KCB Consultants Ltd.

Resolution Copper Mining LLC

Resolution Copper Project

Skunk Camp Site Investigation

Doc. # CCC.03-81600-EX-REP-00012 – Rev. 0

UM09441A21.730

November 2019

KCB Consultants Ltd.

November 1, 2019

Resolution Copper Mining LLC
P.O. Box 1944
Superior, Arizona
85273

Ms. Victoria Peacey
Senior Manager - Permitting and Approvals

Dear Ms. Peacey:

Resolution Copper Project
Skunk Camp Site Investigation
Doc. #: CCC.03-81600-EX-REP-00012 – Rev. 0

We are pleased to submit the report for the Skunk Camp Site Investigation.

Yours truly,

KCB CONSULTANTS LTD.

Kate Patterson, P.E.
Project Manager

CK/KP:dl

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Resolution Copper Mining LLC

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1 INTRODUCTION

1.1 General

Resolution Copper Mining LLC (RCM) is proposing to develop the Resolution Copper Project, an underground copper mine, using the panel cave mining method. The mine site is approximately two miles east of the town of Superior in the Pioneer Mining District, Pinal County, Arizona. The project mine plan includes generation and safe storage of approximately 1.37 billion tons (Bton) of tailings over a 41-year mine life.

Processing would generate two physically, mineralogically, and geochemically discrete tailings streams known as "scavenger" tailings referred to as non-potentially acid generating (NPAG) and "pyrite" tailings referred to as potentially acid generating (PAG); NPAG tailings would account for approximately 84% of tailings produced by weight and PAG tailings would account for the remaining 16%.

The Skunk Camp site is approximately 13 miles southeast of the town of Superior and the proposed concentrator site (West Plantsite) and approximately 13 miles southeast of the ore body, refer to Figure 1.

KCB Consultants Ltd. (KCBCL) completed an Draft Environmental Impact Statement (DEIS) design[1] for a tailings storage facility (TSF) at the Skunk Camp site which includes segregated PAG tailings cells and a dry[2] NPAG beach.

This report summarizes the results of the geotechnical and hydrogeological site investigations undertaken in 2018 and 2019 to further the current understanding and/or confirm foundation and seepage conditions for the site including:

- The potential for foundation liquefaction, or the presence of other weak materials within the dam foundation.
- The potential for high local seismicity, and the potential impacts of a(n) active fault(s) within the impoundment foundation, if present.
- The presence of erodible and/or dispersive residual soil.
- The availability and quality of borrow material for construction.
- Hydrogeological and seepage assessments, including seepage flow paths and monitoring.
- Hydrostratigraphy, hydraulic gradients, hydraulic conductivity and seasonal variations.
- Establish baseline groundwater quality.

[1] Defined in Rio Tinto Study Definition Guidance Note – Release 3 (Rio Tinto 2019)
[2] Overflow tailings directed to the interior of the impoundment thickened to a minimum of 60% solids content and deposited on a beach to increase evaporation and avoid a continuous process water pond on the beach surface, thus decreasing seepage into the foundation. Typically conventional tailings operations deposit overflow tailings to the interior of the impoundment at approximately 25-30% solids.

The Skunk Camp site is located on private and state land. The following is a breakdown of completed investigations:

- Field mapping on State land and private property;
- Geotechnical Holes: DH19-3, DH19-3A, DH18-5, DH19-7, DH18-8, DH18-8A, DH19-8B; DH19-11, DH19-12, DH19-12A, DH19-14, DH19-16, DH19-17;
- Hydrogeological Holes: RC19-3, RC18-4, RC19-7, RC19-8, RC19-8A, RC19-8B, RC19-8C, RC19-8D, RC18-9, RC19-10, RC19-13; RC19-15;
- Geophysics line: SL-4; and
- Test Pits: TP19-8, TP19-8A, TP19-9, TP19-10, TP19-11, TP19-13.

1.2 Report Organization

The main text of this report is organized into a series of factual sections as follows:

- Section 2: *Project Site Conditions* – Background and general information for the site.
- Section 3: *Scope and Methodology of Investigations* – A description of what investigations are planned and what has been carried out to date, and the methodology used.
- Section 4: *Summary of Results* – Factual results from each investigation method.
- Section 5: *Laboratory Testing Results* – Summary of geotechnical laboratory testing results
- Section 6: *Preliminary Site Characterization* – Working characterization where each geologic unit is described based on data collected to date.

1.3 Key References

Several relevant studies have been utilized to inform the understanding of the Skunk Camp site, including:

- Geology maps (Cornwall, Banks, and Phillips 1971, Cornwall and Krieger 1978, Dickinson 1991, Dickinson 1992).
- Well logs and spring inventory from the Arizona Department of Water Resources (ADWR 2018).
- Arizona Department of Water Resources (ADWR). 2009. Arizona Water Atlas - Section 3.6 Dripping Springs Wash Basin.
- Freethey, G.W. and T.W. Anderson. 1986. Predevelopment hydrologic conditions in the alluvial basins of Arizona and adjacent parts of California and New Mexico: USGS Hydrologic Investigations Atlas-HA664.
- Site-specific seismic hazard assessment (SHA) of the Near West site prepared by Lettis Consultants International, Inc. (LCI 2017a and 2017b), which is assumed to be applicable to

the Skunk Camp site for this stage of design as the radius of the analysis covers the Skunk Camp area.

- Site reconnaissance and preliminary hydrogeological characterization of the Skunk Camp site developed by Montgomery & Associates (M&A) (M&A 2018) in support of the Draft Environmental Impact Statement (EIS).
- Site visits conducted by KCBCL in 2018.
- Regional and local limestone assessment carried out for the Near West site (KCB 2018).
- M&A well inventory (M&A 2019a - Fleming, J., "RE: Skunk Camp SI Execution Plan Update", e-mail message to K. Patterson, February 22, 2019).
- Klohn Crippen Berger (KCB) 2018. DEIS Design For Design Alternative 6 – Skunk Camp. Doc. # CCC.03-81600-EX-REP-00006-Rev. 2. September 7.
- Site reconnaissance and preliminary hydrogeological characterization of the Skunk Camp site developed by Montgomery & Associates (M&A 2018) in support of the Draft Environmental Impact Statement (EIS).

Information adopted from these and other reference reports are cited herein as appropriate. Original reports should be referred to for specific information and further discussion.

2 PROJECT SITE CONDITIONS

2.1 Setting and Physiography

The Skunk Camp site is within the Basin and Range physiographic zone of Arizona (Figure 2.1), adjacent to the northern boundary with the Central Highlands Transition physiographic zone, marked by the southern edge of the Superstition Mountains (URS 2013).

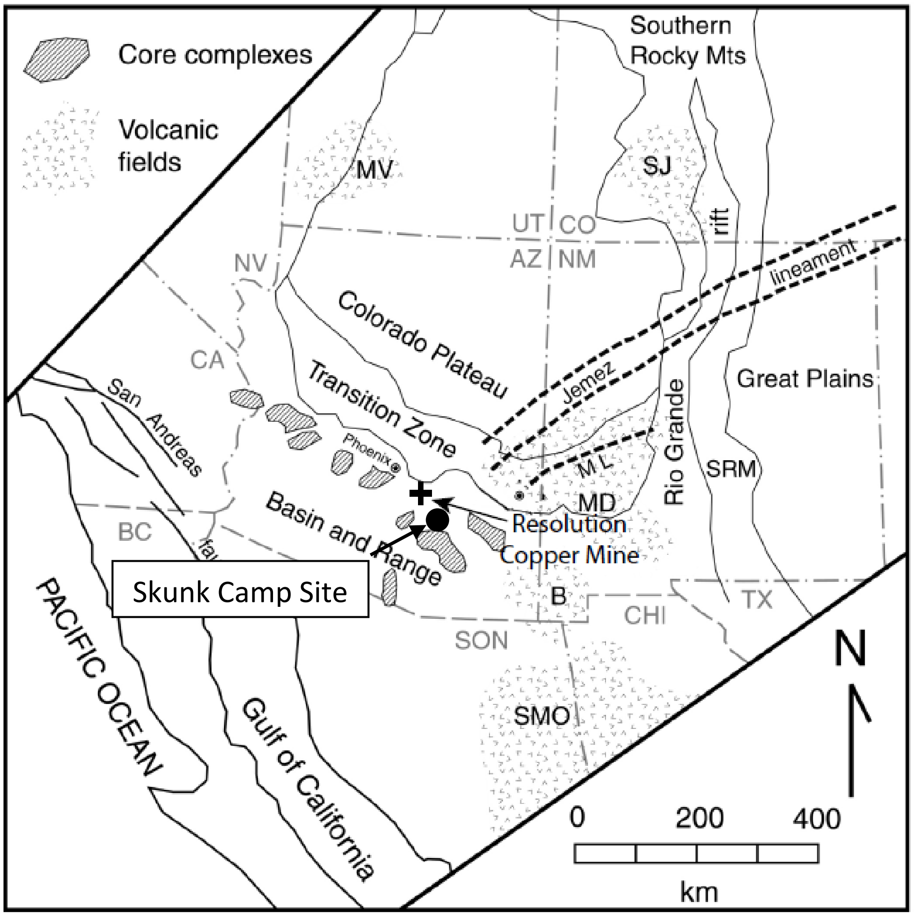
The Basin and Range mountain ranges are composed of fault-block mountains formed during extensional faulting and crustal thinning. The Central Highlands Transition zone is a northwest trending escarpment marking the transition from the Colorado Plateau to the north with the Basin and Range province to the south (see Figure 2.1).

The proposed Skunk Camp TSF site is located in the Dripping Springs Wash Basin (refer to Figure 1). The Dripping Springs Wash Basin is approximately 378 square miles in area and is described by the Arizona Department of Water Resources (2009) as consisting of a mid-elevation mountain range and Arizona uplands Sonoran desert scrub.

The Dripping Spring Mountains define the western boundary of the site, while the Mescal Mountains and Pinal Mountains define the eastern boundary. The approximate base elevation of the proposed TSF is El. 3,160 ft and the peaks of adjacent mountains are: El. 4,566 ft at Haley Mountain (Dripping Spring Mountains), El. 6,568 ft at El Capitan Mountain (Pinal Mountains), and El. 7,848 ft at Pinal Peak (Pinal Mountains).

Within the proposed TSF area, the drainages are ephemeral and infilled with sand and gravel alluvial deposits. When present, surface water flows in Dripping Springs Wash from northeast to southwest approximately 13 miles upstream of its confluence with the Gila River. The proposed site is located just southwest of the surface water divide between Dripping Springs Wash and Mineral Creek, see Figure 1. Surface water south of the divide flows through the site, roughly southeast through Dripping Springs Wash Basin to the Gila River, while surface water north of the divide flows into the Mineral Creek basin, which flows into the Gila River approximately 16 miles downstream of the confluence of Dripping Springs Wash and the Gila River.

Figure 2.1 Regional Physiographic and Seismic Setting (URS 2013)



Modified from: Drewes *et al.* (1985)

2.2 Land Use

The project site is located outside of the Arizona Department of Water Resources (ADWR) Aquifer Management Areas, on a mixture of State Trust and private land. The current site uses are:

- The site and immediate surrounding area have several ranching properties and permanent dwellings and is currently used for livestock grazing, ranching and as road access to recreational areas (e.g. hunting).
- Access across the site is by compacted gravel roads, accessed from Highway 77, located southeast of the site.
- There are no known historic mines within the proposed TSF footprint, but there is historic and active mining in the region. Surrounding mining activity include:
  - **Ray Mine**, 5 miles to the west of the proposed Skunk Camp TSF area (over the Dripping Spring Mountains), is an active open pit copper mine currently owned and operated by ASARCO Grupo Mexico (Figure 1).

- **Rattler Mine (Troy Mine)**, 5.4 miles to the south of the proposed Skunk Camp area (within the Dripping Spring Mountain Range), is an inactive underground copper / base metals mine currently optioned by Q-Gold Resources, and actively undergoing exploration activities (see Appendix VII – Figure VII-4). The abandoned workings include three tunnels and at least one adit 160 ft long. No known workings extend under the footprint of the proposed TSF.
- **Dripping Spring Mine**, 6.0 miles to the south-southeast of the proposed Skunk Camp area (within the Dripping Spring Mountain Range), is a closed polymetallic underground and open pit mine which operated from 1901 to 1953 (see Appendix VII). Mine workings at the site reached shallow depths of 50 ft to 75 ft. Adjacent historic workings include C and B Mine and Cowboy Mine, both inactive underground workings (see Appendix VII, Figure VII-4.) No known workings extend under the footprint of the proposed TSF.
- **Christmas Mine**, 14.8 miles to the southeast of the proposed Skunk Camp area, is a closed underground and open pit copper mine, which closed in 1992 (Figure 1). The property is currently owned by Freeport McMoRan. Several historic mine workings are also identified in the area around Christmas Mine.

2.3 Climate

The Skunk Camp TSF site is within a semi-arid climate zone with low average annual precipitation and high estimated average annual evaporation. There is no climate station within the vicinity of the site; The nearest climate station is 8 miles to the south at Kearny (ID: 024590). The estimated climate data assumed for the site is presented in Table 2.1 and based on regional trends.

Table 2.1 Average Monthly Precipitation, Temperature and Evaporation

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Precipitation (in)[1]	1.5	2.0	2.0	0.7	0.3	0.4	3.1	2.5	1.4	1.6	2.2	1.4	19.0
Temperature (F)[2]	46	50	55	62	70	78	84	82	77	67	54	47	65
Evaporation Pan (in)[3]	1.7	2.4	3.7	5.2	9.8	11.6	10.7	9.4	7.9	5.0	2.5	1.7	71.5

Notes:
1. Precipitation for the Skunk Camp site (Lat. 33.1968° Long. -110.9059°) was estimated from a precipitation-elevation relationship of regional climate stations from six regional climate stations within 110 miles from the site: Superior (ID: 028348), Miami (ID: 025512), Kearny (ID: 024590), San Carlos Reservoir (ID: 027480), Roosevelt 1 WNW (ID: 027281) and Oracle 2 SE (ID: 026119). The relationship was checked against the regional estimate from the Arizona Water Atlas (ADWR 2009).
2. Temperature for the Skunk Camp site (El. 3300 fasl) was estimated from a temperature-elevation relationship created from regional stations in Arizona. Temperature stations used in creating the relationship include: San Carlos Reservoir (027480), Globe 2 (023500), Globe (023505), Miami (025512), Globe (Ranger Stn) (023498), San Carlos (027475), Sierra Ancha (027876), Florence (023027), Superior (028348), Roosevelt 1 WNW (027281).
3. Evaporation for the Skunk Camp site (El. 3300 fasl) was estimated from an evaporation-elevation relationship created from regional lakes or reservoirs in Arizona. Evaporation measurements from lakes ore reservoirs include: Sierra Ancha, San Carlos Reservoir, Mesa, Tempe A S U, Hawley Lake, Grand Canyon Natl Park.

The region experiences three seasonable types of precipitation events (AWA 2013):

- Winter storms that occur from October to March – typically long duration, low intensity events.
- Summer monsoonal storms that occur from June to September – typically short duration, high intensity thunderstorms.
- Tropical storms that occur from August to October – rare events, but produce the most extreme rainfalls in southern Arizona. These events are typically remnants of oceanic storms and typhoons of high intensity and moderate duration (~24 hours).

2.4 Seismicity

The Skunk Camp TSF site is 19 miles away from the Near West site and for the purposes of this assessment is assumed to have a similar seismic hazard to that calculated for Near West by LCI (2017b). The region has low historic seismicity (LCI 2017b); from the Near West site: 16 earthquakes within 62 miles (100 km) and 51 earthquakes within 124 miles (200 km) are part of the seismic record that dates back to 1830. Only two of the recorded earthquakes had a moment magnitude (Mw) greater than 5, both in excess of 62 miles (100 km) of the site. None of the recorded earthquakes have had a Mw >6.

The site-specific seismic hazard assessment completed for Near West based on Vs(30) measurements for the Tertiary Conglomerate includes estimates of the peak ground accelerations (PGA) and spectral accelerations at return periods up to 10,000 years, and both uniform hazard spectra (UHS) and conditional mean spectra (CMS). The results indicated that the hazard from short period ground motions is controlled by the background seismicity (seismicity not associated with known faults) close to the site, whereas the distant San Andreas Fault influences the hazard for longer periods, similar to the period of most large earthfill structures.

The mean PGA calculated for the Near West site, for the design 10,000-year return period event, was 0.15 g, for an assumed Vs(30) of 2,300 ft/s to 3,450 ft/s (associated with “softer” rock types such as Tertiary Conglomerate and Pinal Schist). These PGA ground motions are associated with a mean magnitude distance combination of Mw 5.7, 16 miles from the Near West site.

The Skunk Camp TSF site sits across Ransome Fault and a mapped unnamed normal fault which bounds the west margin of Dripping Spring Valley (Cornwall et al. 1971), which in this report is referred to as “Dripping Spring Fault”. These faults are not thought to have been active within the Quaternary period (2.6 Ma to present) because they were not identified as active in the Near West site seismic hazard assessment (LCI 2017b). However, the Skunk Camp TSF site is closer to known Quaternary active faults (e.g. Whitlock Wash fault at approximately 45 miles away) which may result in slight increases to the short period seismic loads at the Near West site.

2.5 Regional Geology

The local geology units are defined by Cornwall and Krieger (1978) and Cornwall et al. (1971) for the map sheets covering the Skunk Camp site. These units have been adopted with some minor modifications (e.g. Tg=Tcg) to conform with previous investigations and to RCM's internal database (Table 2.2).

The regional basement in the area of the proposed Skunk Camp TSF site consists of facies of the Precambrian Pinal Schist. The Schist is overlain by the younger Precambrian Apache Group, comprising Pioneer Formation Siltstone and Sandstone; Dripping Spring Quartzite; Mescal Limestone; Basalt; and the Troy Quartzite. All of the Precambrian rock units are intruded by Precambrian Diabase dykes and sills. The Precambrian rocks are in turn overlain by Paleozoic sedimentary rocks, including the Abrigo Formation, Bolsa Quartzite, and the Martin, Escabrosa and Naco Limestones. The entire sequence of rock units are intruded by Late Cretaceous and Tertiary dikes and plutons, including the Rattler Granodiorite; Rhyodacite Porphyry; and the Teapot Mountain Porphyry. Tertiary Tuffs and Conglomerates were deposited over the older rocks in the region (Cornwall et al. 1971).

The pre-Tertiary rocks in the region have been deformed, mostly by tilting and faulting, with most faults dipping steeply, indicating normal movement. Normal faulting has produced graben features with stratigraphic displacements in excess of 2,000 ft (Figure 3). Dripping Spring Wash flows through one such graben which is infilled with a thick package of Tertiary Conglomerate (Cornwall et al. 1971).

Table 2.2 Geologic Units at Skunk Camp Site

Simplified Label	Description	Age
Qal	Alluvium	Quaternary
Qp	Pediment	Quaternary
Tss	Tertiary Sandstone	Miocene
Tcg	Tertiary Conglomerate	Miocene-Pliocene
Ti	Teapot Mountain Porphyry	Paleocene
TKi	Rhyodacite Porphyry	Tertiary-Cretaceous
Ki	Rattler Granodiorite	Upper Cretaceous
Pn	Naco Limestone	Pennsylvanian
Me	Escabrosa Limestone	Mississippian
Dm	Martin Limestone	Devonian
Ca	Abrigo Formation	Upper and Middle Cambrian
Cb	Bolsa Quartzite	Middle Cambrian
Yd	Diabase	Younger Precambrian
Yt	Troy Quartzite	Younger Precambrian
Yb	Basalt	Younger Precambrian
Ym	Mescal Limestone	Younger Precambrian
Yds	Dripping Spring Quartzite	Younger Precambrian
Yp	Pioneer Formation	Younger Precambrian
Ysc	Scanlan Conglomerate	Younger Precambrian
Yg	Ruin Granite	Younger Precambrian
Xp	Pinal Schist	Precambrian

2.6 Hydrogeological Setting

An understanding of the regional hydrogeological setting has been developed based on the following public and private reports, figures and studies described in Section 1.3.

2.6.1 Hydrostratigraphy

The site is located within a broad alluvial valley that is flanked to the east and west by mountains. This valley is known as the Dripping Springs Wash and is bounded by the Dripping Springs Mountains to the west and the Pinal Mountains to the east. The Precambrian basement rocks are typically comprised primarily of granitic, volcanic and metamorphic crystalline units. The water yield from these units is likely to be controlled by the degree and continuity of fractures. This unit is overlain by Precambrian Siltstone, Sandstone and Quartzite and Paleozoic Limestone with varying water yields. Several perennial and ephemeral springs occur on the Dripping Springs Mountains along the contact between the Precambrian metamorphic units and the younger Precambrian Quartzite units.

The primary aquifer in the study area occurs at the base of the Dripping Springs Wash with the primary producing aquifers located within the Tertiary Sandstone and Conglomerate units, locally known as the Gila Formation. The lateral extent of this aquifer is unknown at this time but it is assumed cover the entire broad valley bottom. The vertical extent is unknown; however the aquifer is known to extend to a depth of at least 980 ft from the ground surface, the same depth as the deepest borehole drilled during the SI program to date. However, wells within the Dripping Springs Wash catchment have been observed to be up to 1,400 ft in depth, and still in the Gila Formation, based on records from the Arizona water well database The median water well depth in the area according to the Arizona water well database is 250 ft.

The Tertiary Sandstone and Conglomerate encountered has a high degree of heterogeneity. The composition of this unit varies from fine to medium grained Sandstone to coarse Conglomerate that contains gravel and cobble sized clasts. Cementation varies from very weak to strong and is moderate to highly calcareous. Weak cementation typically occurs in the sandstone and strong cemented zones occur within the Conglomerate.

The Tertiary Sandstone and Conglomerate is overlain by unconsolidated Alluvial sediments that consist primarily of sand and gravel with varying proportions of silt and clay. This unit is not expected to provide a reliable groundwater source as the majority of water in this unit likely reports to the underlying Tertiary Sandstone and Conglomerate.

2.6.2 Groundwater Flow Regime

The regional groundwater flow within the Dripping Springs Wash basin is assumed to flow from the northwest to southeast along a shallow dipping potentiometric surface that eventually reports to the Gila River. Tertiary Conglomerate is weakly to strongly cemented and the degree of cementation varies both laterally and vertically within the Formation. Extensive alternating cemented and uncemented layers, or continuous cemented zones, may act as confining layers that effectively confine the groundwater within Tertiary Sandstone/Conglomerate. The depth to groundwater ranges between 70 ft to 270 ft below ground surface.

The Dripping Springs Wash groundwater basin is bounded to the east by the Pinal Mountains, to the south near the Gila River and to the north at or near Mineral Creek. These groundwater boundaries are generally a reflection of the surface water divide. At the western groundwater boundary groundwater may flow under the Dripping Springs Mountains towards the Ray Mine. This may occur because of a pumping-induced groundwater sink related to dewatering efforts at the Ray Mine that is located in an adjacent surface water catchment.

The highland areas of Dripping Springs Wash Basin, including Pinal Peak, form a large portion of the upstream catchment and is anticipated to be a primary source of groundwater recharge for the region. Downstream of the site, the Gila River, a perennial water course, acts as the regional drainage point for the surface water catchment.

2.6.3 Groundwater Usage

Based on the results obtained from the Arizona State water well records for the Dripping Springs Wash basin area, groundwater is predominantly used for livestock watering, irrigation and domestic purposes. According the state well records there are 11 wells located within one mile of the facility and 22 wells located up to four miles downgradient of the proposed facility. It is noted that the information in the records may not accurately represent the actual well construction or pumping rates. The well locations and depth, water use, and depth to water are summarized in Table 2.3.

Table 2.3 Water Well Record and Groundwater Usage Summary

ADWR Number	ADWR Easting (m)(1)	ADWR Northing (m)(1)	Owner Name	Well Depth (ft bls)(2)	Completion Date	Pump Rate (gal/min)	Water Level (ft bmp)(3)	Water Use
Wells within TSF footprint								
55-632797	509247	3673529	Hebbard & Webb Co	300	1947-05-01	35	164	Livestock
55-632794	507536	3673624	Hebbard & Webb Co	392	1943-05-01	35	175	Livestock; domestic
55-632795	507536	3673624	Hebbard & Webb Co	400	1941-08-01	35	231	Livestock; domestic
55-632796	507536	3673624	Hebbard & Webb Co	400	1936-06-01	35	172	Livestock; domestic
55-632800	509144	3671211	Hebbard & Webb Co	250	1940-05-01	35	73	Livestock
55-205266	510662	3672522	Webb Cattle Co	230	2005-02-01	35	180	Livestock
55-632798	510763	3672421	Hebbard & Webb Co	300	1947-05-01	35	165	Livestock
55-632801	510763	3672421	Hebbard & Webb Co	400	1951-05-01	35	175	Livestock
55-622477	510254	3670510	Rick Larry Jodsaas	900	---	6	120	Livestock
Wells within 1 mile of TSF footprint								
55-632799	507135	3669599	Hebbard & Webb Co	51	1951-01-01	35	2	Livestock
55-615943	508645	3668293	AZ State Land Dept	501	---	---	240	Industrial
55-622471	511461	3669309	Rick Larry Jodsaas	1,400	1962-03-14	1,200	92.6	Irrigation / Domestic
Wells 3 to 4 miles downgradient from TSF footprint								
55-607650	514661	3668238	Brown, J. A.	250	1979-08-03	40	50	Domestic / Livestock / Irrigation
55-085753	514662	3668036	Brown, J. A.	200	1980-10-09	20	80	Irrigation

ADWR Number	ADWR Easting (m)(1)	ADWR Northing (m)(1)	Owner Name	Well Depth (ft bls)(2)	Completion Date	Pump Rate (gal/min)	Water Level (ft bmp)(3)	Water Use
55-227590	514662	3668036	F. Jane Bechtold	NA	NA	NA	NA	Domestic
55-615315	515865	3668042	AZ State Land Dept	250	1979-01-01	NA	88	Unknown
55-624275	515766	3667539	Bearup, W. E.	150	1934-01-01	170	85	Irrigation / Livestock / Domestic
55-624276	515766	3667539	Bearup, W. E. (CGL Family Trust, Glenn Links Trustee)	300	1953-01-01	NA	102	Irrigation
55-568046	515665	3667639	Altobelli Properties LLC	300	1998-11-19	NA	90	Domestic
55-502917	515164	3667737	Wind Spirit Community	365	1982-07-13	30	160	Domestic / Irrigation
55-581480	515063	3667837	Alfred Yslas	200	2000-06-19	NA	118	Domestic
55-808287	515064	3667636	James F. Didominicus	254	1972-01-01	NA	81	Domestic / Irrigation
55-808288	515064	3667636	James F. Didominicus	198	1973-01-01	NA	89	Domestic / Irrigation
---	---	---	Melvin P. Farmer	125	1978-05-08	---	77	Domestic
55-808015	515265	3667637	Cynthia M. Phillips	160	1970-12-31	NA	60	Domestic / Irrigation
55-807702	514863	3667836	John Herrick & Patricia Ann Smith	310	1974-02-01	20	65	Irrigation / Domestic
55-085953	514662	3667835	Vonderhorst Irrev Tr, James E. McKee Trustee	200	1980-10-24	30	75	Domestic
55-648945	514662	3667835	Vonderhorst Irrev Tr, James E. McKee Trustee	200	1974-01-01	15	120	Domestic
55-808289	514865	3667435	James F. Didominicus	203	1968-01-01	NA	84	Domestic / Irrigation
55-607669	515065	3667435	BLM-Phoenix District	300	1928-12-31	375	92	Domestic / Irrigation / Livestock / Wildlife
55-625194	515065	3667435	Schweitzer, M. J.	250	NA	NA	NA	Irrigation / Livestock / Domestic
55-800051	515868	3667036	BLM-Phoenix District	120	1928-12-31	15	74	Livestock / Wildlife
55-800052	515868	3667036	BLM-Phoenix District	150	1928-12-31	170	73	Irrigation / Domestic / Livestock / Wildlife
55-518323	513670	3667633	Amado, Charlie	NA	NA	NA	70	Unknown

Notes:
1. Coordinate system is UTM, NAD 83, meters.
2. bls – below land surface
3. bmp – below measuring point
4. Confirmation and flow measurements were carried out by Montgomery and Associates.
5. Coordinates, depths, and other details are derived from the ADWR database and may not reflect actual conditions.

2.6.4 Regional Springs

There are 11 mapped (10 confirmed) springs located with the Dripping Springs Wash basin and of these nine are located along the Dripping Springs Mountains. A spring survey was completed by M&A in 2018 and a summary of the results are provided in Table 2.4. Spring locations are shown on Figure 2.

Table 2.4 Summary of Springs Near Skunk Camp

Spring Name	Easting (ft) (1)	Northing (ft) (1)	Elevation (ft)	Land Owner	Spring Site Confirmed (2)	Flow (gal/min) (2)
Haley Spring	1001699.0	795686.5	3540	Private - Hebbard & Webb	Yes	0 to <0.01
Looney Spring	999502.3	800145.3	3750	Private - Hebbard & Webb	Yes	0
Skunk Spring	1001038.0	800627.3	3620	Private - Hebbard & Webb	Yes	0
Stone Cabin Spring	1016889.0	813167.2	4040	Private - Hebbard & Webb	Yes	0
Stone Cabin Box Spring	1014232.0	810586.9	3820	Private - Hebbard & Webb	Yes	2
Chimney Spring	997738.7	805745.1	3860	Private - Hebbard & Webb	Yes	0
Indian Spring	999583.8	807047.6	3680	Private - Hebbard & Webb	Yes	0.18
Woodchopper Spring	997985.4	803855.5	3910	Private - Hebbard & Webb	Yes	0.25
Cockleburr Spring	1000726.0	801692.0	3640	Private - Hebbard & Webb	Yes	0
Spirit Spring	NA	NA	NA	NA	No	---
Walnut Spring	1000144.0	810595.6	3440	Private - Hebbard & Webb	Yes	1.05

Notes:
1. Coordinate system is State Plane, Arizona Central, NAD 83, international feet.
2. Confirmation and flow measurements were carried out by Montgomery and Associates.

3 SCOPE AND METHODOLOGY OF INVESTIGATIONS

3.1 Site Investigation Summary

Site investigations at Skunk Camp were completed between November 2018 and July 2019.

The objectives, scope, and methodology used for each type of investigation are described in this section, and summarized on Table 3.1. All completed air rotary holes are shown on Table 3.2. All completed diamond holes are shown on Table 3.3.

Surface geophysics have been completed on one line (SL-4) that crosses the Dripping Springs Wash at location 8.

The geotechnical and hydrogeological drilling and instrument installation portion of the site investigation program was carried out by two drilling contractors, Cascade Drilling (Cascade) and National Exploration Wells and Pumps (National), using licensed Arizona drilling operators under the supervision of KCBCL field engineers.

Eight geotechnical holes (DH) were drilled using Cascade's track mounted Boart Longyear LF-70 hydraulic rotary drill rig, and were completed by diamond coring techniques, including:

- 6 in tricone drill-bit in soil and HQ3 equipment in rock;
- Standard Penetration Testing (SPT) or Large Penetration Testing (LPT) in soil with energy measurements;
- Packer tests and falling head tests in bedrock (Tertiary Conglomerate);
- Point load tests on the core; and
- Vibrating Wire Piezometers (VWPs) that were installed and grouted.

Five geotechnical holes (DH) were drilled using National's track mounted Christensen CT14 hydraulic rotary drill rig, and were completed by diamond coring techniques, including:

- PQ3 equipment for near-surface drilling, and HQ3 equipment in rock (3 holes);
- PQ3 equipment for holes that required well installations (2 holes);
- Packer tests and falling head tests in bedrock;
- VWPs that were installed and grouted; and
- Monitoring well installation in two holes (one abandoned).

For geotechnical boreholes (DH), the borehole logs, photographs, point load test measurements and VWP and well information are included in Appendix I. Penetration testing results are included in Appendix V.

Twelve hydrogeological boreholes (RC) were completed by conventional percussion air rotary techniques using:

- Cascade’s truck mounted GEFCO Speedstar 50K hydraulic top drive drill rig;
- an Air Rotary Casing Hammer (ARCH) for the installation of the surface casing;
- borehole infiltration and airlift yield tests conducted throughout drilling; and
- production wells or monitoring wells were installed after hole completion.

For hydrogeological boreholes (RC), the borehole logs, photographs and well installation details are included in Appendix II.

Downhole geophysics were completed in selected boreholes. See Section 3.2.2 for further discussion; reports are included in Appendix III.

At two hydrogeological well locations (RC18-9 and RC19-8) both a specific capacity test and a 24-hour constant rate pumping test was conducted upon completion of the drilling program by Cascade drilling and supervised by KCBCL. The tests were conducted using a Pulstar pump hoist, Variable Frequency Drive (VFD), submersible pumps and flow meters provided by Cascade. Slug tests were completed at three well locations in four wells. All hydrogeological testing results are included in Appendix VI.

A field mapping program was completed by two KCBCL representatives with two RCM geologists between November 20, 2018 and November 25, 2018, observations are included in Appendix VII.

Six test pits were completed between June 25, 2019 and June 27, 2019. Methods are described in Section 3.4, results are presented in Section 4.2; logs and test results are included in Appendix VIII.

A summary of the laboratory testing proposed and completed to date is included in Appendix IX. Additional testing results will be added in a subsequent revision.

Table 3.1 Summary of Site Investigation Program

Activity	Number of Investigations	Summary of Work	By Who
Investigation Siting and Site Reconnaissance (for existing wells)		Conduct cultural survey of investigation locations and access routes. Confirm access. Conduct reconnaissance on existing wells (e.g. status, pumping rates, televiewer).	RCM
Field Mapping Program	n/a	Ground truth geology map. Map visible faults with surface exposure. Characterize surficial geology units, including spatial variability. Identify potential unknown conditions.	KCBCL (and potentially LCI)
Surface Geophysics	1 line	Seismic refraction to determine depth of Alluvium, and rippable depth. Compression wave (P-wave) expected to reach depths of 240 ft to 300 ft. One MASW sounding comprising a 230 ft string of geophones on each seismic line. Electrical resistivity on SL-4 (completed), SL-5, and 2,200 ft of SL-1 centered on SL-2.	HGI
Test Pits	6	Log near-surface stratigraphy. Retrieve soil and rock samples for visual assessment of soil stratigraphy, soil relative density, bedrock lithology, bedrock structure, strength, laboratory testing and borrow suitability assessment. Conduct infiltration testing (using double ring infiltrometer).	Earthworks Contractor: Dalmolin Monitoring: KCBCL
Air Rotary Holes (RC)	12	Confirm hydrostratigraphic units and identify potential preferred seepage pathways. Carry out falling head tests in soil. Install pumping and/or monitoring wells (standpipe piezometers) to monitor groundwater levels and collect water quality samples. Collect the required information to complete the APP permit application including baseline water quality and aquifer hydraulic parameters.	Driller: Cascade Monitoring: KCBCL
Diamond Drill Holes (DH)	13	Retrieve soil samples and bedrock cores for visual assessment of soil stratigraphy, soil relative density, bedrock lithology, bedrock structure, strength and laboratory testing. Install vibrating wire piezometers to determine groundwater levels and to provide monitoring points during pumping tests in wells installed in RC holes. Carry out Packer testing within the diamond hole to assess permeability of in situ bedrock.	Driller 1: Cascade Driller 2: National Monitoring: KCBCL
Geotechnical Laboratory Testing		Strength, durability and index testing of soil and bedrock. Permeability testing of rock cores.	Sample Collection: KCBCL Laboratory: KCBCL Coordination and Reporting: KCBCL
Geochemical Laboratory Testing		Water chemistry sampling carried out by KCBCL on behalf of M&A. Soil and rock geochemical sampling carried out by KCBCL on behalf of Duke HydroChem.	Sample Collection: KCBCL WQ Laboratory: SVL Analytical, Inc. Coordination and Reporting: M&A (water), Duke Hydrochem (soil/rock).

Table 3.2 Summary of Proposed Air Rotary Drill Holes

Group	ID	Easting[1] (ft)	Northing[1] (ft)	Location	Land Ownership	Method	Testing	Depth (ft)	Expected Encountered Geologic Units	Target Geologic Units	Installation
Paired Air Rotary and Diamond Holes	RC19-3[2]	1,009,064	790,263	West Abutment of Main Dam	State Land	Air Rotary 10 in diameter minimum	Air lift flow rate after each rod Conduct pumping tests on 6 in production and monitoring wells Collection of groundwater samples for laboratory analysis at the beginning and end of pumping test Televiewer	815	Alluvium, Tertiary Conglomerate, Escabrosa Limestone	Weathering profile in Tcg, presence of water-bearing bedding planes in Tcg. Escabrosa Limestone (Me) and other limestones, evaluate dissolution	6 in well in Limestone Vibrating Wire Piezometer (VWP) above screen in Tcg or soil
	RC19-7[2]	1,006,603	795,353	Ransome Fault near Haley Spring	Private			760	Alluvium, Tertiary Conglomerate	Permeability across Ransome Fault Requirement for APP and characterization	6 in well on first water producing feature encountered in bedrock. VWP above screen.
	RC19-8[2]	1,011,109	793,751	½ mile upstream of Main Dam centreline (cL)				250	Alluvium, Tertiary Conglomerate	Alluvium groundwater, weathering profile in Tertiary Conglomerate (Tcg), presence of water-bearing bedding planes in Tcg,	6 in well east of DS Fault
	RC19-8A[2]	1,010,522	793,495					401	Alluvium, Tertiary Conglomerate		4 in well west of DS Fault
	RC19-8B[2]	1,010,829	793,752	½ mile upstream of Main Dam centreline (cL)				130.5	Alluvium, Tertiary Conglomerate	Alluvium, Tertiary Conglomerate	6 in well with wire wrapped screen in Tertiary Conglomerate
	RC19-8C[2]	1,010,866	793,687					90	Alluvium	Alluvium	6 in well with wire wrapped screen in Alluvium
	RC19-8D[2]	1,010,872	793,667					507	Alluvium, Tertiary Conglomerate	Alluvium, Tertiary Conglomerate	6 in well with wire wrapped screen in highest producing zone within Tertiary Conglomerate
Air Rotary hole only	RC18-4[2]	1,001,150	809,836	On Mineral Creek just north of saddle				269	Alluvium, Tertiary Conglomerate	Evaluate water level and potential flow paths for cross-catchment flow. Alluvium groundwater, weathering profile in Tcg, presence of water-bearing bedding planes in Tcg.	4 in well on first water producing feature encountered in bedrock. VWP above screen
	RC18-9[2]	1,005,426	806,268	DS Wash north of impoundment				402	Alluvium, Tertiary Conglomerate	Alluvium groundwater, weathering profile in Tertiary Conglomerate (Tcg), presence of water-bearing bedding planes in Tcg Needed for APP Purposes and to inform hydrogeology	6 in well on first water producing feature
	RC19-10[2]	1,007,783	808,570	Unnamed wash north of impoundment	State Land			650	Alluvium, Tertiary Conglomerate	Alluvium groundwater, weathering profile in Tertiary Conglomerate (Tcg), presence of water-bearing bedding planes in Tcg Needed for APP Purposes and to inform hydrogeology	6 in well on first water producing feature
	RC19-13[2]	1,005,466	801,569	Slash S Ranch	Private			350	Alluvium, Tertiary Conglomerate	Alluvium groundwater, weathering profile in Tcg, presence of water-bearing bedding planes in Tcg.	6 in well on first water producing feature
	RC19-15[2]	1,003,614	808,853	Saddle between Dripping Spring Wash and Mineral Creek	State Land			985	Tertiary Conglomerate	Groundwater level and chemistry to aid in defining groundwater divide between Dripping Spring Wash and Mineral Creek	6 in well with wire wrapped screen in Tertiary Conglomerate

Notes:
1. Coordinate system is State Plane, Arizona Central, NAD 83, international feet.
2. Hole ID, depths and coordinates are as-built, not initially proposed values.

