEM, INC.

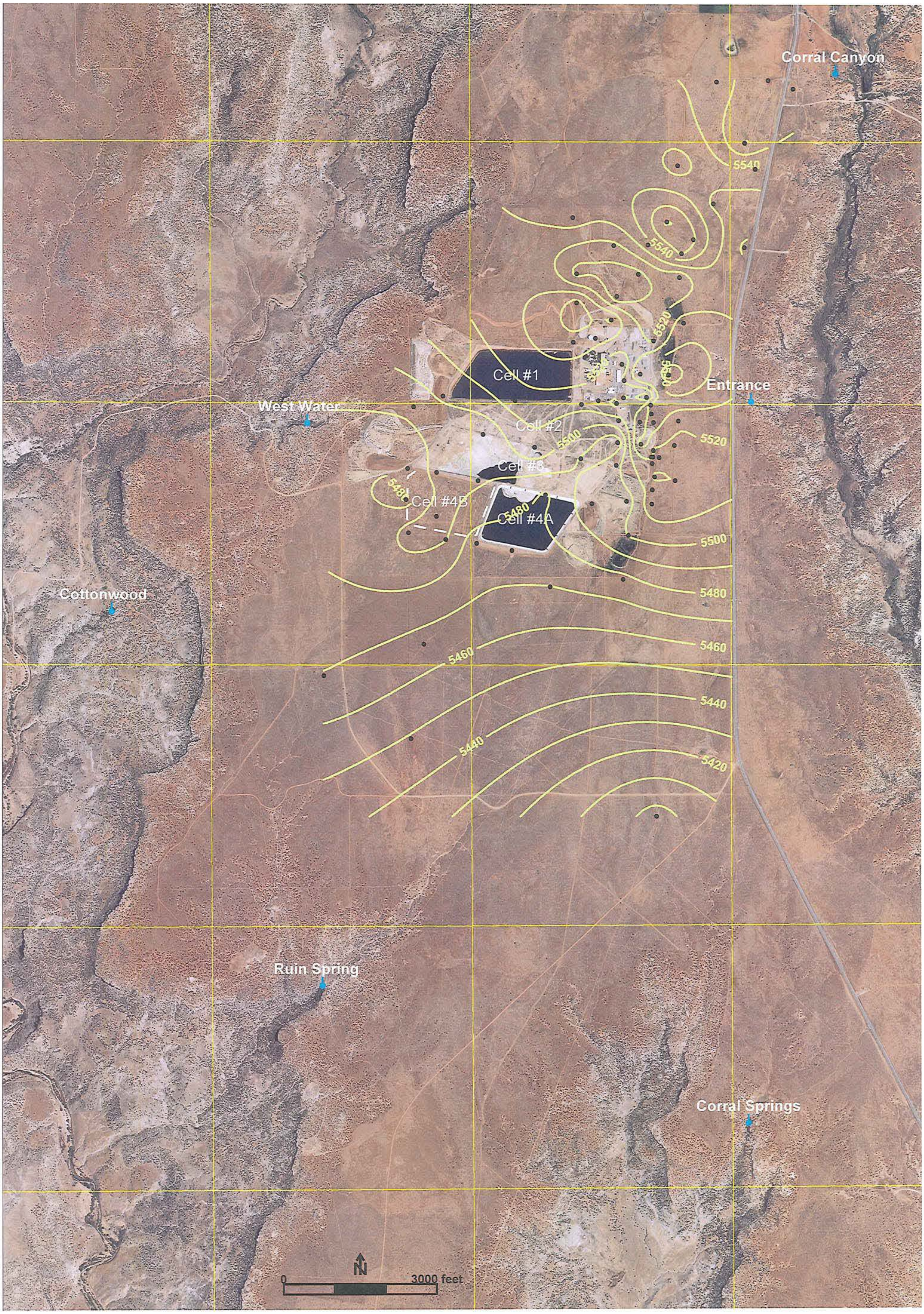
DETAIL MAP SHOWING PERCHED MONITORING WELL LOCATIONS WHITE MESA SITE

APPROVED	DATE	REFERENCE	FIGURE
SJS		H:/718000/ cell4bjuly2010/springsQ2/phwelloc.srf	1B

HYDRO
GEO
CHEM, INC.

PHOTOGRAPH OF THE CONTACT BETWEEN THE BURRO CANYON FORMATION AND THE BRUSHY BASIN MEMBER

APPROVED	DATE	REFERENCE	FIGURE
SJS		H:/718000/ cell4bjuly2010/springsQ2/contact.srf	2



EXPLANATION

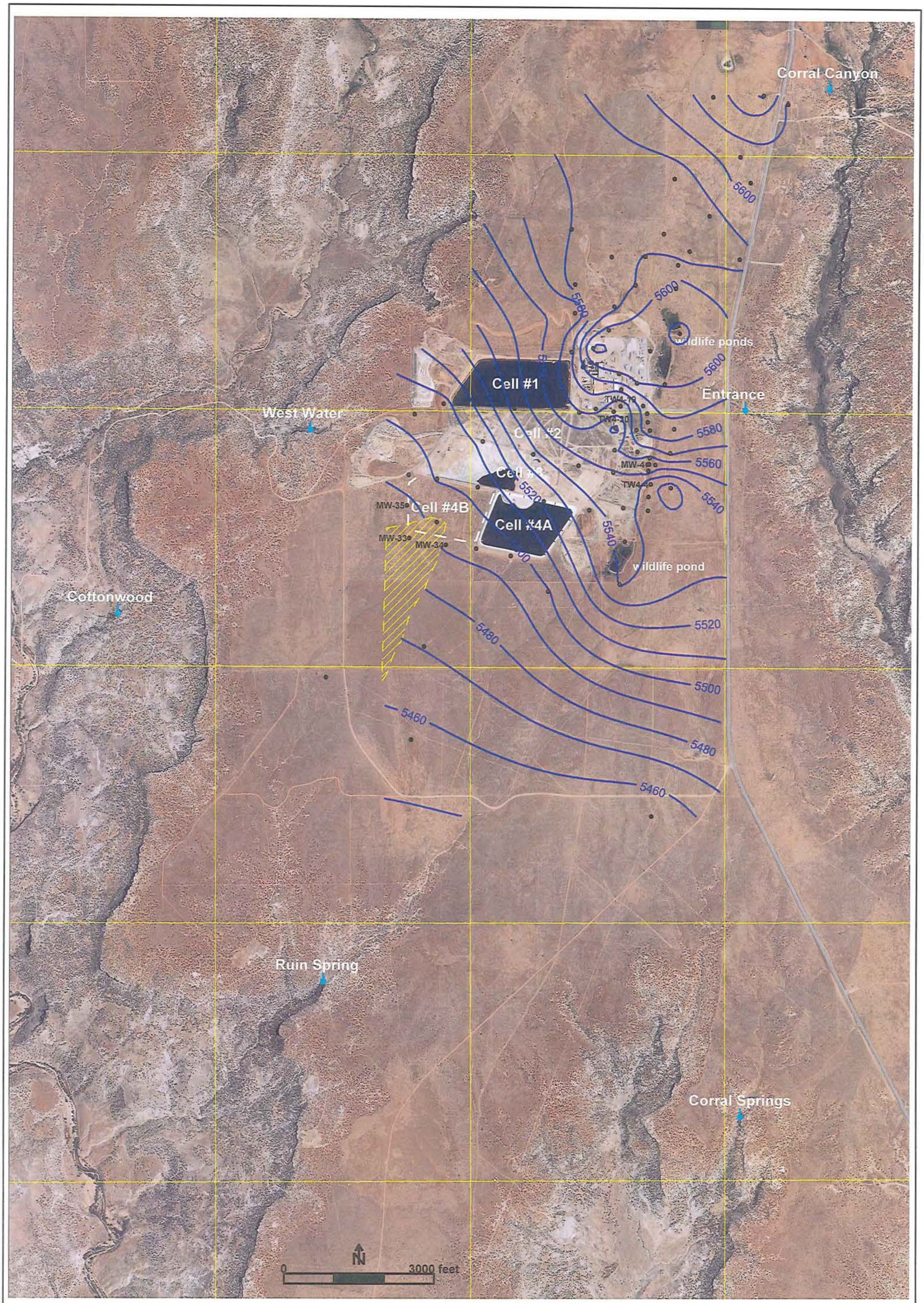
● Perched Monitoring Well

Ruin Spring — Seep or Spring

HYDRO GEO CHEM, INC.

APPROXIMATE ELEVATION OF TOP OF BRUSHY BASIN (FEET AMSL) (generated by kriging data from on-site wells)

APPROVED	DATE	REFERENCE	FIGURE
SJS		H:/718000/cell4bjuly2010/springQ2/phbbQ2.srf	3



EXPLANATION

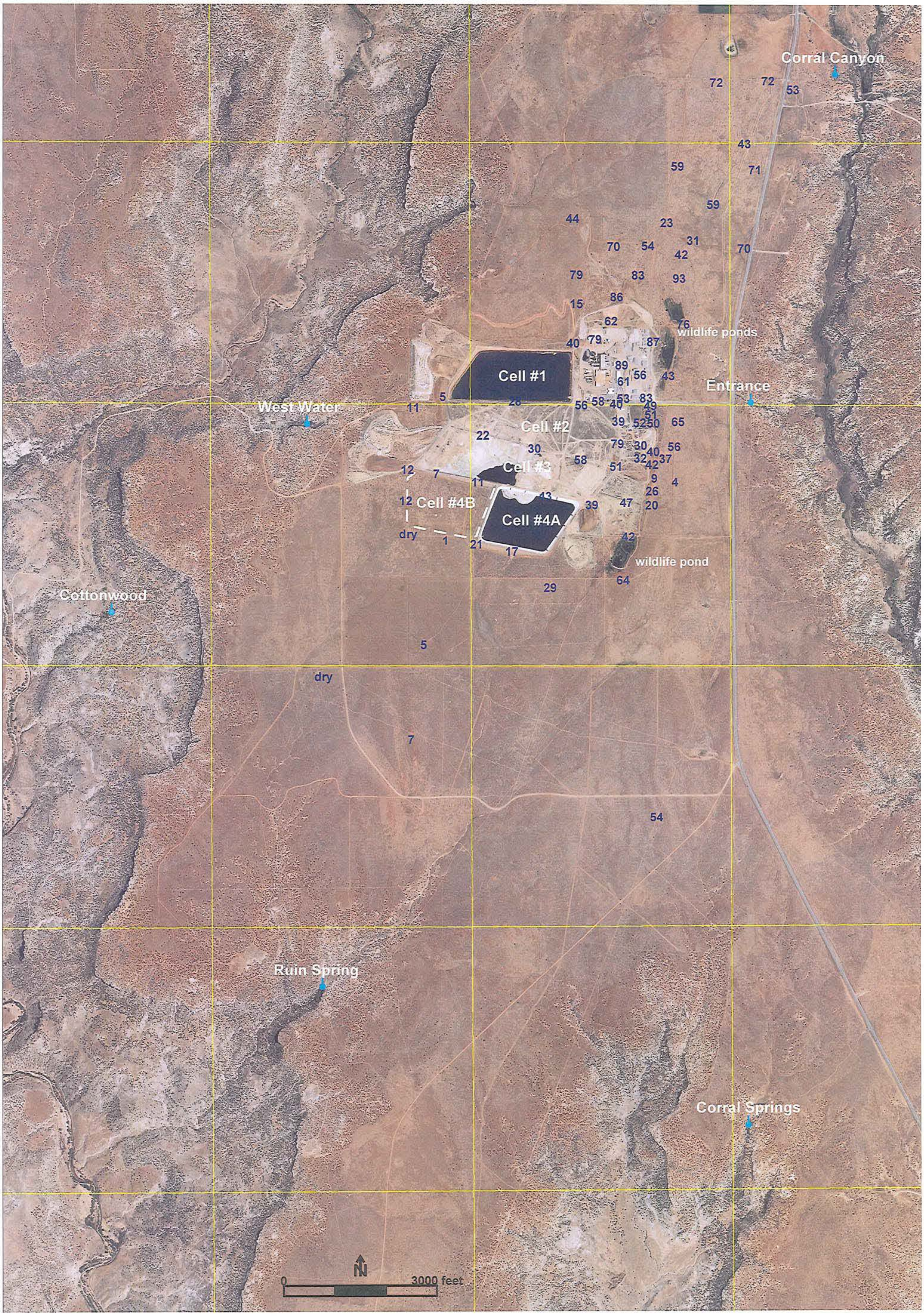
- Perched Monitoring Well
- Ruin Spring — Seep or Spring
- Estimated Dry Area (Kriged Brushy Basin Surface > Kriged Perched Water Surface)

NOTES: MW-4, TW4-4, TW4-15 (MW-26), TW4-19 and TW4-20 are pumping wells; Water levels for MW-33, MW-34, MW-35 (installed August 2010), are from the 3rd Quarter, 2010

HYDRO GEO CHEM, INC.