Table 3.3 Summary of Proposed Diamond Drill Holes

Group	ID	Easting(1) (ft)	Northing(1) (ft)	Location	Land Ownership	Method	Testing	Depth (ft)	Expected Encountered Geologic Units	Target Geologic Units	Installation
Paired Air Rotary and Diamond Holes	DH19-3(2)	1,009,070	790,192	West Abutment of Main Dam	State Land	Tricone with SPT/LPT in soil, then HQ core in bedrock	SPT/LPT in soil Packer tests in rock Televiewer	402	Alluvium, Tertiary Conglomerate, Escabrosa Limestone	Relative density of Alluvium, Tg weathering and potential for piping, clay layers, and bedding planes. Packer testing in Tcg and Limestone.	VWP String in Limestone and other rock units
	DH19-3A(2)	1,009,094	790,193	West Abutment of Main Dam		HQ Core angled at 75° from horizontal towards 155° true	Packer tests in rock Televiewer	1032	Alluvium, Tertiary Conglomerate, Paleozoic Limestone	Permeability and depth of Paleozoic Limestone	VWP String in limestone and other rock units
	DH19-7(2)	1,006,565	795,372	Ransome Fault near Haley Spring	Private	Tricone with SPT/LPT in soil, then HQ core in bedrock	SPT/LPT in soil Packer tests in rock Televiewer	502	Alluvium, Tertiary Conglomerate	Permeability across Ransome Fault. Added to aid APP application and characterization	Sting of VWPs in DH Hole
	DH18-8(2)	1,011,072	793,909	½ mile upstream of Main Dam centreline (cL)		HQ Core - Angled at 60° from horizontal towards DS Fault (to southwest)	Packer tests in rock Televiewer	95	Alluvium, Tertiary Conglomerate	Tcg, weathering, clay layers, and bedding planes.	VWP string west of fault, on fault, and east of fault
	DH18-8A(2)	1,010,856	793,710			Vertical tricone	SPT/LPT in soil	82	Alluvium, Tertiary Conglomerate	Relative density of Alluvium, depth of Alluvium, terminate at Tertiary bedrock contact	VWP at base of Alluvium
	DH19-8B(2)	1,011,109	793,799.0			HQ Core - Angled at 60° from horizontal towards DS Fault (to southwest)	Packer tests in rock Televiewer	651	Alluvium, Tertiary Conglomerate	Tcg, weathering, clay layers, and bedding planes.	VWP string west of fault, on fault, and east of fault
Diamond Hole Only	DH18-5(2)	1,015,613	798,355	PAG Cell Embankment		Tricone with SPT/LPT in soil, then HQ core in bedrock	SPT/LPT in soil Packer tests in rock Televiewer	267	Alluvium, Tertiary Conglomerate	Relative density of Alluvium, Tcg weathering, clay layers, and bedding planes.	VWP string in Alluvium and Tertiary Conglomerate (Tcg), and basement
	DH19-11(2)	1,000,027	799,533	Looney Spring		HQ Core – Angled at 75 ° from horizontal towards 245° true	Packer tests in rock Televiewer	2693	Apache Group units	Permeability of Apache Group Hydraulic gradients in Dripping Spring Mountains	VWP string (5) in Apache Group4
	DH19-12(2)	1,019,495	801,311	Skunk Camp Wash	State Land	PQ Core	Packer tests in rock Televiewer	788	Alluvium, Tertiary Conglomerate, Paleozoic Limestone	Permeability and depth of Paleozoic Limestone	2 in Sch40 PVC standpipe well
	DH19-12A(2)	1,019,439	801,314	Skunk Camp Wash		PQ Core	Packer tests in rock Televiewer	399	Alluvium, Tertiary Conglomerate	Tcg	2 in Sch40 PVC standpipe well
	DH19-14(2)	1,001,953	795,176	Haley Spring	Private	HQ core in bedrock	Packer tests in rock Televiewer	790	Apache Group units	Permeability of Apache Group Hydraulic gradients in Dripping Spring Mountains	VWP string (4) in Apache Group
	DH19-16(2)	1,009,343	795,682	Dripping Spring Wash		Tricone with SPT/LPT in overburden, then HQ core in bedrock	SPT/LPT in overburden Packer tests in rock Televiewer	794	Alluvium, Tertiary Conglomerate	Density of alluvium, Tcg weathering, clay layers, and bedding planes.	VWP string in alluvium and Tertiary Conglomerate (Tcg)
	DH19-17(2)	1,009,319	795,828	Dripping Springs Wash		HQ Core	Televiewer	1435	Alluvium, Tertiary Conglomerate, Granodiorite	Depth and units underlying Tertiary Conglomerate	String of VWPs in DH Hole

Notes:
1. Coordinate system is State Plane, Arizona Central, NAD 83, international feet.
2. Hole ID, depths and coordinates are as-built, not initially proposed values.

3.2 Geophysics

3.2.1 Surface Geophysics

One seismic refraction and resistivity line has been completed (SL-4 on Figure 2).

Objective

SL-4 was intended to target the Dripping Spring Fault through compression wave (P-Wave) refraction imaging near location 8 to inform the angle of a hole to intersect with the fault (DH18-8, DH19-8B). SL-4 was also intended to determine the thickness of Alluvium, the rippable depth and overall thickness of weathered and unweathered Tertiary Conglomerate.

Methodology

Surface geophysical surveys were carried out by HGI Hydrogeophysics (HGI) on November 14th and 15, 2018, along line SL-4 (Figure 2). The methodology is summarized below.

Two geophysical surveys were carried out along SL-4:

- 1,645 ft of electrical resistivity with 10 ft electrode spacing.
- 1,580 ft of seismic refraction with 20 ft geophone spacing.

3.2.2 Downhole Geophysical Surveys

Objectives

The purpose of the downhole geophysical surveys was to:

- obtain oriented structural measurements from optical and acoustic televiewers;
- identify weak zones or open fractures with caliper;
- confirm lithology for hydrogeological holes from the optical televiewer; and
- determine if natural gamma can be used to help identify facies changes in bedrock.

Methodology

Downhole geophysical surveys were conducted by Southwest Exploration Services (SWE) of Chandler, Arizona, in open holes prior to installation of instrumentation. Downhole tools included:

- QL Combo Tool
  - 3-arm caliper, natural gamma, fluid temperature, fluid conductivity;
- ALT QL OBI40 2G
  - Optical televiewer; and
- ALT QL ABI43 2G
  - Acoustic televiewer.

At DH19-11 the following additional tools were run to aid with interpretation of the aerial geophysics:

- ALT E-LOG IP
  - Electrical resistivity
- QL MAG SUS
  - Magnetic susceptibility

The following holes have received downhole geophysical surveys:

- DH18-5
- DH19-8B
- RC18-4
- RC19-8
- RC19-8A
- RC18-9
- RC19-13
- DH19-3A
- DH19-7
- DH19-11
- DH19-12
- DH19-14
- DH19-16
- DH19-17
- RC19-3
- RC19-7
- RC19-8D
- RC19-10
- RC19-15

3.3 Field Mapping

Field mapping was carried out by KCBCL on State Land and on private land. Field mapping is summarized below and described in detail in Appendix VII.

3.3.1 Objectives

The objectives of the field mapping program were to:

1. Ground truth geological mapping by Cornwall et al. (1971) and Cornwall and Krieger (1978).
2. Aid in characterizing the Dripping Spring Fault and Ransome Fault, particularly where the faults are currently mapped as outcropping in the Tertiary strata.
3. Develop an understanding of spatial variability of Tertiary Conglomerate, Pediment, and Travertine properties within the proposed TSF footprint.

4. Identify the degree of weathering and characteristics of other geologic units within the vicinity of the proposed TSF abutments and determine if there is a potential for piping.
5. Categorize dissolution potential of the various Limestone units in the proposed TSF right abutment based on surficial observations of dissolution, if any.
6. Potentially identify currently unknown conditions (e.g. mines, unknown springs, unknown land use etc.) or structural features (e.g. faults) not shown on the geological maps, if any.

3.3.2 Methodology

Field mapping was carried out between November 20 and 25, 2018. Field observations were made at 79 locations (identified as mapping points (MP)), over the six days.

To address the above objectives, mapping targeted the following areas:

1. Right abutment of Main Embankment and Limestone exposed downstream.
2. Major faults exposed on the western extent of the proposed TSF (Dripping Spring and Ransome Faults).
3. Overall coverage of Tertiary Sandstone/Conglomerate to identify facies, if present.
4. Any exposures of limestone within or close to the TSF:
    a. Mescal Limestone at base of Dripping Spring Mountains.
    b. Escabrosa Limestone upstream of TSF along Stone Cabin Wash.

3.4 Test Pitting

A test pit program was carried out in order to help characterize the geology and hydrogeology of surficial materials and to investigate proposed borrow sources. This test pit program is summarized below and described in detail in Appendix VIII.

3.4.1 Methodology

Test Pits were excavated using a tracked mini-excavator, operated by Dalmolin, between June 25, 2019 and June 27, 2019. KCBCL staff logged the test pit, took pictures and collected samples. Moisture and weathering characteristics were noted, along with a description of the difficulty of test pit excavation – for potential borrow materials.

A single infiltration test was conducted at the base of each test pit, which ranged in depth from 3 ft to 4.5 ft. Infiltration test methods are described in Section 3.9.1.

Test Pits were backfilled with excavated material upon completion and driven over by the tracked excavator for compaction.

3.4.2 Sampling

Sampling was undertaken at test pits as bulk samples for index, durability, compaction and permeability tests. Samples were collected and shipped to KCBCL's Vancouver laboratory.

- 5 gallon bucket bulk samples were collected from each test pit. These bulk samples were shipped to our lab in Vancouver for the following testing:
  - UCS (where possible, e.g. in rock units);
  - Grain size;
  - Hydrometer;
  - Atterberg Limits;
  - Specific Gravity;
  - Proctor Compaction; and
  - Hydraulic Conductivity (K).
- Geochemical sampling.

3.5 Geotechnical Drilling Program

3.5.1 Introduction

Geotechnical drilling was conducted for holes with the prefix DH (Figure 2). Geotechnical drilling was carried out by Cascade Drilling (Cascade) using a Boart Longyear LF-70 track mounted rig, and by National Exploration Wells and Pumps (National) with a Christensen CT14 track mounted rig. Drilling generally comprised mud-rotary drilling using a 6 in tricone drill-bit in soil and HQ3 (2.4 in core diameter) or PQ3 (3.3 in core diameter) coring in rock.

For Cascade's drill rig setup, testing through the soil profile comprised of SPT or LPT at five-ft intervals, or where lithology was free of coarse gravel and cobbles (see Section 3.5.4). In bedrock, testing comprised SPT/LPT testing in weathered rock, and packer testing throughout, as well as indicative falling head and constant head tests.

For National's drill rig setup, testing comprised packer testing throughout the bedrock, as well as occasional indicative falling head tests.

3.5.2 Objectives

The objectives of the geotechnical drilling program included:

- to determine the relative density and thickness of Quaternary Alluvium to assess the potential for foundation liquefaction;
- to identify and obtain samples of any potentially weak layers in bedrock, if present, to determine the potential impacts on embankment stability;

- to measure the hydraulic conductivity of bedrock to determine the potential for uncontrolled seepage or piping through the dam abutments or foundation that could potentially affect a downstream receptor or dam integrity and cannot be easily or reliably mitigated; and
- to identify and characterize major faults within the foundation, to determine the potential for high local seismicity, and the potential impacts of a fault within the Main Dam foundation seepage, if present.
- to determine depths to basement rocks, along with hydraulic properties

Boreholes had the following targets:

- DH18-5 targeted the foundation of the PAG cell embankment, with SPT/LPT testing (with SPT Analyzer) of weathered Tertiary Conglomerate and packer testing of unweathered Tertiary Conglomerate and provided VWP monitoring points for regional groundwater gradients.
- DH18-8 was angled at 60° from horizontal to intercept the Dripping Spring Fault upstream of the Main Embankment.
- DH18-8A was a short hole to allow SPT/LPT testing (with SPT Analyzer) of Alluvium, which requires a vertical hole.
- DH19-8B was a replacement angle hole for DH18-8 because DH18-8 failed to reach target depth.
- DH19-3 was meant to assess the potential for piping in the Tertiary Conglomerate below the main dam abutment.
- DH19-3A was a replacement for DH19-3, which failed to reach target depth, angled 75° from horizontal to intercept the Paleozoic Limestone and provides VWP monitoring points for pumping well RC19-3-PW.
- DH19-7 targeted the Tertiary Conglomerate and provides VWP monitoring points for pumping well RC19-7.
- DH19-11 was angled 70° from horizontal and was meant to help characterize the groundwater gradients to the west of the proposed facility and to better define the potential for cross-catchment groundwater flow, particularly from Ray Mine.
- DH19-12 was originally intended as an RC hole, but was changed due to the expected difficulty of the larger rig getting to the location. This hole targeted the Paleozoic Limestone and was meant to provide a monitoring well.
- DH19-12A was a replacement for DH19-12, after the well installation was abandoned.
- DH19-14 was meant to help characterize the groundwater gradients to the west of the proposed facility and to better define the potential for cross-catchment groundwater flow.
- DH19-16 was added to provide data on the Tertiary Conglomerate at the PAG tailings area.
- DH19-17 was added to provide additional structural and geological data at depth near DH19-16.

3.5.3 Methodology

Drilling

Geotechnical holes (DH) were drilled using a combination of mud-rotary tricone and diamond coring, as follows, and summarized in Table 3.4.

Mud-rotary tricone drilling in soil, used in eight holes, consisted of:

- Soil drilled with a 6 in diameter tricone on 4.5 in outer diameter (OD) rods.
- Relative density tests by SPT or LPT at 5 ft intervals (3 holes).
- Bentonite mud used as a circulation fluid to avoid heave affects on SPT/LPT results.
- Vertical holes for all holes with relative density testing (SPT/LPT).

Mud-rotary diamond drilling with PQ3 core in soil and bedrock, used in 5 holes, consisted of:

- Core sampled with a five ft PQ3 core barrel (4.9 in OD, 3.25 in core diameter).
- Water, polymer, or bentonite mud used as a circulation fluid as required (typically water to avoid the affect of mud or polymer on test results – see logs in Appendix I-A).
- Soil was cased with PWT casing (3 holes – DH19-12, DH19-12A, and DH19-17).
- Vertical holes, except DH19-3A (75° from horizontal towards dipping Paleozoic Limestone) and DH19-11 (70° from horizontal dipping towards Ray Mine).
- PQ3 core rods became HWT casing as the drilling switched to HQ3 core, except for DH19-12 and DH19-12A.

Mud-rotary diamond drilling with HQ3 core in bedrock, used in 11 holes, consisted of:

- Core sampled with a five ft HQ3 core barrel (3.8 in OD, 2.4 in core diameter).
- Water, polymer, or bentonite mud used as a circulation fluid as required (typically water to avoid the affect of mud or polymer on test results – see logs in Appendix I-A).
- Packer hydraulic conductivity tests were completed in most holes (see Section 4.6.3 for summary table).
- Vertical holes for most holes, except DH19-3A (75° from horizontal towards dipping Paleozoic Limestone), DH18-8 and DH19-8B (60° and 62°from horizontal, respectively, targeting the Dripping Spring Fault) and DH19-11 (70° from horizontal dipping towards Ray Mine).
- Soil was cased with HWT casing.

Table 3.4 Summary of Geotechnical Drilling Methodology

Drilling Contractor	Hole ID	Drilling Methods
Cascade Drilling	▪ DH18-5. ▪ DH18-8. ▪ DH18-8A. ▪ DH19-8B. ▪ DH19-3. ▪ DH19-7. ▪ DH19-14. ▪ DH19-16.	▪ Mud rotary tricone drilling in soil. ▪ Mud-rotary diamond drilling with HQ3 core in bedrock.
National	▪ DH19-3A. ▪ DH19-11. ▪ DH19-17.	▪ PQ3 core in soil and weathered bedrock followed by HQ3 core in bedrock.
	▪ DH19-12. ▪ DH19-12A.	▪ PQ3 core only in soil and bedrock.

Geotechnical Logging

Soil samples obtained from SPT/LPT tests were logged and classified using the Unified Soil Classification System (UCSC) according to the ASTM D2487 and D2488 Standard.

The rock drill core was geotechnically logged according to ASTM D6032, with the following parameters being logged:

- Total Core Recovery (TCR), Rock Quality Designation (RQD – ASTM D6032), and Solid Core Recovery (SCR);
- Field description of rock strength and weathering based on breaking with rock hammer (ISRM 1977);
- Lithology; and
- Spacing, planarity, roughness, infill, and orientation relative to core axis of discontinuities.

Core was logged at the drill rig and is stored in the RCM core handing facility.

3.5.4 In situ Relative Density Testing

SPT and LPT tests were conducted in soil and weathered bedrock at approximately five ft intervals according to ASTM D1586. Variance from ASTM included using the LPT sampler where gravel prevented using the SPT and using a 140 lb hammer and AWJ rods for LPT tests (Daniels el al. 2003). The sampler was driven 18 in, and blows were recorded every 3 in to identify blows affected by gravel. The field N value (blows per ft) was reported as the number of blows to drive the sampler from 6 in to 18 in.

All testing was carried out in holes filled with bentonite mud. Prior to all tests holes were sounded to confirm depth and the absence of slough. All testing took place under above the local water table, and holes were kept full of drilling mud to ground surface.

Penetration testing used the following equipment:

- SPT sampler: 2 in OD, 1 ⅜ in ID shoe, 1 ½ in barrel ID with AWJ rods.
  - Sleeve not used
- LPT sampler: 3 in OD, 2 ⅜ in ID shoe, 2 ½ in barrel ID with AWJ rods.
  - Sleeve not used
- Central Mountain Equipment (CME) automatic-trip hammer with 140 lb hammer and 30 in drop height for both SPT and LPT tests.
- KCBCL owned SPT Analyzer from Pile Dynamics was used to record and process the Energy Transfer Ratio (ETR) for each SPT/LPT drive at each hole.

3.6 Geotechnical Instrumentation

All DH holes were backfilled with cement-bentonite grout with a mix of 2.5 water: 1 cement: 0.3 bentonite by weight from bottom to top using a tremie pipe. Vibrating wire piezometers (VWP) were installed within the grouted annulus of the hole, in accordance with the methodology of Mikkelson and Green (2003) and Contreras et al. (2008). Up to five VWP's were installed in each hole.

The general installation procedure for the VWP included the following:

- Prior to installation, the porous VWP stone filter was saturated in a known depth of water to flush trapped air out of the porous stone. The saturation B-unit value and temperature of the VWP were recorded while submerged to confirm good working order and establish the ambient barometric conditions.
- The VWP tips were installed pointing upwards to maintain filter saturation during installation.
- The VWP cable was attached to the outside of Schedule-40 1 in PVC pipe (1.3 in OD, 1.0 in ID) for DH holes and to steel standpipes for RC holes, and taped every 5 ft.
- DH holes were backfilled with a mix of 2.5 water: 1 cement: 0.3 bentonite grout.
- RC holes were backfilled above the well screen and bentonite seal with a mix of 1 water : 1.1 cement : 0.03 bentonite.
- Extra lengths of cable were taped to the top of stick-up pipes and the VWP cable tips were sealed.
- A metal monument type protective casing was placed over the VWP cables to protect from wildlife and vandalism.
- VWP readings were measured after installation, and a datalogger was attached for ongoing monitoring.

The VWPs were manufactured by Geokon Instruments Inc (Geokon) and were procured by RCM. The VWPs were calibrated by Geokon prior to shipment. The calibration records for VWP's are provided in Appendix I-D.

Installation details for all VWP's installed in DH and RC holes are presented in Table 3.5 and shown on the drill hole logs in Appendix I-A (DH holes) and Appendix II-A (RC holes), as well as in the schematics of Appendix I-C (DH holes) and Appendix II-C (RC holes). Initial water level measurements are described in Section 4.5.

Table 3.5 Vibrating Wire Piezometers Installed in DH and RC Holes

Hole ID (As-Built)	Instrument ID	Ground Elevation (ft)	Installation Unit[1]	VWP Tip Depth (ft)[2]	VWP Tip Elevation (ft)	VWP Serial Number	C.F (Mpa/ B Unit)	Tk (Mpa/ °C rise)	Geokon Model and MPa rating	Initial Field Readings			
										B Value (Zero Pressure)	Temp (Zero Pressure) (°C)	Initial Pressure (mbar)	Date of reading
DH19-3A	DH19-3A-VWPA	3359.5	Paleozoic Limestone	922.9[3]	2436.5	1847876	-0.001254	0.0008007	4500SH-5MPa	8777.8	22.3	905.9363657	2019-05-24
DH19-3A	DH19-3A-VWPB	3359.5	Tertiary Conglomerate	627.9[3]	2731.6	1845401	-0.0007949	0.0006476	4500S-3MPa	8677	22.2	905.9363657	2019-05-24
DH19-3A	DH19-3A-VWPC	3359.5	Tertiary Conglomerate	338.1[3]	3021.4	1845398	-0.0008236	0.000428	4500S-3MPa	8744.4	22.8	905.9363657	2019-05-24
DH18-5	DH18-5-VWPB	3310.2	Tertiary Conglomerate	186	3050.2	1839290	-0.0005511	0.0003294	4500S-2MPa	8631	19.4	-	2018-12-05
DH18-5	DH18-5-VWPA	3310.2	Tertiary Conglomerate	260	3124.2	1839291	-0.0005399	0.0001629	4500S-2MPa	8896.2	20.9	-	2018-12-05
DH19-7	DH19-7-VWPA	3433.7	Tertiary Conglomerate	489	2944.7	1845402	-0.0008346	0.0006493	4500S-3MPa	8782	12.9	901.7008735	2019-04-30
DH19-7	DH19-7-VWPB	3433.7	Tertiary Conglomerate	390	3043.7	1847022	-0.0005455	0.0003678	4500S-2MPa	8747.5	12.8	901.7008735	2019-04-30
DH19-7	DH19-7-VWPC	3433.7	Tertiary Conglomerate	294	3139.7	1847025	-0.0005189	0.00008278	4500S-2MPa	8896	13.5	901.7008735	2019-04-30
DH18-8A	DH18-8A-VWPA	3165.0	Tertiary Sandstone	82	3083.5	1839431	-0.0002404	-0.000008815	4500S-1MPa	8716.9	8.3	-	2018-12-17
DH18-8A	DH18-8A-VWPB	3165.0	Quaternary Alluvium	63	3102.0	1839433	-0.0002816	-0.00001125	4500S-1MPa	8713.3	8.5	-	2018-12-17
DH19-8B	DH19-8B-VWPA	3163.8	Tertiary Conglomerate	554.9[3]	2608.9	1839057	-0.0005519	0.0003421	4500S-2MPa	8971.3	13.4	-	2019-01-25
DH19-8B	DH19-8B-VWPB	3163.8	Tertiary Sandstone	221.2[3]	2942.7	1839288	-0.0005555	0.0003264	4500S-2MPa	8761.6	12.9	-	2019-01-25
DH19-8B	DH19-8B-VWPC	3163.8	Tertiary Sandstone	97.1[3]	3066.7	1839289	-0.0005545	0.0001783	4500S-2MPa	8772	12.9	-	2019-01-25
DH19-12	DH19-12-VWP	3546.9	Tertiary Conglomerate	317.4	3229.5	1847024	-0.0005569	-0.00003414	4500S-2MPa	8764.3	16.8	901.5655418	2019-06-03
DH19-14	DH19-14-VWPA	3642.0	Dripping Springs Quartzite	780	2862.0	1847878	-0.00127	0.0004441	4500SH-5MPa	8820.4	20.9	903.0071193	2019-05-28
DH19-14	DH19-14-VWPB	3642.0	Dripping Springs Quartzite	614	3028.0	1847877	-0.001256	0.0006564	4500SH-5MPa	8738.5	20.4	903.0071193	2019-05-28
DH19-14	DH19-14-VWPC	3642.0	Mescal Limestone	400	3242.0	1847023	-0.000565	0.000377	4500S-2MPa	8657	26.1	903.0071193	2019-05-28
DH19-14	DH19-14-VWPD	3642.0	Diabase	265	3377.0	1630991	-0.0002766	-8.085E-07	4500S-1MPa	8885.1	28.1	903.0071193	2019-05-28
DH19-16	DH19-16-VWPA	3212.1	Tertiary Conglomerate	373	2839.1	1911293	-0.0005383	0.0003121	4500S-2MPa	8735.4	27.2	911.1515421	2019-06-11
DH19-16	DH19-16-VWPB	3212.1	Tertiary Conglomerate	131.5	3080.6	1902179	-0.0002603	0.0001341	4500S-1MPa	8851.9	27.2	911.1515421	2019-06-11
DH19-16	DH19-16-VWPC	3212.1	Quaternary Alluvium	32	3180.1	1902178	-0.0002625	0.0000831	4500S-1MPa	8615.9	26.9	911.1515421	2019-06-11
DH19-17	DH19-17-VWPA	3215.7	Ratler Granodiorite	1100	2115.7	1914564	-0.001257	0.001027	4500SH-5MPa	8481.3	32.4	904.4271222	2019-06-20
DH19-17	DH19-17-VWPB	3215.7	Ratler Granodiorite	890	2325.7	1847879	-0.001256	0.0005583	4500SH-5MPa	8670.7	32.4	904.4271222	2019-06-20
RC19-3	RC19-3-VWP	3356.2	Tertiary Conglomerate	500.2	2856.0	1845399	-0.0008188	0.0004090	4500S-3MPa	8696.6	27.5	905.0449412	2019-05-02
RC18-4	RC18-4-VWP	3535.6	Tertiary Conglomerate	194	3341.6	1839432	-0.0002942	-0.00001423	4500S-1MPa	8764.6	11.2	-	2018-12-15
RC19-8A	RC19-8A-VWP	3178.6	Tertiary Sandstone	110	3068.6	1839293	-0.0005396	0.0003181	4500S-2MPa	8758.2	14.4	-	2019-01-11
RC18-9	RC18-9-VWP	3533.2	Tertiary Conglomerate	200	3333.2	1839292	-0.0005408	0.00009657	4500S-2MPa	8714.4	10.5	-	2018-12-07
RC19-10	RC19-10-VWP	3824.4	Tertiary Conglomerate	260	3564.4	1845400	-0.0008314	0.0004112	4500S-3MPa	8831.4	19.4	902.6884032	2019-05-18
RC19-15	RC19-15-VWP	3721.2	Tertiary Conglomerate	427	3294.2	1912412	-0.0005434	0.0001784	4500S-2MPa	9001.9	33.8	907.3485233	2019-07-13

Notes:
1. Refer to Section 4.2 for discussion of general foundation lithology.
2. Depths are from ground surface at time of drilling.
3. Depths for angled boreholes are vertical depth from surface.

3.7 Hydrogeological Drilling Program

3.7.1 Introduction

Hydrogeological drilling was conducted for holes with the prefix RC (Figure 2; and Appendix II). Drilling and well installation was carried out by Cascade Drilling using a GEFCO Speedstar 50K truck mounted rig. During drilling through Alluvium and weathered bedrock, hydraulic testing was performed, comprising both falling head and constant head tests at twenty feet intervals. Upon completion of drilling, the holes were instrumented to be monitoring or pumping wells to allow for additional future testing.

3.7.2 Objectives

The objectives of the hydrogeological drilling program include:

- Obtain quantifiable knowledge of hydrostratigraphy, hydraulic gradients, hydraulic conductivity and seasonal variations to support site characterization, and provide relevant information for the BADCT[3] evaluation for the TSF.
- Establish a preliminary understanding of the flow paths towards potential downstream groundwater receptors of the proposed TSF site to identify suitable locations of monitoring sites.
- Establish baseline groundwater quality.

Hydrogeological boreholes had the following targets:

- RC18-4 investigated the presence of a potential groundwater divide that corresponds with the nearby surface water divide between Mineral Creek and Dripping Springs Wash.
- RC18-9 assessed the groundwater flow regime within the Alluvium and Tertiary Conglomerate. This location was the first to be drilled and is used as a water supply source.
- RC19-8 was used to identify and assess hydraulic connectivity across the Dripping Spring Fault and assess groundwater flow regime within the Alluvium and Tertiary Conglomerate. RC19-8 was designed to be a pumping well.
- RC19-8A was used as a monitoring well pair for RC19-8 for the Dripping Spring Fault hydraulic connectivity assessment. This location is comprised of two nested wells and a VWP.
- RC19-3 targeted Paleozoic Limestone units potentially underlying the west abutment of the proposed Main Dam to assess the hydraulic characteristics of these units at this location to support assessment of seepage potential from the proposed facility through this unit.
- RC19-8B and RC19-8C were added to enhance the production and monitoring network at location 8 in order to characterize the hydraulic parameters of Quaternary Alluvium and shallow Tertiary Conglomerate upstream of the Main Dam.

[3] Best Available Demonstrated Control Technology (ADEQ 2005)

- RC19-8D was added to provide a higher capacity well screen at the same location as RC19-8 to prove high flow rates could be pumped from Tertiary Conglomerate.
- RC19-10 was used to refine the groundwater gradients and flow directions north of the facility.
- RC19-15 was used to allow measurement of the water table and the assumed groundwater divide between Dripping Springs Wash and Mineral Creek and enable a pumping test to measure response across the assumed divide.

3.7.3 Methodology

Drilling

The hydrogeological air rotary boreholes (RC) were all drilled at a vertical orientation through the Alluvium / weathered bedrock using a 10.63 in diameter tricone bit, which allowed the installation of an 11 in, inside diameter, surface casing.

The surface casing was advanced in the predrilled hole using a 5,000 lb hammer, with a 12 in stroke, until the casing reached refusal into the underlying competent bedrock. Once the surface casing was seated into the bedrock the tricone bit was replaced with a 10 in diameter downhole hammer bit, and the borehole was advanced until the target depth was achieved.

Dry sections of the borehole required the injection of between 1 gal/min and 5 gal/min of water to reduce dust levels and allow efficient removal of cuttings. This drilling water was supplied by Johnavitch, a contractor contracted through RCM, from a source in or near the town of Winkelman, AZ.

Drill cuttings were routed through an 8-in diameter hose to a cyclone where samples of the cuttings were collected. A composite sample of the cuttings was collected at 5 ft intervals. These samples were logged at the rig by a KCBCL hydrogeologist.

Unsaturated Zone Hydraulic Testing

To calculate field saturated hydraulic conductivity values, borehole infiltration tests were conducted in the unsaturated Alluvium and upper bedrock in all hydrogeological boreholes. The testing included both constant head and falling head methods; and, was conducted within the surface casing. The testing procedure is outlined as follows:

- The surface casing was advanced to a workable height to take observations from the drill deck. The first test generally occurred between 17 ft and 20 ft below ground surface as 20 ft casing lengths were used.
- An open hole test section was created by advancing the tricone hole to 2.5 ft to 4 ft past the shoe of the surface casing.
- The diameter of the open hole, depth of casing and depth of open hole were measured and recorded.

- The hole was pre-soaked for a minimum of 15 minutes, and if possible, up to 12 hours, by pumping water into the hole at a rate of 10 gal/min to 15 gal/min. Care was taken to avoid scouring of the hole by directing the hose flow onto side of the casing at the start of the test.
- After saturation, flow rates were measured using a stopwatch and five-gallon bucket.
- The constant rate test was completed as the first test of the testing program. The flow rate for the test was measured and adjusted until the flow rate was enough to maintain a steady water level that was at least 2.5 times the diameter of the casing for at least 15 minutes and up to one hour. Water levels were measured using an electric water depth sounder.
- Upon completion of the constant head test an open hole falling head test was completed.

The testing was undertaken throughout the drilling process until either the borehole reached 70 ft in depth or until the surface casing refusal was reached.

3.8 Hydrogeological Instrumentation

3.8.1 Monitoring and Pumping Wells

Monitoring and pumping wells were installed in the hydrogeological boreholes immediately following drilling. VWPs were installed in the annulus of boreholes above the well screens, in selected boreholes. Instrument installation depths were selected based on the borehole geophysics results, drilling observations and in situ testing results. The final design of the monitoring and pumping wells was confirmed following discussions with other project team members and stakeholders.

Monitoring and pumping well installations were completed with one of the following installation types:

- Solid steel pipe and slotted steel pipe (12 rows, 3 in long and spaced, 0.125 in aperture slot) with a two ft sump at the bottom. The inside diameter of the steel pipe ranged between 4.0 in and 6.0 in. Backfilled with a subangular to sub-rounded gravel pack with a minimum grain size diameter of 0.25 in.
  - RC19-3, RC18-4, RC19-7 (also wire wound screen), RC19-8, RC19-8AS, RC18-9, RC19-10, RC19-13.
- Solid steel pipe with wire wrapped slotted screen (0.150 in to 0.20 in aperture slots). The inside diameter of the steel pipe was 6.0 in. Filter pack consisted of 12/20 filter sand or 3/8 in to 3/16 in crusher run gravel.
  - RC19-7 (also slotted steel pipe), RC19-8C, RC19-8D, RC19-15.
- Schedule 40 or Schedule 80 PVC wells, with machine fabricated slots of 0.02 in to 0.15 in aperture and an inside diameter of 2.0 in, 2.9 in or 6.0 in. Backfilled with 10/20 filter sand or subangular to sub-rounded gravel pack with a minimum grain size diameter of 0.25 in.
  - RC19-8AD, RC19-8B, DH19-12A.

For most wells, filter material was poured around the well screens to between approximately 3 ft and 42 ft above the top of the well screen. The exception to this is DH19-12A-MW, which had a shale trap (rubber gasket to prevent backfill from falling down hole) placed 5 ft above the screen and the filter sand was poured above it for another 115 ft.

The annulus above the well screen and gravel pack was backfilled with approximately 10 ft to 160 ft of coated bentonite pellets (and bentonite chips, if above the water table.) Above this, a cement-bentonite grout (mixed to a ratio of 1 water : 1 cement : 0.03 bentonite by weight) was placed to the surface. Lockable monument protective casings were installed at each well following installation for surface protection. The total depth of the wells range between 71 ft and 985 ft below ground surface. VWPs were installed in RC19-3, RC18-4, RC19-8A, RC18-9, RC19-10 and RC19-15 with the objective of assessing vertical gradients and seasonal water table fluctuations. Table 3.6 provides details of the monitoring well installations, while the installation schematics are provided in Appendix II-C.

Table 3.6 Summary of Installed Wells

Hole ID (As-Built)	Well ID	Instrument Inner Diameter (in)	Well Material Type	Ground Elevation (ft)	Installed Formation	First Groundwater Strike Depth (ft)	Piezometer Screen Depth Range (ft)		Filter Pack Depth Range (ft)	
							From	To	From	To
RC19-3	RC19-3-PW	6	Steel	3356.2	Tertiary Conglomerate	290	610	750	590	789.1
RC18-4	RC18-4-MW	4	Steel	3535.6	Tertiary Conglomerate	175	227	267	223	270
RC19-7	RC19-7-PW	6	Steel	3433.7	Tertiary Conglomerate / Sandstone	343	350	450	340	451
							670	750	649.5	758
RC19-8	RC19-8-PW	6	Steel	3162.0	Tertiary Sandstone / Conglomerate	95	148	168	130	250
							208	248		
RC19-8A	RC19-8AS	4	Steel	3178.6	Tertiary Sandstone / Conglomerate	110	230	270	224.6	274.5
	RC19-8AD	2	PVC				378	398	371.5	398
RC19-8B	RC19-8B-MW	6	PVC	3165.7	Tertiary Sandstone / Conglomerate	76	85	125	75	127
RC19-8C	RC19-8C-MW	6	Steel	3166.3	Quaternary Alluvium	81	31	71	28	72
RC19-8D	RC19-8D-PW	6	Steel	3166.7	Tertiary Conglomerate / Sandstone	115[2]	202	222	180	507
							262	322		
							402	502		
RC18-9	RC18-9-PW	5.5	Steel	3533.2	Tertiary Conglomerate / Sandstone	190	320	400	302	402
RC19-10	RC19-10-MW	4	Steel	3824.4	Tertiary Conglomerate / Sandstone	260	465.3	647.3	437.2	650
DH19-12A[1]	DH19-12A-MW	2.9	PVC	3544.7	Tertiary Conglomerate	- [3]	288.4	386.3	168	399
RC19-13	RC19-13-PW	6	Steel	3404.7	Tertiary Conglomerate / Sandstone	160	268	348	230.5	350
RC19-15	RC19-15-PW	6	Steel	3721.2	Tertiary Conglomerate	465	595	975	553	985

Notes:
1. Although DH19-12A-MW was not installed in an RC hole, we have included it here.
2. Cuttings were moist at 65 fbgl – but this may have been due to a perched water table from the falling head test.
3. Due to the nature of mud rotary diamond coring, the water strike depth was not noted.

3.8.2 Monitoring and Pumping Well Development

Well development was undertaken at the completion of drilling, within the open hole, once the target depth of the hole was reached, and within the well casing at the completion of well installation. The purpose of the well development was to remove the fine materials (such as drill cuttings and drilling polymer) from the borehole annulus adjacent to the gravel packed section of the well and to promote hydraulic connection between the aquifer and the installed well. The presence of drill cuttings and/or drilling polymer on the borehole wall may influence the hydraulic testing results.

Generally, well development was undertaken using airlifting techniques with the air compressor on the drill rig over two phases. The first phase comprised airlift development within the open hole, while the second phase of development was completed after the well installation. The two inch diameter PVC well at RC19-8AD was developed using the Pulstar pump hoist rig provided by Cascade using a bailer and a surge block. The development of RC19-10 included the use of a hand-bailer. Following airlift development, pumping wells RC18-9 and RC19-8 were further developed using a submersible pump prior to the commencement of the test pumping programs. Additional work on pumping wells is underway by M&A (2019b, c).

The airlift development was undertaken at each well until the discharge water from the well was clear and free of sediment and three consecutive measurements of field parameters, taken five minutes apart, were within 10% of each other. Notes regarding water color, turbidity and sediment content were recorded at regular intervals during the development process.

Table 3.7 provides a summary of the measured field parameters upon completion of well development.

Table 3.7 Summary of Field Water Quality Parameters Measured During Well Development

Instrument ID	Flow Rate During Development (gal/min)	Field Water Quality Parameters				Observations at Completion of Development
		Temperature (C˚)	EC (ms/cm)	pH	Turbidity (NTU)	
RC19-3-PW	90	24.2	0.558	8.20	6.0	Sample RC19-3_DEV (RESH-1000944) taken at 16:00 on 30-Apr-19
RC18-4-MW	1.3	21.80	0.839	8.48	10.2	Sample RC18-4_DEV (RESH-1000909) taken at 14:15 on 16-Dec-18
RC19-7-PW	90	24.7	0.557	9.6	- (1)	Sample RC19-7_DEV (RESH-1000954) taken at 13:37 on 12-Jun-19
RC19-8-PW	39.6	21.82	0.618	8.34	4.9	Sample RC18-8_DEV (RESH-1000916) taken at 15:05 on 23-Jan-19
RC19-8AS	60.0	22.57	0.524	8.45	77.1	Sample RC18-8AS_DEV (RESH-1000911) taken at 16:30 on 13-Jan-19

Instrument ID	Flow Rate During Development (gal/min)	Field Water Quality Parameters				Observations at Completion of Development
		Temperature (C°)	EC (ms/cm)	pH	Turbidity (NTU)	
RC19-8AD	1.3	23.54	0.816	7.34	0	Sample RC19-8AD_Dev (RESH-1000919) taken at 16:10 on 27-Jan-19
RC19-8B-PW	Bailed, ~0.56	21.8	0.648	7.57	0(2)	Sample RC19-8B_DEV (RESH-1000947) taken at 13:24 on 27-May-19
RC19-8D-PW	45	24.39	0.496	8.56	43	Sample RC19-8D_DEV (RESH-1000958) taken at 11:45 on 25-Jun-19
RC18-9-PW	120	23.73	0.457	8.42	2.4	Sample RC18-9_DEV (RESH-1000899) taken at 16:00 on 08-Dec-18
RC19-10-PW	0.5	29.1	0.684	8.02	34.9	Sample RC19-10_DEV (RESH-1000946) taken at 11:40 on 25-May-19
RC19-13-PW	6.3	22.89	0.713	8.35	76.8	Sample RC19-13_DEV (RESH-1000920) taken at 14:25 on 1-Feb-19
RC19-15-PW	127	25.7	0.451	8.59	18.2	Sample RC19-15_DEV (RESH-1000961) taken at 11:00 on 16-Jul-19

Notes:
1. No Turbidity measurement taken.
2. Turbidity measurement was negative, indicating that the calibration was slightly off.

3.8.3 Groundwater Quality

Groundwater samples were collected upon completion of well development at all well locations and groundwater samples were also collected at the beginning and end of both constant rate pumping tests. A 0.45-micron syringe filter was used to filter the samples for analysis of dissolved constituents.

The samples were submitted to SVL and AZ laboratories by M&A for analysis. Analytical parameters included:

- Physico-chemical Parameters (pH, Dissolved Oxygen, electrical conductivity);
- Major ionic constituents (Ca, Na, Mg, K, CO_3, HCO_3, SO_4, Cl,);
- Dissolved and Total Metals;
- Cyanide;
- Nitrites and Nitrates;
- Sulfide; and
- Elemental Uranium.

Refer to Table 3.7 for a summary of the development samples taken.

3.9 Hydraulic Testing

3.9.1 Test Pit Infiltration Testing

Single ring infiltration tests were carried out in the floor of test pits to determine field saturated hydraulic conductivities. Tests used a 12.2 in inner diameter ring, either driven into the ground in Quaternary Alluvium, or resting on a planar surface and sealed with bentonite powder in Gila Sandstone or Conglomerate. Tests were carried out as falling head tests, except at TP19-9, where constant head tests were also carried out.

Test results are presented in Section 4.6.1, and results are presented in Appendix VI.

3.9.2 Packer Testing

Borehole packers were used to enable hydraulic conductivity testing of isolated horizons within open boreholes drilled by PQ or HQ sized diamond coring (DH). Inflatable packers were used to seal off (isolate) the desired section of the boreholes prior to testing. Once the packers were inflated and the selected interval isolated, hydraulic testing is undertaken by injecting water into the formation under constant pressure, with measurement of the average stabilized flow rate (or water consumption) at the test pressure. This was repeated at different pressure steps to measure formation response at different pressures.

Packer testing was carried out in six vertical drill holes and four inclined boreholes. The hydraulic testing program utilized both single and double packer systems with the general objective to test the relative hydraulic conductivity of the rock mass and intersected structures.

Test intervals and depths were selected by KCBCL staff based on lithology and interpretation of structural features determined from logging of rock core, review of core photographs, and interpretation of structural features from core relative to other boreholes in the vicinity. Test intervals were estimated ahead of drilling and locally adjusted based on actual geology drilled and to avoid seating the packer in highly fractured rock.

Packer tests were conducted using a HQ3 single-packer assembly, and an HQ3 double-packer assembly. Prior to commencing each packer test the borehole was flushed using fresh potable water provided by the site general contractor for a minimum of 30 minutes to remove drilling mud and polymers. The packer test equipment was inspected and tested at surface prior to deployment into the borehole.

Falling head tests were conducted prior to packer testing with the packer inflated. The packer testing program comprised the implementation of five steps of incrementally increasing and decreasing pressure. The maximum pressure applied was calculated as 80% of the estimated overburden pressure. This maximum pressure step was typically the middle or third step with the second and fourth steps being 75% of the maximum pressure, and the first and fifth steps being 50% of the maximum pressure.

Packer testing intervals adopted for the packer tests ranged in length between 5 ft and 199 ft with a median test length of 99 ft. The test lengths were generally longer than ideal packer testing interval lengths; difficulties were encountered with progress being slower than anticipated, with packer equipment malfunctions, and with borehole stability that limited the number of packer tests that could be conducted, and limited deployment of the double packer.

3.9.3 Pumping Tests

Pumping test programs were completed at RC18-9 and RC19-8 and comprised: 1) multi-rate pumping tests; 2) constant rate pumping tests; and 3) recovery tests. The multi-rate test was performed prior to the constant rate test to assess the capacity of the well to yield groundwater. The information collected from the test was analyzed to identify a sustainable pumping rate for the subsequent constant rate test. The constant rate test was performed to identify the hydraulic parameters of the aquifer, including transmissivity / hydraulic conductivity, based on groundwater level drawdown measurements from within the pumping well and surrounding monitoring wells. At the completion of the constant-rate test the recovering groundwater level in the pumping well and surrounding monitoring wells were monitored to allow further analysis of the aquifer hydraulic parameters.

The pumping tests were performed by the pump division of Cascade Drilling. The tests at RC18-9 and RC19-8 were initiated on January 29, 2019 and February 27, 2019, respectively. The pumping test program was monitored by a KCBCL hydrogeologist. Prior to the commencement of the pumping tests a KCBCL hydrogeologist collected manual water level measurements using an electric depth sounder and installed Pressure Transducer Data Loggers (PTDLs) in surrounding monitoring wells or existing irrigation wells to monitor changes in groundwater levels prior to, during and after the pumping test. Nearby VWPs were also equipped with dataloggers for the duration of the pumping tests.

Additional pump testing was undertaken on RC19-8D, RC19-7, RC19-13 and RC19-15. These tests were completed under the supervision on M&A and have been reported by M&A (2019b, c).

Multi-rate Pumping Tests

Prior to conducting the specific capacity test, both RC18-9 and RC19-8 were pumped for one hour to further develop the well, confirm the system was in good working order (specifically the Variable Frequency Drive (VFD) and Flowmeter) and identify settings for the selected pumping rates. Once the wells recovered to within 95% from the one hour of trial pumping, the multi-rate testing commenced. The test at RC18-9 comprised four one-hour steps at the following discharge rates:

- 20 gal/min
- 35 gal/min
- 50 gal/min
- 65 gal/min

The multi-rate test at RC19-8 consisted of three 50 minutes steps at the following discharge rates:

- 25 gal/min
- 50 gal/min
- 65 gal/min

Manual water level measurements were collected during the tests by Cascade using an electric depth sounder. Drawdown measurements are presented graphically in Appendix II. Upon completion of the multi-rate tests the groundwater level in the pumping well recovered to within 95% of pre-pumping levels prior to commencement of the subsequent constant-rate test.

Constant-rate Pumping Tests

The constant-rate tests were completed on RC18-9 and RC19-8 at pumping rates of 77 gal/min and 55 gal/min, respectively, for 24-hour durations. Water levels in the pumped wells were recorded using a pressure transducer and manual measurements. Water levels at surrounding monitoring wells (RC19-8AD, RC19-8AS, RC19-13, RC18-4 and well 55-632800 – Figures 2 and 4) were recorded using pressure transducers programmed at one-minute intervals. Manual water level measurements were collected intermittently at the well 55-632800, RC19-13, RC19-8AS and RC19-8AD (Figures 2 and 4). All pressure transducer data were corrected for atmospheric pressure variations recorded using a barometric pressure logger recording at one-minute intervals.

Field water quality parameters (i.e. pH, Electrical Conductivity (EC), temperature, Dissolved Oxygen (DO), Turbidity and Oxidation-Reduction Potential (ORP)) were measured and recorded at one-minute intervals throughout the 24-hour constant rate tests at both RC18-9 and RC19-8 using a YSI 650MDS water quality meter, equipped with a flow-thru cell. Two groundwater samples were collected during each of the 24-hour constant rate tests at both RC18-9 and RC19-8, with the first sample collected within 1.5 hours of the test commencement and the second after 24 hours of pumping prior to the cessation of the test.

3.9.4 Slug Tests

Slugs tests were completed at RC18-4, RC18-9, RC19-8AD and RC19-8AS to determine the hydraulic conductivity of the screened formation in the immediate vicinity of each monitoring well. Slug testing was undertaken using a solid PVC cylinder, which was submerged into the well below the water level, displacing the cylinder volume. The water level was allowed to recover to static conditions, with the rate of recovery being recorded. Once the water level had recovered to static conditions, the slug was removed from the well, causing the lowering of the water level. This water level was also allowed to recover to static conditions, with the rate of recovery also being recorded. This process allowed for two groundwater level recovery curves to be analyzed for hydraulic conductivity.

A summary of the slug test procedure is outlined below:

- The static water level in the well was measured using an electronic water level meter.
- A PTDL was lowered into the well and set below the static water level and the length of the PVC slug below the water level.

- A PVC slug was introduced into the well and lowered to a level just above the water level in the well, taking care not to disturb the PTDL.
- The PVC slug was rapidly and completely submerged into the water column resulting in displacement of the water and causing the water level to raise; marking the beginning of the falling head test.
- Measurements of the recovering water level were undertaken, both manually and with the PTDL until the water level returned to within 90% of the static water level.
- The slug was then removed from the water column causing a decrease in the water level marking the beginning of the rising head test.
- Measurements of the recovering water level were undertaken both manually and with the PTDL until the water level returned to within 90% of the static water level.

Further details on the test and associated results are presented in Section 4.3.6.

Additional slug tests were completed on RC18-4 and RC19-10. These tests were undertaken by M&A with the associated methodology and results in M&A (2019b, c).

3.10 Laboratory Testing

Samples were obtained from Air Rotary cuttings, SPT/LPT samples, HQ3 and PQ3 core:

- Air rotary cuttings were collected at 5 ft intervals and about 1 pound were stored in mesh bags.
    - The bags were sealed in 5 gallon buckets and transported to the RCM core handling facility.
- SPT/LPT samples were removed from the split-spoon, scraped of smear, and sealed in plastic bags as disturbed samples.
    - SPT/LPT samples were placed in core boxes and shipped to KCBCL's laboratory in Vancouver, BC.
- HQ3 and PQ3 core was sampled at the drill, dried with a cloth, and wrapped in cellophane.
    - Sealed core samples were placed in core boxes and shipped to KCBCL's laboratory in Vancouver, BC.

Laboratory testing completed to date includes (Table 3.8):

- Point load testing of core conducted both in the field and at the RCM core handling facility according to ASTM D5731;
- Uniaxial tests of unconfined compressive strength (UCS) of core (ASTM D7012);
- Particle size distribution (PSD) using sieve (ASTM D1140), hydrometer (ASTM D422), and Atterberg limits (ASTM D4319) of soil and completely weathered bedrock:

  - Weathered bedrock was crushed with a rubber tipped mortar and pestle.
- Direct shear testing (single point peak and residual) of siltstone beds within Tertiary Sandstone and Conglomerate:
  - Consolidated to 44 psi, then soaked for 3 days in distilled water.
  - Loaded to 174 psi, then sheared to ~5 mm displacement for peak.
  - After peak, cycled at ~2 mm displacement for multiple cycles until residual strength was reached (no additional drop in strength upon cycling).
- Flexible-wall permeameter testing of HQ3 core, with flow parallel to the core axis (ASTM D5084).

Ongoing laboratory testing includes (results pending):

- Thin section analysis of Paleozoic Limestone units (Pn, Dm, Me, Ym) to determine carbonate mineralogy and level of dissolution;
- X-ray diffraction of Tertiary Sandstone and Conglomerate matrix to determine clay mineralogy;
- Thin section analysis of Tertiary Sandstone and Conglomerate to determine mineralogy of cement, porosity, and evidence of dissolution;
- X-ray diffraction of Paleozoic Limestone units (Pn, Dm, Me, Ym) to determine % carbonate;
- Direct Shear testing (single point peak and residual) of clay layers within Quaternary Pediment;
  - Consolidated to 44 psi, then soaked for 3 days in distilled water.
  - Loaded to 174 psi, then sheared to ~5 mm displacement for peak.
  - After peak, cycled at ~2 mm displacement for multiple cycles until residual strength was reached (no additional drop in strength upon cycling).
- Flexible wall permeability tests on reconstituted compacted samples of clay from Quaternary Pediment); and geochemical testing of soil and rock completed by others.

Table 3.8 Summary of Laboratory Testing

Unit	Test Type	# of Tests
Quaternary Alluvium	PSD - Sieve only (ASTM D422)	5
	Standard Proctor (ASTM D698)	2
Quaternary Pediment (Qp)	Water Content (ASTM D2216)	1
	Specific Gravity (ASTM D854)	1
	Atterberg Limits (ASTM D4318)	1
	PSD - Sieve / Hydrometer (ASTM D422)	1
	Standard Proctor (ASTM D698)	1
	Direct Shear (ASTM D3080)	1
Residual Soil (from Tss or Tcg)	Atterberg Limits (ASTM D4318)	2
	PSD - Sieve / Hydrometer (ASTM D422)	2
All Tss or Tcg	Atterberg Limits (ASTM D4318)	4
	PSD - Sieve / Hydrometer (ASTM D422)	15
	PSD - Sieve only (ASTM D422)	4
	Standard Proctor (ASTM D698)	4
	Flexible Wall Permeameter (ASTM D5084)	8
	Direct Shear (ASTM D3080)	3
	Unconfined Compressive Strength (UCS) (ASTM D7012/C)	34
	Point Load Strength Test – dry (ASTM D5731)	17
	Point Load Strength Test – 24-hour soak (ASTM D5731)	14
	Point Load Strength Test – 7-day soak (ASTM D5731)	13
	Slake Durability (ASTM D4644)	4
Tss only	Atterberg Limits (ASTM D4318)	2
	PSD - Sieve / Hydrometer (ASTM D422)	1
	PSD - Sieve only (ASTM D422)	2
	Standard Proctor (ASTM D698)	2
	Direct Shear (ASTM D3080)	3
	Flexible Wall Permeameter (ASTM D5084)	1
	Unconfined Compressive Strength (UCS) (ASTM D7012/C)	2
	Slake Durability (ASTM D4644)	2
Tcg only	Atterberg Limits (ASTM D4318)	2
	PSD - Sieve / Hydrometer (ASTM D422)	8
	PSD - Sieve only (ASTM D422)	2
	Standard Proctor (ASTM D698)	2
	Flexible Wall Permeameter (ASTM D5084)	5

Unit	Test Type	# of Tests
Tcg only	Unconfined Compressive Strength (UCS) (ASTM D7012/C)	20
	Point Load Strength Test – dry (ASTM D5731)	17
	Point Load Strength Test – 24-hour soak (ASTM D5731)	14
	Point Load Strength Test – 7-day soak (ASTM D5731)	13
	Slake Durability (ASTM D4644)	2
Mescal Limestone (Ym)	Flexible Wall Permeameter (ASTM D5084)	1
	Unconfined Compressive Strength (UCS) (ASTM D7012/C)	2
	Point Load Strength Test – dry (ASTM D5731)	1
Paleozoic Limestone	Unconfined Compressive Strength (UCS) (ASTM D7012/C)	2
Completely Weathered Diabase	Collapse Test (ASTM D4546)	1
Diabase (Ydb)	Flexible Wall Permeameter (ASTM D5084)	2
	Unconfined Compressive Strength (UCS) (ASTM D7012/C)	2
	Point Load Strength Test – dry (ASTM D5731)	2
	Point Load Strength Test – 24-hour soak (ASTM D5731)	1
	Point Load Strength Test – 7-day soak (ASTM D5731)	1
Dripping Springs Quartzite (Yds)	Unconfined Compressive Strength (UCS) (ASTM D7012/C)	4
	Point Load Strength Test – dry (ASTM D5731)	3
	Point Load Strength Test – 24-hour soak (ASTM D5731)	2
	Point Load Strength Test – 7-day soak (ASTM D5731)	2
Quartz Diorite (Ki)	Unconfined Compressive Strength (UCS) (ASTM D7012/C)	1
	Point Load Strength Test – dry (ASTM D5731)	1
	Point Load Strength Test – 24-hour soak (ASTM D5731)	1
	Point Load Strength Test – 7-day soak (ASTM D5731)	1
Pioneer Shale	Unconfined Compressive Strength (UCS) (ASTM D7012/C)	1
	Point Load Strength Test – dry (ASTM D5731)	1
Ruin Granite	Unconfined Compressive Strength (UCS) (ASTM D7012/C)	1
	Point Load Strength Test – dry (ASTM D5731)	1

4 SUMMARY OF RESULTS

4.1 Geophysics

Results from electrical resistivity and seismic refraction surveys are summarized below.

Seismic refraction results for SL-4 are shown on Figure 4.1. Electrical resistivity results for SL-4 are shown on Figure 4.2. Both seismic and resistivity surveys show a two-layer structure, with a resistive/lower velocity layer near the surface overlying a more conductive/higher velocity layer at depth. The contact between these layers shows two distinct alluvial channels, with the upper layer about 25 ft thick outside the channels, and up to 95 ft thick within the channels.

Drilling showed the near-surface layer to be Alluvium, and the deeper layer to be Tertiary Conglomerate. DH18-8A was originally located over Dripping Springs Wash (Figure 4.1 Station 940 ft) to provide a relative density profile through Alluvium. Following the geophysical survey, the hole was moved west to align with the thickest portion of the inferred Alluvium. The seismic refraction P-wave boundary of 6,300 ft/s agreed well with the Alluvium-Tertiary Sandstone contact at DH18-8A, but overestimated the depth at Dripping Springs Wash were Sandstone was seen at the surface, and has P-wave velocities as low as 3,500 ft/s to 25 ft deep, and the 6,300 ft/s boundary was 50 ft deep.

In the electrical resistivity profile, a sharp contrast between a resistive upper layer and a conductive lower layer follows the Alluvium-Sandstone contact (Figure 4.2). The sharp contrast marking the contact overestimates the depth of Alluvium by about 30 ft at DH18-8A in the center of the channel but does show Alluvium pinching out at the channel margins.

SL-4 was also intended to locate the Dripping Spring Fault, so that proposed DH-8 could be drilled at an angle across it. The geophysics contractor (HGI) interpreted a potential fault between stations 850 and 950 ft (Figure 4.2), and DH18-8 and DH19-8B were aligned to target the feature but did not conclusively confirm the presence of a fault (Appendix I-A).

The lower layer had P-wave velocities of greater than 6,300 ft/s, ranging up to 9,000 ft/s, indicating Tertiary Conglomerate within the lower layer would be classified as marginal to non-rippable based on the Caterpillar Handbook for a D9 tractor (Caterpillar 2000). Weathered Tertiary Conglomerate was observed on the east bank of Dripping Springs Wash, indicating an approximately 40 ft thick zone of rippable Tertiary Conglomerate where it is exposed at the surface.

Figure 4.1 Seismic Refraction Profile at SL-4

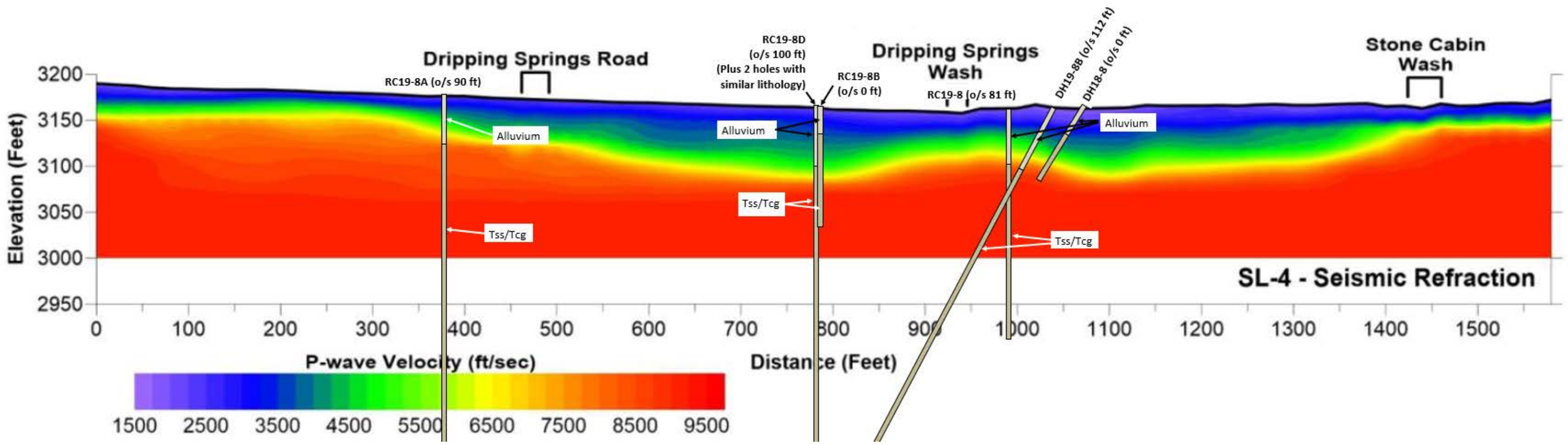
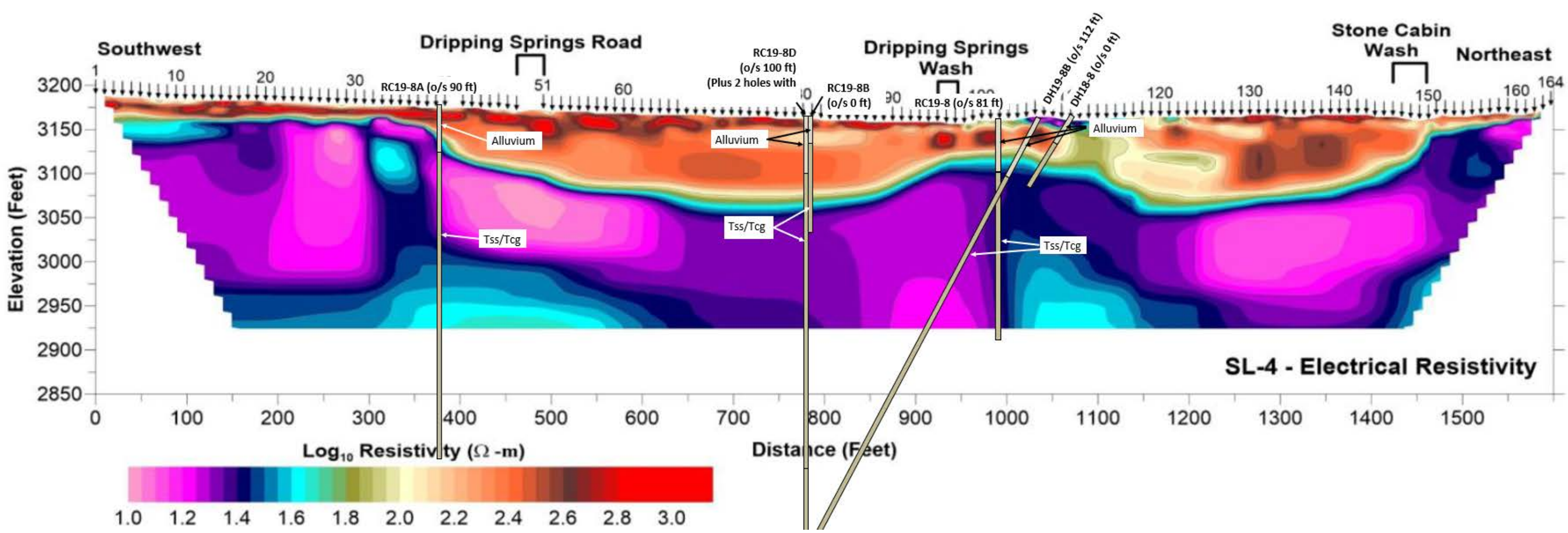


Figure 4.2 Electrical Resistivity Profile of SL-4



4.2 Test Pit Results

Six test pits were excavated at five locations, intersecting the following materials (Table 4.1):

- Quaternary Alluvium (two test pits)
  - Sand and gravel, medium to coarse sand, fine to coarse gravel, well graded, trace cobbles and boulders up to 1.5 ft, loose to compact to 4.5 ft, light grey, dry, stratified.
- Quaternary Pediment (one test pit)
  - Interbedded clayey gravel and sandy clay. Clay is sandy, red, hard, trace gravel up to 3 in, low to intermediate plasticity, jointed.
- Tertiary Sandstone (two test pits)
  - Fine to medium sand sized grains, trace to some gravel up to 3 in, fine to coarse, greyish light brown, horizontal bedding, moderately spaced irregular bedding joints, moderate to strong cementation, strong HCl reaction, moderately weathered, extremely to very weak rock (R0-R1).
- Tertiary Conglomerate (two test pits)
  - Fine to coarse gravel and fine to coarse sand sized grains, some cobbles up to 10 in, brownish grey, horizontal bedding, no obvious defects, moderate to strong cementation, moderate to strong HCl reaction, extremely weak to weak rock (R0-R2). Difficult to excavate.

Infiltration tests were carried out on the floor of tests pits. Methods are described in Section 3.4, and results are presented in Section 4.6.1.

Table 4.1 Summary of Test Pits

Test Pit ID	Easting(1) (ft)	Northing(1) (ft)	Depth (ft)	Material Units Encountered
TP19-8	1,009,755	794,754	4.5	Quaternary Alluvium
TP19-8A	1,009,647	794,812	3.0	Tertiary Sandstone
TP19-9	1,006,807	796,369	4.5	Quaternary Alluvium / Tertiary Conglomerate
TP19-10	1,014,232	799,697	4.0	Quaternary Pediment
TP19-11	1,015,772	798,463	4.0	Fill / Tertiary Sandstone
TP19-13	1,006,583	795,366	4.0	Tertiary Conglomerate

4.3 Geotechnical Drilling Results

Thirteen geotechnical holes were drilled during the investigation (Table 4.2, Figure 2). Drill logs are presented in Appendix I-A. Sample and core photographs are in Appendix I-B.

Table 4.2 Summary of Geotechnical Holes

Hole ID (Completed)	Hole ID (Proposed)	Coordinates			Hole Inclination (degrees)(2)	Hole Azimuth (degrees)(3)	Drill Hole Depth (ft)
		Easting (ft)(1)	Northing (ft)(1)	Ground Elevation (ft)			
DH19-3	DH-3	1,009,070(4)	790,192(4)	3360(4)	90	-	402
DH19-3A	DH-3	1,009,094	790,194	3359.5	75	220	1032.5
DH18-5	DH-5	1,015,614	798,356	3310.2	90	-	267
DH19-7	DH-7	1,006,566	795,373	3433.7	90	-	502
DH18-8	DH-8	1,011,072(4)	793,909(4)	3168(4)	60	220	95
DH18-8A	DH-8A	1,010,856	793,711	3165.0	90	-	82
DH19-8B	DH-8	1,011,110	793,799	3163.8	62	220	651
DH19-11	DH-11	1,000,027(4)	799,533(4)	4024(4)	70	255	2693
DH19-12	DH-12	1,019,495	801,311	3546.9	90	-	788
DH19-12A	DH-12	1,019,440	801,314	3544.7	90	-	399
DH19-14	DH-14	1,001,954	795,177	3642.0	90	-	794
DH19-16	DH-16	1,009,344	795,683	3212.1	90	-	442
DH19-17	DH-17	1,009,319	795,829	3215.7	90	-	1435

Notes:
1. Coordinate system is State Plane, Arizona Central, NAD 83, international feet.
2. Hole inclination is degrees from horizontal.
3. Hole azimuth is relative to true north.
4. Coordinates were obtained with hand held GPS. Elevation was estimated from digital terrain model.
5. All holes were drilled as a combination of 6 in tricone in soil and HQ3 core in bedrock.

4.3.1 DH19-3 Results

Lithology

- 0 ft to 14.5 ft: Quaternary Alluvium: Gravel (GP), coarse, and cobbles, trace sand, light gray.
- 14.5 ft to 402 ft: Tertiary Conglomerate: brownish gray, coarse sand sized to cobble sized grains, trace boulders, completely weathered and dense to 22 ft, fresh to highly weathered and extremely weak to weak (R0-R2) below.
  - Some highly to completely weathered zones of coarse conglomerate are present throughout the hole.

Major Structures

- Drill fluid circulation was lost at 267.7 ft; core sample showed a 0.7 ft zone with the sandy matrix washed out and only gravel recovered. RC19-3 was also being drilled on the same pad approximately 70 ft away at the time.

4.3.2 DH19-3A Results

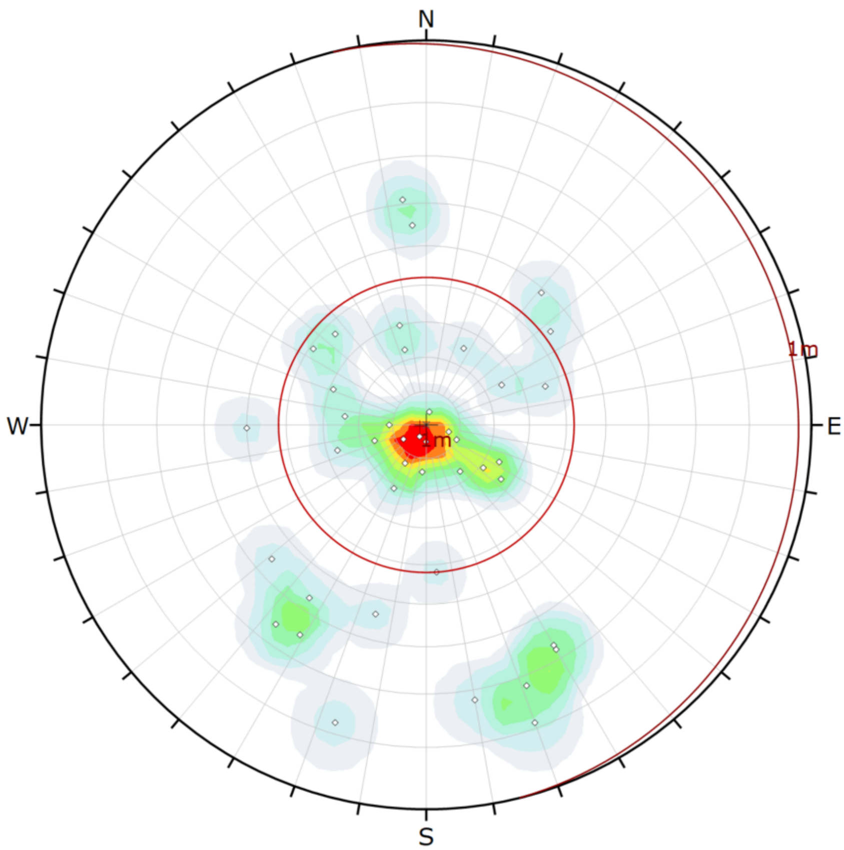
Lithology

- 0 ft to 16.5 ft: Quaternary Alluvium, cobbles (GP), coarse, and gravel, some sand, trace silt, light brown dark gray, weak cementation.
- 16.5 ft to 891.4 ft: Tertiary Conglomerate, brownish gray, coarse sand to cobbles, moderately weathered to completely weathered, extremely weak (R0) to weak (R2). Very weak to weak calcite cementation.
- 891.4 ft to 986 ft: Paleozoic Limestone, gray white, silt/clay sized crystals to coarse sand sized crystals, fresh to slightly weathered, weak (R2) to medium-strong (R3), fine (1 mm) laminations, highly weathered seams with strong iron oxidation.
  - Formation uncertain, to be confirmed by ongoing thin section analysis.
- 986 ft to 1013.2 ft: Basalt Porphyry, dark bluish-black aphanitic heavily fractured volcanic dyke.
- 1013.2 ft to 1032.5 ft: Paleozoic Limestone, gray white, silt/clay sized crystals to coarse sand sized crystals, fresh to slightly weathered, weak (R2) to strong (R4), fine (1 mm) laminations, widely spaced joints with iron oxidation.

Major Structures

- Discontinuities visible in the televiewer profile have variable orientations, with one roughly horizontal set (Figure 4.3, Appendix III).
- Open joints were observed in Paleozoic Limestone at:
  - 891.5 ft: sub-horizontal wash-out;
  - 904.3 and 905.8 ft: open joints; and
  - 938.4 to 958.6: several open joints and potential faults.
- Paleozoic Limestone did not have any major dissolution features, and drill fluid circulation was maintained.

Figure 4.3 Stereonet Plot of Structural Measurements from DH19-3A Televiewer Data



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 1.10
	1.10 - 2.20
	2.20 - 3.30
	3.30 - 4.40
	4.40 - 5.50
	5.50 - 6.60
	6.60 - 7.70
	7.70 - 8.80
	8.80 - 9.90
	9.90 - 11.00
Maximum Density	10.73%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m		2	76	

Plot Mode	Pole Vectors
Vector Count	42 (42 Entries)
Hemisphere	Lower
Projection	Equal Angle

4.3.3 DH18-5 Results

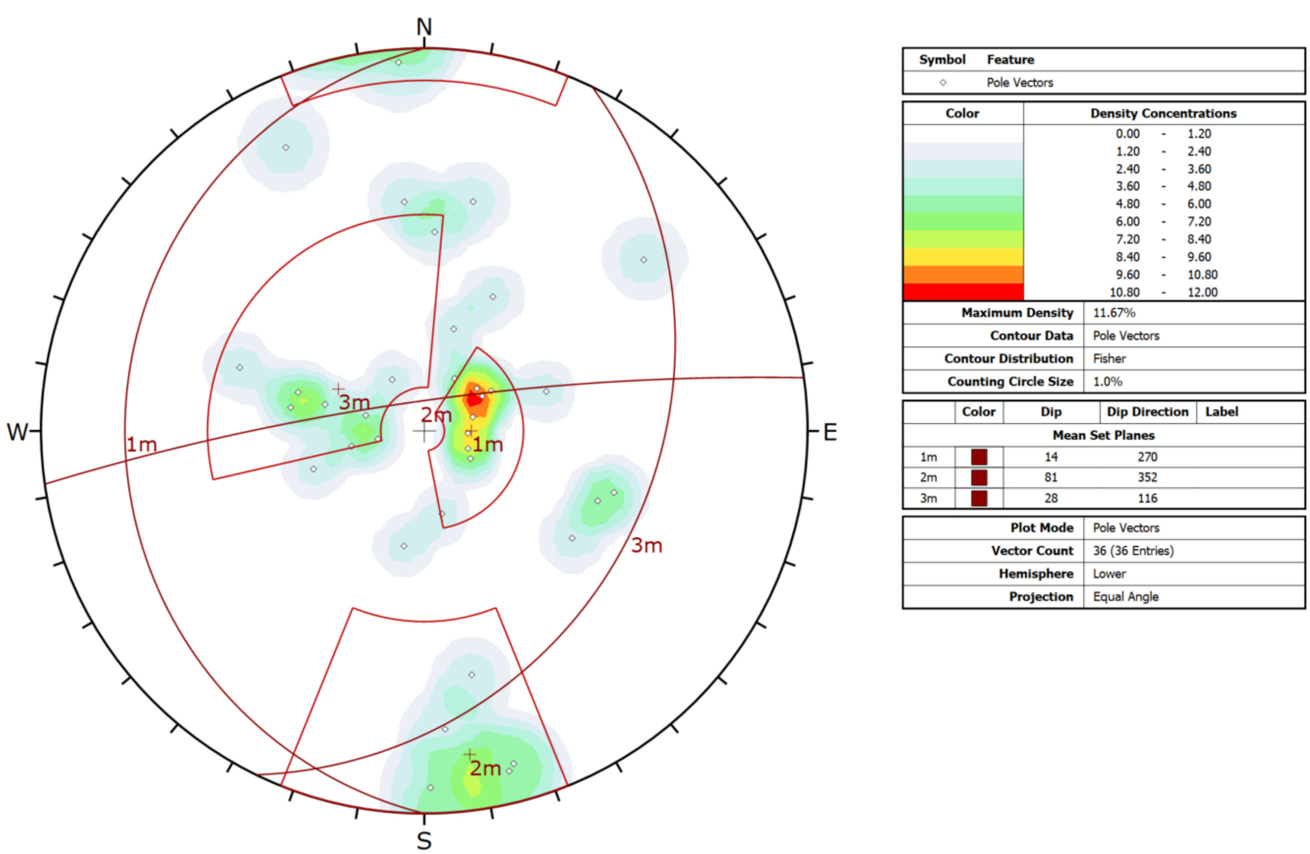
Lithology

- 0 ft to 5 ft: Fill, colluvium, and residual soil.
- 5 ft to 267 ft: Tertiary Conglomerate with lesser interbedded Sandstone.

Major Structures

- Discontinuities visible in the televiewer profile have variable orientations, but fall into three sets (Figure 4.4, Appendix III):
  - Bedding dips approximately 15° to the west.
  - Features oblique to bedding with an average dip/dip direction of 28/116.
  - Sub-vertical featured trending east-west with an average dip/dip direction of 81/352.
- Caliper shows hole widening from 182 ft to 186 ft, with a concentration of subhorizontal discontinuities (Appendix III). This corresponds to zones of completely weathered Sandstone seen in drill core (Appendix I-A).

Figure 4.4 Stereonet Plot of Structural Measurements from DH18-5 Televiewer Data



4.3.4 DH19-7 Results

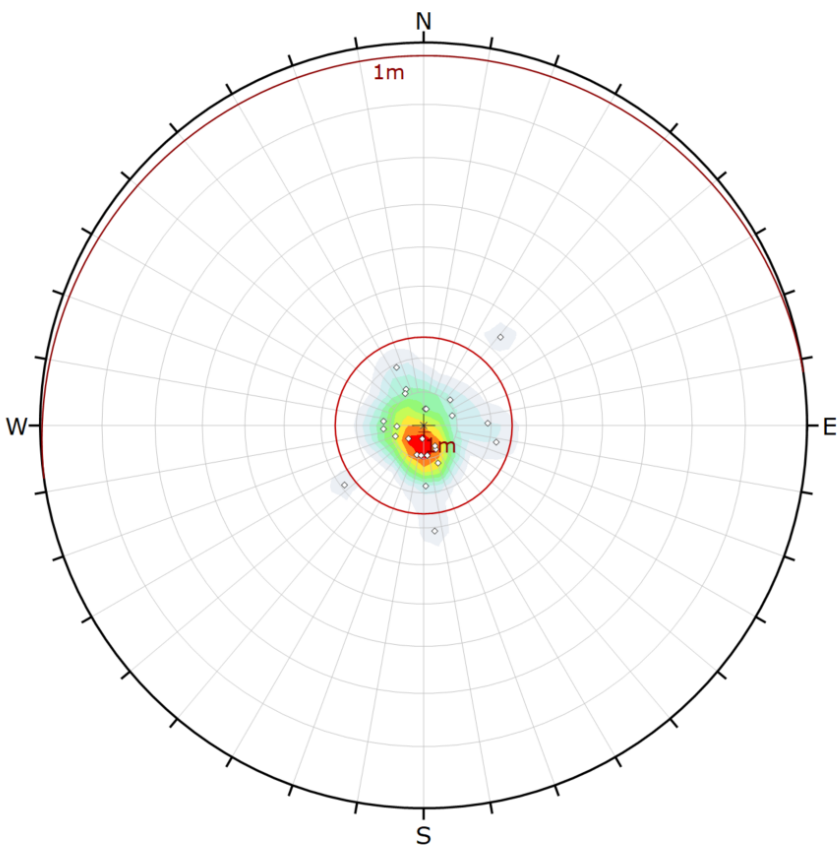
Lithology

- 0 ft to 8.3 ft: Fill and Residual soil derived from Tertiary Conglomerate
- 8.3 ft to 502 ft: Tertiary Conglomerate, light brown to dark brown, coarse sand to cobbles, fresh to moderately weathered, extremely weak (R0) to very weak (R1), weakly cemented with zones of very weak cementation.