2nd QUARTER, 2010 PERCHED WATER ELEVATION CONTOURS (FEET AMSL) (generated by kriging data from on-site wells)

APPROVED	DATE	REFERENCE	FIGURE
SJS		H:/718000/cell4bjuly2010/springQ2/phwlQ2.srf	4



EXPLANATION

NOTE: Saturated thicknesses for MW-34 and MW-35 (installed August 2010), are from the 3rd Quarter, 2010

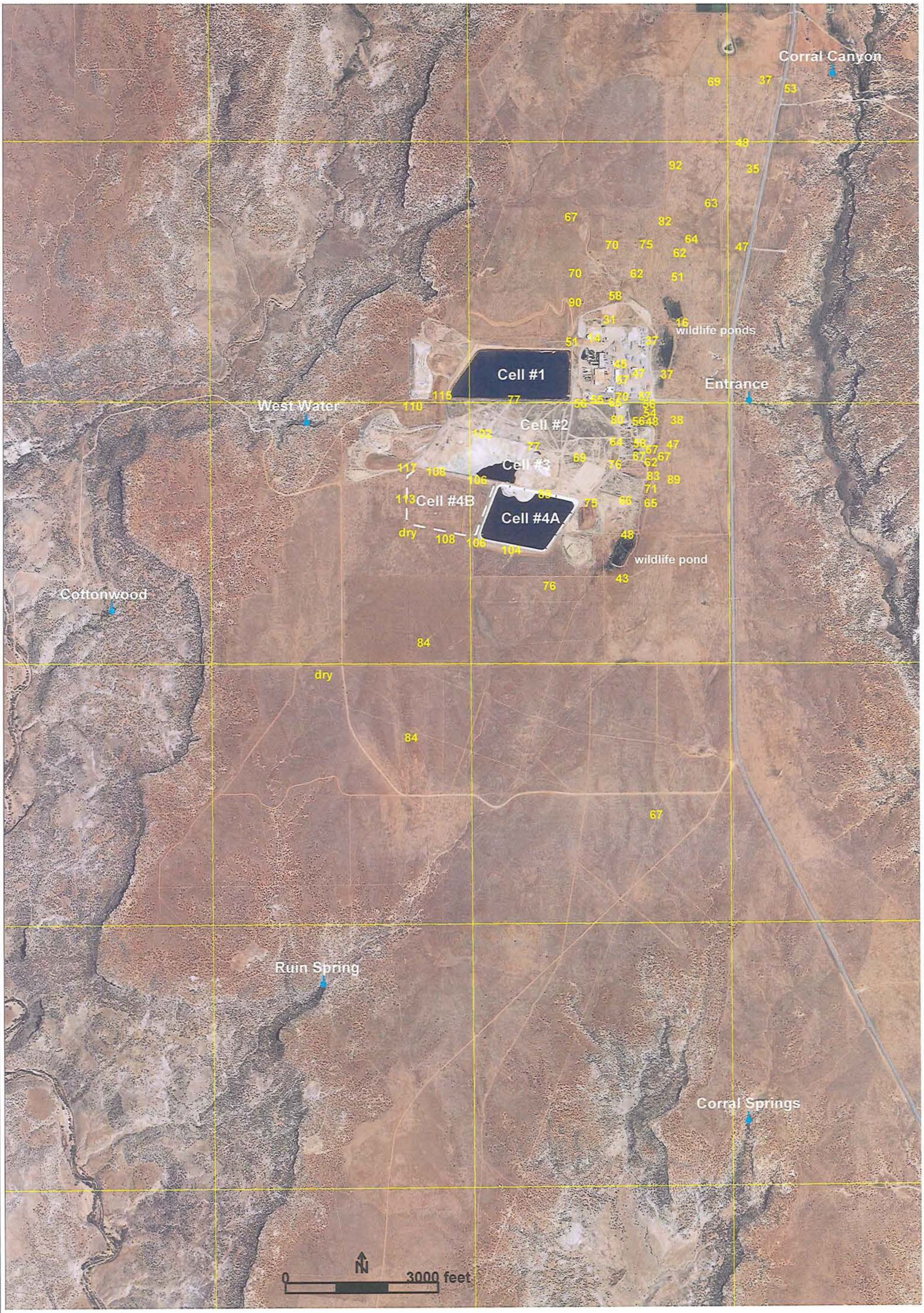
12 Perched Zone Saturated Thickness (feet)

Ruin Spring
Seep or Spring

HYDRO GEO CHEM, INC.

2nd QUARTER, 2010 PERCHED ZONE SATURATED THICKNESS WHITE MESA SITE

APPROVED	DATE	REFERENCE	FIGURE
SJS		H:/718000/cell4bjuly2010/springQ2/phsatQ2.srf	5



EXPLANATION

NOTE: Depths to water for MW-34 and MW-35 (installed August 2010), are from the 3rd Quarter, 2010

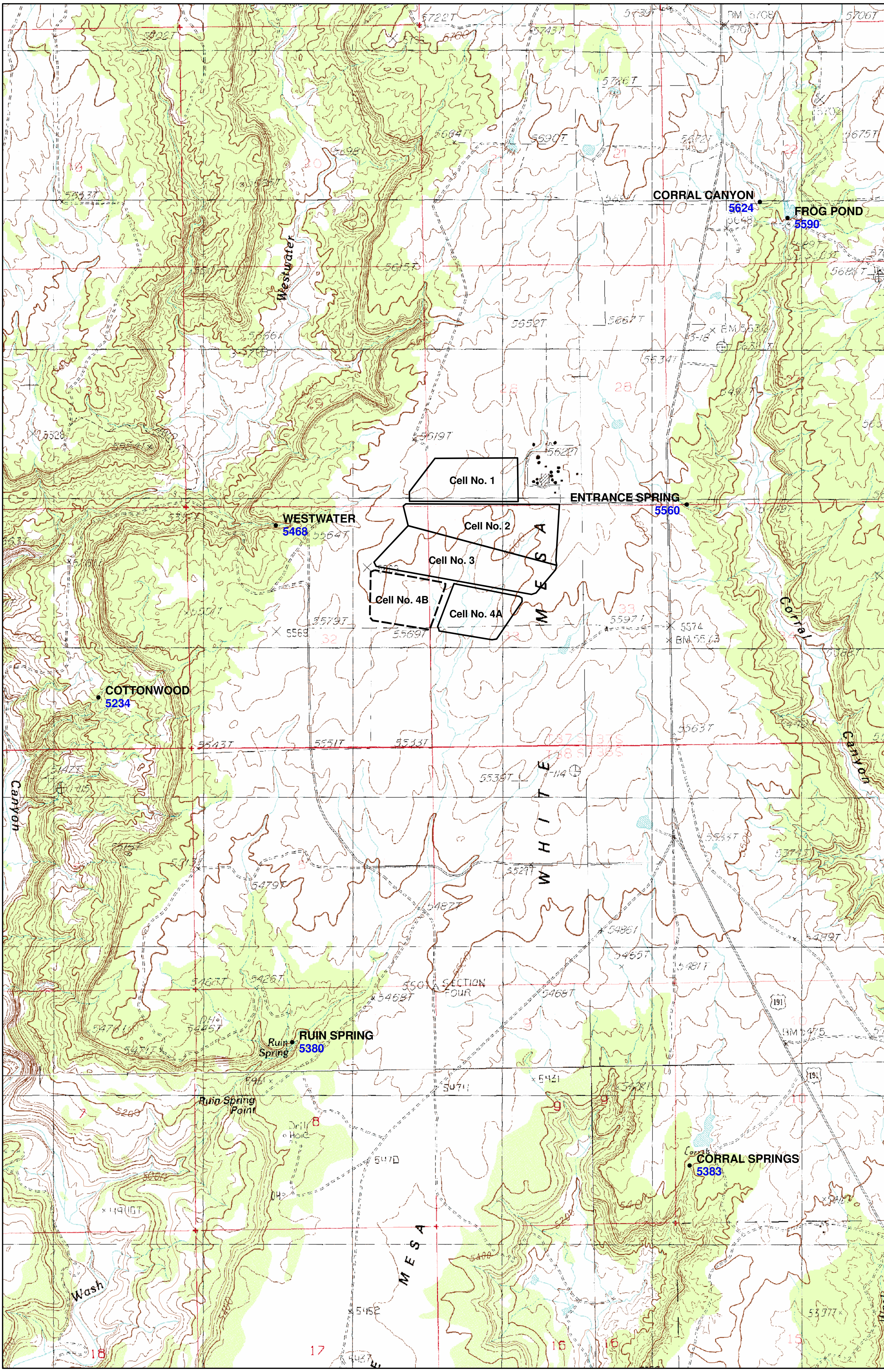
108 Depth to Perched Water (feet)

Ruin Spring Seep or Spring

HYDRO GEO CHEM, INC.

2nd QUARTER, 2010 DEPTHS TO PERCHED WATER WHITE MESA SITE

APPROVED	DATE	REFERENCE	FIGURE
SJS		H:/718000/cell4bjuly2010/springQ2/phdtwQ2.srf	6



0.5 0.25 0 0.5 1
Mile

● **WESTWATER** Seep or Spring
5468 Elevation (feet) above mean sea level

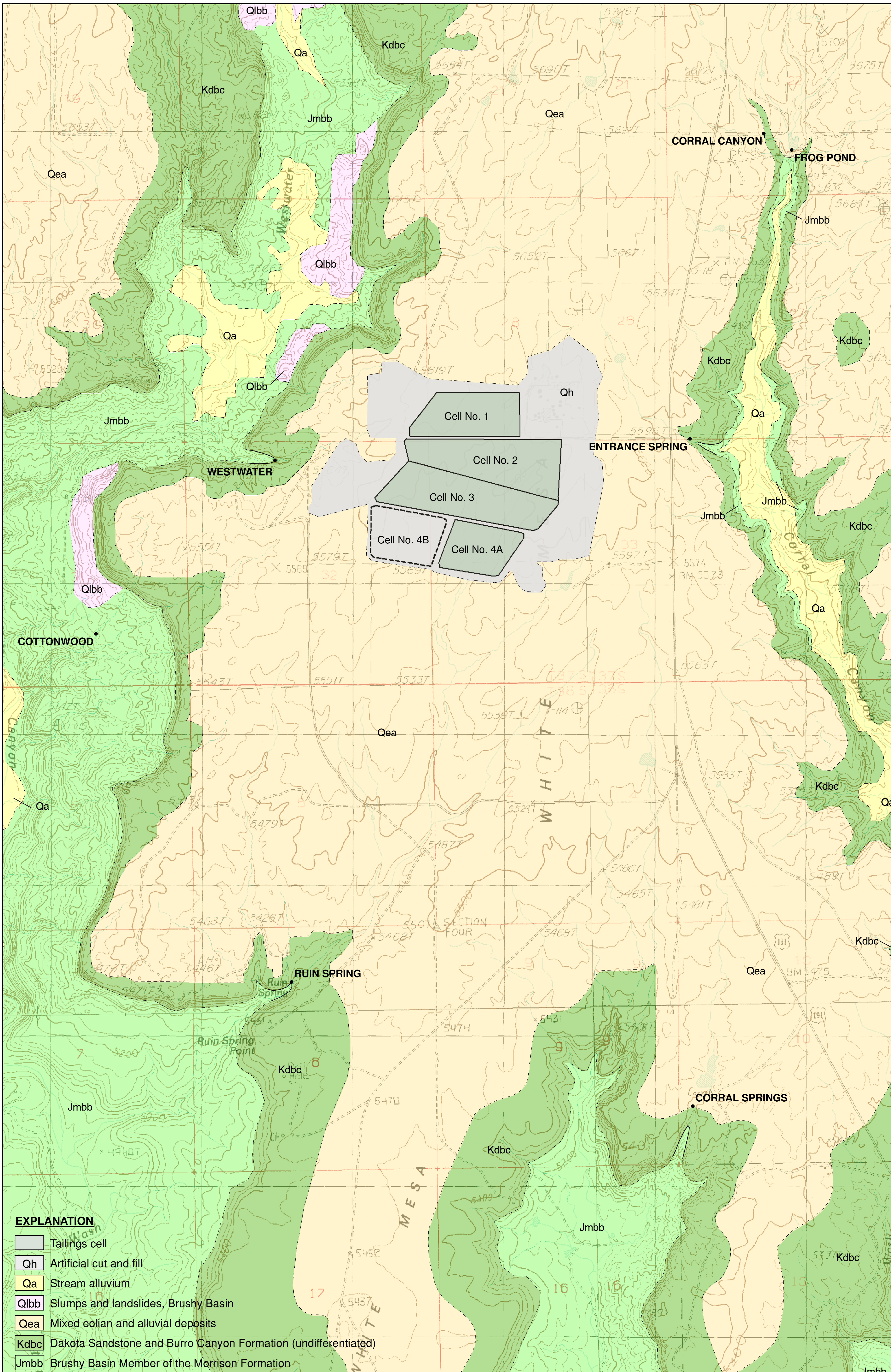
NORTH

HYDRO GEO CHEM, INC.