Major Structures

- Discontinuities visible in the televiewer profile have on average sub-horizontal orientations typically varying up to 10 degrees from horizontal (Figure 4.5, Appendix III).
- Partly open sub-horizontal discontinuities were seen at 66.5 ft and 71.4 ft.

Figure 4.5 Stereonet Plot of Structural Measurements from DH19-7 Televiewer Data



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 3.50
	3.50 - 7.00
	7.00 - 10.50
	10.50 - 14.00
	14.00 - 17.50
	17.50 - 21.00
	21.00 - 24.50
	24.50 - 28.00
	28.00 - 31.50
	31.50 - 35.00
Maximum Density	34.54%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m		2	352	

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Hemisphere	Lower
Projection	Equal Angle

4.3.5 DH18-8 Results

Lithology

- 0 ft to 36 ft: Fill, colluvium, and residual soil derived from Tertiary Sandstone.
- 36 ft to 95 ft: Interbedded Tertiary Sandstone and Conglomerate.

Major Structures

- Subhorizontal bedding.
- Many drill breaks perpendicular to core axis.
- All drill fluid circulation was lost on a pair of sub-horizontal discontinuities at 82.5 ft and 82.8 ft, bounding 0.3 ft of extremely weathered fine grained Sandstone (R0).

4.3.6 DH18-8A Results

Lithology

- 0 ft to 64.5 ft: Quaternary Alluvium: Interbedded coarse sand and fine to coarse gravel, some cobbles, trace silt, brown; clasts are quartzite, some diabase.
- 64.5 ft to 82 ft: Tertiary Sandstone: tan, medium to fine sand, slightly weathered, very weak (R1), no obvious bedding, crudely stratified, trace dispersed angular fine gravel, breaks easily horizontally on rough planar surfaces.

Major Structures

- Subhorizontal bedding.
- Most discontinuities are subhorizontal; a single inclined tight discontinuity at 30° from horizontal was observed at 78 ft.

4.3.7 DH19-8B Results

Lithology

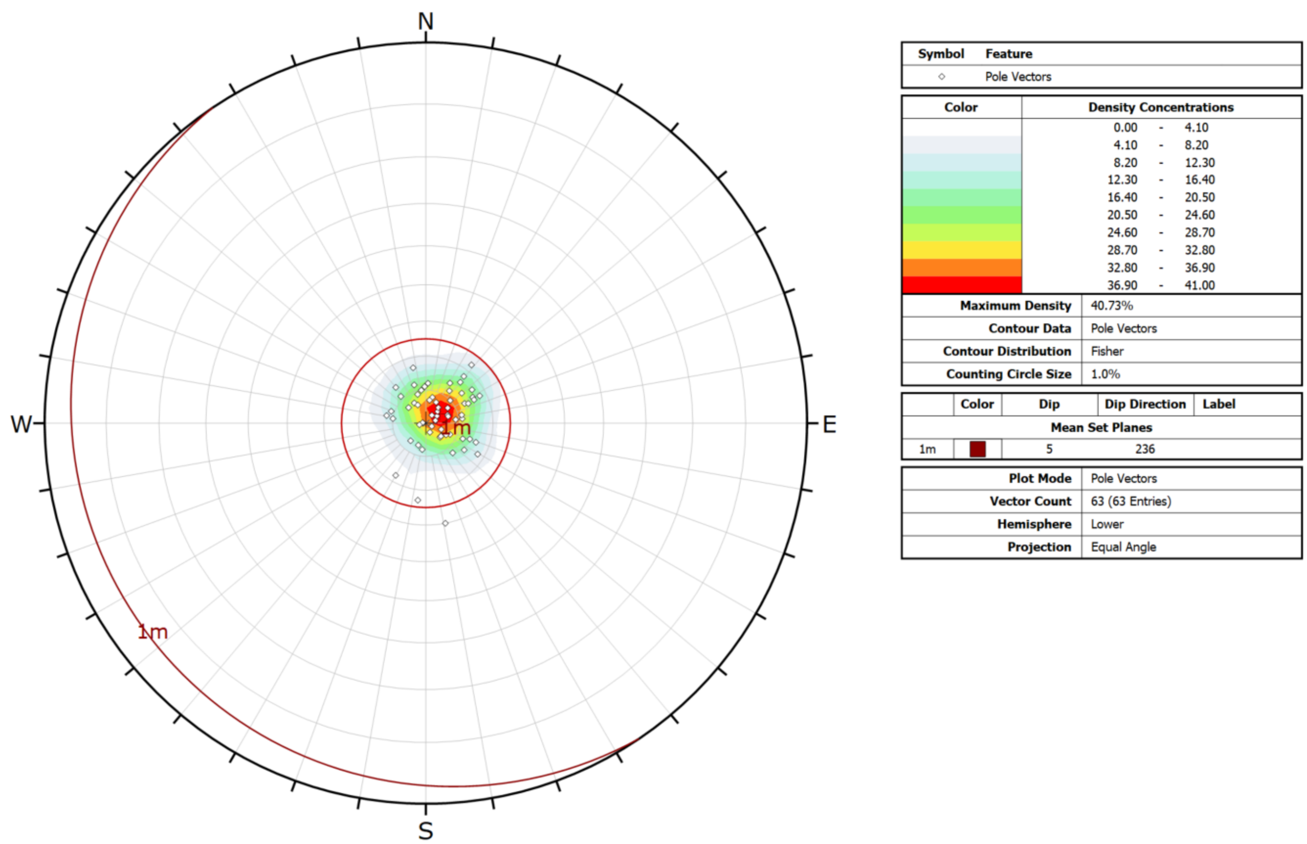
- 0 ft to 75.5 ft: Quaternary Alluvium: SAND (SP), coarse, some cobbles, some gravel, trace silt, brown, clasts are quartzite, some diabase.
- 75.5 ft to 467 ft: Tertiary Sandstone with lesser interbedded Conglomerate.
- 467 ft to 651 ft: Tertiary Conglomerate with lesser interbedded Sandstone.

Major Structures

- Bedding is sub-horizontal.
- Only sub-horizontal discontinuities were seen in the televiewer, with an average dip of 5° to the southwest (Figure 4.6 - Appendix III).

- Caliper shows hole widening from 304.8 ft to 305.2 ft (269 ft vertical below surface), with a concentration of subhorizontal discontinuities (Appendix III). The zone corresponded to zero recovery from 301 ft to 306 ft in the drill core (Appendix I-A). This may correspond to a clay layer within Tertiary Conglomerate in RC18-8A at 277 ft depth.
- Interbedded Conglomerate layers are sub-horizontal and preferentially weathered.

Figure 4.6 Stereonet Plot of Structural Measurements from DH19-8B Televiewer Data



4.3.8 DH19-11 Results

Lithology

DH19-11 was drilled in the mountain block west of Dripping Spring wash, where a complex sequence of Apache Group rocks was intersected:

- 0 ft to 108.9 ft: Tertiary Conglomerate, silt, sand, gravel, and cobbles, brown, mostly matrix supported, slightly to moderately weathered, zones of extremely weak rock (R0) up to 0.5 ft thick, no obvious defects.

- 108.9 ft to 354 ft: Mescal Limestone, cherty dolomite
- 354 ft to 362 ft: Diabase, aphanitic, black, moderately jointed.
- 362 ft to 417 ft: Dripping Springs Quartzite, mostly siltstone.
- 417 ft to 606.5 ft: Dripping Springs Quartzite, altered and brecciated zones.
- 606.5 ft to 612 ft: Fault zone. Breccia, quartzite fragments in a hard silt matrix grading downwards into Diabase fragments.
- 612 ft to 818.5 ft: Diabase, fine to medium grained, closely jointed but healed or very tight.
- 818.5 ft to 893.5 ft: Pioneer Shale, purple to black siltstone.
- 893.5 ft to 906 ft: Fault zone. Breccia, quartzite fragments in a hard silt matrix grading downwards into Diabase fragments.
- 906 ft to 1091 ft: Diabase, fine to medium grained, closely jointed but healed or very tight.
- 1091 ft to 1155 ft: Pioneer Shale, purple to black silicified siltstone.
- 1155 ft to 1189 ft: Scanlan Conglomerate, widely jointed.
- 1189 ft to 1477.5 ft: Ruin Granite, very widely jointed.
- 1477.5 ft to 1491 ft: Fault zone. Breccia, granite fragments in a hard silt matrix grading downwards into Diabase fragments.
- 1491 ft to 1504.4 ft: Diabase, faulted lower contact.
- 1504.4 ft to 1699.4 ft: Pioneer Shale, purple to black silicified siltstone.
- 1699.4 ft to 1747 ft: Scanlan Conglomerate, widely jointed.
- 1747 ft to 2334.5 ft: Ruin Granite, coarse grained.
- 2334.5 ft to 2633.1 ft: Diabase, intrusive contacts.
- 2633.1 ft to 2693 ft: Ruin Granite, very widely jointed.

Major Structures

- Preliminary results show discontinuous and sub-horizontal openings or washouts spaced roughly 10 ft to 15 ft vertically in Tertiary Conglomerate (Appendix III).
- Mescal Limestone near surface has some open bedding planes and joints, but no obvious dissolution features were seen (Appendix III), which corresponds to observations from core.
- Apache Group units are faulted and brecciated with several widenings of the hole and open features.
- Drill fluid circulation was lost following a packer test between 350 ft and 550 ft.
- Two voids at least 5 in diameter were found in Pioneer Shale at 870.3 and 874 ft, lined with quartz crystals. This portion of the hole was not imaged by televiewer due to hole stability issues.

4.3.9 DH19-12 Results

Lithology

- 0 ft to 22.3 ft: Quaternary Alluvium, sand and gravel, some cobbles and boulders.
- 22.3 ft to 635.2 ft: Tertiary Conglomerate, sand, gravel, and cobbles, variably clast to matrix-supported.
- 635.2 ft to 788 ft: Escabrosa Limestone, grey, massive, relatively pure limestone with zones of up to 15% dissolution cavities to 3 in diameter.

Major Structures

- At 122.5 ft a subhorizontal opening was seen in Tertiary Conglomerate.
- Escabrosa Limestone had open dissolution features at:
  - 642 ft: open joints infilled with calcite, partially dissolved;
  - 647.3 ft to 648.3 ft: open dissolution cavities up to 1 in diameter;
  - 650 ft to 652 ft: open dissolution cavities up to 2 in diameter;
  - 654 ft to 656.5 ft: open joints;
  - 661 ft to 662.6 ft: open joints; and
  - 692 ft to 696 ft: partly open joints and a 3 in cavity.

4.3.10 DH19-12A Results

Lithology

- 0 ft to 14.8 ft: Quaternary Alluvium, sand and gravel, some cobbles and boulders.
- 14.8 ft to 399 ft: Tertiary Conglomerate, sand, gravel, and cobbles, variably clast to matrix-supported.

4.3.11 DH19-14 Results

Lithology

DH19-14 was drilled in the mountain block west of Dripping Spring wash, where a complex sequence of Apache Group rocks was intersected:

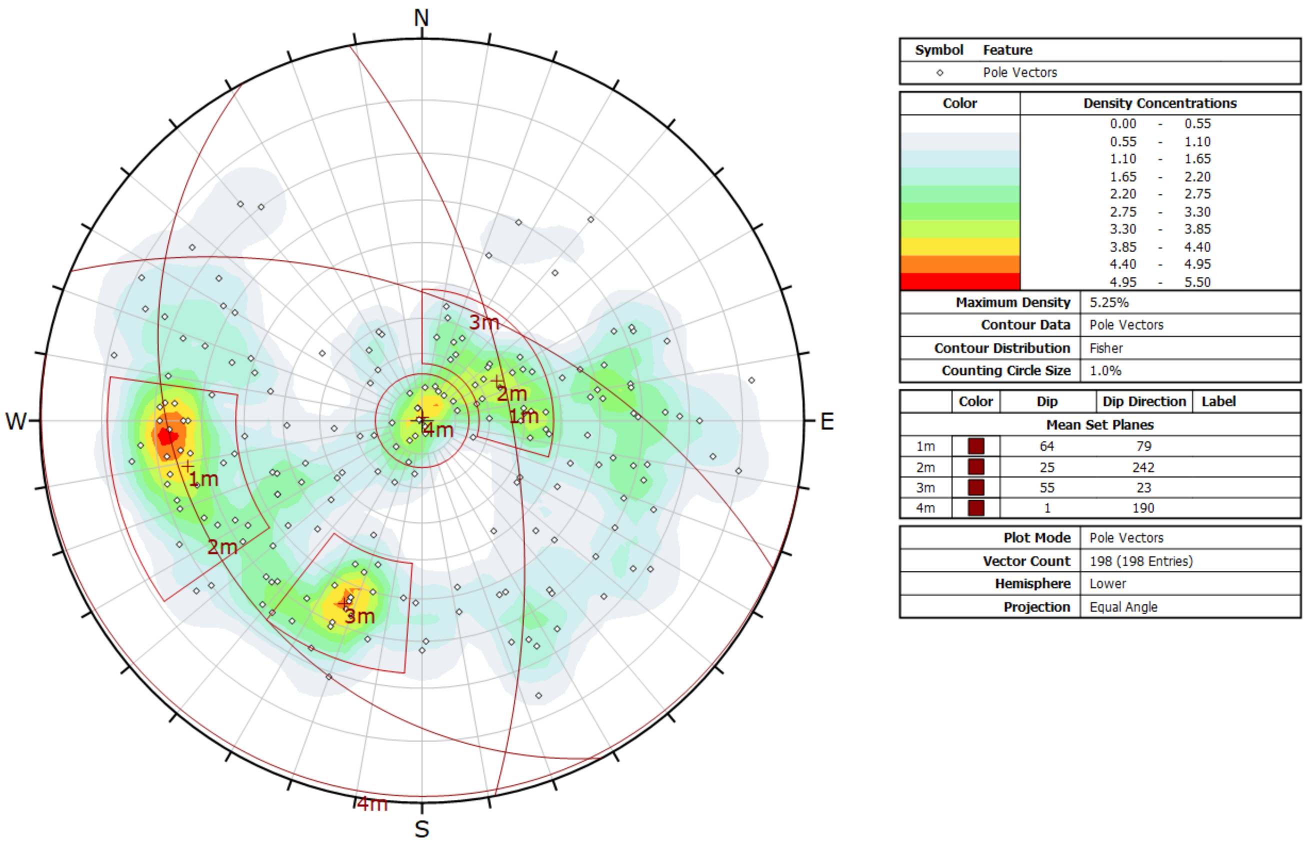
- 0 ft to 12 ft: Residual soil derived from Diabase, silt, some fine to coarse angular gravel, low plasticity.
- 12 ft to 376.1 ft: Diabase, gray, fine grained, completely weathered, common rubble zones to 35 ft depth.
- 376.1 ft to 416 ft: Mescal Limestone, grayish white, slightly weathered, no obvious dissolution features, dolomitic below 416 ft.

- 416 ft to 536 ft: Dripping Springs Quartzite, gray and fresh with some brecciated matrix-supported zones.
- 536 ft to 602.4 ft: Diabase, fine grained, completely weathered, joints infilled with calcite.
- 602.4 ft to 603.6 ft: Dripping Springs Quartzite.
- 603.6 ft to 610.5 ft: Mescal Limestone, grayish white, fine grained, moderately to highly weathered, no obvious dissolution features.
- 610.5 ft to 652 ft: Dripping Springs Quartzite, dark red, slightly to moderately weathered, very fractured.
- 652 ft to 700.1 ft: Diabase, dark gray, medium grained, fresh to slightly weathered.
- 700.1 ft to 790.5 ft: Dripping Springs Quartzite, some interbedded siltstone and brecciated zones.

Major Structures

- Discontinuities visible in the televiewer profile have variable orientations, but fall into four sets (Figure 4.7, Appendix III):
  - Steep easterly dipping features with an average dip/dip direction of 64/079.
  - Steep north-easterly dipping features with an average dip/dip direction of 25/242.
  - Shallow south-westerly dipping features with an average dip/dip direction of 55/023.
  - Sub-horizontal features with an average dip/dip direction of 01/190.

Figure 4.7 Stereonet Plot of Structural Measurements from DH19-14 Televiewer Data



4.3.12 DH19-16 Results

Lithology

- 0 ft to 32 ft: Quaternary Alluvium, coarse sandy gravel with some interbedded sandy silt layers.
- 32 ft to 442 ft: Tertiary Conglomerate, brown, fine sand to coarse gravel, slightly to moderately weathered, matrix-supported with interlayered clast-supported zones.

Major Structures

- Several partly open sub-horizontal openings are visible in the upper 100 ft (Appendix III).
- Open to partly open sub-horizontal zones or open-work gravel or bedding joints are visible at 128.4, 132.2, 147.5, 153.5, and 158.0 ft.
- No inclined joints are visible.

4.3.13 DH19-17 Results

Lithology

- 0 ft to 22.3 ft: Quaternary Alluvium, sand and gravel, fine to coarse sand and fine to coarse gravel.
- 22.3 ft to 827.6 ft: Tertiary Conglomerate, tannish gray, coarse sand to cobbles, fresh to completely weathered, extremely weak (R0) to medium strong rock (R3).
- 827.6 ft to 1435 ft: Quartz Diorite, light gray, coarse grained, highly fractured, iron-oxide staining on joints.

Major Structures

- Televiewer results are being interpreted by RCM, and a Stereonet of features will be included in a forthcoming revision.
- Open to partly open sub-horizontal zones or open-work gravel or bedding joints are visible at 367.5 ft, 383.7 ft, 385.0 ft, 387.0 ft, and 389.5 ft.

4.3.14 In situ Relative Density Testing Results

In situ relative density was measured with SPT and LPT samplers as described in Section 3.5.4. Relative density tests were carried out in DH18-5, DH18-8A, DH19-16 in weathered Tertiary Conglomerate and in Quaternary Alluvium respectively:

- DH18-5: Testing from 3 ft to 28 ft in weathered Tertiary Sandstone/Conglomerate.
- DH18-8A: Testing from 5 ft to 57 ft in Quaternary Alluvium, and at 67 ft in weathered Tertiary Sandstone.
- DH19-16: Testing from 5.3 ft to 26.5 ft in Quaternary Alluvium, and at 32 ft in weathered Tertiary Conglomerate.

Testing interval blow counts for 3 in intervals, SPT N-values (blows/ft), and ETR are reported in Appendix V-A. Where tests showed evidence of breaking through gravel, N-values were scaled from the blows per 3 in, using the lowest measured value from within the 6 in to 18 in portion of the drive where possible, or from the 0 in to 6 in seating drive if early refusal was met.

The ETR measured with KCBCL's SPT Analyzer ranged from 52% to 68%, averaging 59% (Appendix V-A). A calibration of the hammer by SPT CAL found ETR to range from 67% to 71%, averaging 69%. The approximately 10% difference between ETR measured in the field and the calibrated value is likely due to the hammer typically operating at a slight angle in the field. The LF-70 diamond rig was not equipped with a mounting point and guide tube, and the hammer was hung from the hoisting line while the test was underway. As a result of leaving slack in the line to ensure the hammer was fully resting on the AWJ rods, the hammer typically leaned from 5° to 10° from vertical during the testing.

Blow counts measured with the LPT sampler were converted to SPT following Daniels et al. (2003), resulting in a conversion ratio of 0.63 SPT blows per LPT blow. The same 140 lb hammer at a 30 in drop was used for both SPT and LPT tests.

Blow counts (N) were corrected for energy, borehole diameter, and rod length (N_{60}), and for overburden pressure ($(N_1)_{60}$) using the procedure outlined in Youd et al. (2001) Calculations are presented in Appendix V-B. The ETR for each SPT or LPT test as measured in the field was used in the correction to account for variability in delivered energy due to the angle of the hammer and the speed at which it is operated (cf. USBR 1999).

$(N_1)_{60}$ results at DH18-5 in weathered Tertiary Conglomerate range from 25 to 56 blows per ft (Figure 4.8). Three tests with the lowest values are between 25 and 28 blows per ft, indicating weathered Conglomerate is dense at DH18-5.

$(N_1)_{60}$ results at DH18-8A in Quaternary Alluvium range from 13 to greater than 50 blows per ft (Figure 4.9). At 47.8 ft a raw N of 21 blows per ft resulted in an $(N_1)_{60}$ of 13 blows per ft, indicating portions of Alluvium may be compact. This test was completed with 6 in of slough in the hole, which could potentially affect the test's reliability; however, the blow counts within the slough zone itself were disregarded as part of the seating blows and the remaining blows are treated as reliable in this report(See Appendix V-A). Blows per 3" were 1,2,6,6,5,4. The upper 6 in of slough was loose but blows per 3 in were even for the remainder of the drive though native ground. Recovery was 12" of uniform coarse sand and fine gravel, suggesting the slough was not recovered.

Two measurements of $(N_1)_{60}$ at 52.7 ft and 57.8 ft had similar values of 28 to 29 blows per ft, indicating Alluvium is dense, possibly with some compact zones.

$(N_1)_{60}$ results at DH19-16 in Quaternary Alluvium range from 24 to 46 blows per ft, indicating Alluvium ranges from dense to very dense (Figure 4.10).

Figure 4.8 Normalized SPT $(N_1)_{60}$ Results in Weathered Tertiary Conglomerate at DH18-5

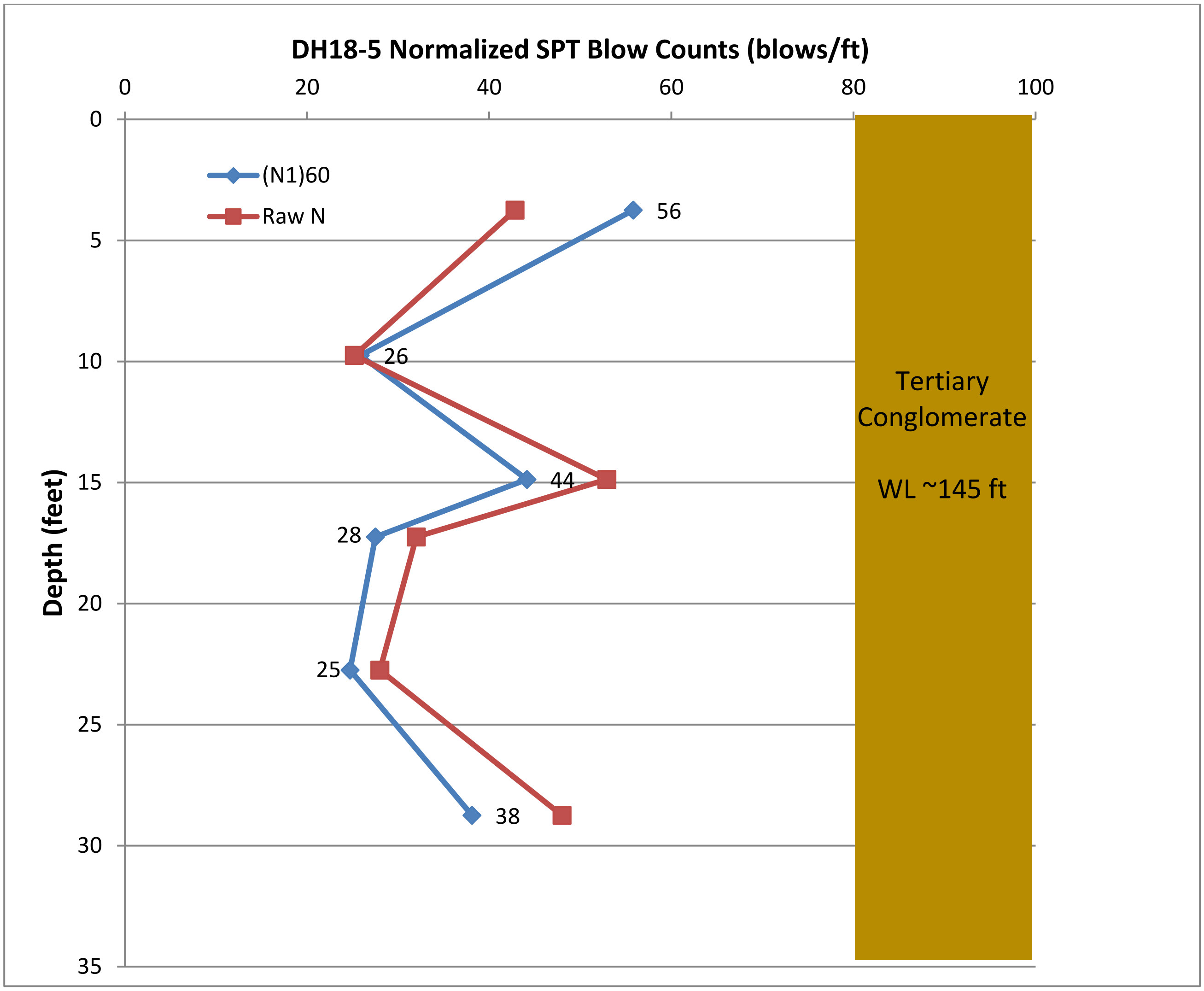


Figure 4.9 Normalized SPT $(N_1)_{60}$ Results in Quaternary Alluvium at DH18-8A

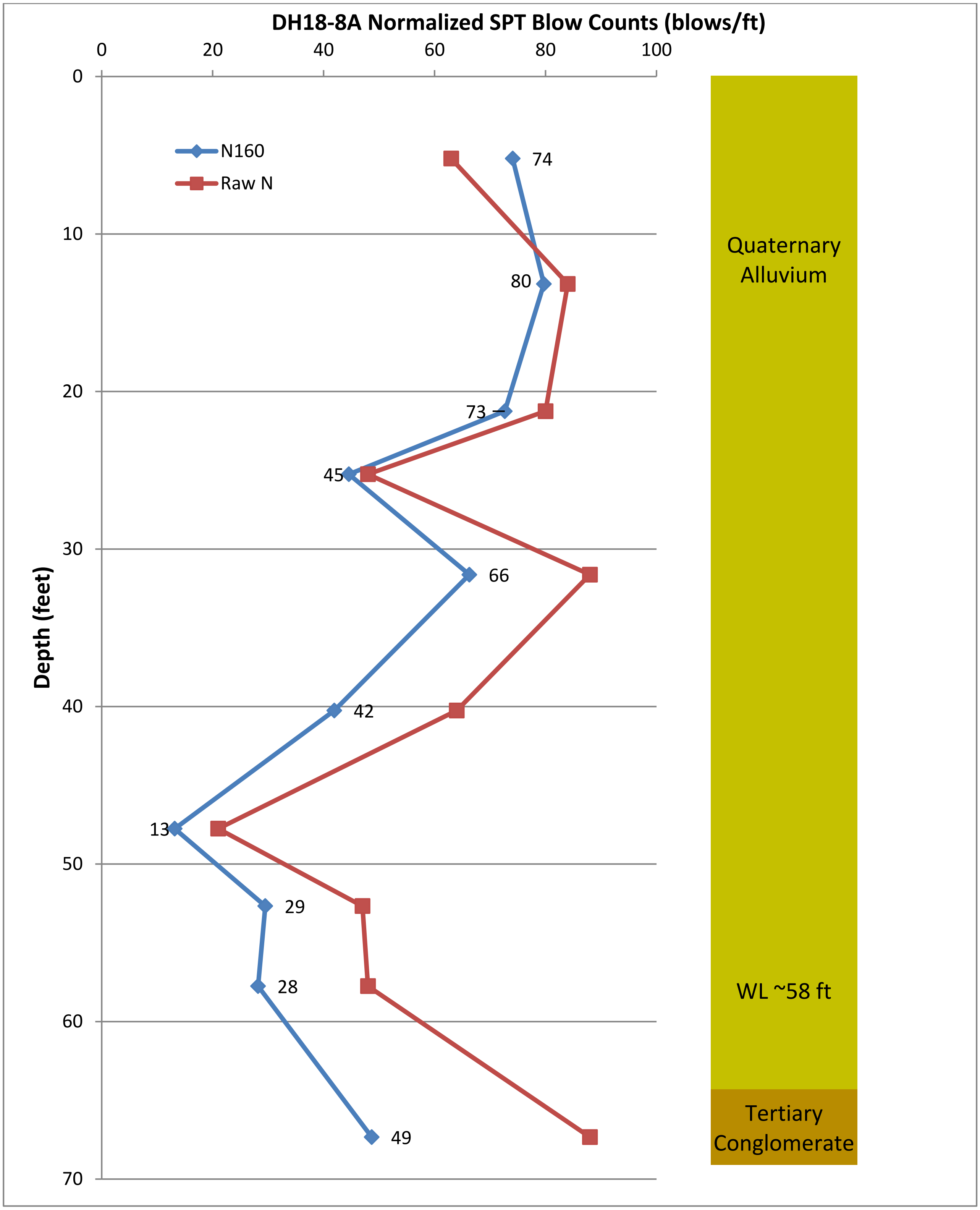
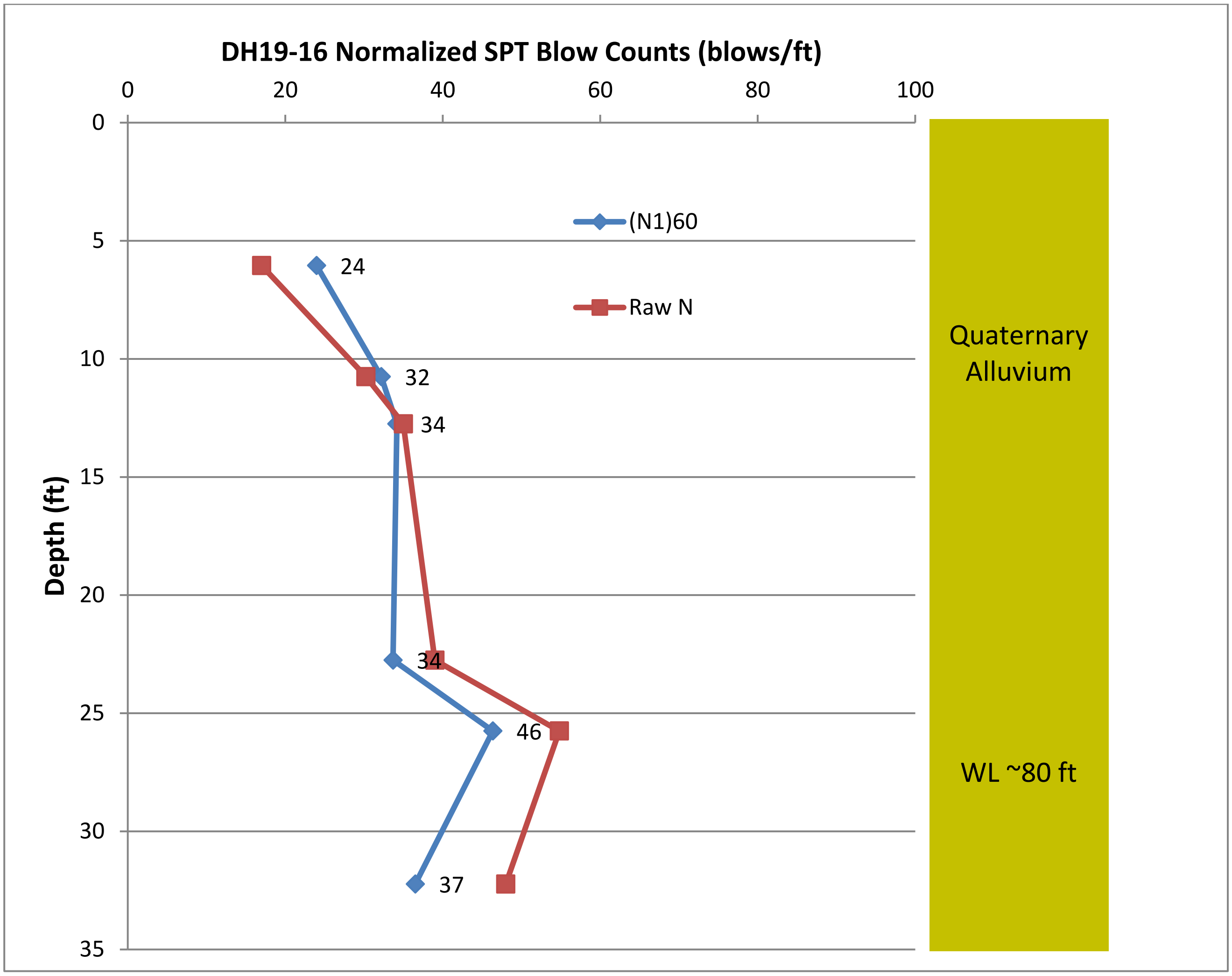


Figure 4.10 Normalized SPT $(N_1)_{60}$ Results in Quaternary Alluvium at DH19-16



4.4 Hydrogeology Drilling Results

Eleven hydrogeological holes were drilled during the investigation (Table 4.3, Figure 2). Drill logs are presented in Appendix II-A. Photographs are in Appendix II-B.

Table 4.3 Summary of Hydrogeological Holes

Hole ID (Completed)	Hole ID (Proposed)	Coordinates			Hole Inclination (degrees) (2)	Drill Hole Depth (ft) (3)
		Easting (ft) (1)	Northing (ft) (1)	Ground Elevation (ft)		
RC19-3	RC-3	1,009,065	790,263	3356.2	90	815
RC18-4	RC-4	1,001,151	809,837	3535.6	90	269
RC19-7	RC-7	1,006,604	795,353	3433.7	90	760
RC19-8	RC-8	1,011,109	793,752	3162.0	90	250
RC19-8A	RC-8A	1,010,523	793,496	3178.6	90	401
RC19-8B	RC-8B	1,010,830	793,752	3165.7	90	130.5
RC19-8C	RC-8C	1,010,866	793,688	3166.3	90	90
RC19-8D	RC-8D	1,010,872	793,667	3166.7	90	507
RC18-9	RC-9	1,005,426	806,269	3533.2	90	402
RC19-10	RC-10	1,007,784	808,571	3824.4	90	650
RC19-13	RC-13	1,005,466	801,570	3404.7	90	350
RC19-15	RC-15	1,003,615	808,853	3721.2	90	985

Notes:
1. Coordinate system is State Plane, Arizona Central, NAD 83, international feet.
2. Hole inclination is degrees from horizontal.
3. Depths are from ground surface at the time of drilling.
4. All holes were drilled as a combination of Air Rotary Casing Hammer in soil and Air Rotary Tricone in bedrock.

4.4.1 Observed Stratigraphy

Encountered Stratigraphy Summary

Soil was encountered at the surface during the drilling program, comprising varying proportions of sub-rounded to subangular sand and gravel with occasional cobbles and boulders and varying amounts of silt and clay. Based on observations made during the program this surficial unit is inferred to be dense to very dense, possibly with localized compact zones, and derived from an alluvial depositional environment; specifically a braided channel setting. Bedding was not observed in this unit, with the characteristics being generally massive with occasional lenses containing higher proportions of silt and sand. The soil was observed to be generally dry to moist and ranging in thickness from 11 ft to 70 ft below ground surface. Underlying the soil is a calcareous Sandstone interbedded with massive calcareous Conglomerate bedrock, known locally as the Gila Formation.

Outcrops of the sandstone/conglomerate bedrock unit are visible along the periphery of the Dripping Springs Wash. The outcrops are generally steeply sloping with some being near vertical and up to approximately 100 ft high, indicating this formation is strongly cemented in places. Uneven weathering of some of the exposed vertical outcrop faces is observed and is likely a result of alternating degrees of cementation/weathering and calcite content.

A summary of the encountered geology at each of the completed hydrogeological boreholes are provided in the following sections.

4.4.2 RC19-3 Results

Lithology

- 0 ft to 14.5 ft: Quaternary Alluvium. Coarse gravel, angular, mainly consisting of Quartzite.
- 14.5 ft to 815 ft: Tertiary Conglomerate. Fine sand sized grains to cobble sized clasts. Clasts consist of Quartzite with lesser amounts of Limestone and trace Diabase in a calcareous cemented matrix.

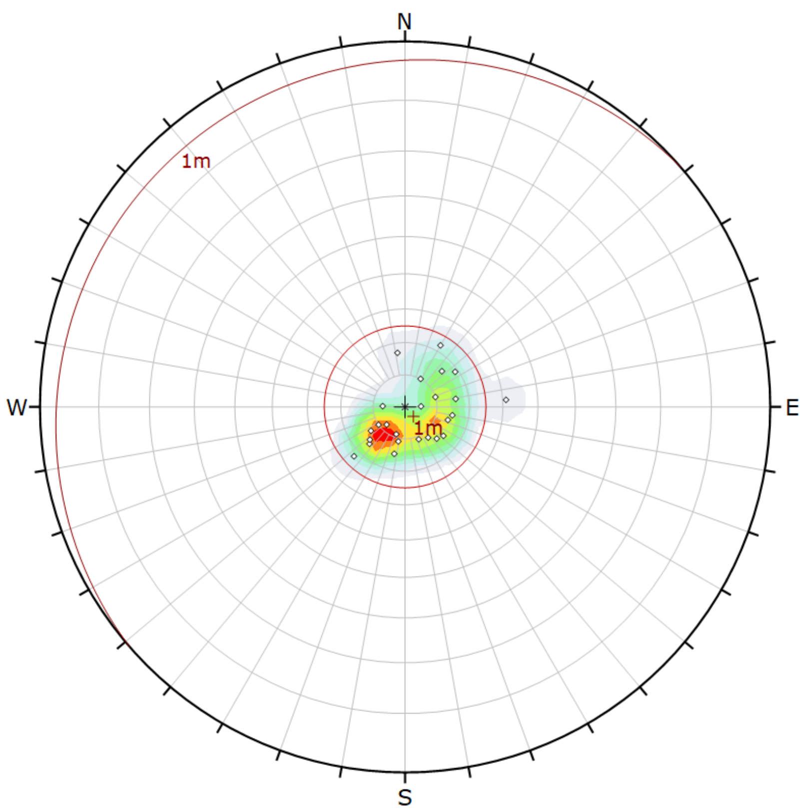
Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Major Structures

- Discontinuities visible in the televiewer profile are sub-horizontal (Figure 4.11, Appendix III).
- Open work zones or bedding joints were observed at 51.4, 71.5, 121.5, 218.9, 266.5, 268.5, 325.1, 327.2, 338.4, 353.8, 415.5, 438.2, 446.1, 544.3, and 619.2 ft.

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Figure 4.11 Stereonet Plot of Structural Measurements from RC19-3 Televiewer Data



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 3.00
	3.00 - 6.00
	6.00 - 9.00
	9.00 - 12.00
	12.00 - 15.00
	15.00 - 18.00
	18.00 - 21.00
	21.00 - 24.00
	24.00 - 27.00
	27.00 - 30.00
Maximum Density	29.53%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m		4	319	

Plot Mode	Pole Vectors
Vector Count	25 (25 Entries)
Hemisphere	Lower
Projection	Equal Angle

4.4.3 RC18-4 Results

Lithology

- 0 ft to 11 ft: Quaternary Alluvium. Fine to coarse sand and gravel, angular to subrounded, consisting of Limestone, Quartzite and Diabase.
- 11 ft to 269 ft: Tertiary Conglomerate. Fine to coarse grained sand and gravel angular to subrounded. Clasts consist of varying proportions of Quartzite, Limestone, Arenite, Diabase and Dacite in a calcareous cemented matrix.

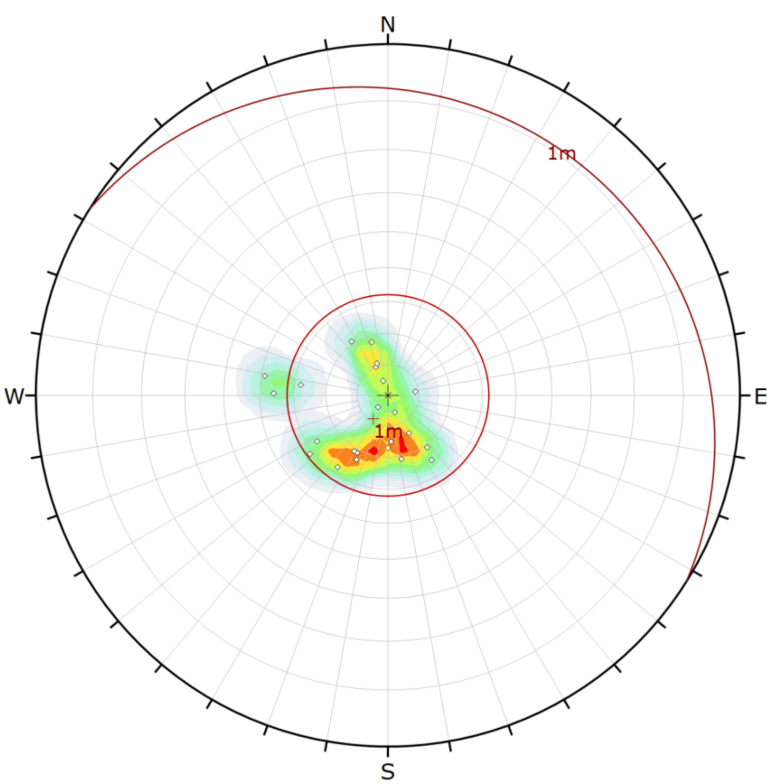
Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Major Structures

- Bedding has an average dip of 9° to the northwest, based on televiewer data (Figure 4.12).
- Caliper shows widening of hole at various depths indicating zones of weathering and/or alteration.
- Inclined discontinuities identified at 218 ft and 221 ft, with orientations of 39/110 and 20/039 respectively. These correspond to an increase in water production noted at 225 ft (Appendix II-A).

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Figure 4.12 Stereonet Plot of Structural Measurements from RC18-4 Televiewer Data



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 2.00
	2.00 - 4.00
	4.00 - 6.00
	6.00 - 8.00
	8.00 - 10.00
	10.00 - 12.00
	12.00 - 14.00
	14.00 - 16.00
	16.00 - 18.00
	18.00 - 20.00
Maximum Density	19.36%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m		9	32	

Plot Mode	Pole Vectors
Vector Count	23 (23 Entries)
Hemisphere	Lower
Projection	Equal Angle

4.4.4 RC19-7 Results

Lithology

- 0 ft to 5 ft: Topsoil. Fine sand with trace gravel.
- 5 ft to 20 ft: Tertiary Conglomerate with interbedded Sandstone. Coarse gravel, subrounded to subangular, consisting of Quartzite, Limestone and Sandstone.
- 20 ft to 65 ft: Tertiary Sandstone with interbedded Conglomerate. Fine to medium sand, subrounded.
- 65 ft to 175 ft: Tertiary Conglomerate with interbedded Sandstone. Silt to coarse gravel, subangular. Clasts consist of varying proportions of Quartzite, Limestone, Sandstone and Mafics.
- 175 ft to 760 ft: Tertiary Sandstone with interbedded Conglomerate. Silt coarse sand, subangular.

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Major Structures

- Televiewer results are being interpreted by RCM, and a Stereonet of features will be included in a forthcoming revision.
- Open work zones are visible throughout the length of the hole (Appendix III).

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

4.4.5 RC19-8 Results

Lithology

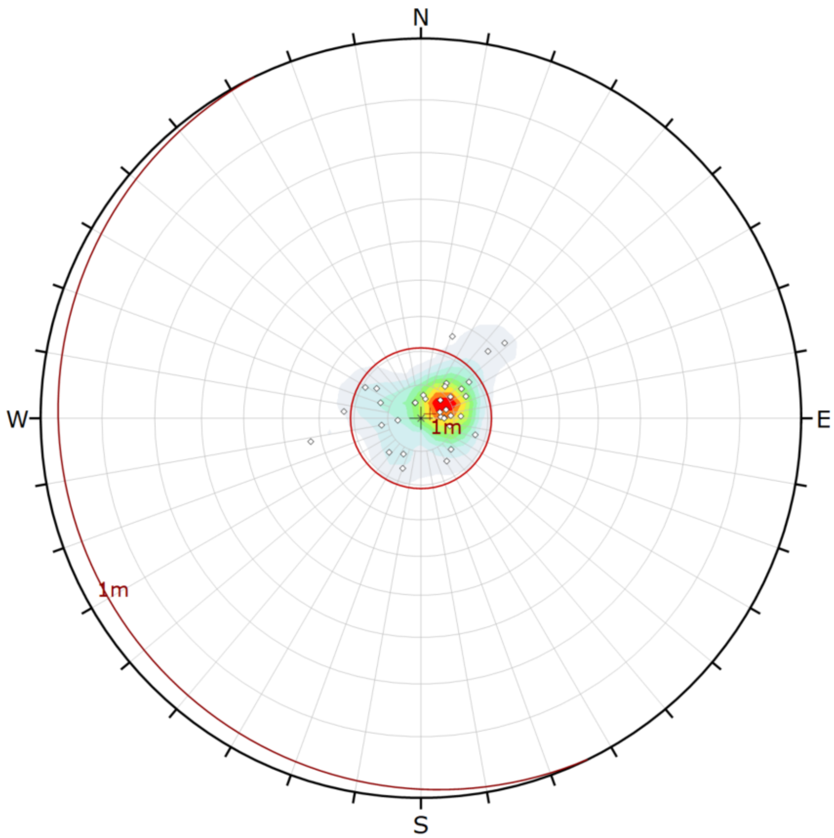
- 0 ft to 60 ft: Quaternary Alluvium. Fine to coarse sand and gravel, subangular to subrounded. Mostly gravel dominated with some sand and silt. Occasional cobble beds.
- 60 ft to 250 ft: Tertiary Sandstone with interbedded Conglomerate. Fine to coarse grained sand and gravel, subangular to subrounded. Clasts consist of Quartzite, Limestone, Arenite, Diabase and Dacite in a calcareous cemented matrix. Alternating Sandstone and Conglomerate sequences.

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Major Structures

- Bedding has an average dip of 3° to the west-southwest based on televiewer data (Figure 4.13).
- No inclined discontinuities were observed in televiewer data.

Figure 4.13 Stereonet Plot of Structural Measurements from RC19-8 Televiewer Data



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 4.00
	4.00 - 8.00
	8.00 - 12.00
	12.00 - 16.00
	16.00 - 20.00
	20.00 - 24.00
	24.00 - 28.00
	28.00 - 32.00
	32.00 - 36.00
	36.00 - 40.00

Maximum Density	39.79%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m		3	244	

Plot Mode	Pole Vectors
Vector Count	35 (35 Entries)
Hemisphere	Lower
Projection	Equal Angle

4.4.6 RC19-8A Results

Lithology

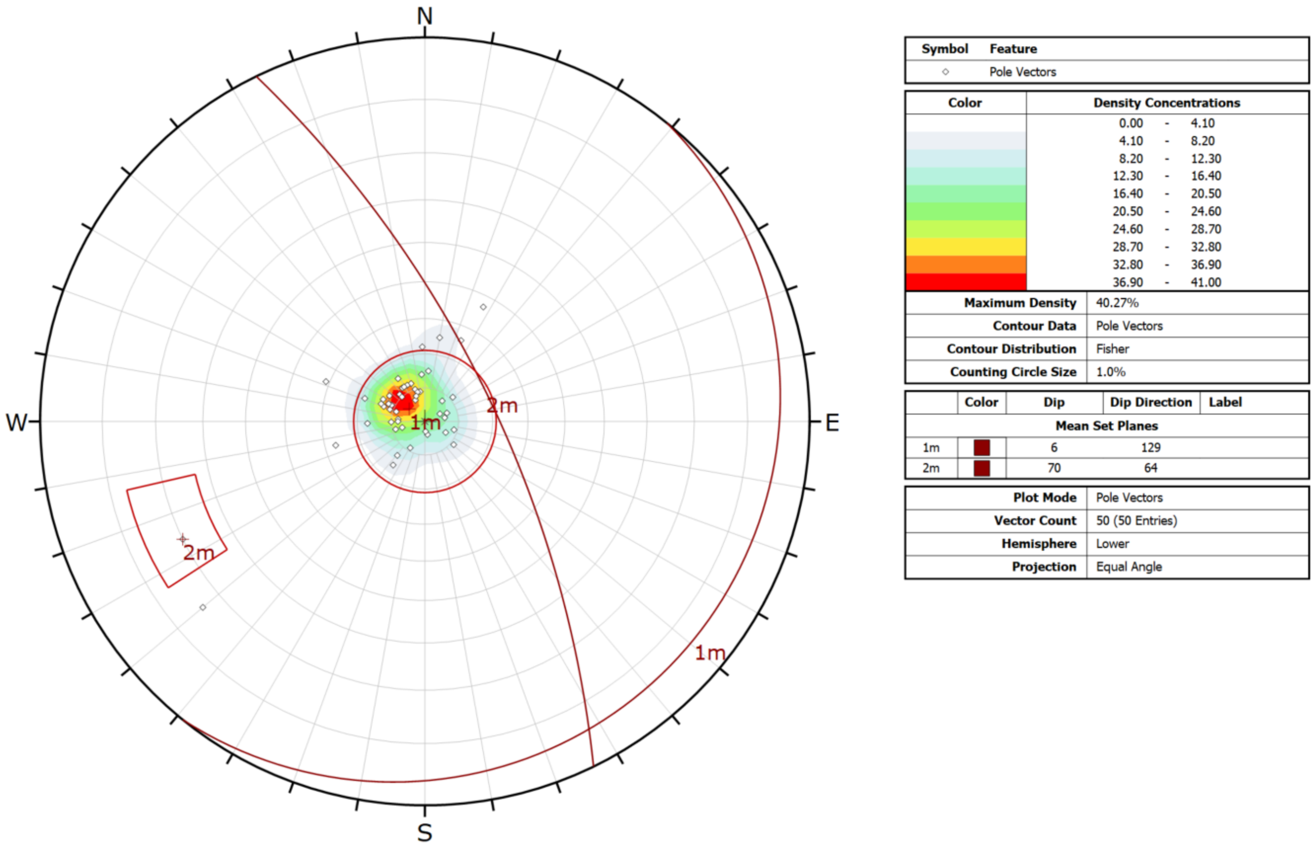
- 0 ft to 53 ft: Quaternary Alluvium. Fine to coarse sand and gravel, angular to subrounded, trace to some silts Clast consist of Quartzite, Arenite and Volcanics (Rhyolite, Diabase, Basalt).
- 53 ft to 276.9 ft: Tertiary Sandstone with interbedded Conglomerate fine to coarse grained sand and gravel, subangular to subrounded. Clasts consist of Quartzite, Limestone, Arenite and Volcanics (Rhyolite, Diabase, Basalt) in a calcareous cemented matrix. Alternating Sandstone and Conglomerate sequences.
- 276.9 ft to 278 ft: Clay (volcanic ash). Fine to coarse grained sand and gravel, subangular to subrounded. Clasts consist of Quartzite, Arenite and Volcanics (Rhyolite, Diabase, Basalt) in a calcareous cemented matrix. Alternating Sandstone and Conglomerate sequences.
- 278 ft to 401 ft: Tertiary Conglomerate interbedded with Sandstone. Fine to coarse grained sand and gravel, subangular to subrounded. Clasts consist Quartzite, Arenite and Volcanics (Rhyolite, Diabase, Basalt) in a calcareous cemented matrix. Alternating Sandstone and Conglomerate sequences.

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Major Structures

- Bedding shows two dominant orientations at an average dip of 6° to the southwest and to the southeast based on televiewer data (Figure 4.14).
- A prominent inclined open discontinuity is present at 85.9 ft dipping 73° towards 071° (east).
  - This feature is sub-parallel to the inferred orientation of the Dripping Spring Fault.
- A second tight inclined discontinuity is present at 348.2 ft dipping 69° towards 084° (east-northeast).

Figure 4.14 Stereonet Plot of Structural Measurements from RC19-8A Televiewer Data



4.4.7 RC19-8B Results

Lithology

- 0 ft to 30 ft: Quaternary Alluvium. Fine to coarse sandy gravel, subangular, consisting of Limestone, Quartzite and Diabase.
- 30 ft to 130.5 ft: Tertiary Sandstone with interbedded Conglomerate. Coarse gravel sized grains to fine sand sized grains.

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Major Structures

- No televiewer survey was carried out.
- No major structures were noted.

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

4.4.8 RC19-8C Results

Lithology

- 0 ft to 67 ft: Quaternary Alluvium. Mostly fine to coarse gravel, with some sand and cobbles, angular to subrounded.
- 67 ft to 90 ft: Tertiary Sandstone. Medium to fine sand sized grains.

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Major Structures

- No televiewer survey was carried out.
- No major structures were noted.

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

4.4.9 RC19-8D Results

Lithology

- 0 ft to 5 ft: Topsoil. Silty Sand, subangular.
- 5 ft to 65 ft: Quaternary Alluvium. Fine to coarse Gravel and Sand, some cobbles, subangular, consisting of 80% Quartzite, 10% basalt and 10% calc mudstone.
- 65 ft to 115 ft: Tertiary Sandstone with interbedded Conglomerate. Fine sand sized grains to fine gravel sized grains.
- 115 ft to 160 ft: Tertiary Conglomerate with interbedded Sandstone. Coarse gravel to fine sand sized clasts with interbedded / alternating 1 ft thick layers of coarse gravel clasts, subangular. Clasts consist of 80% Sandstone and 20% Quartzite.
- 160 ft to 400 ft: Tertiary Sandstone with interbedded Conglomerate. Fine sand sized grains to coarse gravel sized grains, subrounded, consisting of Quartzite and Chert, silt and Mica, in a calcite cemented matrix.
- 400 ft to 507 ft: Tertiary Conglomerate with interbedded Sandstone. Coarse gravel to silt/clay sized clasts, subangular, consisting of 40% Quartzite, 30% Mafics, 20% Limestone and 10% Sandstone. Sandstone decreases with depth.

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Major Structures

- Televiewer results are being interpreted by RCM, and a Stereonet of features will be included in a forthcoming revision.
- No obvious defects were observed in televiewer profiles (Appendix III).

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

4.4.10 RC18-9 Results

Lithology

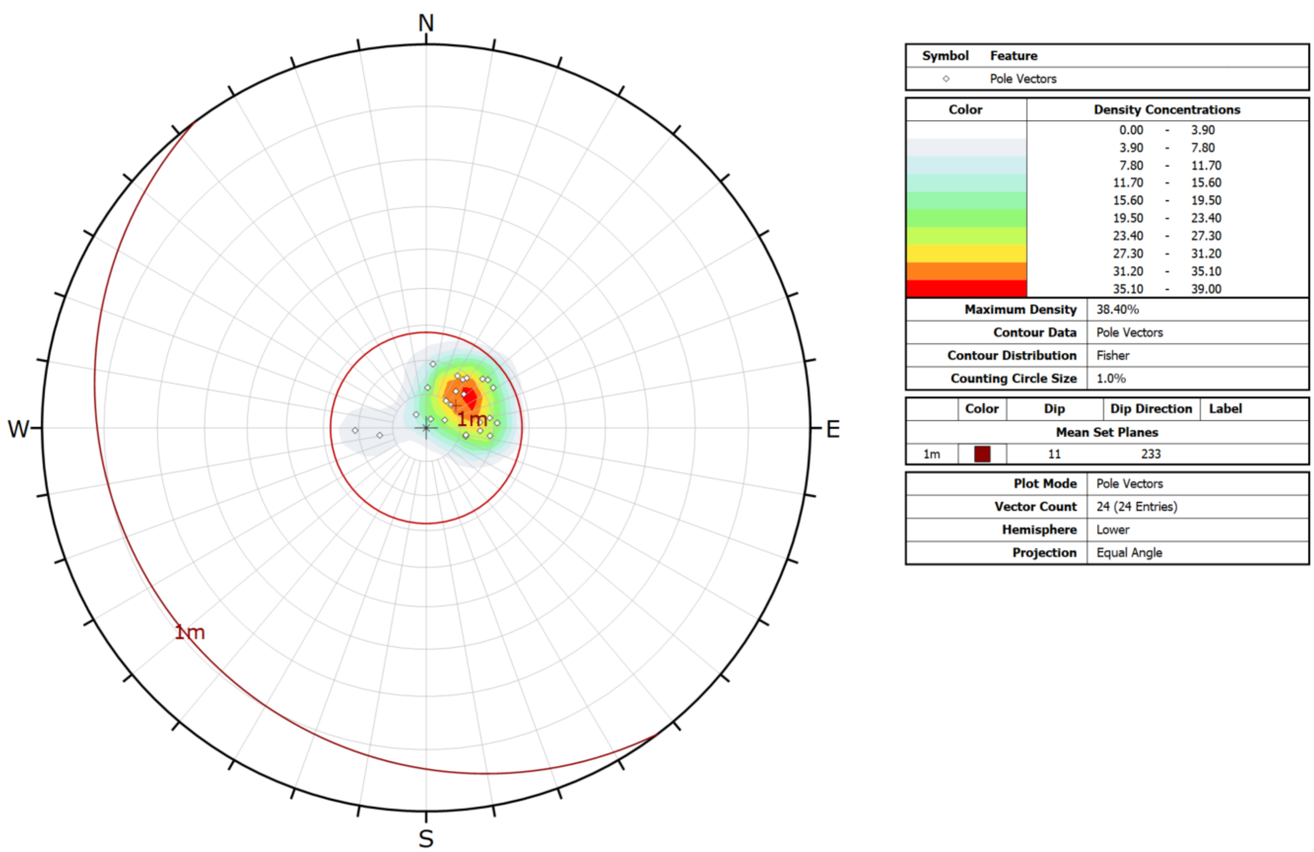
- 0 ft to 70 ft: Quaternary Alluvium. Fine to coarse sand and gravel, trace to some silt, angular to subrounded and clasts consisting of varying proportions of Limestone, Quartzite and Diabase. Stratified sand and gravel units in places.
- 70 ft to 402 ft: Tertiary Conglomerate interbedded with Sandstone. Fine to coarse grained sand and gravel angular to subrounded. Clasts consist of Quartzite, Limestone, Arenite, Diabase and Dacite in a calcareous cemented matrix. Alternating Sandstone and Conglomerate sequences.

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Major Structures

- Bedding has an average dip of 11° to the southwest based on televiewer data (Figure 4.15).
- No inclined discontinuities were observed in televiewer data (Appendix III).

Figure 4.15 Stereonet Plot of Structural Measurements from RC18-9 Televiewer Data



4.4.11 RC19-10 Results

Lithology

- 0 ft to 25 ft: Quaternary Pediment. Clayey sand and silt, some gravel, subangular to subrounded.
- 25 ft to 650 ft: Tertiary Conglomerate with interbedded Sandstone. Fine gravel sized grains to silt/clay sized grains with interbedded cobble and boulder layers, subrounded, clasts consist of 80% Sandstone and 20% Conglomerate.

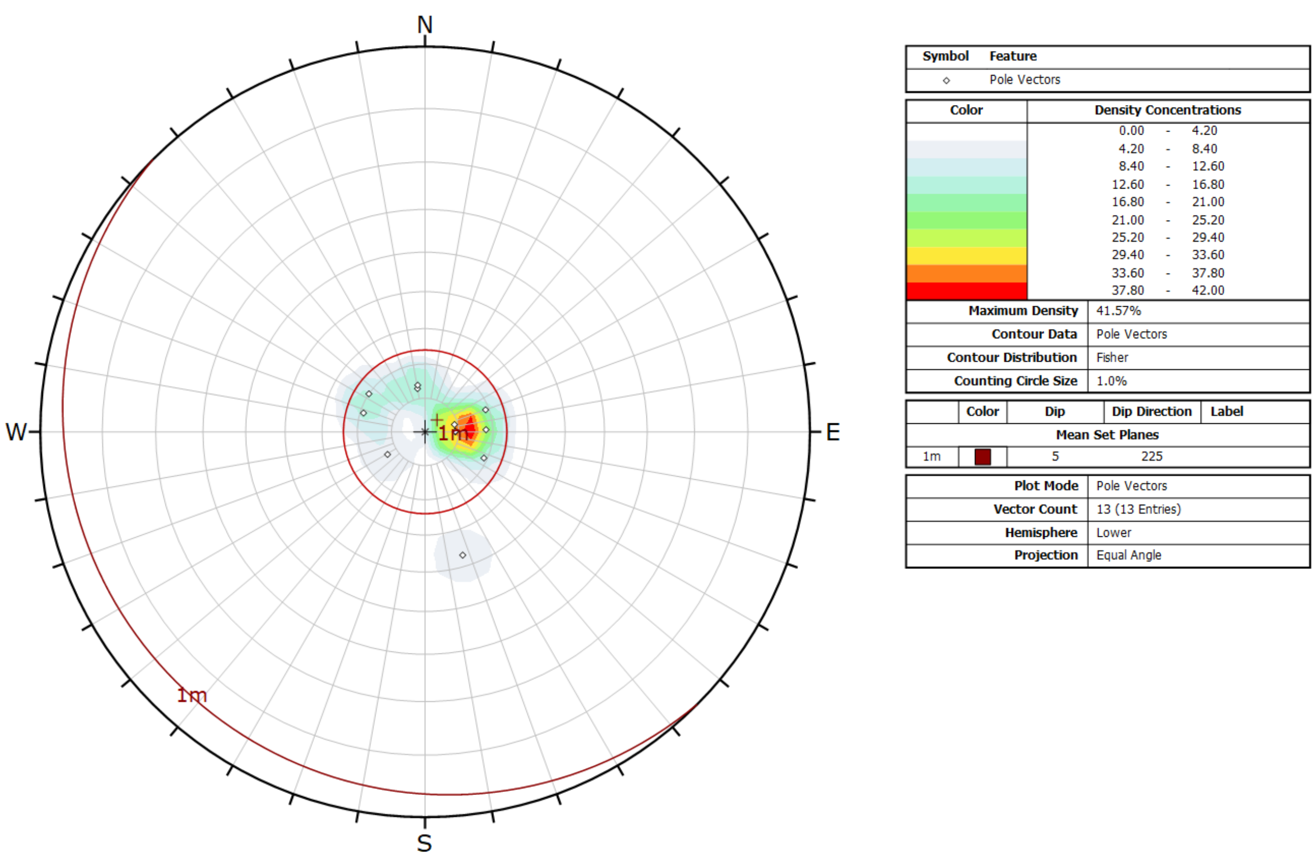
Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Major Structures

- Bedding has an average dip of 5° to the southwest based on televiewer data (Figure 4.16).
- Washouts with widening of hole diameter were observed at 232.8 and 235.2 ft.
- No inclined discontinuities were observed in televiewer data (Appendix III).

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Figure 4.16 Stereonet Plot of Structural Measurements from RC19-10 Televiewer Data



4.4.12 RC19-13 Results

Lithology

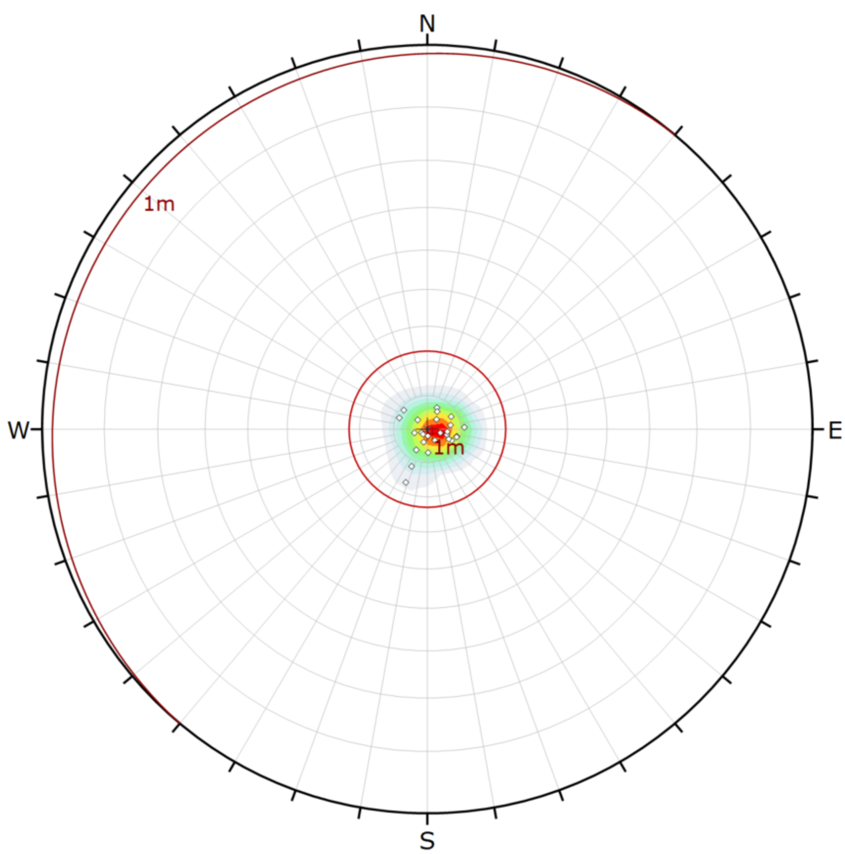
- 0 ft to 27 ft: Quaternary Alluvium.
- 27 ft to 350 ft: Tertiary Conglomerate interbedded with Sandstone. Fine to coarse grained sand and gravel, subangular to subrounded. Clasts consist Quartzite, Arenite and Volcanics (Rhyolite, Diabase, Basalt) in a calcareous cemented matrix. Alternating Sandstone and Conglomerate sequences.

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Major Structures

- Bedding is sub-horizontal, with an average dip of 2° to the northwest.
- No inclined defects were observed.
- At 86.5 ft the 3-arm caliper shows a widening of the hole and may be an open work layer of Conglomerate.

Figure 4.17 Stereonet Plot of Structural Measurements from RC19-13 Televiewer Data



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 6.70
	6.70 - 13.40
	13.40 - 20.10
	20.10 - 26.80
	26.80 - 33.50
	33.50 - 40.20
	40.20 - 46.90
	46.90 - 53.60
	53.60 - 60.30
	60.30 - 67.00
Maximum Density	66.86%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m		2	310	

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Hemisphere	Lower
Projection	Equal Angle

4.4.13 RC19-15 Results

Lithology

- 0 ft to 99 ft: Quaternary Alluvium. Fine to coarse sand and fine gravel, subangular, clasts consisting of 70% Quartzite and 30% Diabase.
- 99 ft to 985 ft: Tertiary Conglomerate. Fine gravel sized grains to silt/clay sized crystals.

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

Major Structures

- Televiewer results are being interpreted by RCM, and a Stereonet of features will be included in a forthcoming revision.
- A single wide open steeply east-southeasterly dipping joint was seen at 425.6 ft (Appendix III). No other obvious defects were seen.

Detailed lithological descriptions are provided in the borehole log in Appendix II-A.

4.5 Hydrogeology Instrumentation Results

4.5.1 Groundwater levels

Manual groundwater level reading and VWP pressure readings were collected by KCBCL field staff during the site investigation program. PTDLs installed in select wells also collected periodic groundwater level measurements. VWP pressure readings were reduced to groundwater levels based on the respective calibration sheet for each VWP. Table 4.4 provides a summary of the available groundwater level data.

Table 4.4 Summary of Groundwater Level Elevations

Hole ID(1)	Instrument ID	Ground Elevation (ft)	Well Screen Interval/ Tip Elevation (ft)	Groundwater Elevation (ft)	Date of Reading
DH19-3A	VWP-A	3359.5	2436.5	3088.9	Jul. 11, 2019
DH19-3A	VWP-B		2731.6	3093.9	Jul. 11, 2019
DH19-3A	VWP-C		3021.4	3096.8	Jul. 11, 2019
DH18-5	VWP-A	3310.2	3050.2	3052.1	Jul. 16, 2019
DH18-5	VWP-B		3124.2	3164.9	Jul. 16, 2019
DH19-7	VWP-A	3433.7	2944.7	3131.5	Jul. 15, 2019
DH19-7	VWP-B		3043.7	3134.9	Jul. 15, 2019
DH19-7	VWP-C		3139.7	Dry	Jul. 15, 2019
DH18-8A	VWP-A	3165.0	3083.5	3092.9	Jul. 16, 2019
DH18-8A	VWP-B		3102.0	3106.6	Jul. 16, 2019
DH19-8B	VWP-A	3163.8	2608.9	3088.6	Jun. 14, 2019(2)
DH19-8B	VWP-B		2942.6	3086.6	Jun. 14, 2019(2)
DH19-8B	VWP-C		3066.7	3089.8	Jun. 14, 2019(2)

Hole ID(1)	Instrument ID	Ground Elevation (ft)	Well Screen Interval/ Tip Elevation (ft)	Groundwater Elevation (ft)	Date of Reading
DH19-12	VWP	3546.9	3229.5	Dry	Jul. 16, 2019
DH19-12A	MW	3544.7	3158.4 – 3256.3	3163.9	Jul. 16, 2019
DH19-14	VWP-A	3642.0	2862.0	3281.1	Jul. 16, 2019
DH19-14	VWP-B		3028.0	3274.1	Jul. 16, 2019
DH19-14	VWP-C		3242.0	3347.6	Jul. 16, 2019
DH19-14	VWP-D		3377.0	3528.6	Jul. 16, 2019
DH19-16	VWP-A	3212.1	2839.1	3125.4	Jul. 11, 2019
DH19-16	VWP-B		3080.6	3132.5	Jul. 11, 2019
DH19-16	VWP-C		3180.1	Dry	Jul. 11, 2019
DH19-17	VWP-A	3215.7	2115.7	2525.8	Jul. 11, 2019
DH19-17	VWP-B		2325.7	3116.3	Jul. 11, 2019
RC19-3	PW	3356.2	2606.2 – 2746.2	3088.3	Jul. 14, 2019
RC19-3	VWP		2856.0	3093.2	Jul. 14, 2019
RC18-4	MW	3535.6	3268.6 – 3308.6	3315.5	Jul. 16, 2019
RC18-4	VWP		3341.6	3349.1	Jul. 16, 2019
RC19-7	PW	3433.7	2683.7 – 2763.7 2983.7 – 3083.7	3132.7	Jul. 15, 2019
RC19-8	MW	3162.0	2914.0 – 3014.0	3087.8	Jul. 14, 2019
RC19-8A	D	3178.6	2780.6 – 2800.6	3102.3	Jun. 19, 2019(2)
RC19-8A	S		2908.6 – 2948.6	3098.9	Jul. 14, 2019
RC19-8A	VWP		3068.6	3099.0	Jul. 11, 2019
RC19-8B	PW	3165.7	3040.7 – 3080.7	3090.2	Jul. 14, 2019
RC19-8C	PW	3166.3	3095.3 – 3135.3	Dry(3)	Jul. 14, 2019
RC19-8D	PW	3166.7	2664.7 – 2964.7	3093.1	Jul. 14, 2019
RC18-9	MW	3533.2	3133.2 – 3213.2	3291(4)	Jul. 15, 2019
RC18-9	VWP		3333.2	3333.5	Jul. 15, 2019
RC19-10	PW	3824.4	3177.1 – 3359.1	3255.5	Jul. 16, 2019
RC19-10	VWP		3564.4	3567.0	Jul. 16, 2019
RC19-13	MW	3404.7	3057.7 – 3137.7	3277.1	Jul. 15, 2019
RC19-15	PW	3721.2	2746.2 – 3126.2	3309.7(5)	Aug. 6, 2019
RC19-15	VWP		3294.2	3340(5)	Aug. 13, 2019

Notes:

1. Hole IDs were changed from proposed once location was confirmed and drilling started.
2. Most recent static water level – before pump tests began.
3. Water level reading is at Elevation 3091.8 ft, but this is likely water within the well sump.
4. Static water level estimated only, due to frequent pumping at this well.
5. Recent static groundwater reading provided by M&A.

4.5.2 Groundwater Quality

Groundwater samples were collected upon completion of well development at all well locations and groundwater samples were also collected at the beginning and end of the constant rate tests. Groundwater quality results are presented by M&A (2019b, c).

4.6 Hydraulic Testing Results

4.6.1 Infiltration Testing in Test Pits

Infiltration testing was carried out on the floor of test pits as falling head tests in a 12.2 in inner diameter single ring, with the exception of one constant head test at TP19-9 (Table 4.5).

Quaternary Alluvium displayed a vertical field saturated hydraulic conductivity of between 4.6×10^{-2} cm/s and 9.9×10^{-3} cm/s.

Quaternary Pediment had vertical field saturated hydraulic conductivity of 2×10^{-4} cm/s.

Tertiary Sandstone had vertical field saturated hydraulic conductivity of between 5.4×10^{-5} cm/s and 7.6×10^{-5} cm/s.

Tertiary Conglomerate had vertical field saturated hydraulic conductivity of between 8.8×10^{-4} cm/s and 2.1×10^{-5} cm/s.

Table 4.5 Summary of Infiltration Test Results in Test Pits

Hole ID	Test Interval (ft)	Type of Test	Test No.	Test Date	Geology	Result (cm/s)
TP19-8	0 - 3	FHT	FH-1	26-Jul-19	Quaternary Alluvium	1.2E-02
TP19-8	0 - 3	FHT	FH-2	26-Jul-19	Quaternary Alluvium	9.9E-03
TP19-8A	0 - 2	FHT	FH-1	26-Jul-19	Tertiary Sandstone	7.6E-05
TP19-9	0 - 4	CHT	CH-1	25-Jul-19	Tertiary Conglomerate	2.1E-05
TP19-9	0 - 4	FHT	FH-1	25-Jul-19	Tertiary Conglomerate	3.0E-04
TP19-9	0 - 1	FHT	FH-2	27-Jul-19	Quaternary Alluvium	4.6E-02
TP19-9	0 - 1	FHT	FH-3	27-Jul-19	Quaternary Alluvium	2.8E-02
TP19-10	0 - 2.5	FHT	FH-1	26-Jul-19	Quaternary Pediment	2.0E-04
TP19-11	0 - 3.5	FHT	FH-1	27-Jul-19	Tertiary Sandstone	5.4E-05
TP19-13	0 - 2	FHT	FH-1	26-Jul-19	Tertiary Conglomerate	8.0E-04
TP19-13	0 - 2	FHT	FH-2	26-Jul-19	Tertiary Conglomerate	8.8E-04

4.6.2 Hydraulic Testing – Unsaturated Zone Testing in RC Holes

Testing for hydraulic conductivity within the unsaturated zone was conducted in the unconsolidated Alluvium and the upper bedrock units immediately below the contact with the unconsolidated Alluvium. Tests were completed using both falling head and constant head techniques and were analyzed using the Porchet Method (van Hoorn 1979) Inverse Borehole method and the method prescribed by Elrick and Reynolds (1986), respectively. Both tests were conducted within 11.0 in diameter steel casing and 10.63 in diameter open borehole. Results of the unsaturated zone testing are summarized in Table 4.6 and details of the analysis are included in Appendix VI-H.

Table 4.6 Summary of Hydraulic Testing Results – Unsaturated Zone

Borehole ID	Test Interval (ft)	Test Type	Test Number	Test Interval Lithology	Observed Flow (US gal/min)	Hydraulic Conductivity	
						cm/s	ft/day
RC18-4	17.6 – 20.6	Falling Head	FH-1	Conglomerate	NA	---(1)	
	32.0 – 35.0	Falling Head	FH-2	Conglomerate	NA	---(1)	
RC18-9	16.3 – 18.6	Falling Head	FH-1	Alluvium	NA	6.7×10^{-3}	19.0
	16.3 – 18.6	Constant Head	CH-1	Alluvium	4	4.0×10^{-2}	112.0
	37.1 – 39.5	Falling Head	FH-2	Alluvium	NA	3.0×10^{-3}	8.6
	37.1 – 39.5	Constant Head	CH-2	Alluvium	1.81	4.0×10^{-2}	113.0
RC19-7	4 - 42	Falling Head	FH-1	Conglomerate		1.2×10^{-4}	3.5×10^{-1}
	4 - 62	Falling Head	FH-2	Conglomerate		3.7×10^{-5}	1.1×10^{-1}
	4 - 82	Falling Head	FH-3	Conglomerate		4.5×10^{-4}	1.3
RC19-8A	17.3 – 19.0	Falling Head	FH-1	Alluvium	NA	7.8×10^{-3}	22.2
	17.3 – 19.0	Constant Head	CH-1	Alluvium	5.83	5.2×10^{-3}	14.7
	36.1 – 39.0	Constant Head	FH-2	Alluvium	NA	4.0×10^{-3}	11.5
	58.0 – 60.0	Falling Head	FH-3	Alluvium	NA	9.5×10^{-4}	2.67
	88.0 – 90.0	Falling Head	FH-A	Sandstone / Conglomerate	NA	---(1)	
RC19-8B	15.5 – 19.5	Constant Head	CH-1	Alluvium		3.9×10^{-2}	111.0
	40 - 43.8	Constant Head	CH-2	Conglomerate	NA	8.9×10^{-4}	2.52
	56 - 57	Falling Head	FH-1	Conglomerate	NA	1.6×10^{-3}	4.43
RC19-8	17.3 – 18.7	Constant Head	CH-1	Alluvium	7.56	1.4×10^{-2}	38.6
	17.3 – 18.7	Falling Head	FH-1	Alluvium	NA	3.1×10^{-2}	88.6
	39.0 – 40.3	Constant Head	CH-2	Alluvium	4.22	1.7×10^{-3}	4.68
	39.0 – 40.3	Falling Head	FH-2	Alluvium	NA	7.5×10^{-3}	21.12
	64.3 – 70.3	Falling Head	FH-4	Tertiary Sandstone	NA	1.9×10^{-3}	8.2

Borehole ID	Test Interval (ft)	Test Type	Test Number	Test Interval Lithology	Observed Flow (US gal/min)	Hydraulic Conductivity	
						cm/s	ft/day
RC19-10	17 - 18.5	Falling Head	FH-1	Pediment	NA	7.9×10^{-5}	2.3×10^{-1}
	27.8 - 32.2	Falling Head	FH-2	Conglomerate	NA	2.5×10^{-5}	7.0×10^{-2}
	46.58 - 50.41	Falling Head	FH-3	Conglomerate	NA	3.7×10^{-5}	1.1×10^{-1}
	67 - 70	Falling Head	FH-4	Conglomerate	NA	5.6×10^{-5}	1.6×10^{-1}
	87.83 - 91	Falling Head	FH-5	Conglomerate	NA	7.8×10^{-5}	2.2×10^{-1}
	108 - 113.83	Falling Head	FH-6	Conglomerate	NA	2.1×10^{-4}	6.0×10^{-1}
	128 - 134	Falling Head	FH-7	Conglomerate	NA	5.3×10^{-5}	1.5×10^{-1}
RC19-3	17.6 - 20	Falling Head	FH-1	Conglomerate		4.2×10^{-4}	1.2
	27.2 – 31	Falling Head	FH-2	Conglomerate		1.1×10^{-4}	3.1×10^{-1}
	134 - 169	Falling Head	FH-3	Conglomerate		9.9×10^{-5}	2.8×10^{-1}
RC19-15	17 - 20.9	Constant Head	CH-1	Weathered Conglomerate	0.7	1.1×10^{-4}	3.1×10^{-1}
	36.8 - 45.8	Constant Head	CH-2	Conglomerate	0.3	1.3×10^{-5}	3.7×10^{-2}
	57.5 - 65.2	Constant Head	CH-3	Conglomerate	0.5	8.6×10^{-6}	2.4×10^{-2}
	76.5 - 84.8	Constant Head	CH-4	Conglomerate	0.76	7.6×10^{-6}	2.2×10^{-2}
	80 - 123.8	Falling Head	FH-1	Alluvium/ Conglomerate		2.9×10^{-5}	8.2×10^{-2}

Notes:
1. Test was inconclusive. Water level did not change during test and no flow was observed.