SEEPS AND SPRINGS ON USGS TOPOGRAPHIC BASE WHITE MESA

Approved	Date	Author	Date	File Name	Figure
SJS	09/17/10	DRS	07/16/10	7180002G	7

K:\718000\GIS\7180002G.mxd: Friday, September 17, 2010 1:02:59 PM



0.5 0.25 0 0.5 1 Mile

Contact - dashed where uncertain

NORTH

HYDRO GEO CHEM, INC.

GEOLOGIC MAP
ON USGS TOPOGRAPHIC BASE
WHITE MESA

Approved	Date	Author	Date	File Name	Figure
SJS	09/09/10	DRS	07/27/10	7180005G	8

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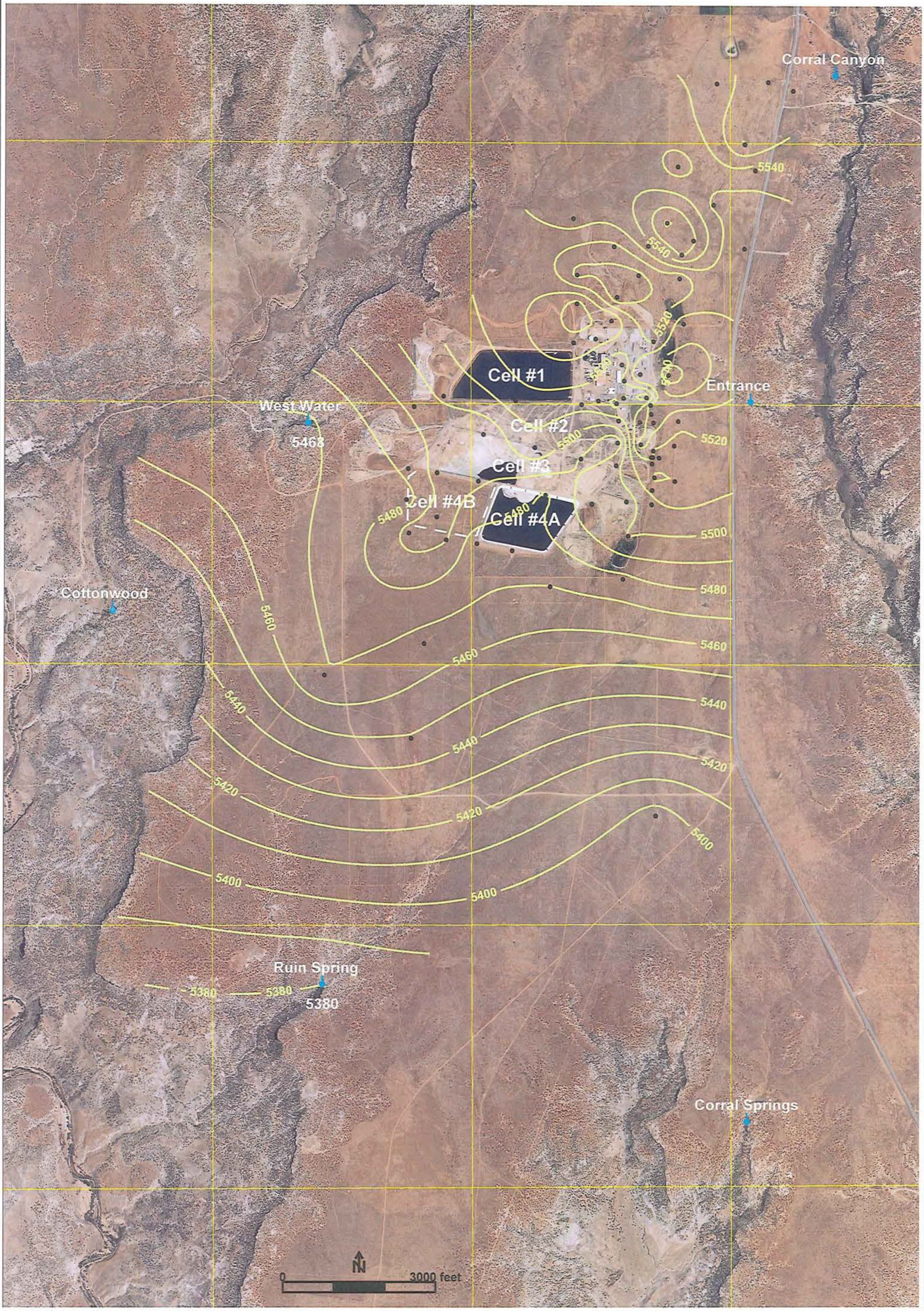


EXPLANATION

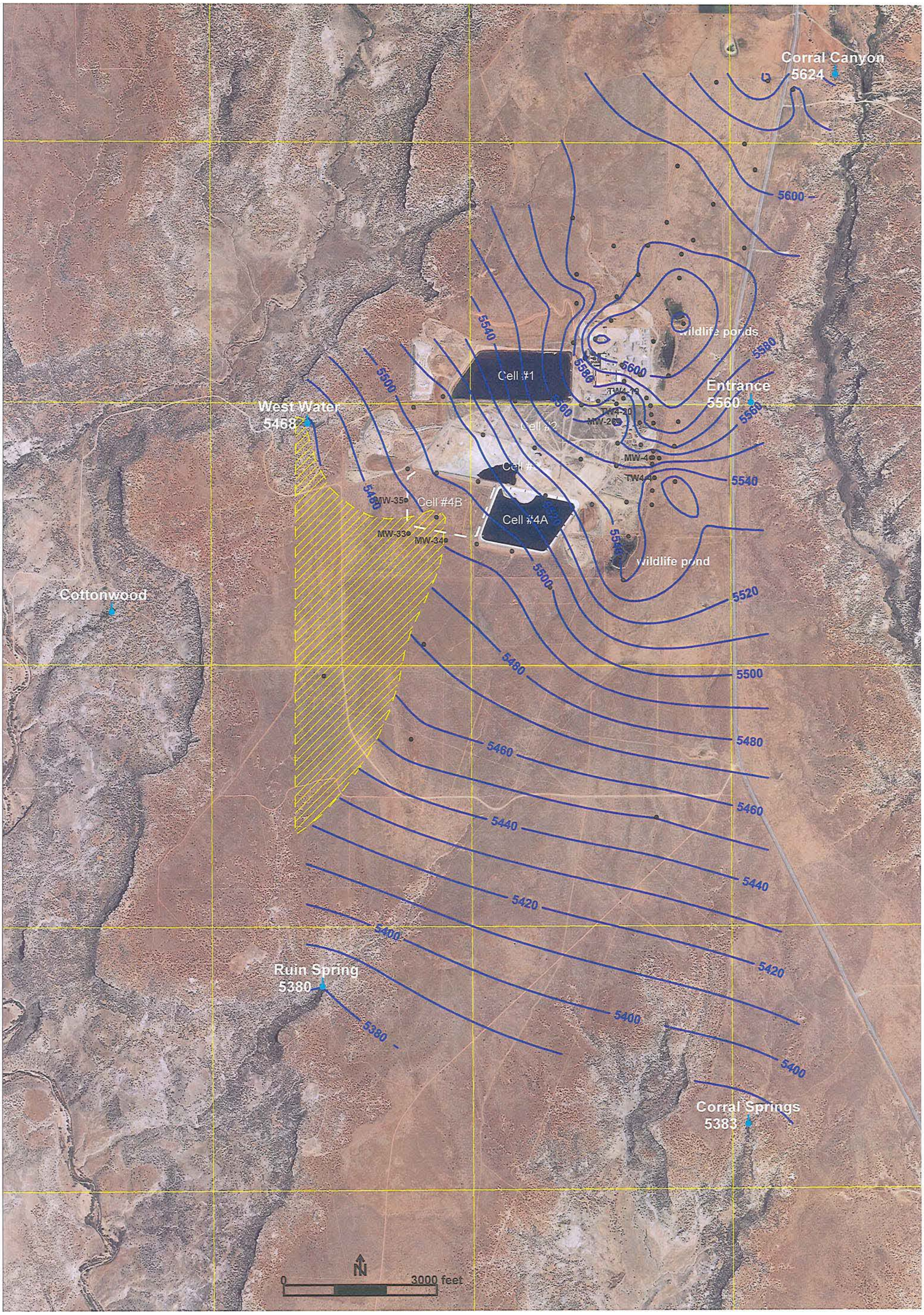
● Perched Monitoring Well

Ruin Spring 5380 — Seep or Spring Showing Elevation (feet amsl)

HYDRO GEO CHEM, INC.

APPROXIMATE ELEVATION OF TOP OF BRUSHY BASIN (FEET AMSL) (generated by kriging data from on-site wells, Ruin Spring and Westwater Seep)

APPROVED	DATE	REFERENCE	FIGURE
SJS		H:/718000/cell4bjuly2010/springQ2/phbbQ2sp.srf	9



EXPLANATION

Perched Monitoring Well

Ruin Spring 5380 — Seep or Spring Showing Elevation

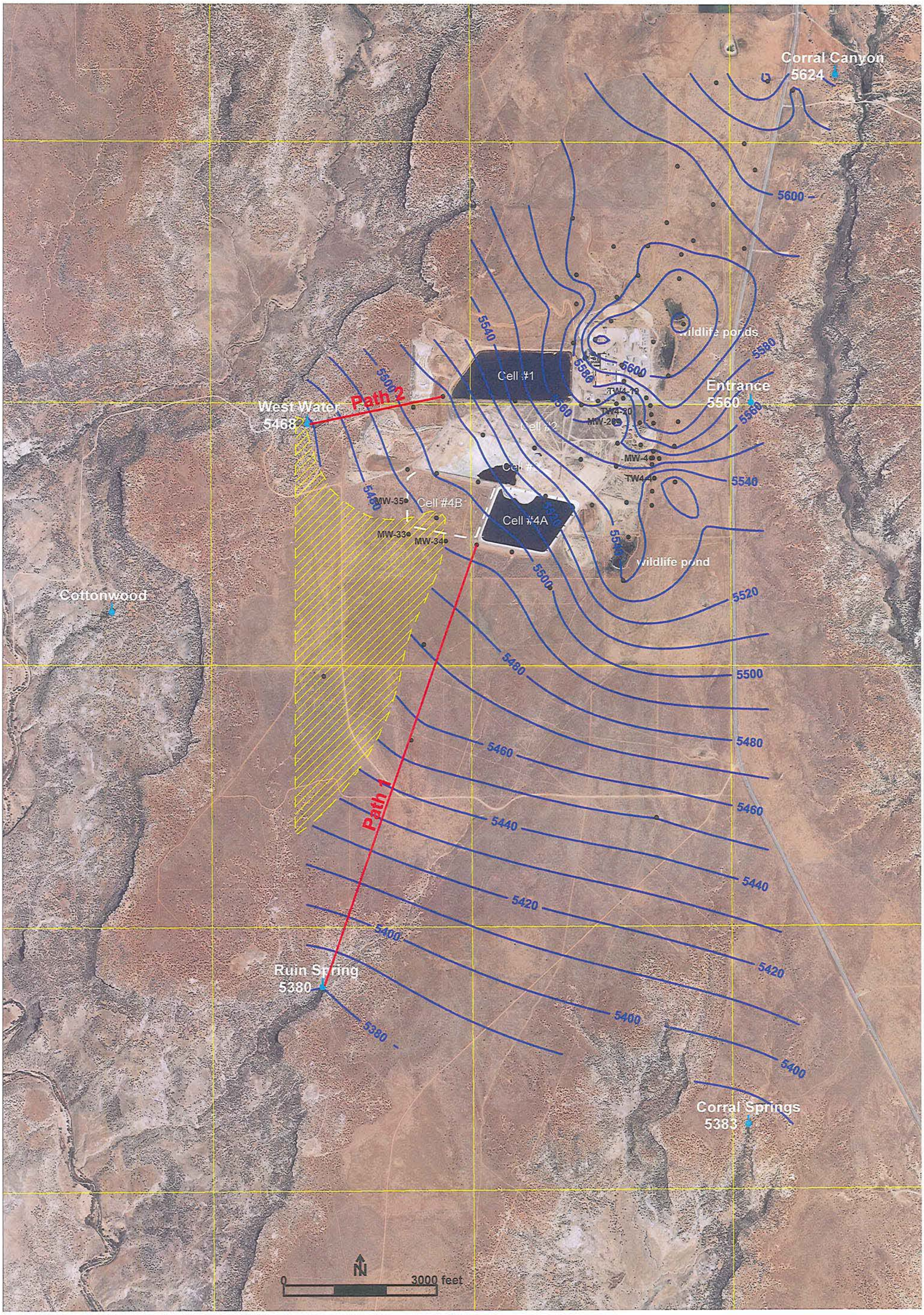
Estimated Dry Area (Kriged Brushy Basin Surface > Kriged Perched Water Surface)

NOTES: MW-4, TW4-4, TW4-15 (MW-26), TW4-19 and TW4-20 are pumping wells;
Water levels for MW-33, MW-34, MW-35 (installed August 2010), are from the 3rd Quarter, 2010

HYDRO GEO CHEM, INC.