4.6.3 Packer Testing

The composition of the bedrock units that were packer tested during the hydraulic testing program are of sedimentary origin (Gila Formation) with varying degrees of fracturing and matrix porosity. The Gila Formation consists of calcareous sandstone interbedded with massive calcareous conglomerate with varying degrees of cementation. The strongly cemented zones were typically less permeable than the non-cemented and weakly cemented zones.

Packer tests were completed on the 3.77-in diameter (HQ3) geotechnical holes and were analyzed using the Houlsby (1976) method of Lugeon value interpretation. Hydraulic conductivity was calculated using the Thiem (1906) and the Hoek and Bray (1974) solutions, which are appropriate for flow through primary porosity medium and fractured rock flow, respectively. A summary of the encountered geology, geological structures and packer test results is provided in the following sections, with results presented in Table 4.7. Further details of the packer testing results are included in Appendix VI.

Table 4.7 Summary of Packer Testing Results

Borehole ID	Test Interval (ft)	Packer Type	Test Number	Test Interval Lithology	Max. Observed Flow (US gal/min)	Flow Type		
						Thiem (cm/s)	Hoek and Bray (cm/s)	Flow Interpretation
DH18-5	177 - 267	Single	P-1	Conglomerate	0.75	1.5×10^{-6}		Turbulent
	204 - 267	Single	P-2	Conglomerate	0.75	1.7×10^{-6}		Turbulent
DH19-8B(1)	93 - 206	Single	P-1	Sandstone	5.94	2.0×10^{-5}	2.7×10^{-5}	Turbulent
	153 - 206	Single	P-2	Sandstone	10.0	6.0×10^{-5}	1.3×10^{-4}	Wash Out
	203 - 301	Single	P-3	Sandstone	5.95	2.0×10^{-5}	4.2×10^{-5}	Turbulent
	313 - 401	Single	P-4	Sandstone	4.10	1.4×10^{-5}	3.0×10^{-5}	Void Filling
	483 - 551	Single	P-5	Conglomerate	2.44	1.0×10^{-5}		Turbulent
	553 - 651	Single	P-6	Conglomerate	1.65	3.3×10^{-6}		Void Filling
	383 - 393	Double	P-7	Sandstone	0.10	1.8×10^{-6}	4.8×10^{-6}	Dilation
DH19-3	206 - 242	Single	P-1	Conglomerate	9.58	7.12×10^{-5}		Washout
DH19-3A	267.4 - 298.6	Single	P-1	Conglomerate	5.0	1.97×10^{-5}		Turbulent
	302.3 - 352.8	Single	P-2	Conglomerate	0.15	6.35×10^{-8}		Void Filling
	364.4 - 415	Single	P-3	Conglomerate	15.77	3.60×10^{-5}		Turbulent
	530.8 - 629.5	Single	P-4	Conglomerate	6.00	7.70×10^{-6}		Turbulent
	699.9 - 817.4	Single	P-5	Conglomerate	0.38	3.64×10^{-7}		Turbulent
	898.3 - 1003.2	Single	P-6	Paleozoic Limestone/ Basalt Porphyry	0.3		4.90×10^{-7}	Turbulent
	1019.4 - 1032.5	Single	P-7	Paleozoic Limestone	0.48		5.40×10^{-6}	Turbulent
DH19-7	174 - 267	Single	P-1	Conglomerate	2.46	4.10×10^{-6}		Turbulent
	304 - 326.5	Single	P-2	Conglomerate	0.12	7.54×10^{-7}		Turbulent
	354 - 400.3	Single	P-3	Conglomerate	0.20	5.59×10^{-7}		Wash Out
	404 - 452	Single	P-4	Conglomerate	0.10	2.34×10^{-7}		Void Filling
DH19-11	74.3 - 149.4	Single	P-1	Conglomerate / Limestone	1.16		9.9×10^{-6}	Turbulent
	157.3 - 353	Single	P-2	Mescal Limestone	0.39		7.0×10^{-7}	Void Filling
	956.3 - 1152	Single	P-6	Pioneer Shale / Diabase	1.48		5.2×10^{-7}	Dilation
	1157.3 - 1354	Single	P-7	Granite / Scanlan Conglomerate	4.32		2.6×10^{-6}	Void Filling
	1754.3 - 1953	Single	P-10	Ruin Granite	55.0		2.7×10^{-5}	Laminar
	1957.3 - 2153	Single	P-11	Ruin Granite	43.5		2.0×10^{-5}	Laminar
	2157.3 - 2353	Single	P-12	Ruin Granite / Diabase	82.9		3.6×10^{-5}	Laminar
	2357.3 - 2553	Single	P-13	Diabase	63.4		2.4×10^{-5}	Dilation
	2557.3 - 2693	Single	P-14	Granite / Diabase	200.77		3.3×10^{-5}	Dilation

Borehole ID	Test Interval (ft)	Packer Type	Test Number	Test Interval Lithology	Max. Observed Flow (US gal/min)	Flow Type		
						Thiem (cm/s)	Hoek and Bray (cm/s)	Flow Interpretation
DH19-12A	262 – 324	Single	P-2	Conglomerate	0.43	1.6×10^{-6}		Turbulent
	318 - 399	Single	P-3	Conglomerate	0.92	7.6×10^{-7}		Turbulent
DH19-14	87.5 - 102	Single	P-1	Diabase	0.4		3.5×10^{-5}	Turbulent
	236 - 302	Single	P-5	Diabase	0.14		6.2×10^{-8}	Dilation
DH19-16	36.5 - 132	Single	P-1	Conglomerate	1.02	6.2×10^{-6}		Laminar
	136.25 - 232	Single	P-2	Conglomerate	0.52	1.9×10^{-6}		Turbulent
	234.5 - 332	Single	P-3	Conglomerate	0.67	2.0×10^{-6}		Turbulent
	335.5 - 442	Single	P-4	Conglomerate	0.81	1.1×10^{-6}		Void Filling

Note:
1. DH19-8B was drilled at 62° from horizontal. Depths are along inclined hole
2. DH19-11 was drilled at 70° from horizontal. Depths are along inclined hole.
3. DH19-3A was drilled at 75° from horizontal. Depths are along inclined hole.

The hydraulic conductivity is generally uniform in the upper 500 ft of the borehole. The calculated hydraulic conductivities are mostly a function of the most permeable unit within the tested interval Tests taken in the upper 500 ft intersect numerous uncemented zones. Tests P-6 and P-7 were conducted in mostly cemented material and the calculated hydraulic conductivity is between a half and one order of magnitude lower.

4.6.4 Slug Testing

Hydraulic conductivity values were estimated from the collected slug test data using AQTESOLV Pro v4.5 software (Duffield 2007). Analytical solutions were selected based on interpreted aquifer lithologies, specific well conditions and aquifer responses (Hyder et. al 1994). Estimates of hydraulic conductivity are summarized in Table 4.8. Detailed results and input parameters for the slug test analysis are provided in Appendix VI.

Table 4.8 Summary of Slug Test Results

Monitoring Well ID	Static Water Level (ft[1]) / Date (2019)	Gravel Pack Interval (ft[1])	Screened Formation	Analytical Solution	Hydraulic Conductivity			
					Falling Head (cm/s)	Rising Head (cm/s)	Average Value (cm/s)	Average Value (ft/day)
RC18-4	213.92 / March 3	223 – 270	Tertiary Conglomerate	KGS[2]	2.0×10^{-4}	2.7×10^{-5}	2.0×10^{-4}	5.7×10^{-1}
				Bouwer-Rice[3]	2.1×10^{-4}	1.5×10^{-4}		
RC19-8AD	70.02 / March 3	371.5 – 398	Tertiary Sandstone / Conglomerate	KGS	2.1×10^{-4}	2.3×10^{-4}	2.3×10^{-4}	6.2×10^{-1}
				Bouwer-Rice	2.0×10^{-4}	2.8×10^{-5}		
RC19-8AS	73.35 / March 3	230 – 270	Tertiary Sandstone / Conglomerate	KGS	2.4×10^{-4}	3.7×10^{-4}	3.0×10^{-4}	8.5×10^{-1}
				Bouwer-Rice	2.8×10^{-4}	3.2×10^{-4}		
RC19-8AS	72.25 / Jan.13, (rising head immediately after development)			KGS	-	9.39×10^{-5}	9.39×10^{-5}	2.7×10^{-1}
RC19-13	213.99 / March 3	268 – 348	Tertiary Sandstone / Conglomerate	KGS	3.8×10^{-5}	1.1×10^{-4}	6.8×10^{-5}	1.1×10^{-1}
				Bouwer Rice	5.6×10^{-5}	6.7×10^{-5}		
RC19-3	262.03 / May 23		Conglomerate	KGS	5.05×10^{-4}	2.11×10^{-4}	3.4×10^{-4}	9.5×10^{-1}
					2.65×10^{-4}	5.05×10^{-4}		
					4.40×10^{-4}	2.65×10^{-4}		
RC19-8B	70.72 / May 28		Conglomerate	KGS	7.30×10^{-4}	5.53×10^{-4}	5.3×10^{-4}	1.50×10^{0}
					5.04×10^{-4}	7.30×10^{-4}		
					4.30×10^{-4}	5.04×10^{-4}		

Notes:
1. Depths are from ground surface.
2. KGS = Kansas Geological Survey; Hyder et. al. (1994).
3. Bower and Rice (1976).

4.6.5 Pumping Test Interpretation

Multi-rate Pumping Tests

Groundwater level drawdown records from the multi-rate tests performed at both RC18-9 and RC19-8 were analyzed using AQTESOLVE Pro v4.5 software (Duffield 2007). The drawdown plots for both tests are provided in Figure 4.18 and Figure 4.19. These drawdown records were analyzed using the Theis Step Drawdown Test analytical solution. A summary of the analytical solution results is provided in Table 4.9 and Table 4.10, while further details are provided in Appendix VI.

Figure 4.18 RC19-8 Multi-rate Pumping Test Hydrograph

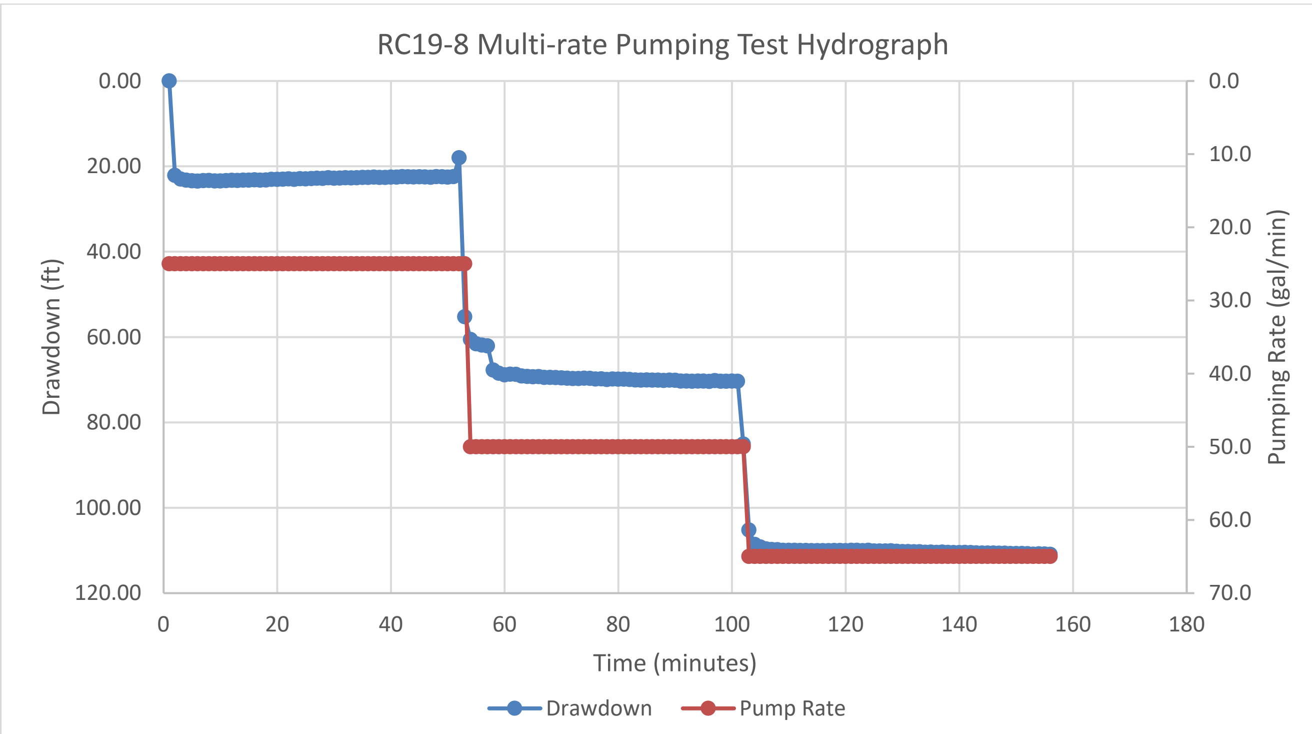


Figure 4.19 RC18-9 Multi-rate Test Pumping Hydrograph

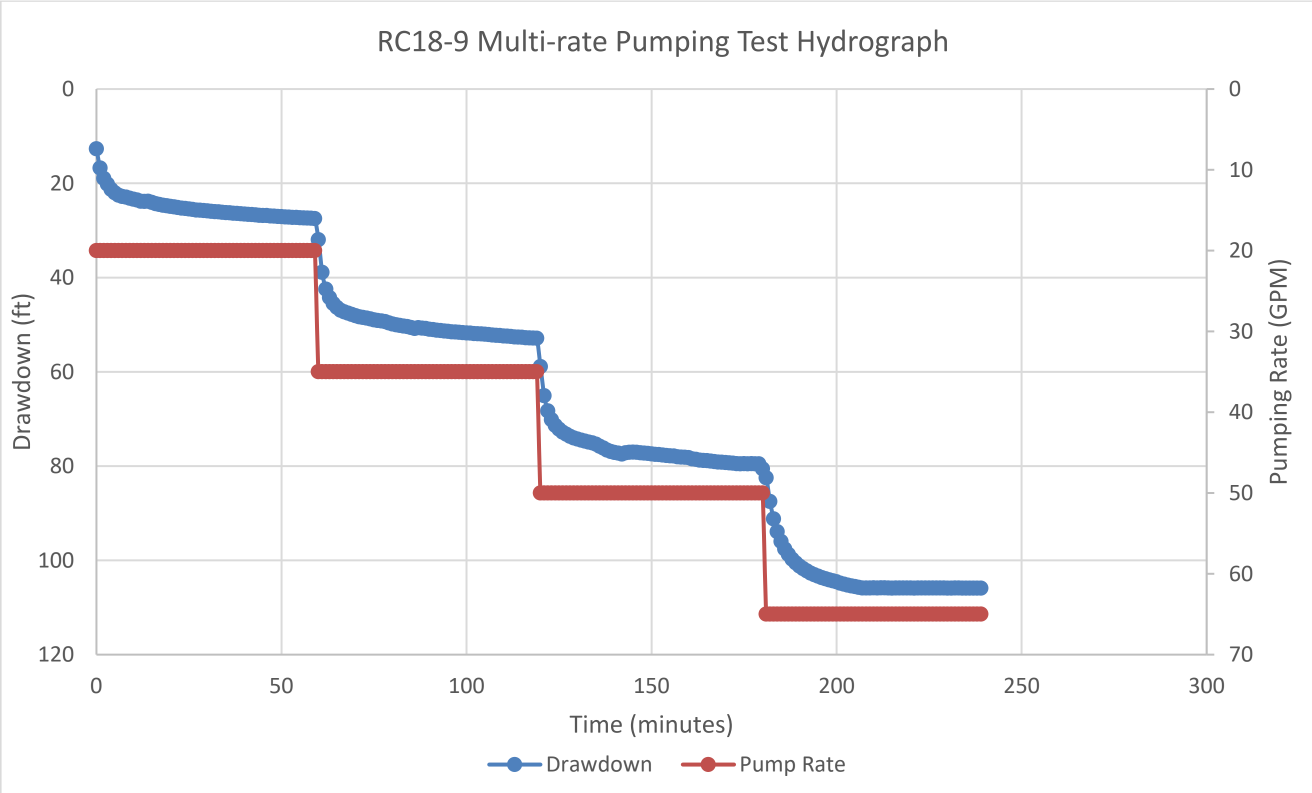


Table 4.9 RC19-8 Summary of Multi-rate Test Analysis

Step Number	Pump Rate (gal/min)	Drawdown (ft)	Specific Capacity (gal/min/ft)	Transmissivity (ft^2/day)
1	25	23	1.1	101
2	50	70.4	0.71	
3	65	110.9	0.58	

Table 4.10 RC18-9 Summary of Multi-rate Test Results

Step Number	Pump Rate (gal/min)	Drawdown (ft)	Specific Capacity (gal/min/ft)	Transmissivity (ft^2/day)
1	20	27.4	0.73	187
2	35	52.9	0.66	
3	50	79.5	0.62	
4	65	105.9	0.61	

Constant Rate Pumping Tests

The constant rate pumping tests at both RC18-9 and RC19-8 were performed approximately 24 hours after the completion of the multi-rate pumping test. Groundwater levels in the pumping wells had recovered to steady-state conditions in the pumping wells prior to commencement of the constant rate test. Surrounding monitoring wells were used as observation wells during the respective constant rate test. A summary of the constant rate test well networks is provided in Table 4.11 and Table 4.12.

Table 4.11 RC19-8 Constant Rate Pumping Test Well Network

Monitoring Well ID	Instrument Type	Distance from RC19-8 (ft)
RC18-4	Monitoring Well	18,867
RC18-4	Monitoring Piezometer	
RC19-8	Pumping Well	0
RC19-8A	Monitoring Well	626
RC19-8A	Monitoring Well	
RC19-8A	Monitoring Piezometer	
Windmill Well	Monitoring Well	347

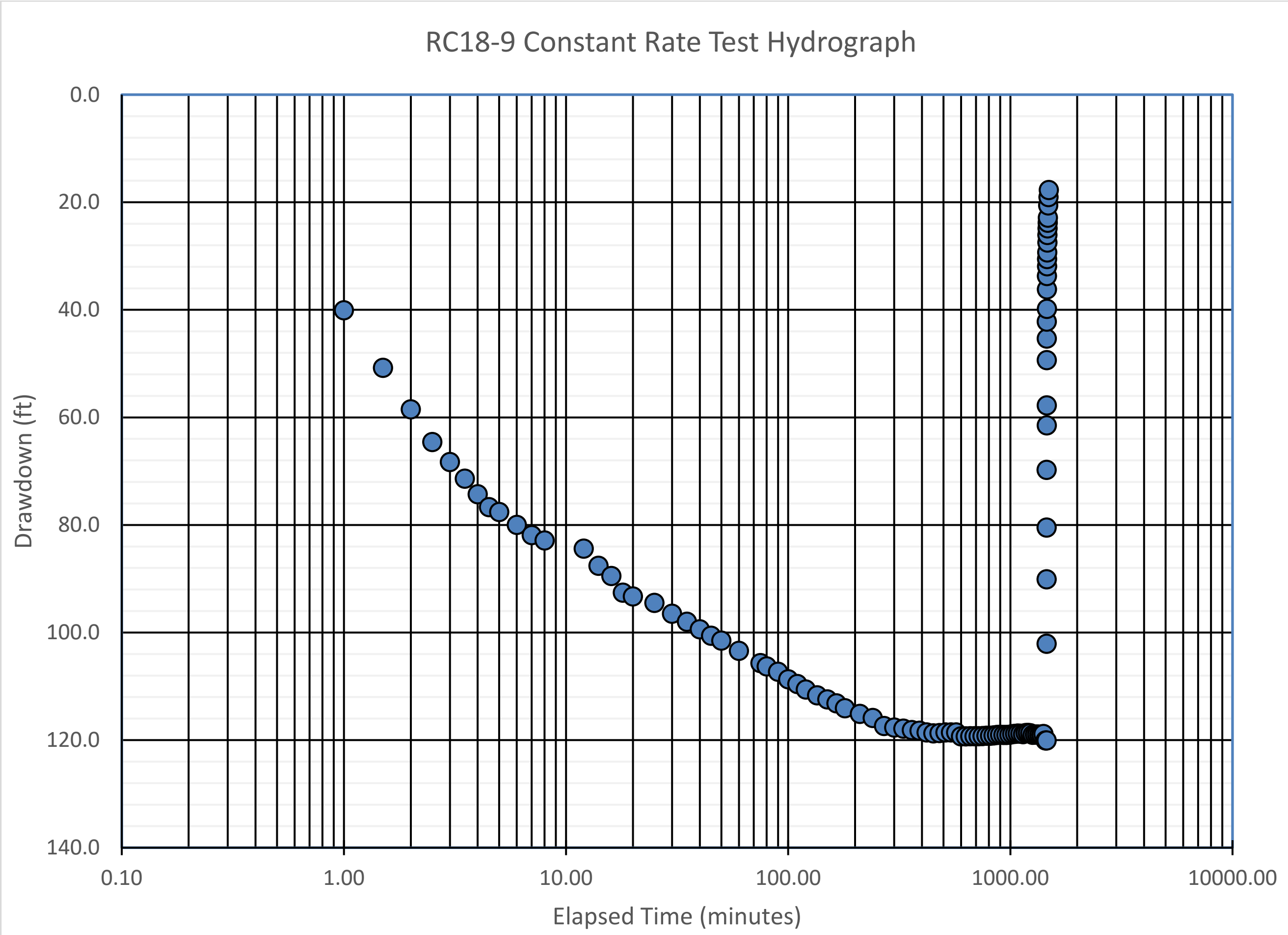
Table 4.12 RC18-9 Constant Rate Pumping Test Well Network

Monitoring Well ID	Instrument Type	Distance from RC18-9 (ft)
RC19-8A	Monitoring Well	13,752
RC19-8A	Monitoring Well	
RC19-8A	Monitoring Piezometer	
RC18-9	Pumping Well	0
RC18-9	Monitoring Piezometer	
RC19-13	Monitoring Well	4700

RC18-9

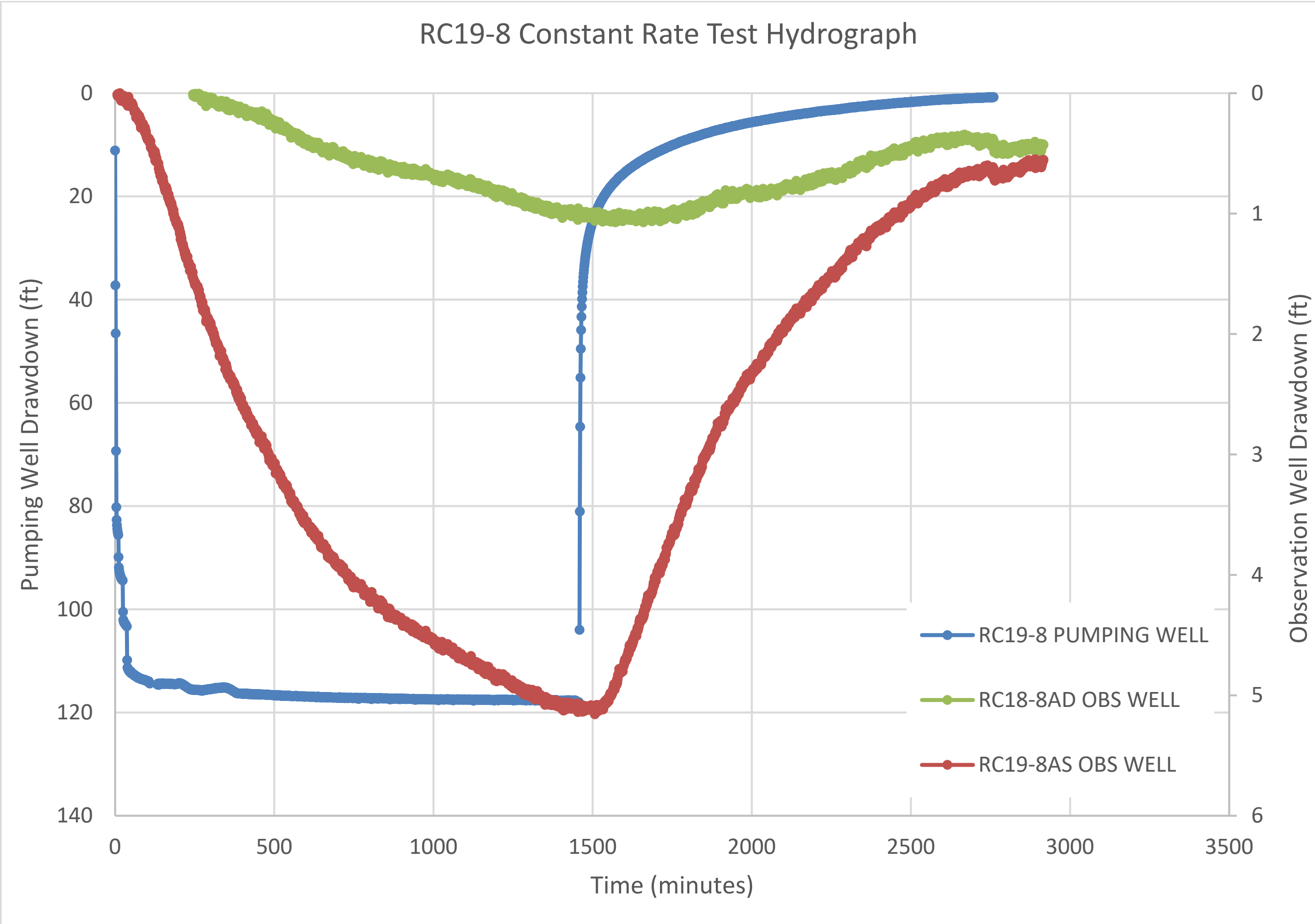
The constant rate test of RC18-9 was undertaken for a duration of 24 hours at a pumping rate of 77 gal/min. PTDLs were deployed in RC19-13, RC18-4, RC19-8AD and RC19-8AS prior to the commencement of the test to monitor groundwater level responses associated with the adjacent pumping. Groundwater level responses were not observed in the surrounding monitoring wells during or after testing. Groundwater level drawdown and recovery records from the pumping test are presented in Figure 4.20.

Figure 4.20 RC18-9 Constant Rate Test Groundwater Level Drawdown and Recovery



The constant rate test of RC19-8 was undertaken for a duration of 24 hours at a pumping rate of 55 gal/min. PTDLs were deployed in RC19-13, RC18-4, RC19-8AD, RC19-8AS 55-632800 (Figure 2 and Figure 4) prior to commencement of the test to monitor groundwater level responses. Intermittent manual measurements were also collected at these wells throughout the test. The combined results of the groundwater level drawdown are presented in Figure 4.21. The figure highlights that RC18-8AS is hydraulically connected to RC19-8 as a similar response in groundwater drawdown due to the pumping at RC19-8 is observed at this location. The response in RC19-8AD is more muted and delayed, indicative of a non-direct hydraulic connection (e.g. lower transmissivity in comparison to RC18-8AS). The slope of the drawdown curve at RC19-8AD flattens and steepens twice during recovery phase and is indicative of delayed yield possibly from upper saturated units. The groundwater levels recovered relatively quickly in RC19-8AS and RC19-8, to within 85% and 99% respectively, after 12 hours of the test cessation. A negative recharge boundary is observed in both observation wells near the end of the recovery tests.

Figure 4.21 RC19-8, RC19-8AS and RC19-8AD Constant Rate Test Groundwater Level Drawdown and Recovery



Drawdown Curve Analysis

The drawdown resulting from pumping the aquifer did not show a delayed water table response typically observed in unconfined aquifers. Furthermore, intersection of groundwater yields during drilling occurred at depths between 150’ and 270’, followed by a rise in groundwater levels to a static water level of between 60’ and 80’ higher than initial groundwater intersection depth, indicating potential confined aquifer conditions. Therefore, analysis of the drawdown curve was undertaken using the Cooper-Jacob method (Kruseman and deRidder 1991). Analysis of the drawdown curves using the Cooper-Jacob method is based on the following assumptions:

- The aquifer is confined.
- The aquifer has a seemingly infinite areal extent.
- The aquifer is homogeneous, isotropic, and of uniform thickness over the area influenced by the test.

- Prior to pumping, the water table is horizontal (or nearly so) over the area that will be influenced by the test.
- The aquifer is pumped at a constant discharge rate.
- The well penetrates the entire thickness of the aquifer and thus receives water by horizontal flow.
- The flow to the well is in an unsteady state.
- The radial distance between the pumping well and the observation wells are small or the time over which drawdown is recorded is large.

The Cooper-Jacob method modified non-equilibrium equation is provided as follows (Kruseman and de Ridder 1991):

$$KD=\frac{2.3Q}{4\pi\Delta s}$$

and

$$S=2.25KD(t/r^2)_o$$

where	Δs	Is the drawdown (in m) of the straight-line approximation across one log cycle
	Q	Is the constant discharge rate (in m^3/day)
	K	Is the hydraulic conductivity of the aquifer (in m/day)
	D	Is the aquifer thickness measured from the base of the well to the static water level (in m)
	S	Is the dimensionless storage coefficient of the aquifer
	r	Is the distance from the pumping well to the observation well (in m)
	t	Is the time (in days) since pumping started
and	T	=KD= the aquifer transmissivity (m^2/day)

Calculated aquifer transmissivity and storativity values from the analysis of both pumping test results are summarized in Table 4.13. Analyses were performed on both drawdown and recovery curves for both pumping tests.

Table 4.13 Summary of Calculated Transmissivity and Storativity Values from Constant Rate Test at RC19-8

Well ID	Distance from RC19-8 (ft)	Transmissivity (1)		Transmissivity (2)		Storativity
		ft²/day	m²/day	ft²/day	m²/day	
RC19-8	0	98.4	9.1	98.7	9.2	-
RC19-8AS	626	380	35.3	380	35.3	0.00023
RC19-8AD		1937	179.9	1943	180.5	0.0014

Notes:
1. Drawdown curve analysis.
2. Recovery analysis.

Table 4.14 Summary of Calculated Transmissivity and Storativity Values from Constant Rate Test at RC18-9

Well ID	Transmissivity (1)		Transmissivity (2)		Storativity
	ft²/day	m²/day	ft²/day	m²/day	
RC18-9	104	9.7	109	10.1	-

Notes:
1. Drawdown curve analysis.
2. Recovery analysis.

4.6.6 Hydraulic Parameter Summary

Figure 4.22 and Figure 4.23 provide a graphical representation of the hydraulic conductivity values versus depth for Tertiary Conglomerate and Alluvium, respectively.

Figure 4.22 Hydraulic Conductivity Results in Unsaturated Conditions

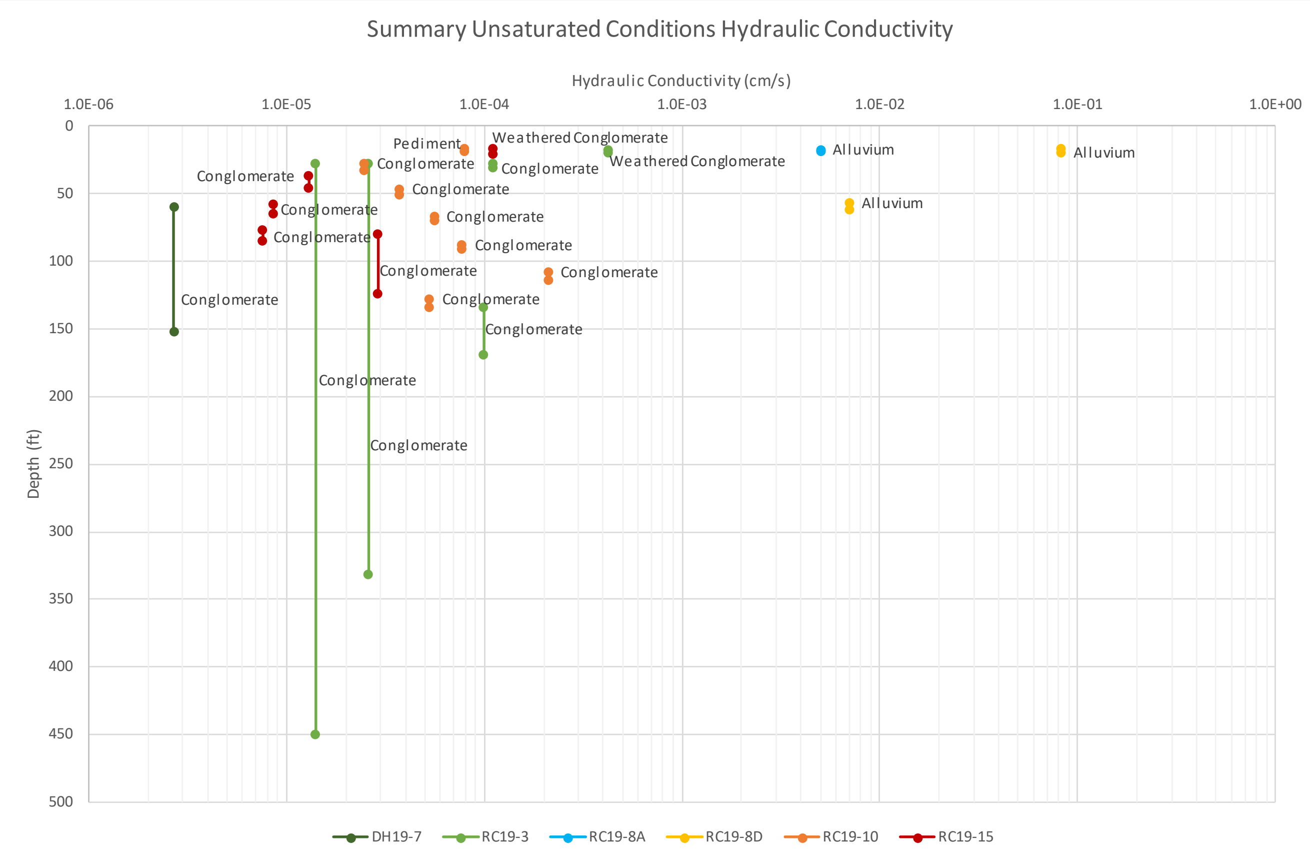


Figure 4.23 Hydraulic Conductivity of Alluvium from Falling Head and Constant Head Tests

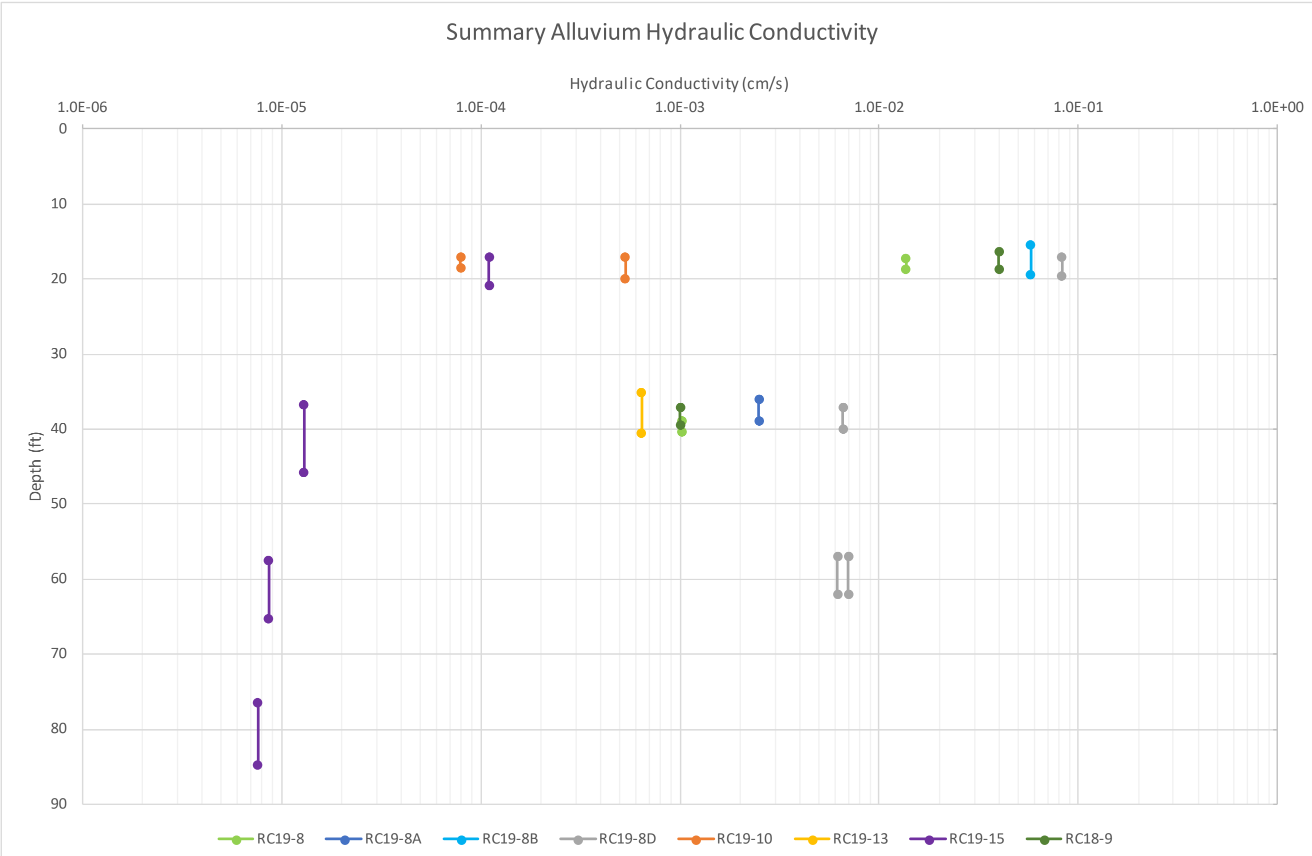


Figure 4.24 Hydraulic Conductivity of Tertiary Sandstone as Observed from Packer Tests