2nd QUARTER, 2010 PERCHED WATER ELEVATION CONTOURS (FEET AMSL) (generated by kriging data from on-site wells, and seeps and springs excluding Cottonwood)

APPROVED	DATE	REFERENCE	FIGURE
SJS		H:/718000/cell4bjuly2010/springQ2/phwlQ2sp.srf	10



EXPLANATION

- Perched Monitoring Well
- Ruin Spring 5380 — Seep or Spring Showing Elevation
- Estimated Dry Area (Kriged Brushy Basin Surface > Kriged Perched Water Surface)
- Pathline for Travel Time Calculation

NOTES: MW-4, TW4-4, TW4-15 (MW-26), TW4-19 and TW4-20 are pumping wells; Water levels for MW-33, MW-34, MW-35 (installed August 2010), are from the 3rd Quarter, 2010

HYDRO GEO CHEM, INC.

PATHLINES USED IN TRAVEL TIME CALCULATIONS (2nd quarter, 2010 perched water elevation contours also shown)

APPROVED	DATE	REFERENCE	FIGURE
SJS		H:/718000/cell4bjuly2010/springQ2/phpathQ2sp.srf	11

APPENDIX A

PHOTOGRAPHS OF SEEPS AND SPRINGS AND SURROUNDING AREAS ON WEST SIDE OF WHITE MESA

TABLE OF CONTENTS

FIGURES

FIGURE A.1

H:/718000/cell4bjuly2010/report.AppA/FigA1.srf

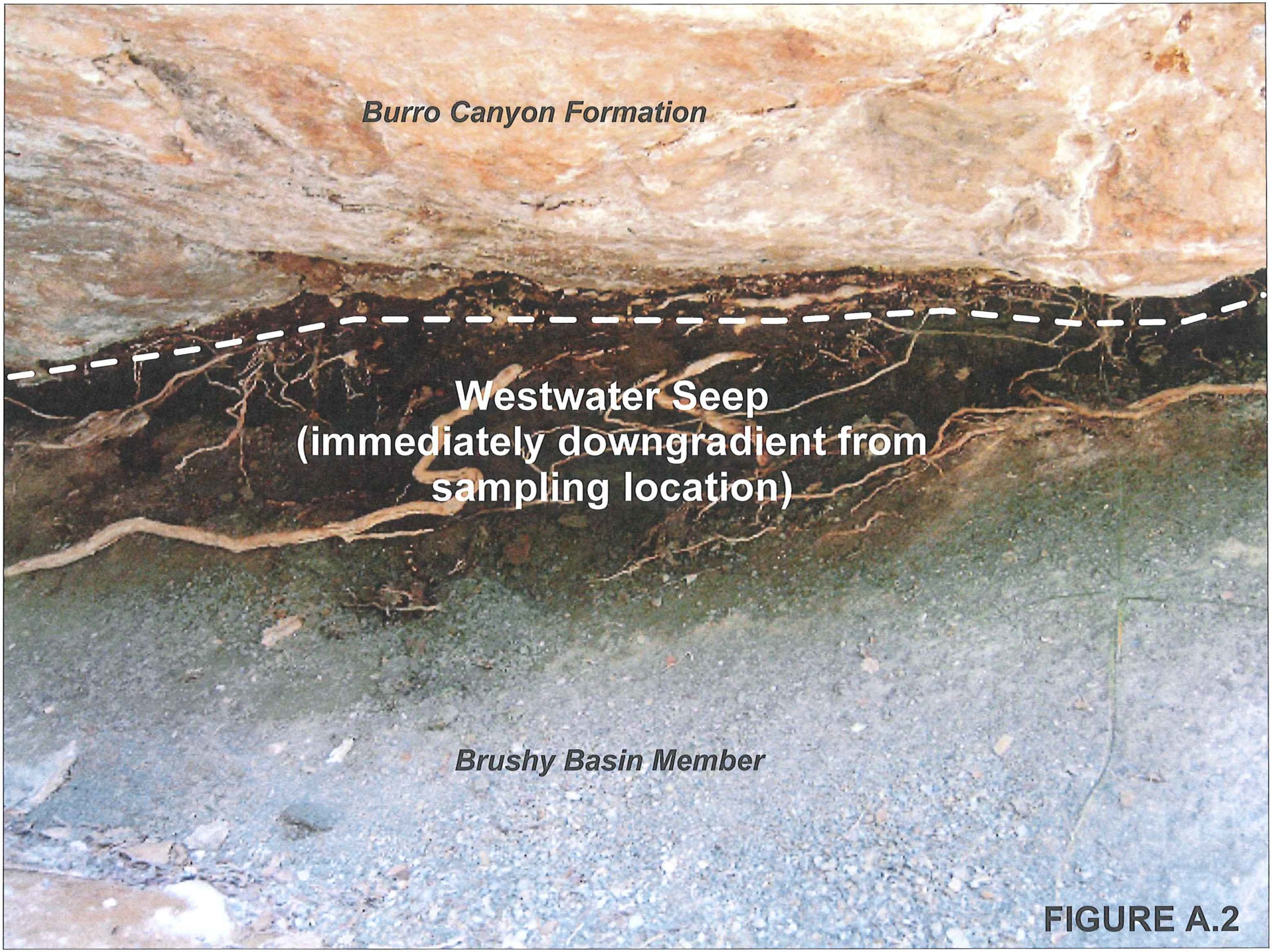
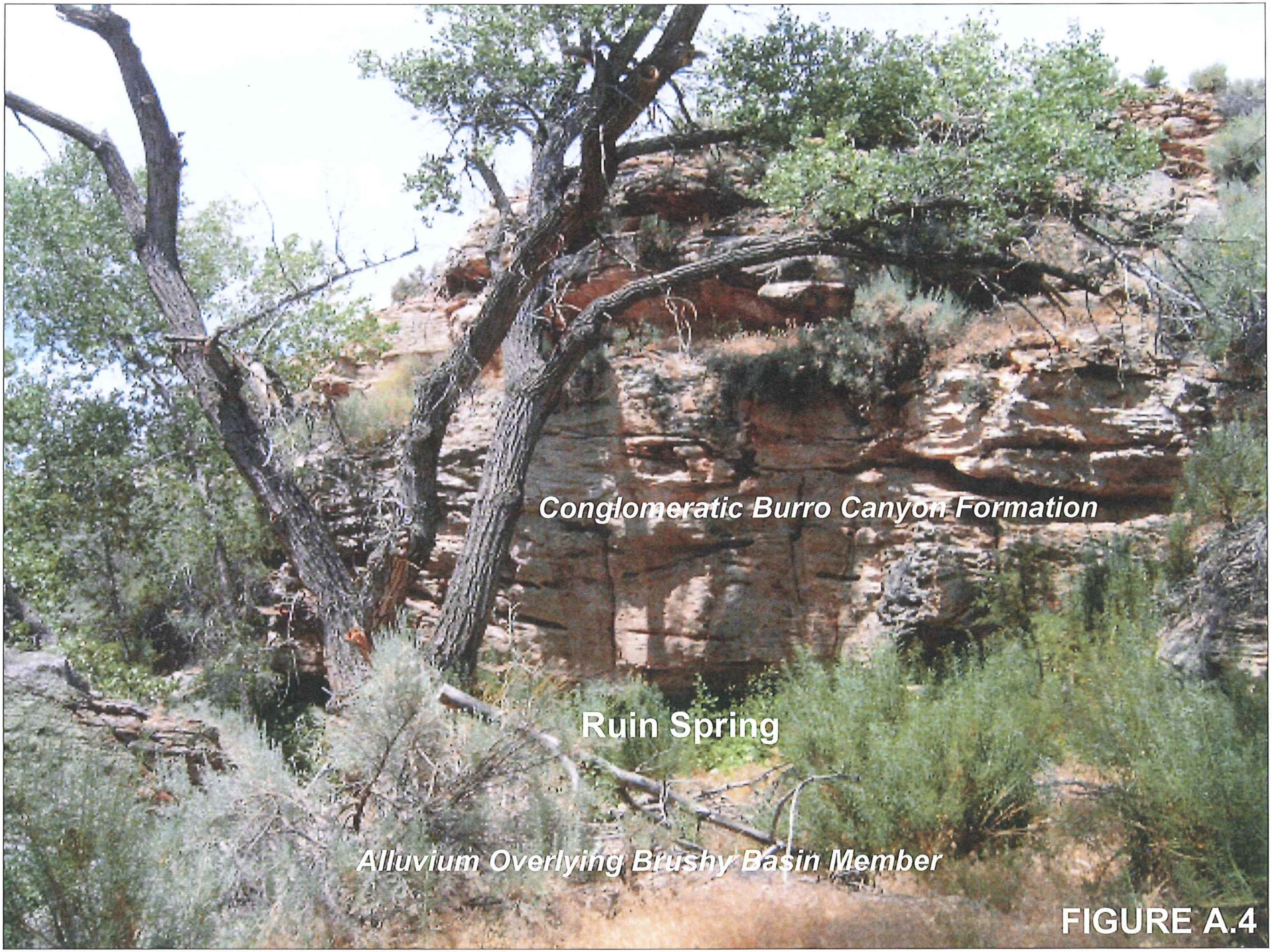

Burro Canyon Formation
Westwater Seep
(immediately downgradient from
sampling location)
Brushy Basin Member

FIGURE A.2

FIGURE A.3

H:/718000/cell4bjuly2010/report/AppA/FigA3.srf



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H:/718000/cell4bjuly2010/report/AppA/FigA5.srf

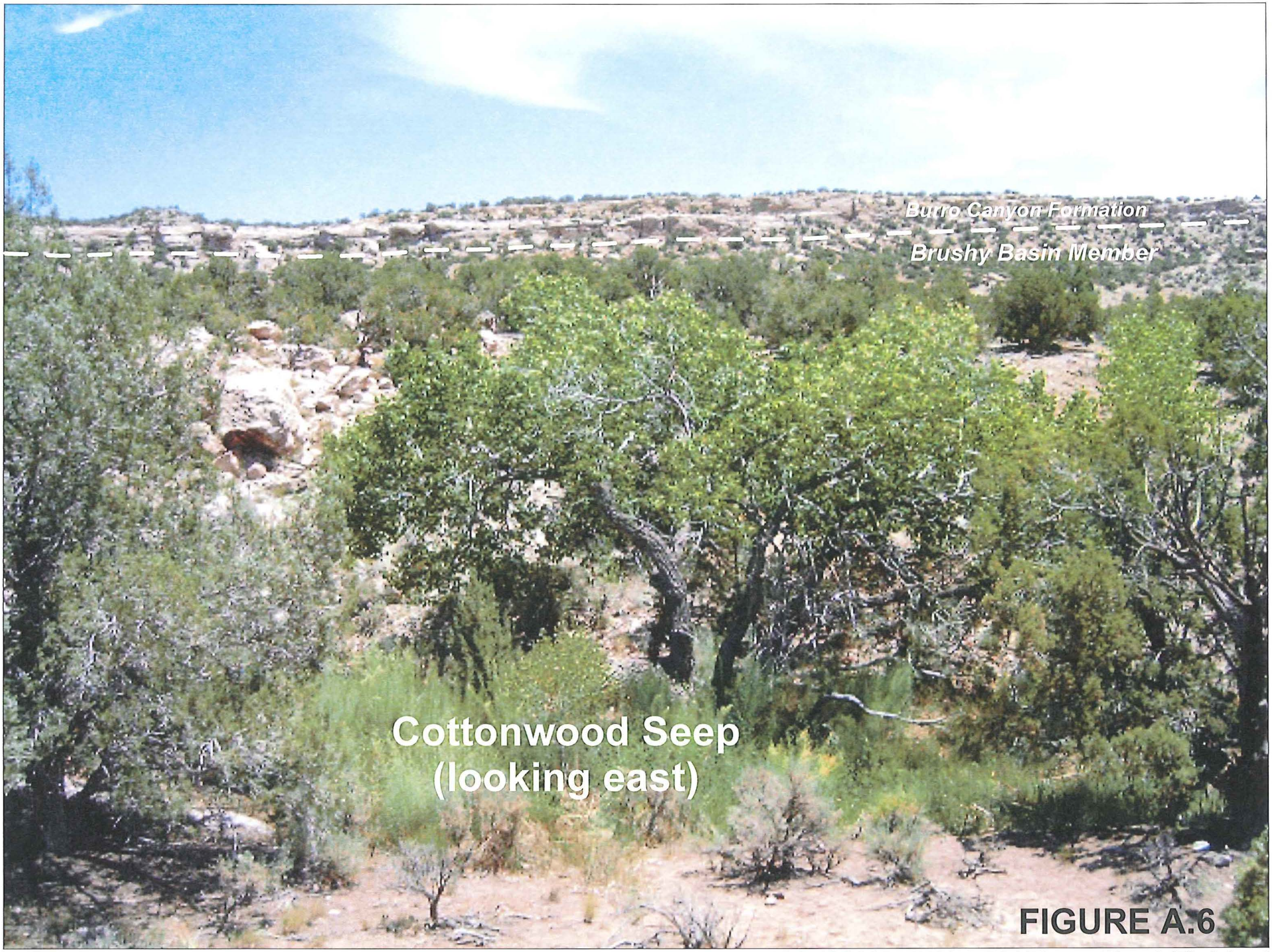

FIGURE A.6

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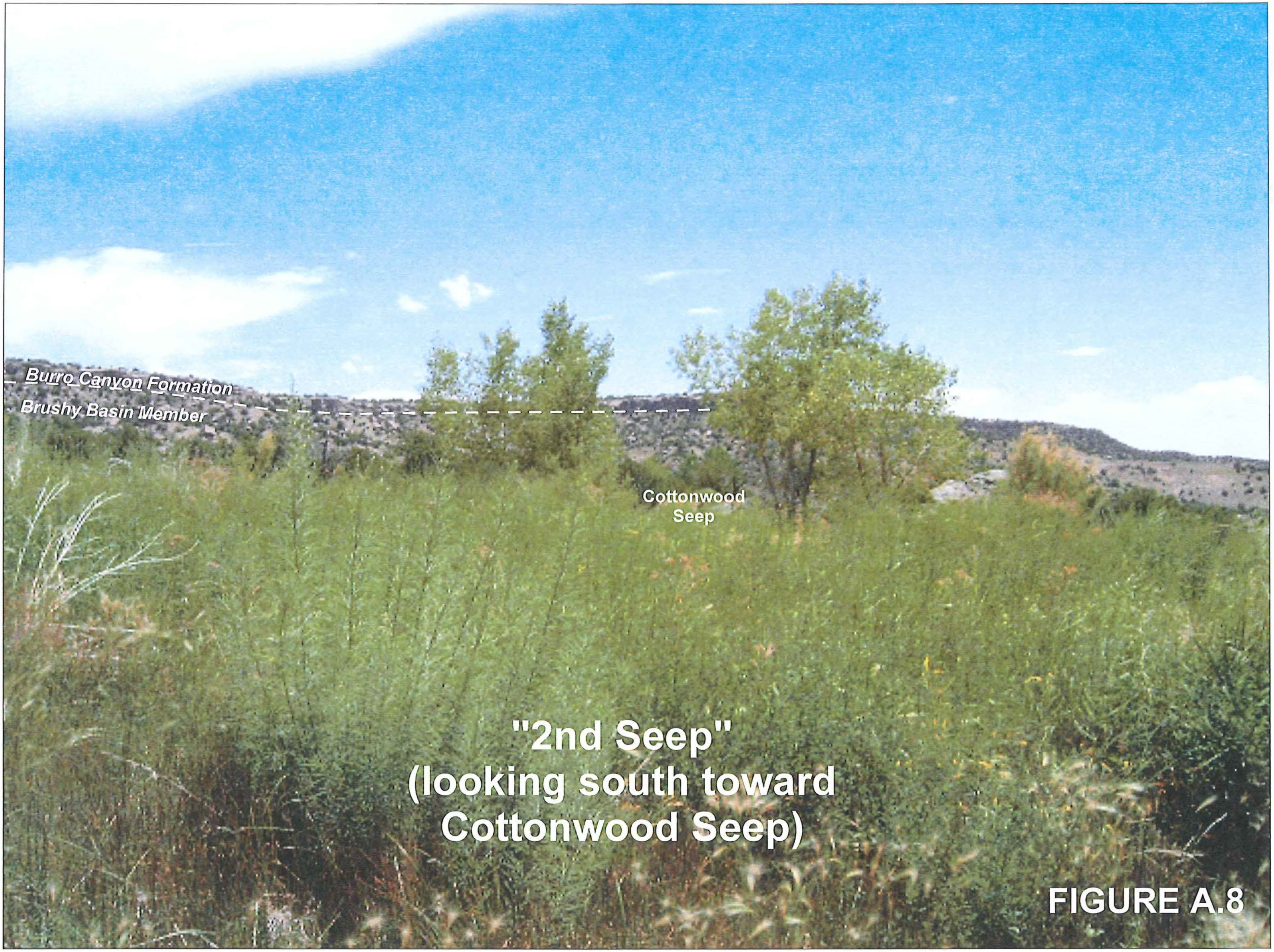

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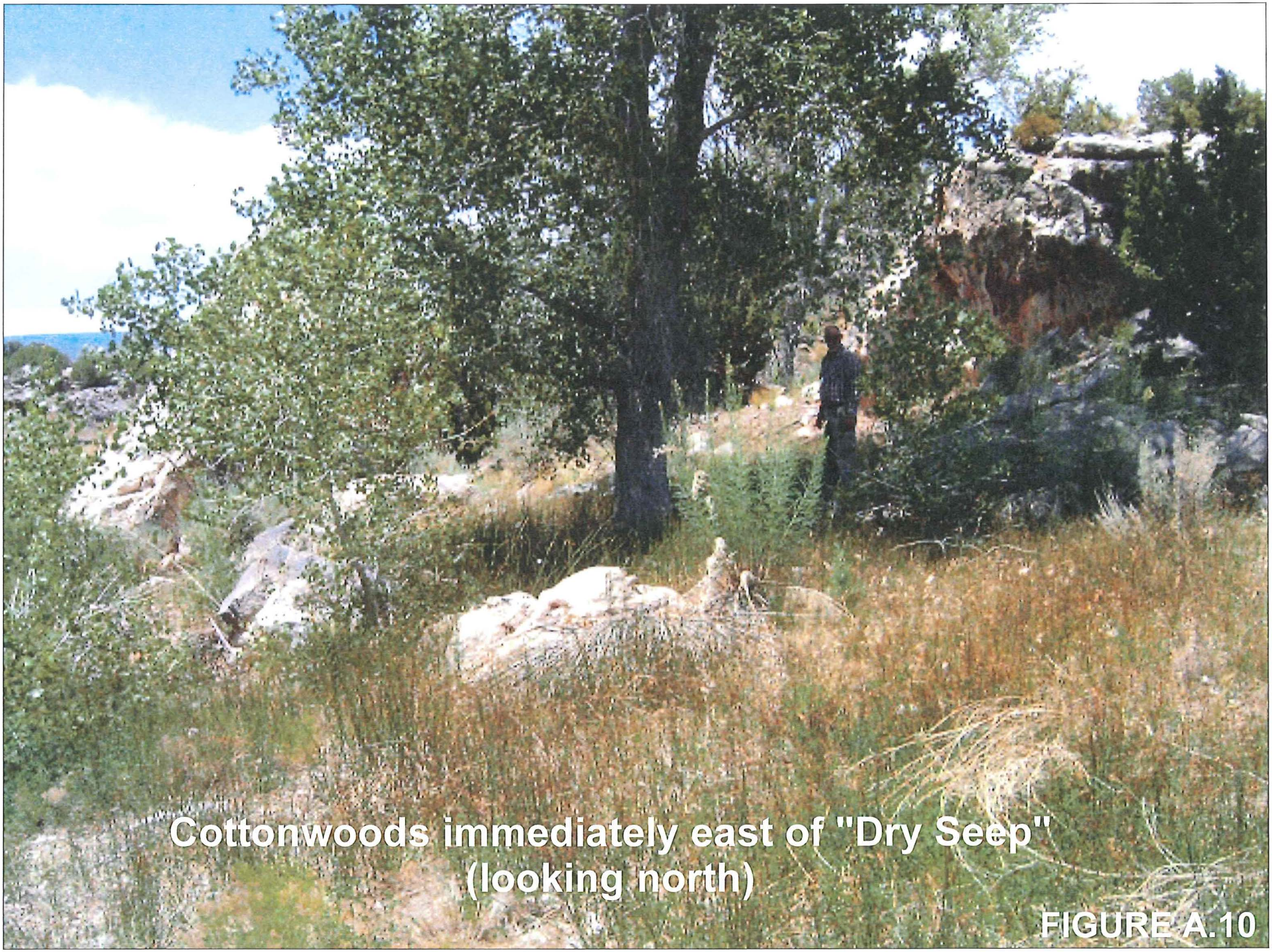

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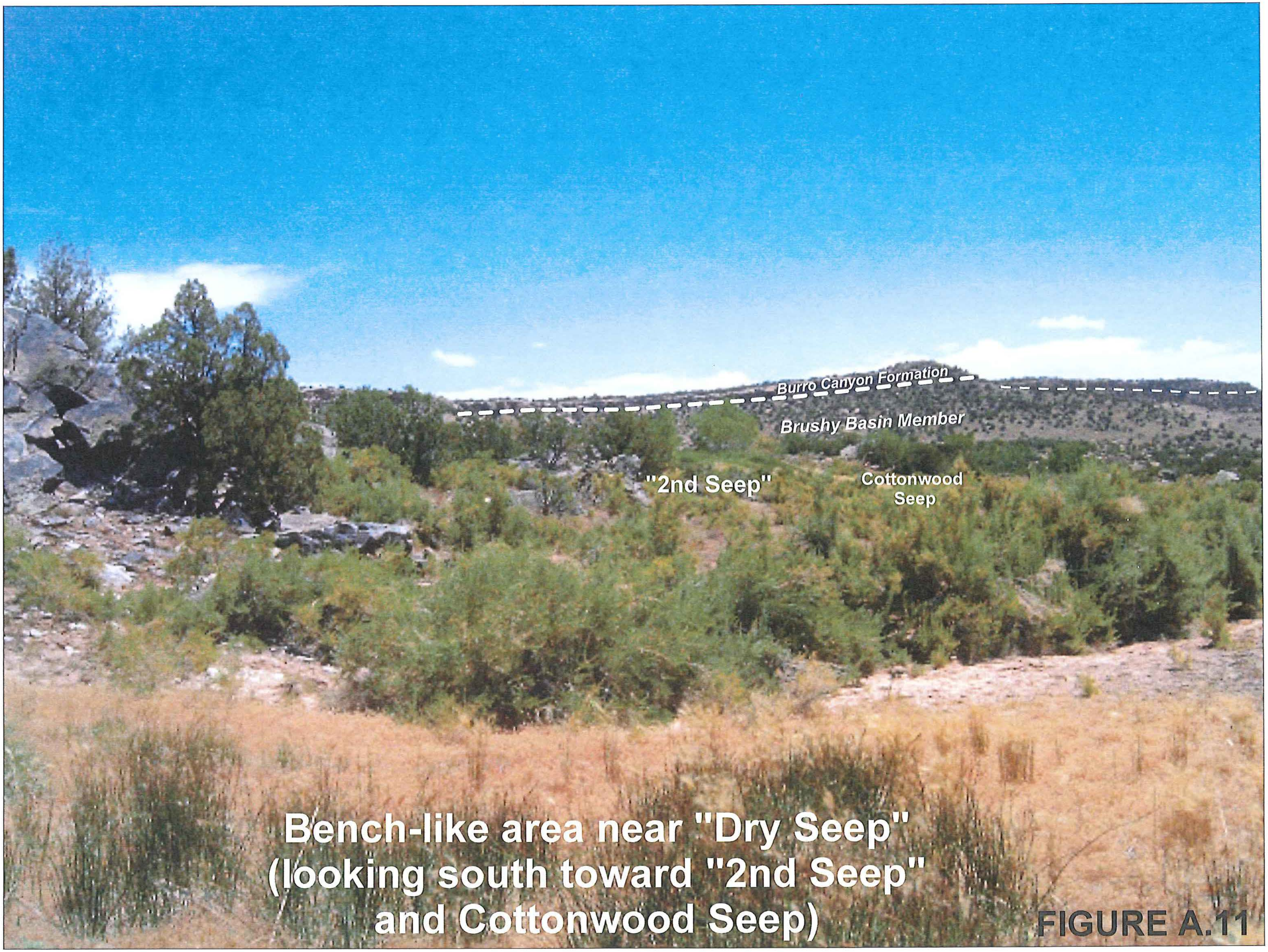