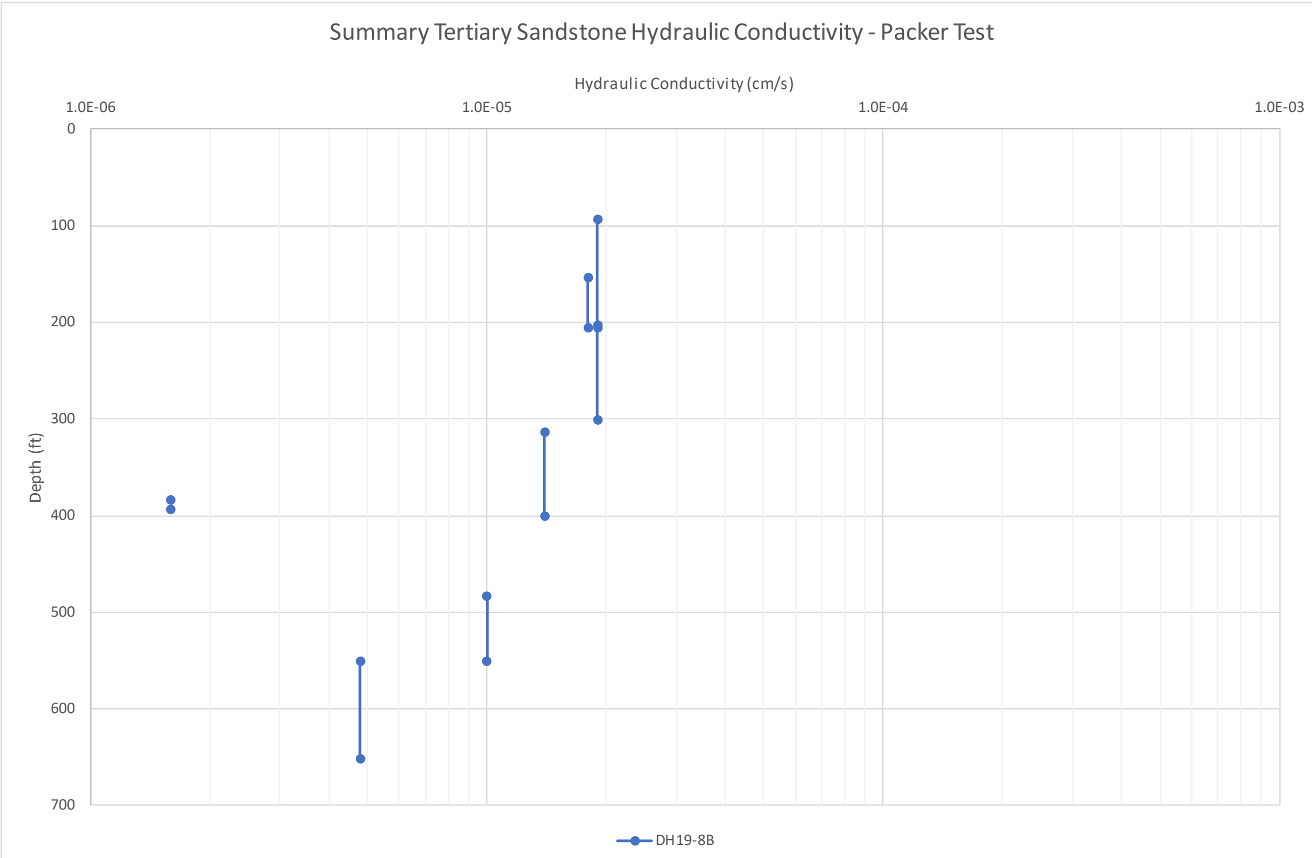


Figure 4.25 Hydraulic Conductivity of Tertiary Sandstone as Observed from Falling Head and Constant Head Tests

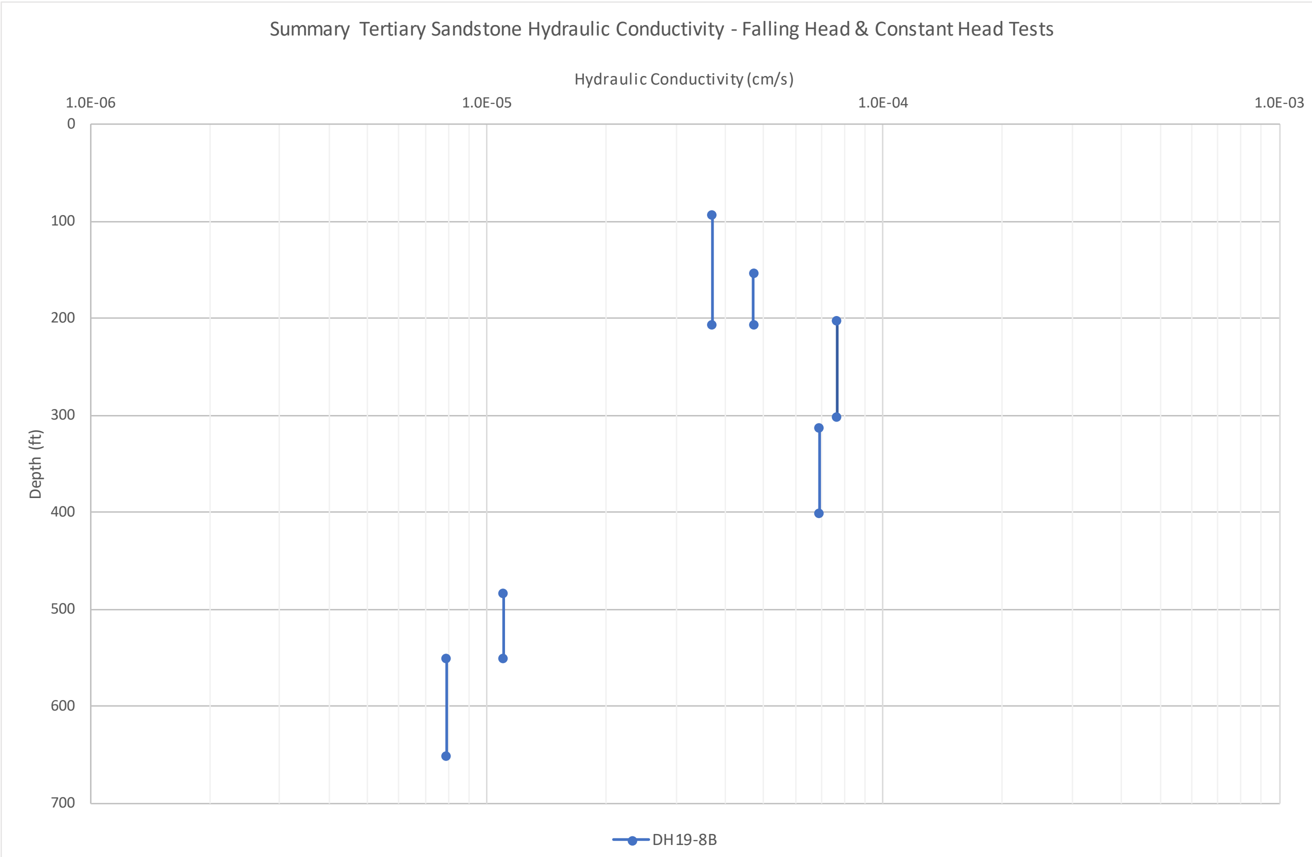


Figure 4.26 Hydraulic Conductivity of Tertiary Conglomerate as Observed from Slug and Pumping Tests

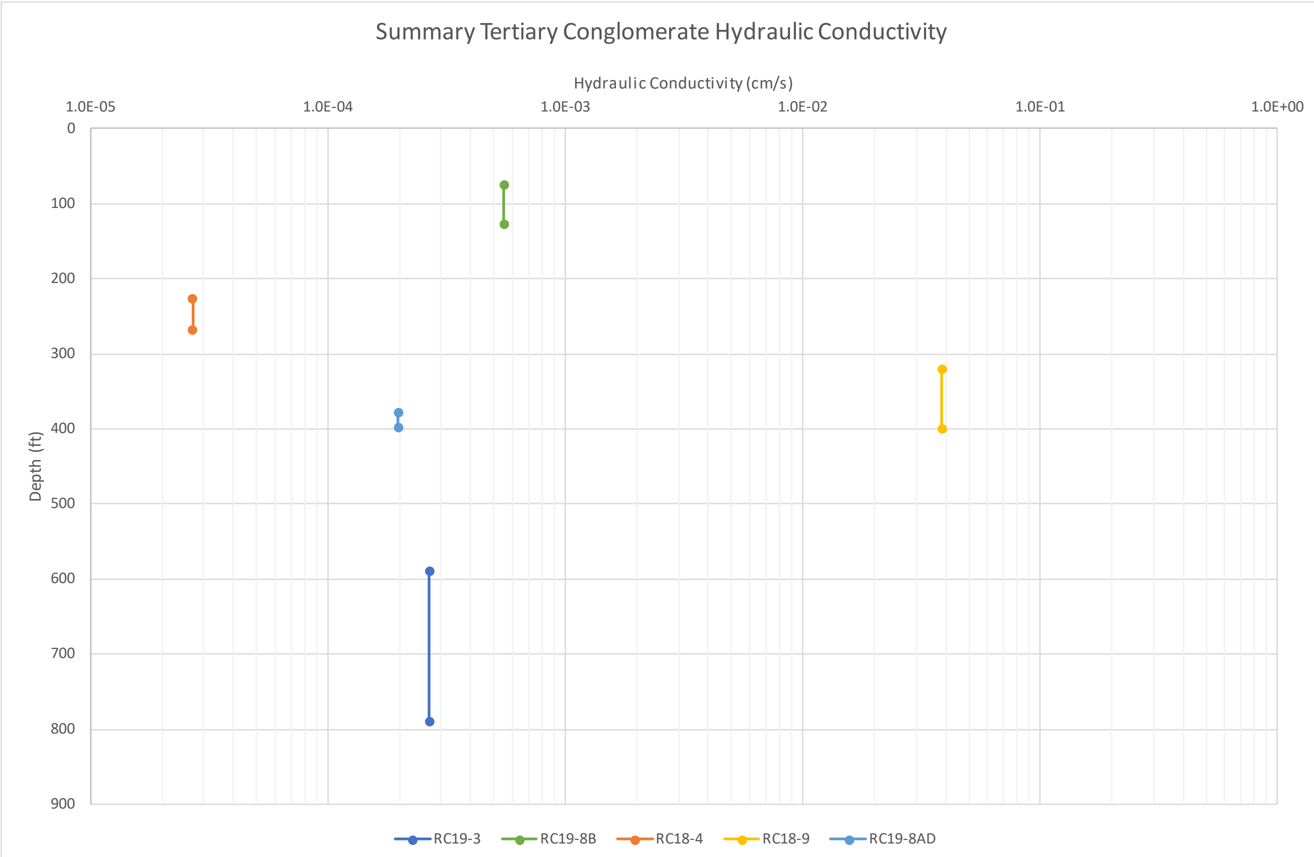


Figure 4.27 Hydraulic Conductivity of Tertiary Conglomerate as Observed from Packer Tests

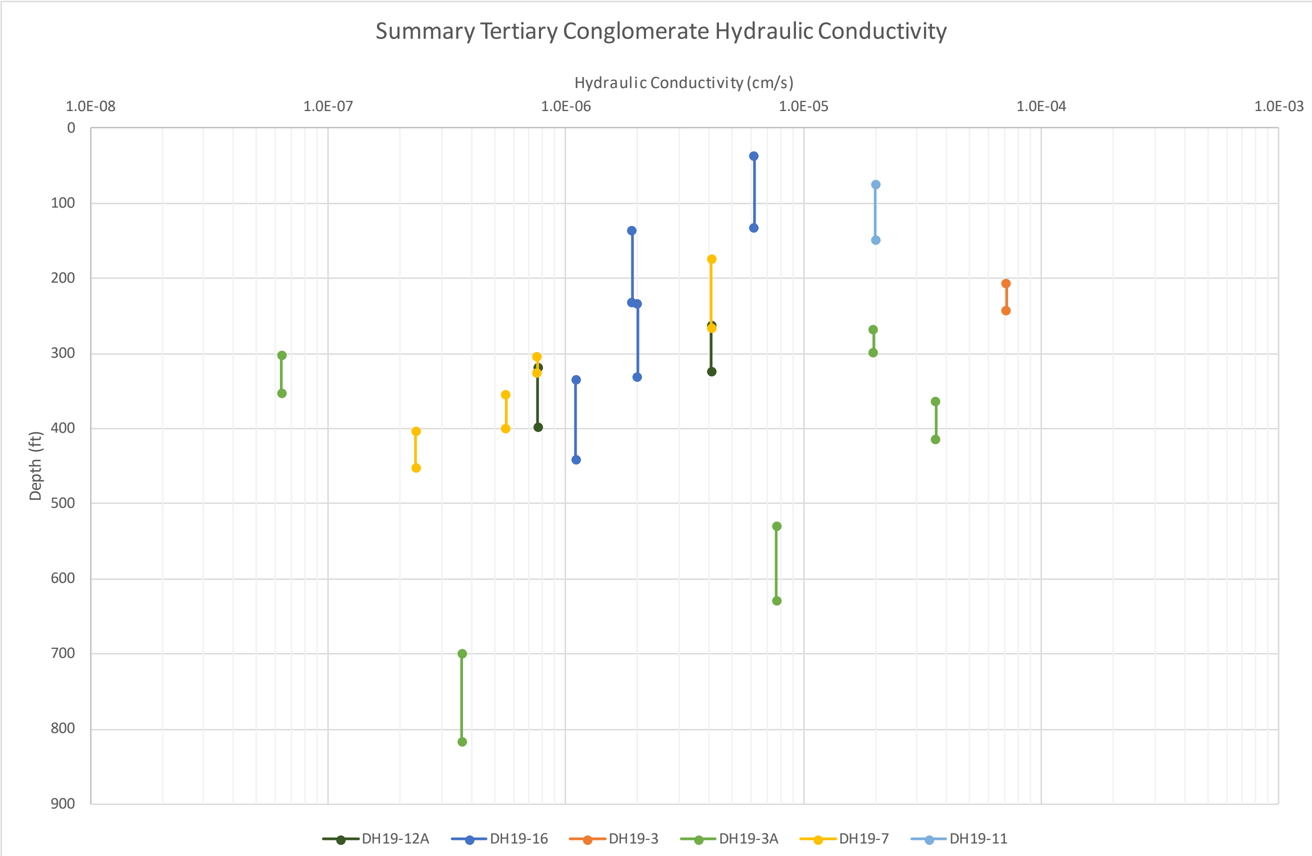
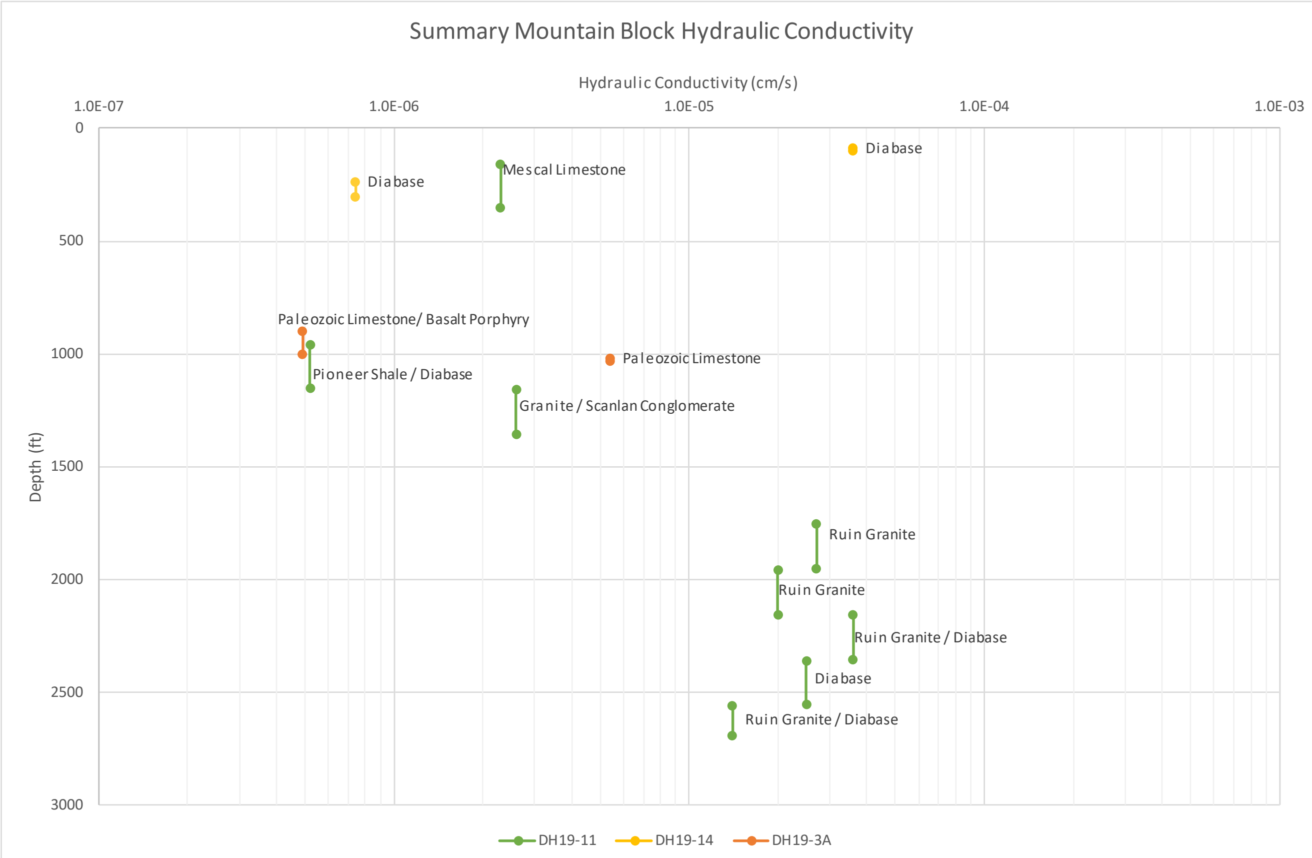


Figure 4.28 Hydraulic Conductivity of Mountain Block Lithologies as Observed from Packer Tests



5 LABORATORY TESTING RESULTS

Testing scope and methodology is described in Section 3.10. All test results completed to date are presented in a summary table in Appendix IX-A, and raw results are presented in Appendix IX-B through Appendix IX-F.

5.1 Sieve, Hydrometer, and Atterberg Limit Results

Samples of Alluvium, Pediment, and weathered Tertiary Sandstone and Conglomerate were tested to determine the particle size distribution. Samples of weathered Tertiary bedrock were selected for ease of crushing with a rubber tipped mortar and pestle. Gradation results for these units are shown on Figure 5.1.

Quaternary Alluvium (DH18-8A #1, 46 ft) had 19% fines (<0.0029 in); however, the sample did not contain the 20% to 30% coarse gravel and cobbles visually observed in the unit.

Quaternary Pediment (TP19-10 #1, 3 ft) included a layer of high plasticity clay with 66% fines, 46% clay (<0.00008 in), a plastic limit of 20%, and a liquid limit of 76%.

Residual soil derived from Tertiary Sandstone (DH18-8 #1, 25 ft) had 46% fines of low plasticity, 47% sand, and 7% gravel.

Gradation results for Tertiary Sandstone and Conglomerate are shown on Figure 5.2. Tertiary Sandstone is nearly 80% finer than fine-sand-sized, 33% fines, a liquid limit of 29%, and a plastic limit of 23% (DH18-8A SPT9, 68 ft). Tertiary Sandstone with interbedded Conglomerate (Tss/Tcg), and Tertiary Conglomerate with interbedded Sandstone (Tcg/Tss), have higher proportions of medium and coarse sand, and 17% and 21% fines, respectively (DH19-8B #10, 143 ft and DH18-5 #1, 38 ft).

Gradation results from Air Rotary cuttings of inferred Claystone or Tuff completely weathered to sandy clay (sample #81, RC18-8A at 276.9 ft) found 36% fines and 21% clay fraction (<0.002 mm); Atterberg limits found a liquid limit of 62% and plastic limit of 27%.

Figure 5.1 Grain Size Results from Quaternary Alluvium and Residual Soil Derived from Tertiary Conglomerate

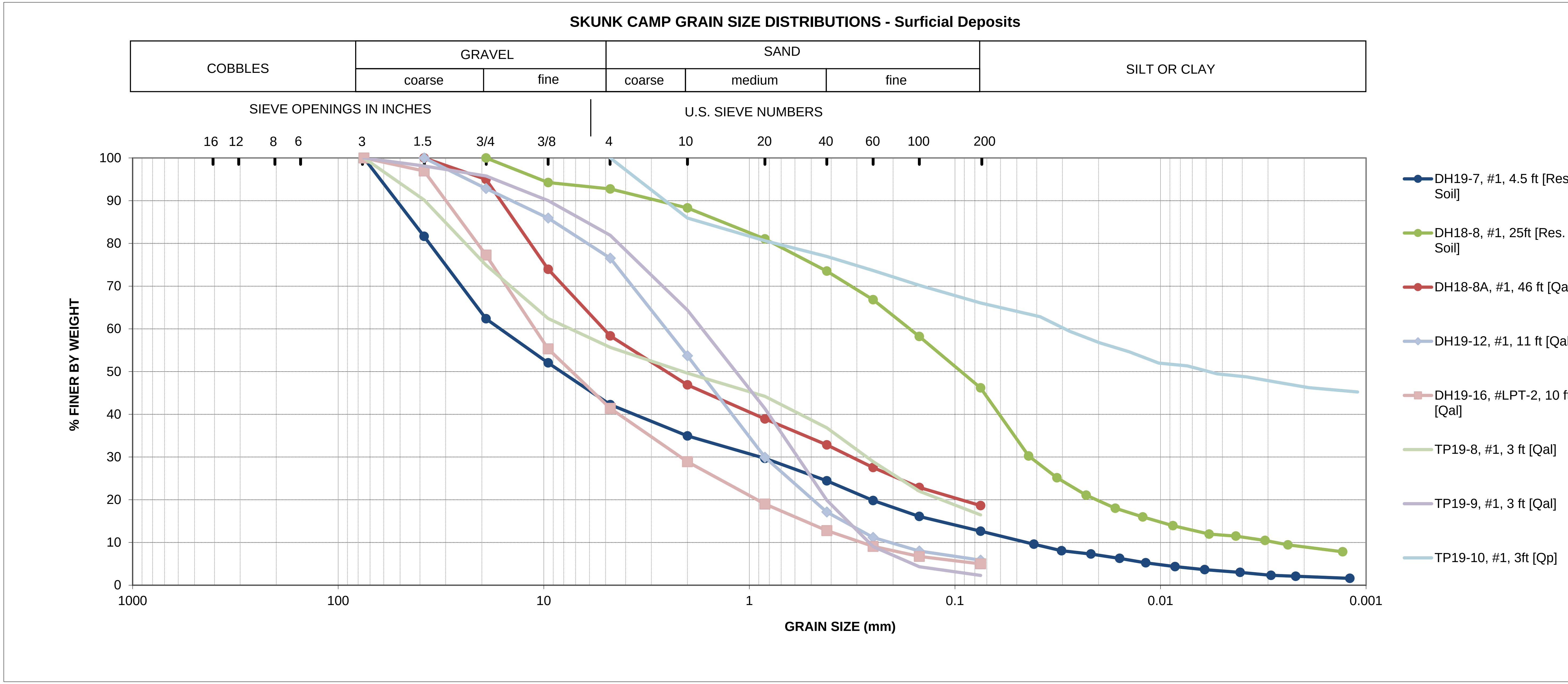
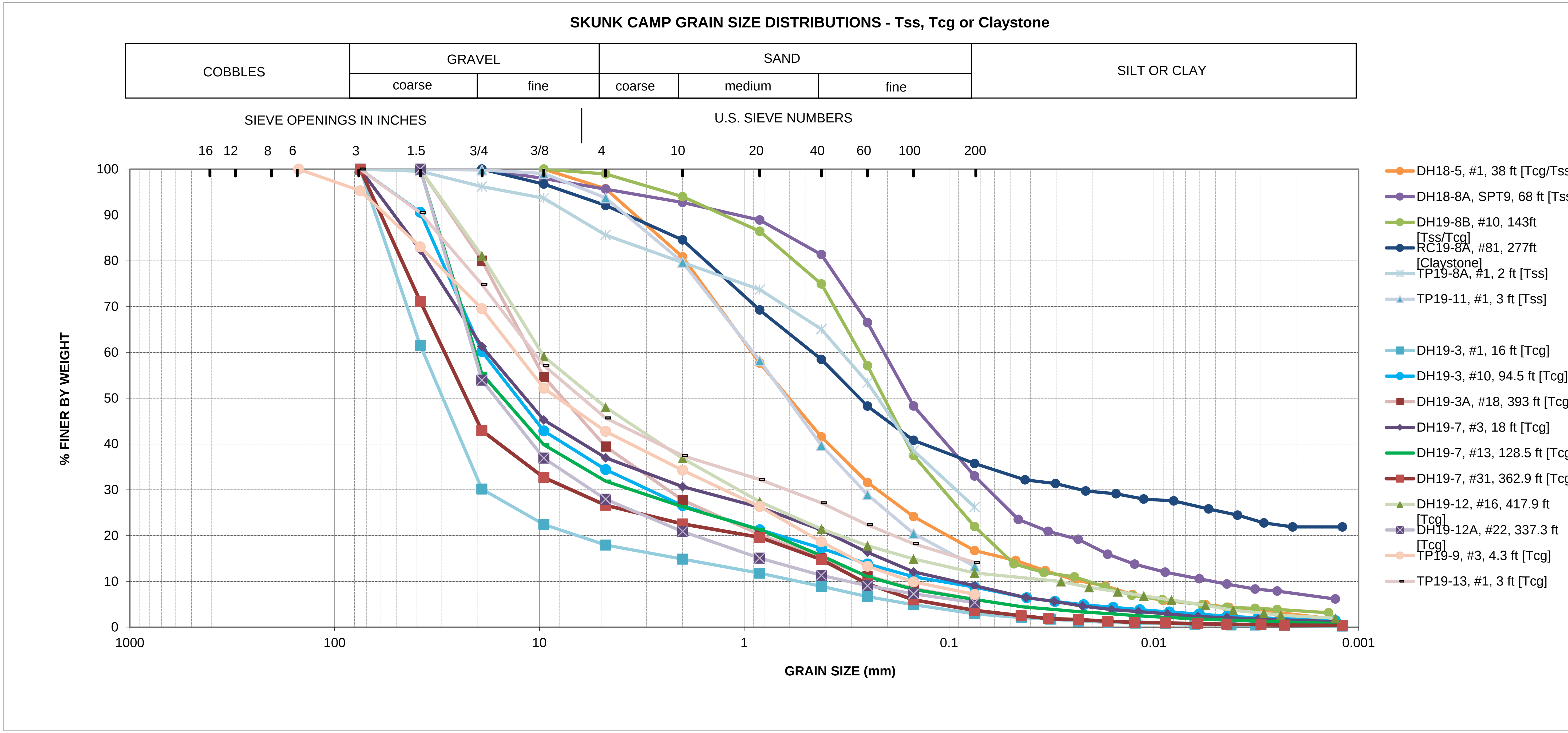


Figure 5.2 Grain Size Results from Tertiary Sandstone and Conglomerate



5.2 Point Load Testing Results

Point load testing was carried out as described in Section 3.10 on HQ3 core of Tertiary Sandstone and Conglomerate (ASTM D5731). No other rock units have been encountered to date. Results are shown on Figure 5.3. Raw data is presented in Appendix I-C.

UCS estimated by point load test was correlated to Uniaxial testing (Section 5.3) resulting in a Strength Conversion Factor (K) of 15 for Tertiary Sandstone and Conglomerate; this factor may change as additional data is collected.

UCS of Tertiary Sandstone and Conglomerate estimated by point load ranged widely from extremely weak rock (R0) to weak rock (R2), with values ranging from 59 psi to 2160 psi. The average value is 659 psi, with a median of 547 psi, which is very weak rock (R1).

As expected, the average strength of Tertiary Sandstone and Conglomerate was less for weathered zones (~300 psi) than for fresh zones (~680 psi to 870 psi for Sandstone and Conglomerate, respectively (Table 5.1). Weathered rock classifies as very weak rock (R1), and fresh rock as weak rock (R2), with only small differences between the average strength of Sandstone compared to Conglomerate, which was slightly stronger (Table 5.1). The lowest strengths were measured in weathered Tertiary Sandstone, with five of thirteen tests showing extremely weak rock (R0 - <150 psi).

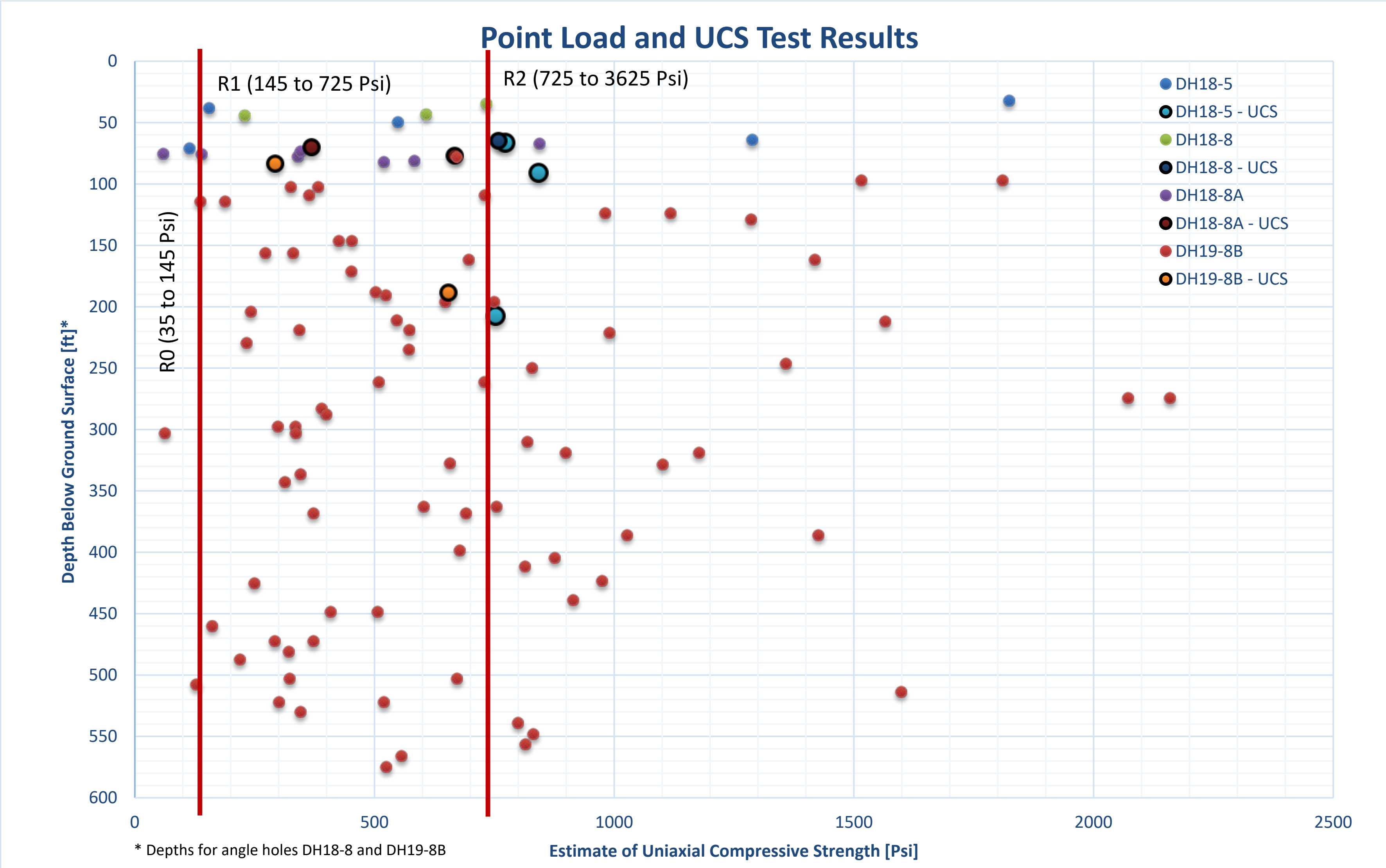
Table 5.1 UCS for facies of Tertiary Conglomerate based on Point Load Tests

	UCS from Point Load Test (psi) K=15			
	Weathered Sandstone	Sandstone	Weathered Conglomerate	Conglomerate
Max.	730	1810	389	2160
Min.	59	128	229	161
Avg.	**291**	**677**	**309**	**872**
Median	325	602	-(1)	774

Note:

1. Only three measurements were taken in Weathered Conglomerate.

Figure 5.3 Point Load and Uniaxial (UCS) Test Results



5.3 Uniaxial Unconfined Compressive Strength Tests

Laboratory testing to date includes twenty eight uniaxial measurements of UCS on drill core (Figure 5.3 and Appendix IX-D – ASTM D7012):

- Five uniaxial tests on Tertiary Sandstone from DH18-8, DH18-8A, and DH19-8B found:
  - two tests from 290 psi to 370 psi, classifying as R1 (very weak rock); and
  - three tests from 650 psi to 760 psi, falling on the boundary between R1 and R2 (very weak to weak rock).
- Eighteen uniaxial tests on Tertiary Conglomerate from DH19-3, DH19-3A, DH18-5, DH19-7, DH19-12, DH19-12A, DH19-16, and DH19-17 found UCS to range from 133 psi to 1566 psi, averaging 627 psi. Average values classify as R1 (very weak rock).
- Two uniaxial tests on Paleozoic Limestone from DH19-3A, with results of 2280 psi and 30 psi, classifying as weak rock (R2) and extremely weak rock (R0) respectively.
- One uniaxial test on Diabase from DH19-14 with a result of 2500 psi, classifying as weak rock (R2).
- Two uniaxial tests on Dripping Spring Quartzite with results of 2500 psi and 90 psi, classifying as weak rock (R2) and extremely weak rock (R0) respectively.

5.4 Direct Shear Testing

Tertiary Sandstone composed of interbedded fine grained Sandstone and Siltstone was sampled from near surface during field mapping at MP18-18 (Appendix VII – Figure VII-3). The sample was trimmed parallel to bedding and mounted in the apparatus. It was then loaded to 43 psi and soaked for 3 days. After soaking, the sample was sheared at either 87 psi or 174 psi vertical stress. Peak secant friction angle at 174 psi was 57°, and residual friction angle was 25° (Figure 5.4). Peak secant friction angle at 87 psi was 68°, and residual friction angle was 34°. Peak strength results suggest a non-linear strength envelope, with a higher strength at low stress; however, additional test results would be needed at low stress to define this curvature. This could be simplified to a peak friction angle of 30° with 170 psi of cohesion, assuming a linear relationship between normal and peak shear stress at failure.

Quaternary Pediment composed of hard, high plasticity clay was sampled from TP19-10. The sample was trimmed and mounted in the apparatus, after which it loaded to 43 psi and soaked for 3 days. After soaking, the sample was sheared at a normal stress of 170 psi. Peak secant friction angle at 170 psi was 16°, and residual friction angle was 10° (Figure 5.5).

Figure 5.4 Direct Shear test results on Tertiary Sandstone from MP18-1. Secant friction angles are labeled.

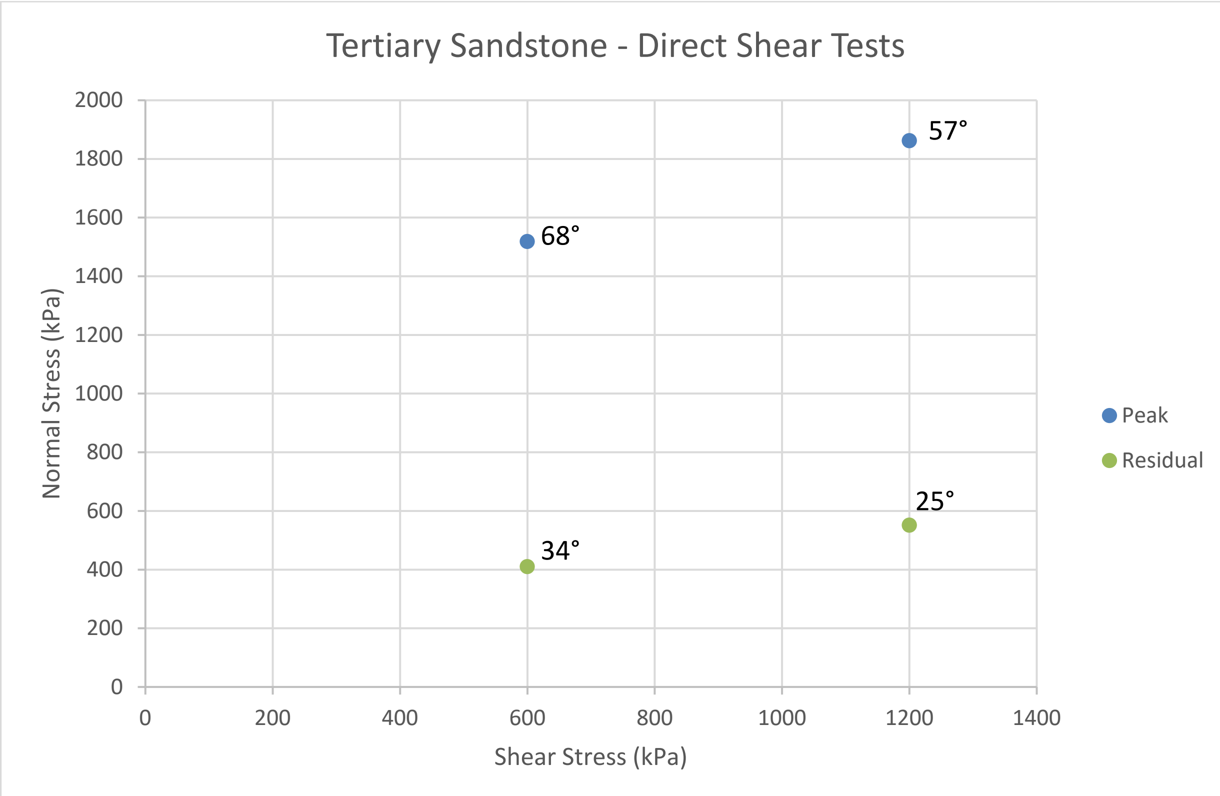
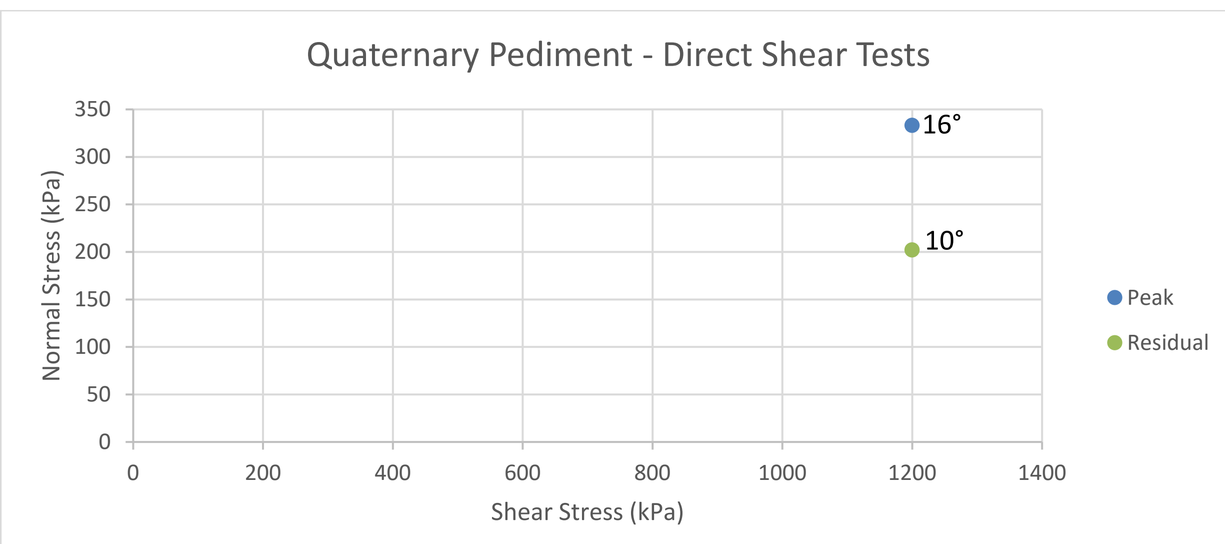


Figure 5.5 Direct Shear test results on Quaternary Pediment from TP19-10. Secant friction angles are labeled.