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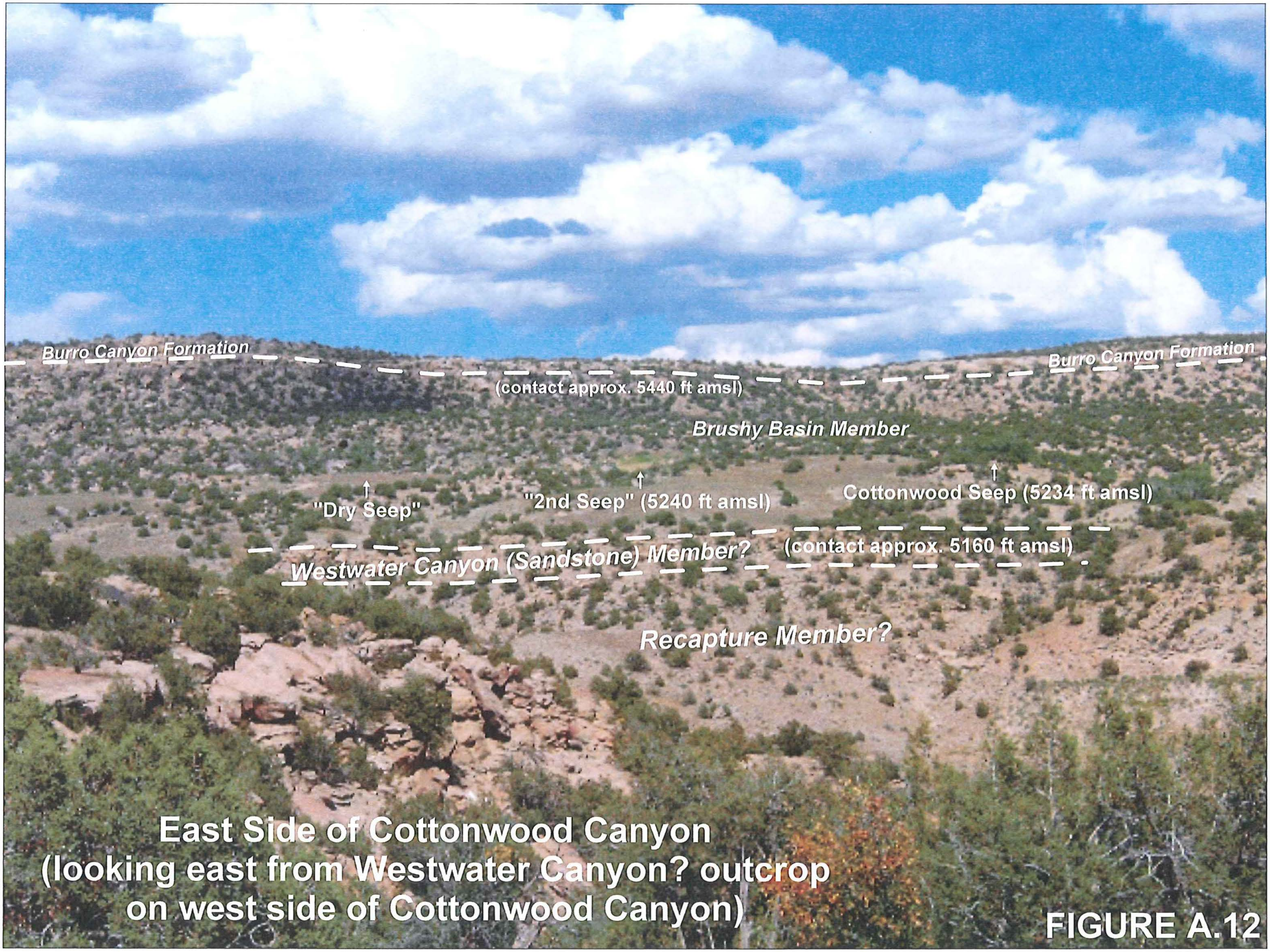

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FIGURE A.13

H:/718000/cell4bjuly2010/report/AppA/FigA13.srf

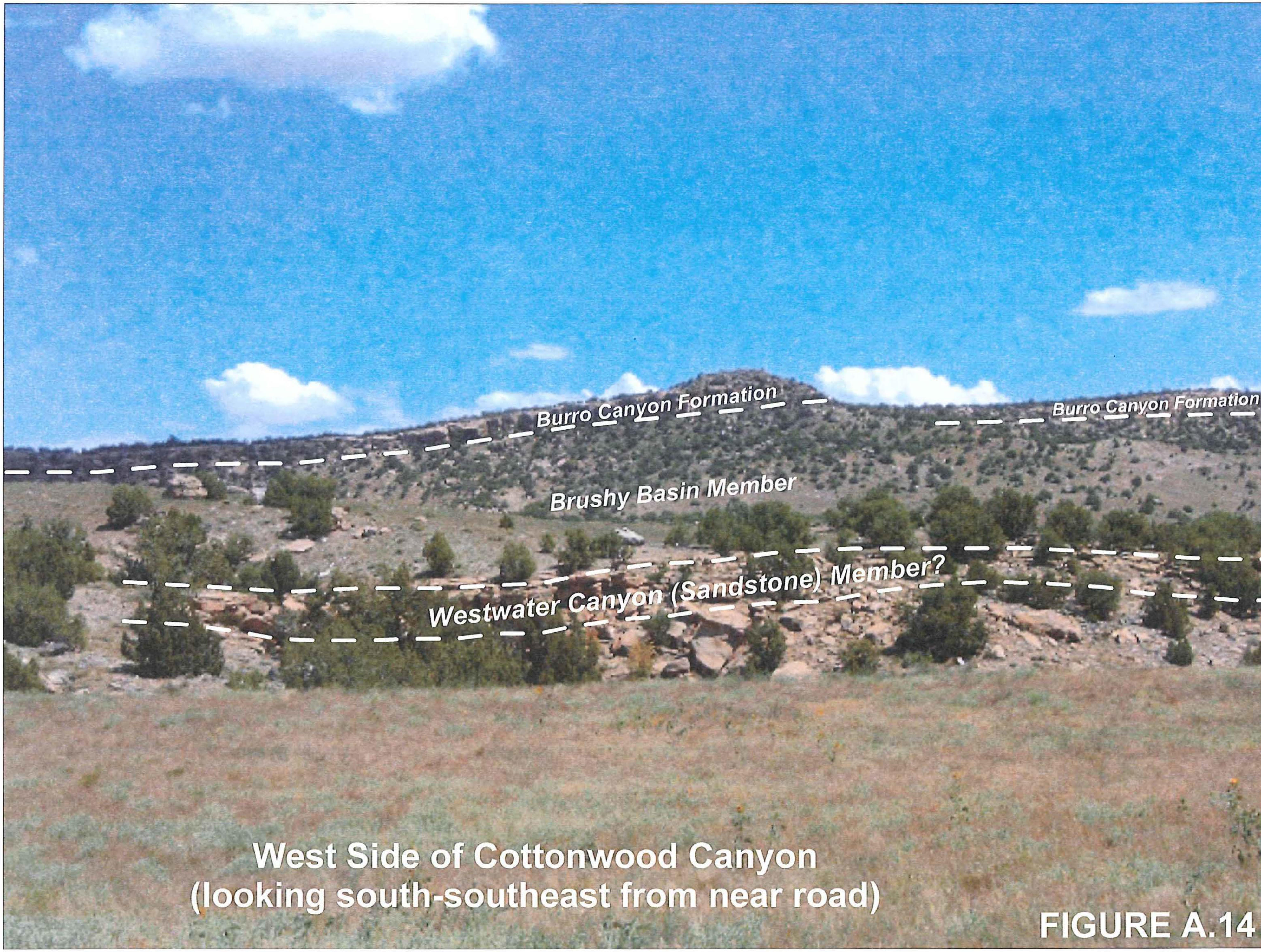

FIGURE A.14

H:/718000/cell4bjuly2010/report/AppA/FigA14.srf

APPENDIX B

PHOTOGRAPHS OF SEEPS AND SPRINGS AND SURROUNDING AREAS ON EAST SIDE OF WHITE MESA

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FIGURES


Cottonwoods Near Corral Canyon Seep

FIGURE B.1

H:/718000/cell4bjuly2010/report/AppB/FigB2.srf

H:/718000/cell4bjuly2010/report/AppB/FigB3.srf

H:/718000/cell4bjuly2010/report/AppB/FigB4.srf

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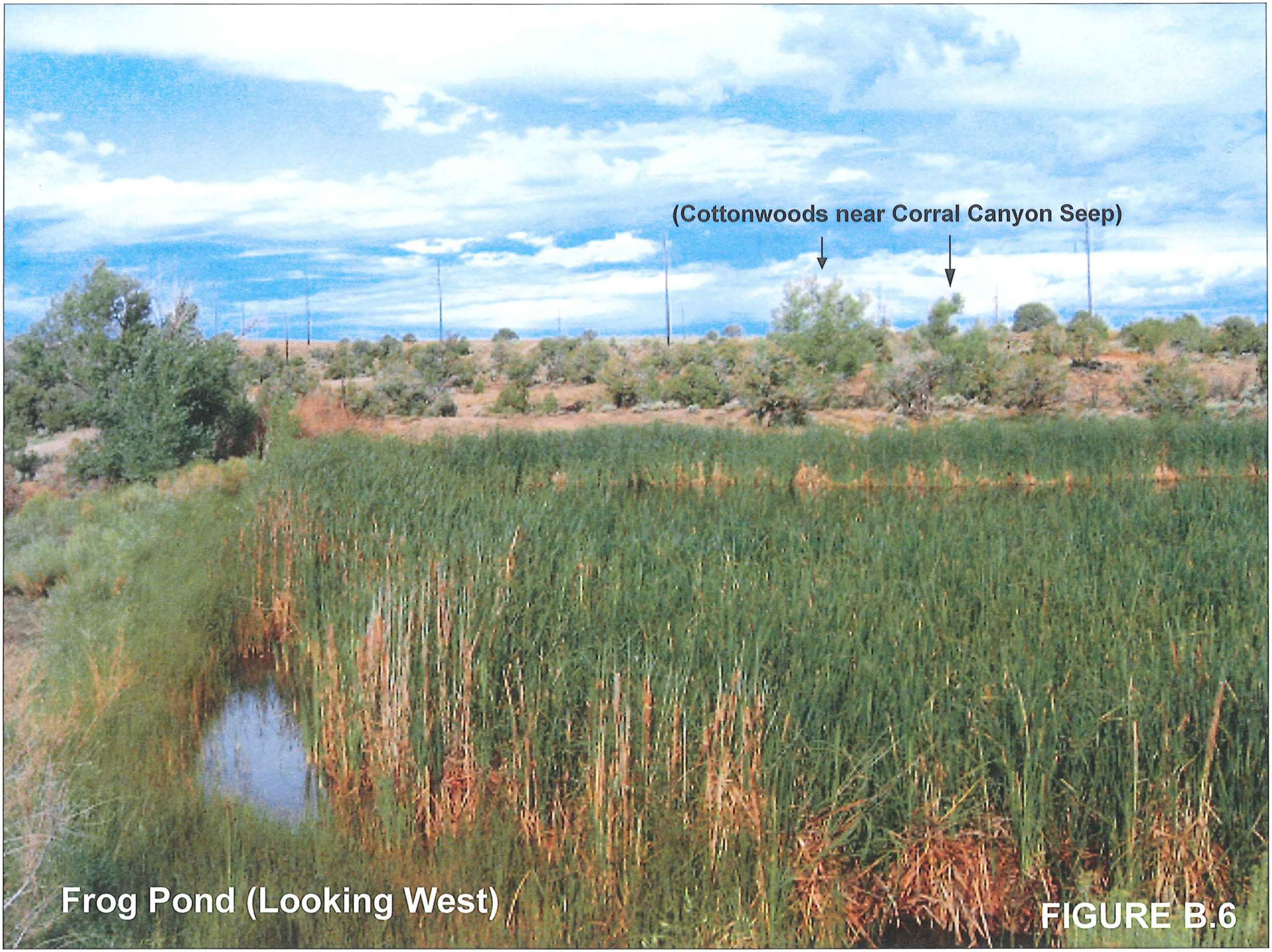

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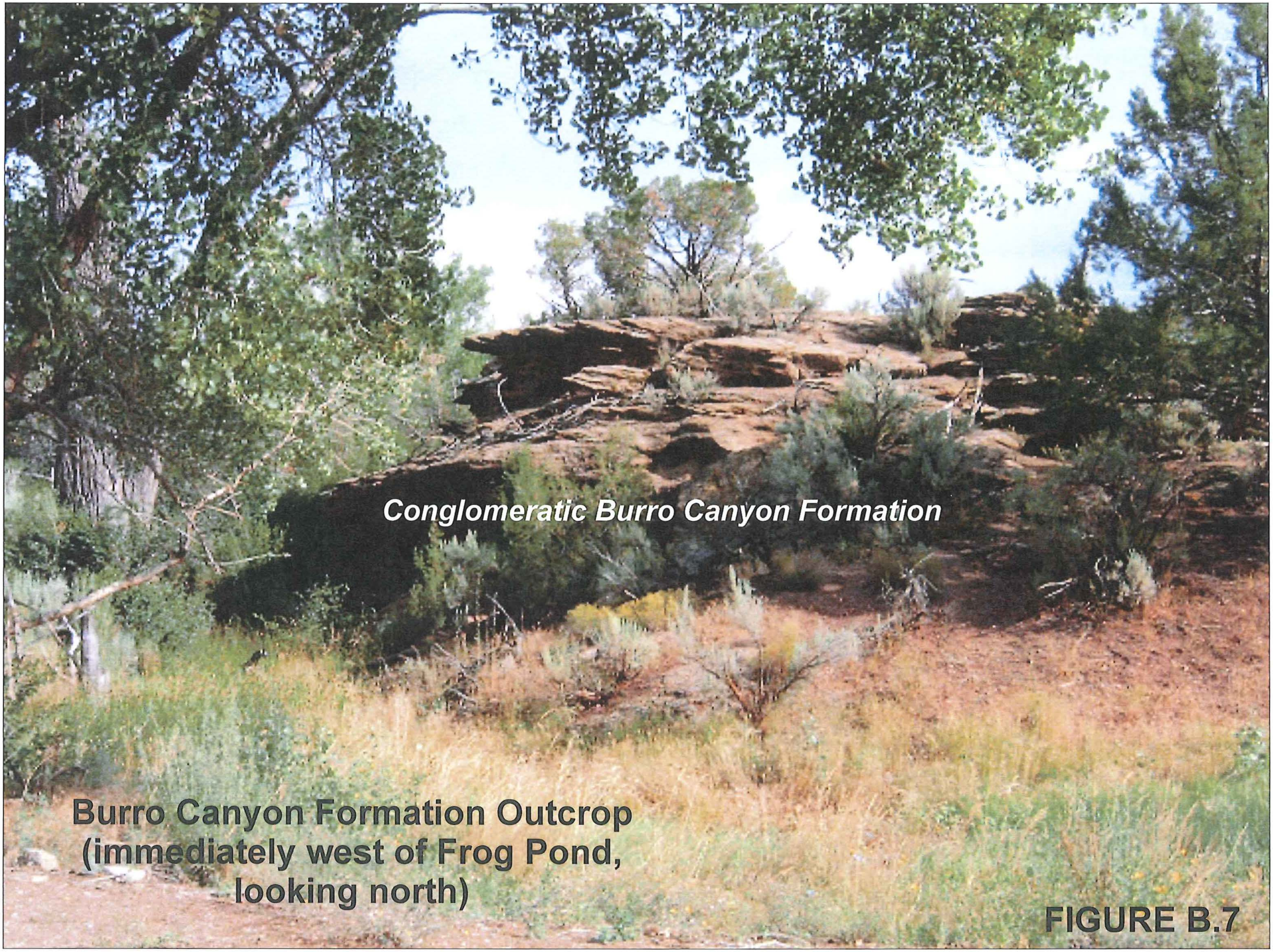

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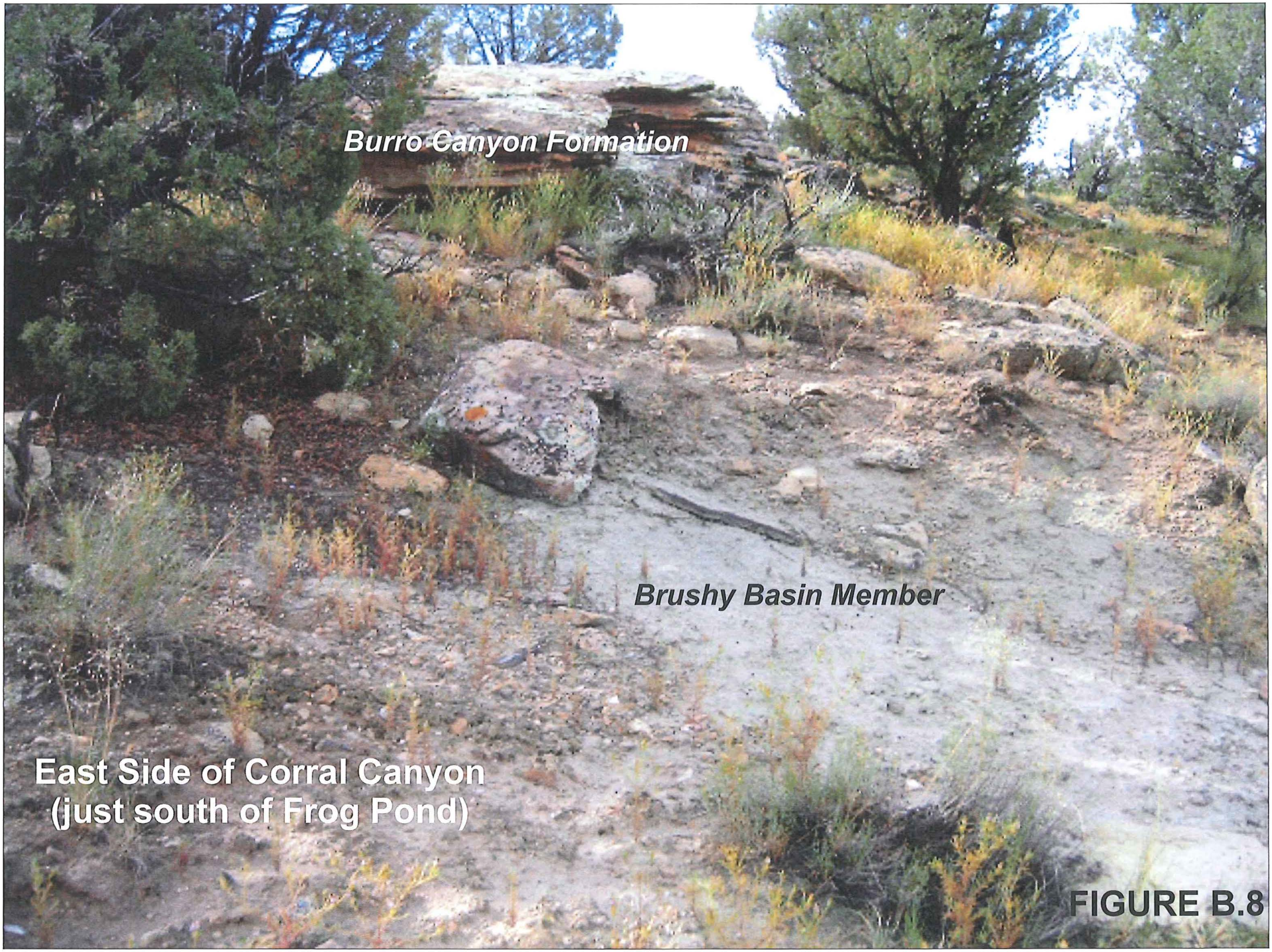
Burro Canyon Formation
Brushy Basin Member
East Side of Corral Canyon
(just south of Frog Pond)
FIGURE B.8

FIGURE B.9

H:/718000/cell4bjuly2010/report/AppB/FigB9.srf

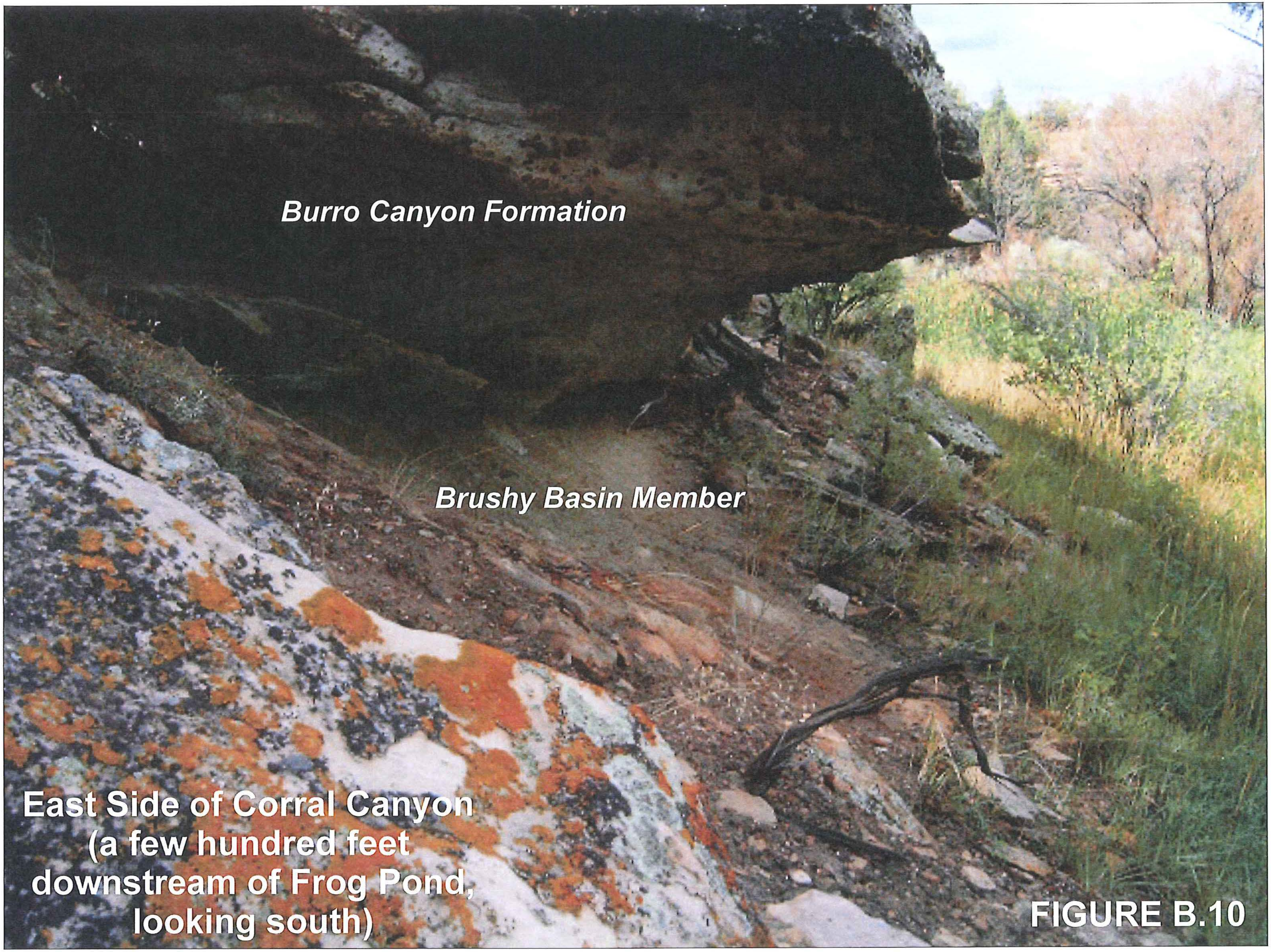
Burro Canyon Formation
Brushy Basin Member
East Side of Corral Canyon
(a few hundred feet
downstream of Frog Pond,
looking south)

FIGURE B.10

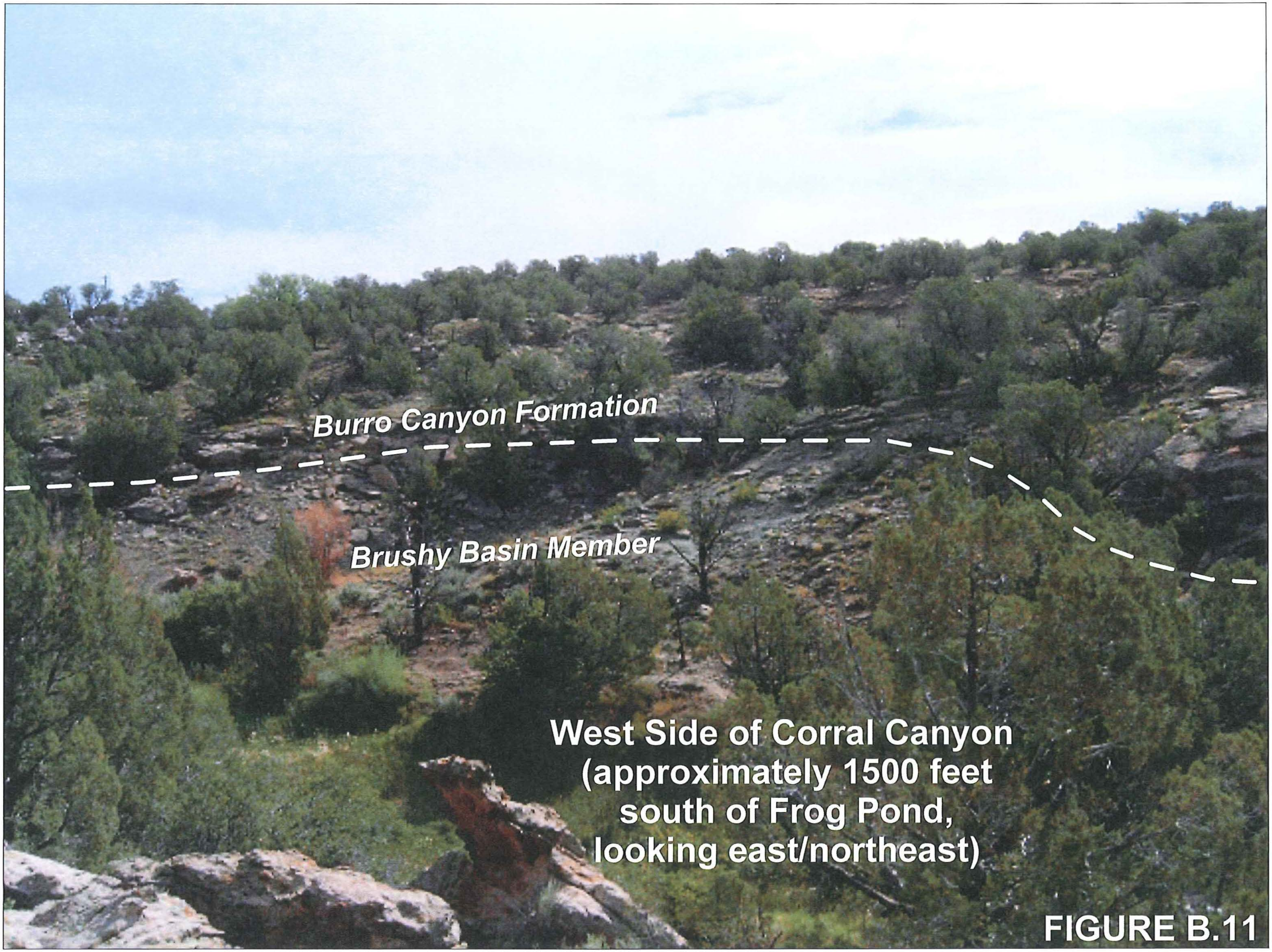

FIGURE B.11

H:/718000/cell4bjuly2010/report/AppB/FigB11.srf

H:/718000/cell4bjuly2010/report/AppB/FigB12.srf

H:/718000/cell4bjuly2010/report/AppB/FigB13.srf

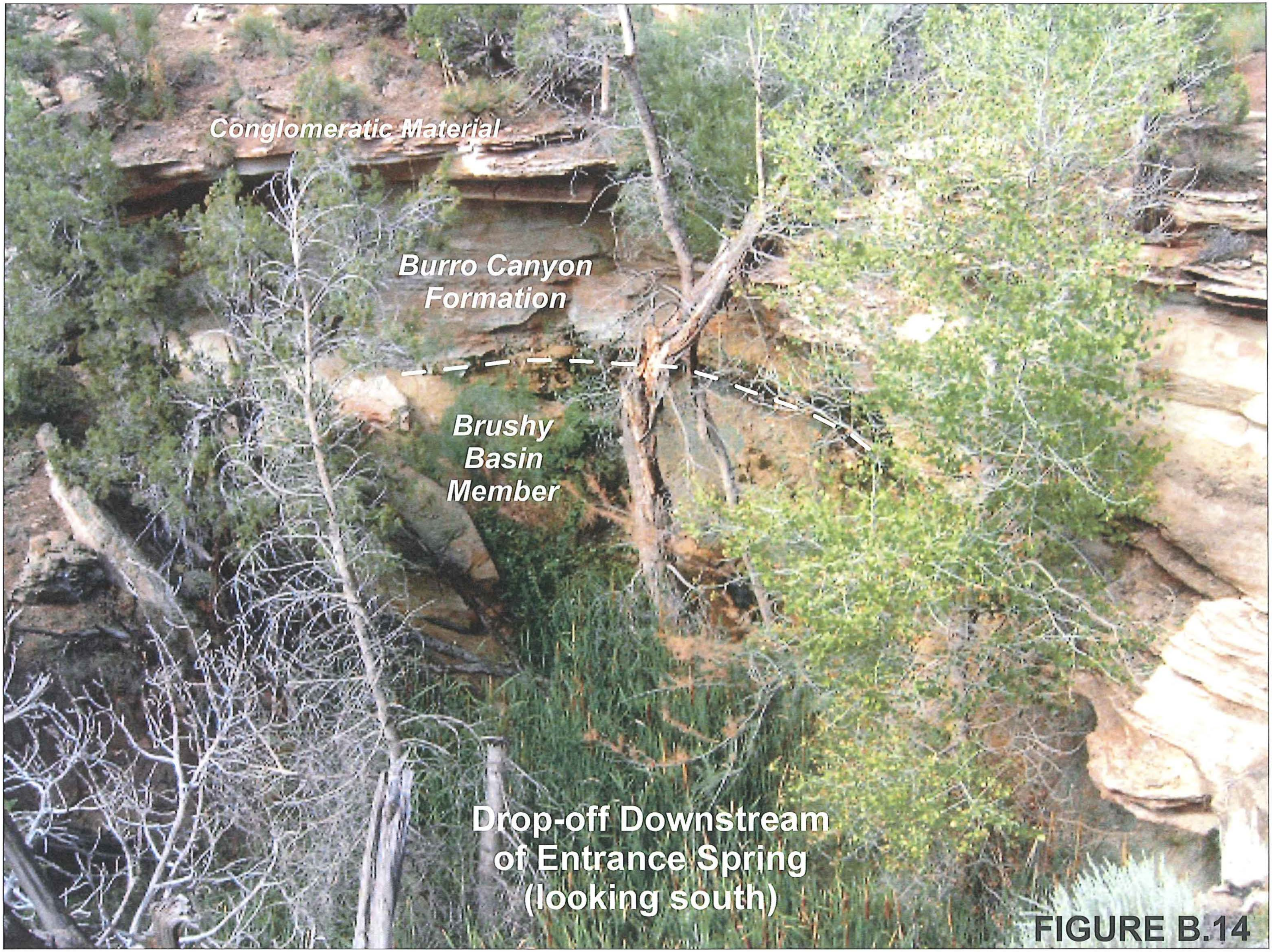

FIGURE B.14

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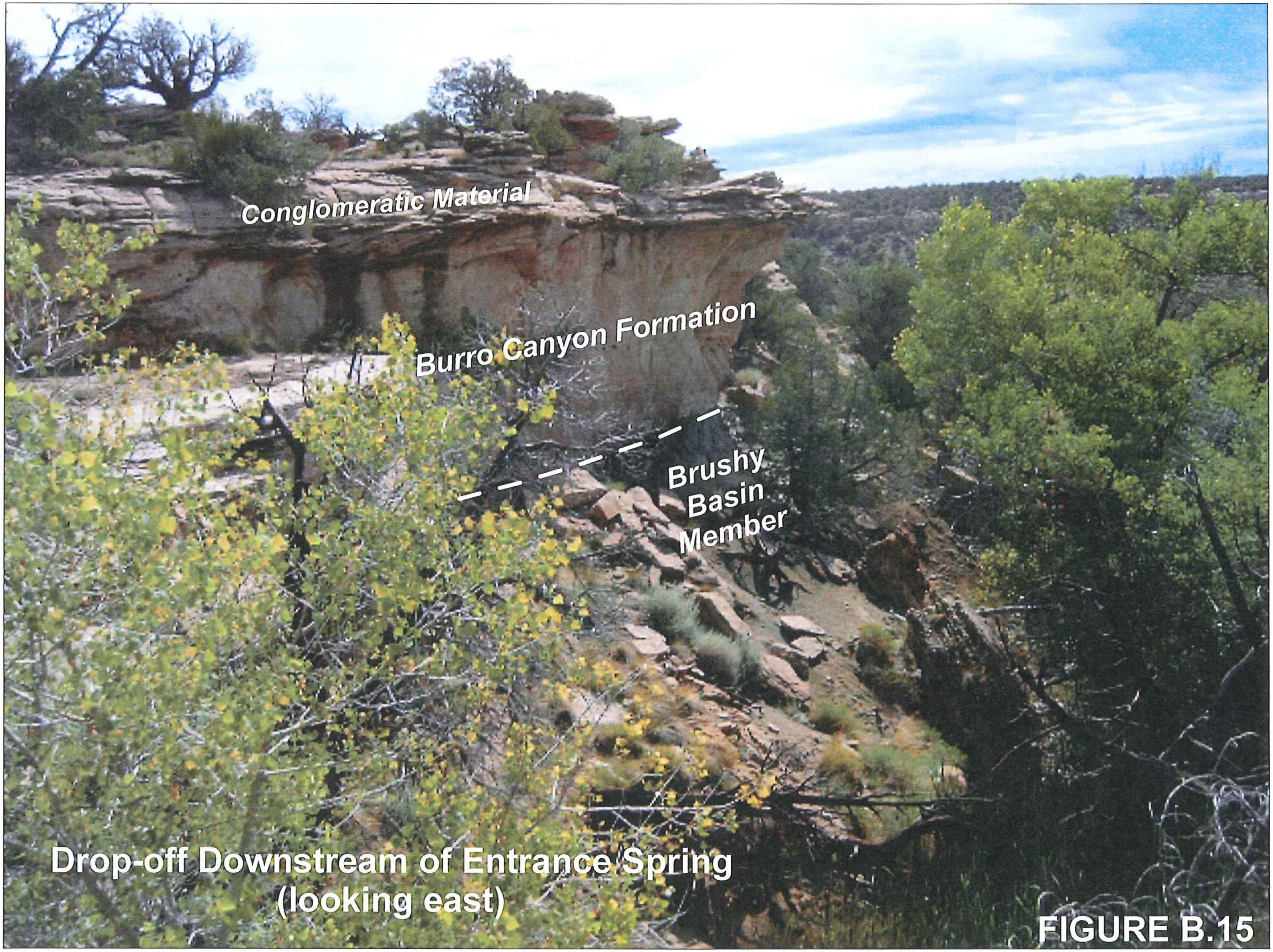
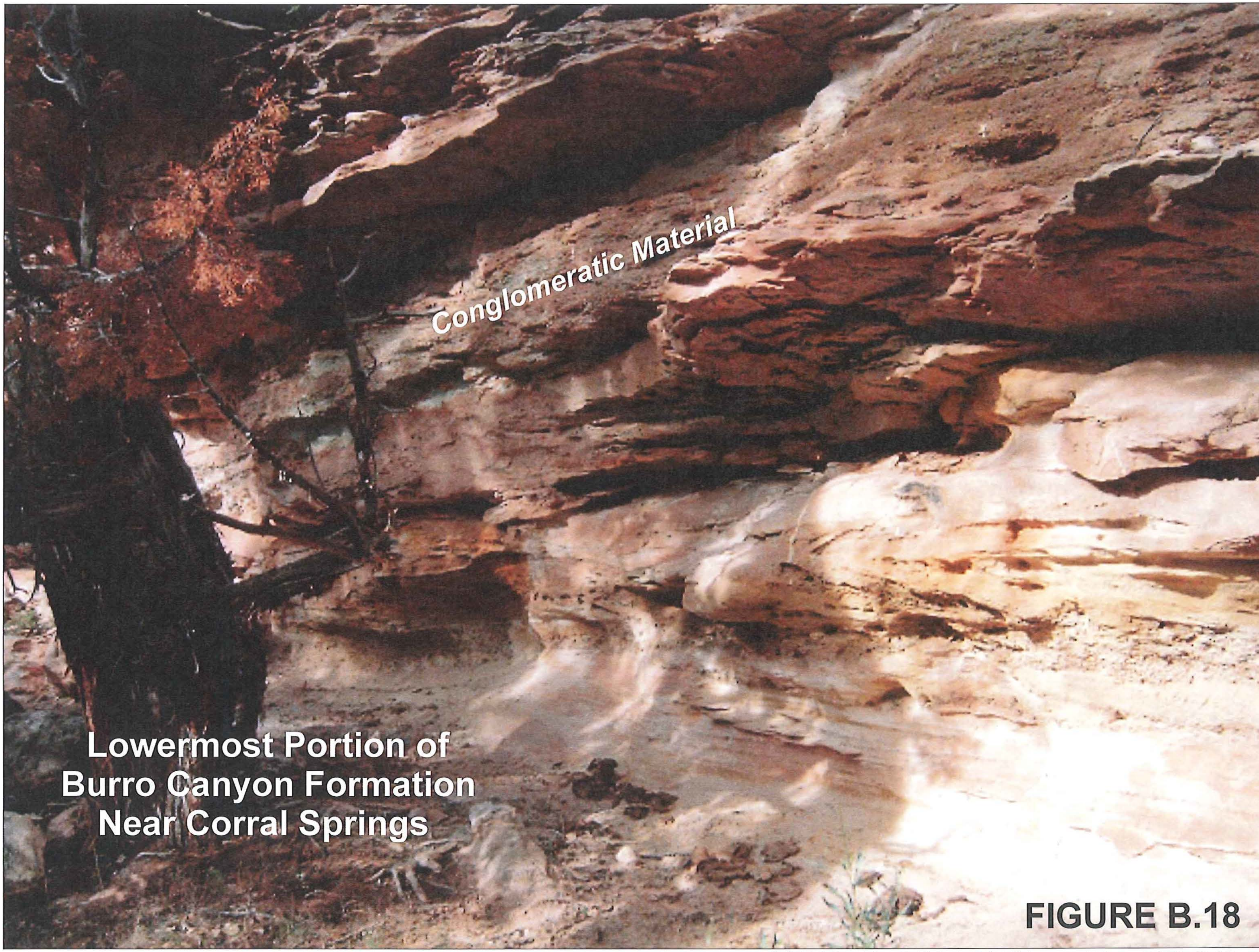


FIGURE B.15

H:/718000/cell4bjuly2010/report/AppB/FigB15.srf

H:/718000/cell4bjuly2010/report/AppB/FigB16.srf

H:/718000/cell4bjuly2010/report/AppB/FigB17.srf



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Stock Pond (dry)
Just Above Corral Springs
(looking east-northeast)
FIGURE B.19