5.5 Collapse Test

A collapse test was carried out on sample DH19-14 #14 from 5 ft depth on residual soil composed of completely weathered Diabase and found a collapse of 0.2% after wetting at 29 psi.

5.6 Flexible Wall Permeameter

Hydraulic conductivity testing of HQ3 core comprising Tertiary Sandstone and Conglomerate was carried out to obtain a measurement of vertical hydraulic conductivity (Kv) at the laboratory scale (Table 5.2).

Table 5.2 Flexible Wall Permeability Tests on Drill Core

Sample ID	Depth (ft)	Lithology	Vertical Hydraulic Conductivity (Kv - cm/s)(1)	Comments
DH18-5 #3	56	Tertiary Conglomerate, coarse sand to fine gravel sized grains, interbedded sandstone layers, slightly weathered, strong acid reaction.	1.12×10^{-8}	Gradient of 20
DH18-8A #4	65.5	Tertiary Sandstone, medium to fine sand sized grains, moderately weathered, moderate acid reaction.	2.03×10^{-6}	Gradient of 6.5
DH19-3 #20	139.1	Tertiary Conglomerate, coarse sand to cobble sized grains, moderately weathered, strong acid reaction.	3.97×10^{-4}	Gradient of 2.2
DH19-7 #4	28.5	Tertiary Conglomerate, coarse sand to cobble sized grains, fresh (unweathered), strong acid reaction.	7.42×10^{-9}	Gradient of 74
DH19-7 #39	462	Tertiary Conglomerate, coarse sand to cobble sized grains, moderately weathered, strong acid reaction.	1.29×10^{-5}	Gradient of 29
DH19-12 #3	41.9	Tertiary Conglomerate, coarse sand to cobble sized grains, moderately weathered, strong acid reaction.	1.96×10^{-4}	Gradient of 1
DH19-16 #10	58.8	Tertiary Conglomerate, fine sand to coarse gravel sized grains, moderately weathered, moderate acid reaction.	1.95×10^{-5}	Gradient of 4.5

Note: 1. Gradient calculated as injection pressure less back pressure, divided by the sample length.

Seven samples were tested:

- DH18-5 sample #3 at 56 ft (Figure 5.6);
- DH18-8A sample #4 at 65.5 ft (Figure 5.7);
- DH19-3 sample #20 at 139.1 ft (Figure 5.8);
- DH19-7 sample #4 at 28.5 ft (Figure 5.9);
- DH19-7 sample #39 at 462 ft (Figure 5.10);
- DH19-12 sample #3 at 41.9 ft (Figure 5.11); and
- DH19-16 sample #10 at 58.8 ft (Figure 5.12).

At DH18-5, the horizontal hydraulic conductivity measured by Packer testing was approximately 2×10^{-6} cm/s (Table 4.7). If laboratory testing of Kv is representative of field Kv, this yields an anisotropy of Kv:Kh of 0.01.

At DH18-8A packer testing was not carried out. Packer testing at DH19-8B from 93 ft to 206 ft found (sub) horizontal hydraulic conductivity of 2×10^{-5} cm/s. If laboratory testing of Kv is representative of field Kv, this yields an anisotropy of Kv:Kh of 0.1.

At DH19-3, the horizontal hydraulic conductivity measured by Packer testing was approximately 7×10^{-5} cm/s (Table 4.7). However hydraulic conductivity measured by slug testing in RC19-3 was approximately 3×10^{-4} cm/s (Table 4.8). If laboratory testing of Kv is representative of field Kv, this yields an anisotropy of Kv:Kh of 1 (slug test) or 6 (packer test). The slug test is considered more representative, showing no anisotropy in coarse Conglomerate at location 3.

At DH19-7, Kv of a core sample from 28.5 ft was 7×10^{-9} cm/s on a cemented piece of core. At RC19-7, the horizontal hydraulic conductivity measured by falling head test from 4 ft to 42 ft was approximately 1 x 10-4 cm/s (Table 4.6). This suggests the presence of cemented zones with much lower hydraulic conductivity than the overall rock mass, which may result in localized extreme anisotropy if oriented sub-horizontally.

Also at DH19-7, Kv of a core sample from 462 ft was 1×10^{-5} cm/s (Table 4.7). Horizontal hydraulic conductivity measured by Packer testing was 2×10^{-7} cm/s, however while drilling RC19-7, 150 gal/min were produced from this zone, suggesting hydraulic conductivity in the order of 10^{-4} cm/s based on analyses at adjacent wells (see M&A 2019b). Anisotropy is uncertain pending additional well testing results.

At DH19-12, Kv of a core sample from 41.9 ft was 2×10^{-4} cm/s (Table 4.7). Horizontal hydraulic conductivity was not measured at shallow depths, but at depths below 200 ft, it was from 2×10^{-6} cm/s to 8×10^{-7} cm/s, suggesting anisotropy of Kv:Kh may be less than 0.001.

At DH19-16, Kv of a core sample from 58.8 ft was 2×10^{-5} cm/s (Table 4.7). Horizontal hydraulic conductivity measured by Packer testing was 6×10^{-6} cm/s. Anisotropy of Kv:Kh is approximately 3.

Figure 5.6 Flexible Wall Permeameter Sample #3 from DH18-5 at 56 ft (core diameter is 2.4 in, length is 4.0 in)

Figure 5.7 Flexible Wall Permeameter Sample #4 from DH18-8A at 65.5 ft (core diameter is 2.4 in, length is 3.0 in)

Figure 5.8 Flexible Wall Permeameter Sample #20 from DH19-3 at 139.1 ft (core diameter is 2.4 in, length is 2.8 in)

Figure 5.9 Flexible Wall Permeameter Sample #4 from DH19-7 at 28.5 ft (core diameter is 2.4 in, length is 2.7 in)

Figure 5.10 Flexible Wall Permeameter Sample #39 from DH19-7 at 462 ft (core diameter is 2.4 in, length is 2.4 in)

Figure 5.11 Flexible Wall Permeameter Sample #3 from DH19-12 at 41.9 ft (core diameter is 3.3 in, length is 3.1 in)

Figure 5.12 Flexible Wall Permeameter Sample #10 from DH19-16 at 58.8 ft (core diameter is 2.4 in, length is 2.4 in)

6 PRELIMINARY SITE CHARACTERIZATION

6.1 Site Geology

The bedrock geology of the Near West and Skunk Camp TSF sites are generally comprised of similar rock units, except Abrigo Formation, Troy Quartzite and Naco Limestone were not found at Near West.

Where available, borehole log information has also been reviewed, to aid in estimating the thickness of Tertiary Conglomerate present within the basin. Preliminary site reconnaissance visits have also been undertaken by RCM and KCBCL staff (RCM 2018) to support the interpretation of the site geology.

Water well log 55-622471, in the vicinity of the proposed Seepage Collection Facility, records Tertiary Conglomerate with an approximate thickness of 1,500 ft. A second water well, 55-205266, at the toe of the proposed PAG Cell 2, located in Skunk Camp Wash, was recorded to have encountered 20 ft of soil, with a water producing zone at 205 ft depth, likely in Tertiary Conglomerate. Other wells in the area did not have lithology logs, but are 300 ft deep or less with water levels between 75 ft and 180 ft. The exception to this is well 55-622477 at the center of the proposed Main Embankment, which was drilled to 900 ft (with a depth to water level measurement of 90 ft). Water well logs were sourced from the ADWR Well Registry (ADWR 2018), with the location of relevant wells shown on Figure 2 and Figure 4.

The bedrock and soil units exposed at the Skunk Camp site are summarized below, in order of age (youngest to oldest); and are based on results from the investigations, and regional mapping (Cornwall et al. 1981, Cornwall and Krieger 1978). The distribution of these units across the site is shown on Figure 2, with geologic sections shown on Figure 3.

6.1.1 Quaternary Alluvium (Qal)

The extent of Quaternary Alluvium over the site is shown on Figure 2. The thickness of Alluvium was identified at several locations:

- At location 8, surface geophysics, confirmed with drilling, identified the thickness of Alluvium to be up to 70 ft thick within Dripping Springs Wash at RC18-8A, and 64.5 ft thick at DH18-8A (Figure 4.1 and Figure 4.2).
- Geophysics line SL-4 suggests Alluvium within Stone Cabin Wash is of similar thickness near location 8 (Figure 4.1 and Figure 4.2).
- At DH19-3/DH19-3A/RC19-3 Alluvium was found to be 14.5 ft thick in a small tributary to Dripping Springs Wash (Figure 2).
- At DH19-12 Alluvium was found to be 22.3 ft thick in a drainage east of Stone Cabin Wash (Figure 2).
- At DH19-16 and DH19-17 Alluvium was found to be 26.5 ft thick in Dripping Spring Wash (Figure 2).

- At RC18-4 Alluvium was found to be 11 ft thick in the Mineral Creek drainage (Figure 2).
- At RC18-9 Alluvium was found to be 70 ft thick in Dripping Spring Wash; note this may be an overestimate of the thickness due to the air rotary method (Figure 2).
- At RC19-13 Alluvium was found to be 27 ft thick in Dripping Spring Wash (Figure 2).
- Alluvium thickness at the Main Embankment centerline and Seepage Collection Facility have not been identified to date.

The Alluvium is composed of:

- GRAVEL (GM) coarse to fine, sandy, some silt, some cobbles, trace boulders up to 3 ft, compact to dense, medium grey, horizontally stratified, and uncemented. No acid reaction was observed. Surface mapping found up to 20% boulders within washes (Appendix VII).

Relative density testing identified the Alluvium to be dense to very dense, with one test showing compact material (Figure 4.9 and Figure 4.10). The test showing compact material may be erroneous due to the presence of 6 in of slough in the hole prior to the test.

During mud-rotary tricone drilling through the Alluvium at DH18-8A circulation of all bentonite drilling mud was repeatedly lost into the formation (Appendix I-A). Evidence of open work gravel and cobble layers was observed in the tricone drilling action and in loss of circulation.

6.1.2 Quaternary Pediment (Qp)

The extent of Quaternary Pediment was mapped by Cornwall et al. (1971) on the Sonora Quadrangle covering most of the site, however the unit was not broken out of areas mapped as Tertiary Conglomerate on geologic mapping of El Capitan Quadrangle by Cornwall and Krieger to the east (Figure 2).

RC19-10 intersected 25 ft of Quaternary Pediment (Appendix I-A). Surface mapping by KCBCL identified the Quaternary Pediment to have formed a veneer of up to 15 ft thick on planar erosional surfaces on top of ridges along the drainages of the Mineral Creek and Dripping Spring Valleys (Appendix VII). Where Quaternary Pediment is mapped on rounded, non-planar ridges, it formed a thin veneer or lag at the surface less than 5 ft thick, with up to 30% boulders.

TP19-10 intersected Pediment composed of 2 ft of silty gravel overlying at least 2 ft of hard, high plasticity clay. The extent of the clay zone is unknown, but is interpreted to underlie flat topped ridges mapped as pediment in the lower reaches of the impoundment and Main Dam footprint. The high plasticity clay had 66% fines, 46% clay (<0.00008 in), a plastic limit of 20%, and a liquid limit of 76%.Quaternary Pediment is composed of:

- GRAVEL (GP-GM) coarse, some sand, some cobbles, some boulders, trace to some silt, reddish-brown, typically, uncemented to weakly cemented, slight to no acid reaction.
- CLAY (CI) sandy, fine to medium, trace gravel up to 3 in, low to intermediate plasticity, hard, red, dry, jointed, trace to some interbedded clayey gravel layers up to 8 in thick.

Quaternary Pediment was deposited by Quaternary streams prior to the incision of the current network of drainages.

Direct shear testing of Quaternary Pediment composed of hard, high plasticity clay was carried out on one sample from TP19-10. The sample was trimmed and mounted in the apparatus, after which it loaded to 87 psi and soaked for 3 days. After soaking, the sample was sheared at a normal stress of 174 psi. Peak secant friction angle at 174 psi was 16°, and residual friction angle was 10° (Figure 5.5).Single-ring infiltration tests were carried out in Quaternary Pediment composed of sandy clay and found low hydraulic conductivity. Relative density is estimated based on surface mapping to be compact to dense, and test pitting found hard clay. Hydraulic conductivity is unexpectedly low, and local knowledge suggests the unit is well suited to developing small surface impoundments for retaining water, with very little infiltration.

6.1.3 Travertine (Qtr)

Travertine (Qtr) was identified as an isolated outcrop near the center of the proposed TSF impoundment, and likely associated with former spring flows. This unit comprised vuggy precipitated carbonate and contains gravel and cobbles. Based on surface mapping, Travertine is a local surface layer a few feet thick and does not extend into the subsurface.

6.1.4 Tertiary Conglomerate (Tcg)

Tertiary Conglomerate is the most widely distributed rock unit on site, distributed across the majority of the proposed TSF footprint (Figure 2). This unit comprises gravels and cobbles derived from the diverse surrounding bedrock lithologies, and is generally well cemented by an arkosic sandstone and siltstone matrix.

Local water well 55-622471 indicates that approximately 1,500 ft of Tertiary Conglomerate is present at the proposed Seepage Collection Facility (Figure 2). In Mineral Valley, southeast of the Ray Mine, Tertiary Conglomerate probably does not exceed 500 ft thick (Cornwall et al. 1971). In Dripping Springs Wash, a diamond drill hole intersected 2,919 ft of Tertiary Conglomerate without encountering the basement (Cornwall et al. 1971).

Based on field mapping observations and preliminary drilling results, KCBCL has differentiated the Tertiary Conglomerate into three facies, which grade into one another (see Appendix VII, Figure VII-4 for the estimated extents of these facies).

Tertiary Conglomerate is composed of:

- CONGLOMERATE, light grayish brown and dark grayish brown, fresh. Coarse to fine gravel sized grains, some coarse to fine sand sized grains, trace cobbles, angular to sub-rounded clasts, varies from clast to matrix supported, crudely stratified to bedded sub-horizontally. Clast lithology varies by area and is primarily Limestone on the east side of the facility, and primarily Quartzite on the west side. Where fresh, HCl reaction is strong to vigorous and strength is weak to medium strong (R2-R3) (Appendix VII, Figure VII–3.4).

- Interbedded SANDSTONE and CONGLOMERATE, light tannish brown, coarse to fine sand sized grains, coarse to fine gravel sized grains, typically matrix supported, crudely stratified to bedded sub-horizontally. Where fresh, HCl reaction is strong and strength is very weak to weak (R1-R2) (Appendix VII, Figure VII–3.5).
- SANDSTONE: tannish brown, medium sand sized grains to fine sand sized grains, slightly weathered, very weak (R1), moderate HCl reaction, crudely stratified sub-horizontally, trace dispersed angular fine gravel, breaks easily horizontally on rough planar surfaces. (Appendix VII, Figure VII–3.6).

All facies of Tertiary Conglomerate include highly weathered zones up to several feet thick, typically becoming less frequent with depth but still present at several hundred feet below surface (DH19-8B, DH19-3, DH19-7). Drill core in weathered zones displayed low RQD (Appendix I-A). Fresh Conglomerate, especially below 200 ft depth, typically has 100% RQD. Weathering is controlled by the degree of dissolution of the carbonate cement bonding the rock. Acid reaction ranges from strong in fresh rock too weak to no reaction in weathered rock.

Intact rock strength of Tertiary Sandstone (Tss) was measured by point load and by uniaxial unconfined compressive strength tests (Table 5.1):

- Weathered Tss
  - Point load found strengths from 60 psi to 730 psi, averaging 290 psi (very weak rock – R1).
- Fresh Tss
  - Point load found strengths from 130 psi to 1800 psi, averaging 680 psi (weak rock – R2).

Intact rock strength of Tertiary Conglomerate (Tcg) was measured by point load and by uniaxial unconfined compressive strength tests (Table 5.1):

- Weathered Tcg
  - Point load found strengths from 230 psi to 390 psi, averaging 310 psi (very weak rock – R1).
- Fresh Tcg
  - Point load found strengths from 160 psi to 2160 psi, averaging 870 psi (weak rock – R2).

Shear strength of Tss was measured by two direct shear tests on a sample of interbedded fine sandstone and siltstone, soaked for 3 days at normal loads of 87 psi and 174 psi. At 174 psi, peak secant friction angle was 57°, and residual friction angle was 25°. Peak secant friction angle at 87 psi was 68°, and residual friction angle was 34°. Peak strength results suggest a non-linear strength envelope, with a higher strength at low stress; however, additional test results would be needed at low stress to define this curvature. This could be simplified to a peak friction angle of 30° with 170 psi of cohesion, assuming a linear relationship between normal and peak shear stress at failure.

Direct shear testing of Tss samples from the Near West site found peak friction angle of 37°, and residual friction angle of 10°. Tss at Near West contained interbedded clay layers, which have not been observed at Skunk Camp to date.

Shear strength of Tcg has not been directly measured due to the presence of gravel.

Televiewer profiles in Appendix II indicate very widely spaced discontinuities occur parallel to bedding, with dip angles of less than 20°, with the exception of two steeply dipping discontinuities in RC19-8A, (Figure 4.14), and a single steeply dipping discontinuity at RC19-15 (Appendix II-A). Two of the three steeply dipping discontinuities are open joints (~1/4 in aperture), and all three are sub-parallel to the inferred orientation of the Dripping Spring fault, striking north-northwest.

The televiewer profiles suggest most of the defects observed in drill core are mechanical breaks caused by drilling. Sub-vertical calcite veins typically less than 0.5 in, up to 1 in thick, were also observed at the surface during KCBCL mapping, likely formed by frost damage and or vegetation.

Bedding dip directions are variable, likely as a result of the high energy depositional environment, but preferentially dip downstream or towards Dripping Springs Wash. At RC18-4 bedding dips to the north, towards the Mineral Creek drainage.

An airfall Tuff unit is noted to occasionally be on top of the Tertiary Conglomerate, or interbedded with the upper portions of the unit, in some areas, particularly to the north of Ray Mine (Cornwall et al. 1971). In RC18-8A, at 276.9 ft below surface, a one ft thick layer of completely weathered Claystone was observed within the Tertiary Conglomerate. Laboratory testing identified 36% fines and 21% clay fraction (<0.002 mm) in this Claystone unit. This layer may be volcanic Tuff completely weathered to clay. In DH19-8B, the caliper shows the hole widening from 304.8 ft to 305.2 ft (269 ft vertical below surface) in a zone of core loss, that may represent another zone of Claystone (Appendix III).

6.1.5 Tertiary Rhyodacite (Tr2)

Vertical Tertiary Rhyodacite dikes are sparsely present within the region of the Skunk Camp site, extruding through the Diabase to the north of the impoundment, and through the Martin Limestone and Troy Quartzite located west of the proposed Seepage Collection Facility. The unit is described as a strong rock which weathers to boulders at surface exposures.

6.1.6 Rattler Granodiorite (Ki)

Rattler Granodiorite is exposed approximately two miles south of the proposed TSF in the Dripping Springs Mountains. It is described by Cornwall et al. (1971) as a medium to coarse grained intrusive rock, intruded into Paleozoic Limestones and cross-cut by Tertiary Rhyodacite in places.

Rattler Granodiorite was intersected in DH19-17 where it was composed of Quartz Diorite, light gray, coarse grained, highly fractured, with iron-oxide staining on joints (Appendix I-A).

6.1.7 Naco Limestone (Pn)

The Naco Limestone is only exposed within a block of Paleozoic Limestones 500 ft south (downstream) of the Main Embankment of the proposed TSF (Figure 2). Naco overlies Escabrosa Limestone, which is present to the east of the proposed TSF, and dips to the east-southeast towards the TSF (Figure 2). Naco may be present in the subsurface at the contact between Tertiary Conglomerate and Paleozoic Limestone along the eastern edge of the TSF.

The unit is composed of white to grey massive Limestone, medium strong rock (R3), with strong acid reaction, slight surface dissolution, and moderately spaced calcite infilled joints. There is no regional evidence of caves forming in this unit, and field mapping observations found no evidence of epikarst development (Appendix VII).

6.1.8 Escabrosa Limestone (Me)

The Escabrosa Limestone unit is exposed within a block of Paleozoic Limestones 500 ft south (downstream) of the Main Embankment of the proposed TSF, and to the northeast of the proposed TSF along Skunk Camp Wash and minor drainages (Figure 2). Escabrosa Limestone is likely present in the subsurface at the contact between Tertiary Conglomerate and Paleozoic Limestone along the eastern edge of the TSF.

Escabrosa Limestone was intersected in DH19-12, where it was composed of Limestone, grey, massive, relatively pure limestone with zones of up to 15% dissolution cavities to 3 in diameter (Appendix I-A). Drill fluid circulation was lost within the unit on a zone of dissolution features.

At DH19-3A, Paleozoic Limestone was intersected, but did not show evidence of dissolution. This unit may be Naco or Martin Limestone. The unit will be confirmed in upcoming thin section analysis.

In upland areas of the Escabrosa Limestone there is prominent honeycomb surface dissolution, and slight to moderate epikarst development (Appendix VII). Within the drainages where erosion has refreshed the surface, there is only slight surface dissolution and no evidence of epikarst. Along Skunk Camp Wash a narrow slot canyon approximately 20 ft deep has been eroded in the Escabrosa Limestone (Appendix VII).

Based on core samples from DH19-12, Escabrosa Limestone has an RQD ranges from 14% to 100%, with an average of 80% (Appendix I-A). Rock strength based on observation of core ranges from weak rock (R2) to strong rock (R4), typically strong rock (R4).

At the Near West site, Escabrosa Limestone was assessed for dissolution potential (KCB 2018): the soluble content was measured to be up to 98%, with cavities up to 1 ft in diameter within the proposed footprint, and caves extending 10’s of feet into the subsurface outside the footprint, created by dissolution. Subvertical solution openings, typically 2 in to 3 in wide, were observed at the surface leading into the subsurface. Based on this Limestone study conducted for the Near West site (KCB 2018), the Escabrosa unit is likely to contain dissolution features.

6.1.9 Martin Limestone (Dm)

Martin Limestone underlies the Escabrosa Limestone, and is exposed within a block of Paleozoic Limestones 500 ft south (downstream) of the Main Embankment of the proposed TSF, and to the northeast of the impoundment along Skunk Camp Wash and minor drainages (Figure 2).

The unit is composed of medium to dark grey Limestone, medium strong rock (R3), with moderate acid reaction. KCBCL mapping identified some surface dissolution and no to slight epikarst development (Appendix VII).

At Near West, the soluble content of this unit was measured to be up to 98% (KCB 2018). Sub-vertical solution openings, typically less than 1 in wide, were rarely observed at the surface leading into the subsurface. Based on this Limestone study conducted for the Near West site (KCB 2018), the Martin unit has the potential to contain dissolution features.

6.1.10 Abrigo Formation (Ca)

Abrigo Formation comprises interbedded Mudstone, Siltstone, Sandstone, and Quartzite. It is exposed in narrow bands along the Dripping Springs Mountains (Cornwall et al. 1971). The Formation is recessive and forms slopes with poor exposure.

6.1.11 Bolsa Quartzite (Cb)

Bolsa Quartzite consists of tan, medium to coarse grained quartzite rich sandstone in massive or crudely graded beds interbedded with medium to fine grained, cross bedded and planar bedded sandstone with dark tan to brown laminations (Cornwall et al. 1971). At the base of Bolsa Quartzite is a boulder conglomerate layer up to 5 m thick. The lower sequence contains dark bands of sediments derived from the underlying diabase. The upper sequence is finer grained and lighter colored.

Surface mapping at Near West found coarse to fine grained quartz arenite, with localized brecciation. Cb tends to form resistant outcrops or have a surface cover of angular boulders (KCB 2018c).

6.1.12 Troy Quartzite (Yt)

Troy Quartzite is exposed throughout the Dripping Spring Mountains, to the west of the proposed facility, and is described as consisting of Sandstone and Quartzite units with thin layers and lenses of poorly sorted to well-sorted pebbles and granules interbedded with the Quartzite units forming cliffs, with intervening slopes underlain by more friable sandstones.

Surface mapping identified massive, widely jointed Quartzite composed of white quartz with speckled black, closely spaced subvertical joints. Rock strength was estimated in the field as strong rock (R4) (Appendix VII). Large freestanding pillars, cavern-like cavities where large blocks have fallen from high bluffs, and orthogonal subvertical joints were also found. This unit appears very durable and forms blocks several feet in diameter.

6.1.13 Diabase (Ydb)

Diabase is exposed upstream of the facility to the northwest and northeast of the proposed TSF, this unit forms the majority of faulted blocks of Apache Group rocks (Figure 2). At Near West it was observed that this unit is weathered to a regolith composed of mostly fine sand at surface, and is highly weathered and closely fractured to a depth of up to 60 ft. This unit was also observed to be highly weathered at the Skunk Camp site during KCBCL mapping (Appendix VII).

Diabase was intersected in DH19-11 and DH19-14 along the eastern foothills of the Dripping Spring Mountains, where it is interlayered with Apache Group sedimentary units (Figure 2, Appendix I-A). Twelve feet of residual soil derived from Diabase was found at DH19-14, composed of silt, some fine to coarse angular gravel, with low plasticity. In general, the unit was closely fractured, but fractures are very tight or healed with calcite.

Based on field investigations at Near West, RQD was observed to vary from 0% to 100% from surface to 140 ft in the Diabase (KCB 2018c). Below 140 ft at Near West RQD was observed to be typically greater than 50%, and often 100%. Below the upper weathered zone at Near West, rock strength is weak to medium strong rock (R2-R3).

6.1.14 Basalt (Yb)

Basalt is exposed in isolated small outcrops within the Apache Group rocks, and is found within areas of Mescal Limestone south of Dry Spring on the west side of the proposed TSF (Figure 2). KCBCL mapping identified the Basalt to be weathered with rust-staining, fine-grained, closely fractured and has medium strength (R3).

6.1.15 Mescal Limestone (Ym)

The Mescal Limestone is exposed along the western edge of the proposed TSF in the foothills of the Dripping Spring Mountains, and in the upper reaches of Pinal Peak east of the TSF (Figure 2). Approximately 5 acres of Mescal Limestone extent occurs within the western edge of the proposed TSF Impoundment footprint approximately 2,700 ft upstream of the Main Embankment centerline.

Mescal Limestone was intersected in DH19-11 and DH19-14, where it was composed of Limestone or Dolomite, slightly weathered, with no evidence of dissolution features (Figure 2, Appendix I-A).

KCBCL surface mapping identified the Mescal Limestone to be white to tan, finely bedded Limestone, medium strong to strong rock (R3 to R4), with no open joints, and weak to moderate reaction to acid (Appendix VII). No epikarst and slight surface dissolution was observed.

Based on field investigations at Near West, the RQD of this unit is generally between 60% and 100%. It is typically fresh, with rare zones of highly weathered rock, especially at contacts with Diabase, where zones of dissolution may occur (KCB 2018c). Rock core was logged as medium strong to strong rock (R3-R4) at Near West. At Near West, the soluble content was measured to be up to 82% (KCB 2018). Surficial dissolution was observed on sub-vertical joints but the joints became tight at the ground surface.

Based on the Limestone study conducted for the Near West site (KCB 2018), the Mescal unit is unlikely to contain large dissolution features.

6.1.16 Dripping Spring Quartzite (Yds)

The Dripping Spring Quartzite is exposed within fault blocks near Haley Spring to the west of the proposed TSF, and the Mescal Mountains to the east of the proposed TSF. It is composed of laminated siltstone grading downwards into fine-grained sandstone and coarse-grained Quartzite.

Dripping Spring Quartzite was intersected in DH19-11 and DH19-14 along the eastern foothills of the Dripping Spring Mountains (Figure 2, Appendix I-A). Composition varied from Quartzite to Siltstone, varying from intact to brecciated, and is weak to medium strong rock (R2-R3). Weathering is slight to moderate, and is highest near faults within the Apache Group.

Prominent zones of brecciation have been observed within the unit at Near West, observed at the surface and in drill holes (KCB 2018c). RQD measured at Near West was variable between 40% and 90%, with occasional zones as low at 0%. Core descriptions from Near West classify intact Quartzite as weak to medium strong rock (R2-R3), and moderately weathered.

6.1.17 Pinal Schist (Xp)

The Pinal Schist facies are the oldest exposed rocks within the region. This unit is a medium- to fine-grained, low to moderate grade metamorphic rock. Generally, the Pinal schist is very closely fractured with common zones of gouge and crushed rock in core samples. At Near West, RQD has been measured as typically low (often zero) with alternating zones of very closely fractured rock, and zones of more widely-spaced fractures, with no clear trend with depth. Foliation-parallel defects are dominant, and persistence is variably low to high (3 ft to 60 ft). Joint surfaces have been observed at Near West to be rough to smooth, with some slickensided, highly weathered surfaces with clay gouge. Intact zones of Pinal Schist were observed at Near West to be medium strong to strong rock (R3-R4); however, much of the core was very weak rock (R1) or too weak to test.

6.2 Evidence of Quaternary Faulting

There is little mapped evidence of faulting within the Tertiary sedimentary rocks within the vicinity of the proposed TSF. Mapped evidence is limited to an approximate 2,300 ft length of the Ransome Fault and an approximate 4,000 ft length of an unnamed sub-fault which cross Tertiary rocks and Quaternary Pediment west of Looney Spring. There was no evidence found of Quaternary faulting, and limited evidence of Tertiary faulting seen in KCBCL field mapping (Appendix VII). Evidence of Tertiary faulting is the large thickness of Tertiary Conglomerate close to the Dripping Springs Mountains (over 2000 ft - Cornwall and Kreiger 1971), however no surface expression was seen by KCBCL.

Geotechnical holes DH18-8 and DH19-8B were drilled at an angle of 60° from horizontal toward the west, towards the inferred position of the Dripping Spring Fault based on mapping by Cornwall et al. (1971). The hole locations were adjusted based on the results of geophysical line SL-4 (see Section 4.1). Neither hole encountered faults, and DH19-8B was drilled to 651 ft deep without conclusive evidence of faulting. No indications of Quaternary faulting have been seen in the results to date.

6.3 Evidence of Potential Karst

Limestone rocks can undergo dissolution and form karstic terrain. Regionally, several large caves are found in southern Arizona, and are formed within Escabrosa Limestone. A literature review, based on regional data, as well as a field mapping and laboratory testing program, was conducted on the Escabrosa, Martin, and Mescal Limestones within the vicinity of the Near West site (KCB 2018). Escabrosa Limestone (Mississippian) is composed of nearly 100% calcite or dolomite and is known to be cave forming. Martin Limestone (Devonian) has similar composition as Escabrosa, and although caves have not been found within this formation, is potentially cave forming based on its similarity to Escabrosa Limestone. Mescal Limestone (Pre-Cambrian) has a higher proportion of non-soluble minerals, and is not judged to be potentially cave forming (KCB 2018).

Core samples from DH19-12 found zones of up to 15% dissolution cavities to 3 in diameter, supporting the potential for Escabrosa Limestone to host karst, although voids larger than 3 in were intersected. DH19-3A did not find evidence of dissolution.

6.4 Site Hydrogeology

A summary of the site hydrogeology is provided in the following sections, comprising the hydrostratigraphic units; groundwater levels, flow, recharge and discharge; and, groundwater quality.

6.4.1 Hydrostratigraphic Units

Interpretation of the hydrostratigraphic units across the Skunk Camp site has been completed based on the background information review (mapped geology, ADWR well logs, previous hydrogeological reports) and results of the field investigation program. These units are summarized as follows.

Quaternary Alluvium

The Quaternary Alluvium (Qal) is typically associated with water courses across the Skunk Camp site, including Dripping Springs Wash, Stone Cabin Wash, Skunk Camp Wash and their associated tributaries. Field investigation results indicate that at the downstream extent of the proposed TSF footprint, adjacent to Dripping Springs Wash, the Alluvium is up to 70 ft thick. It is anticipated that the thickness of the Alluvium would decrease upstream from this location.

Limited groundwater was identified in the Alluvium in the vicinity of the proposed TSF site, with limited saturated thickness observed within the vicinity of Location 8. The VWP installed at the base of the alluvium in DH18-8A did not display saturated conditions following installation, however, minor saturated conditions were observed following rainfall events. Moist conditions within this formation were encountered during the hydrogeological borehole drilling program (rotary air circulation), however, groundwater was not observed. Hydraulic testing of the Alluvium identified this unit to have a hydraulic conductivity of 10^{-1} cm/s and 10^{-3} cm/s (Table 4.6). Additional pump testing is being undertaken by M&A (2019b, c).

Tertiary Conglomerate / Sandstone

Underlying the Alluvium within the vicinity of the proposed TSF site is the Tertiary Conglomerate / Sandstone. For the purposes of the hydrogeological conceptualization, the Quaternary Pediment (Qp), a veneer of sand and gravel forming raised pediments in the center of the proposed TSF, is considered to be part of this hydrostratigraphic unit. This unit is laterally extensive, including a large area upstream of the proposed TSF to the north and north-northeast. Site investigations and a review of available background information identify the Tertiary Conglomerate / Sandstone to be up to ~2,900 ft adjacent to Dripping Springs Wash, interpreted to be the location of the thickest portion of the unit. A decrease in formation thickness is interpreted away from Dripping Springs Wash, towards the lateral extents of the unit. Existing regional mapping of this unit have identified distinct Conglomerate and Sandstone units as part of the Tertiary package, which have been mapped as Tcg and Tss, respectively. Within the vicinity of the proposed TSF layout Tcg has been mapped, while the Tss has been mapped downstream of the proposed TSF. However, as discussed in Section 6.1.4 and below, localized mapping and drilling results have identified local variability between Conglomerate and Sandstone within the Tertiary unit.

Three facies of the Tertiary Conglomerate have been identified, comprising Conglomerate; interbedded Sandstone and Conglomerate; and, Sandstone. These facies occur as consolidated strata within the formation, and vary relative to location across the unit extent, with coarser grained strata located higher in the catchment. Based on the available information to date from the background review and site investigations, the Tertiary unit is heterogenous with no distinct marker beds or facies that is laterally extensive across the unit. This is evident by the similar observed water levels and elevations in the area within the vicinity of location RC19-8. Figure 6 displays water levels at ten monitoring locations screened and installed at depths between 95 ft and 550 ft below ground surface. The static water level elevations are all within 10 ft of each other regardless of the installation depth and suggests the Tertiary unit is hydraulically connected to at least the maximum depth drilled of approximately 500 ft.

Groundwater was encountered within the Tertiary unit at depths of 150 ft to 380 ft below the ground surface. This was observed in both boreholes drilled during the site investigation program and available well logs of established domestic / livestock water wells within the vicinity of the proposed TSF. Following the intersection of groundwater, during the current drilling program, groundwater levels rose above the intersection levels and groundwater yields increased, indicative of an aquifer with some degree of confinement. This semi-confined characteristic of the aquifer is further suggested by the results of the hydraulic testing completed on this unit with drawdown extending a lateral distance of greater than 650 ft in less than two hours of pumping. The calculated storativity values ranged between 0.0014 and 0.00023, which again is indicative of the aquifer being both continuous and semi-confined.

These characteristics will be further refined based on the results of pump testing by M&A (2019b, c). Hydraulic testing of this unit also identified hydraulic conductivity of 6×10^{-7} to 4×10^{-2} cm/s for the conglomerate; and, 2×10^{-6} to 2×10^{-3} cm/s for the sandstone.

Groundwater flow within the Tertiary unit is interpreted to be via interconnected fractures within the formation, along bedding plane of the various strata of the formation and, to a less extent, associated with the primary porosity of the formation, although this would be limited by the cementation of the unit.

Tertiary Faulting

Regional Tertiary faults have been identified across the Skunk Camp site, with the two most prominent and relevant to the proposed TSF being the Dripping Springs Fault and the Ransome Fault (see Section 6.2). Being Tertiary age, both faults are interpreted to intersect through Tertiary Conglomerate, and were likely active during deposition of the formation (Cornwall et al. 1971). The influence of these faults on Tertiary Conglomerate is uncertain as site investigations to date have not encountered / tested these faults. KCBCL anticipates that the hydraulic characteristics of these faults will be addressed as part of the subsequent field investigation program.

Drilling to date has not encountered evidence confirming the presence of these fault splays, preliminary interpretation of the hydraulic conductivity distribution across the study area have indicated potential correlation between higher hydraulic conductivity values and the interpreted fault alignment.

Other Units

Underlying and beyond the extent of the Tertiary unit are several older bedrock units (Mountain Block units) comprising Limestones, Quartzites, Diabases, Basalts and Schists. Hydraulic testing of these units, based on packer testing completed during the drilling of DH19-3A, DH19-14 and DH19-11, indicate that hydraulic conductivities of the Mountain Block units range from 5×10^{-7} to 3×10^{-5} cm/s. Additional pump testing is being undertaken by M&A (2019b, c).

6.4.2 Groundwater Levels, Flow, Recharge and Discharge

Quaternary Alluvium

Limited groundwater was identified within the Quaternary Alluvium. However, due to the relatively high hydraulic conductivity (1.0×10^{-5} cm/s to 1×10^{-3} cm/s) of the Alluvium, it is interpreted that during and following periods of rainfall, associated runoff and flow within the various washes within the catchment, recharge to the Quaternary Alluvium would occur. Therefore, the groundwater flow within this unit can be considered as an ephemeral system with the aquifer draining down gradient (towards the southeast, parallel with Dripping Springs Wash) following recharge events towards the Alluvium of the Gila River, or potentially infiltrating into the underlying Tertiary units, where zones of higher hydraulic conductivity (e.g. zones of fracturing) allow this. Preliminary interpretation of test pumping results completed by M&A (2019b) have identified the occurrence of this recharge mechanism, with monitoring results from pumping tests completed on pumping wells screened in the Tertiary displaying re-circulation of test discharge water that has been discharged into adjacent alluvium washes.

Discharge from the alluvium may also occur via evapotranspiration from vegetation within the Alluvium extent.

Observed groundwater levels in the underlying Tertiary Conglomerate are below the interpreted base of the Alluvium. Therefore, within the vicinity of the proposed TSF, it is unlikely that Tertiary Conglomerate contributes to flow in the overlying Alluvium, resulting in a downward hydraulic gradient from the Alluvium to Tertiary Conglomerate.

Tertiary Conglomerate

The interpreted groundwater piezometric surface for the Tertiary Conglomerate is provided in Figure 4 Groundwater flow in Tertiary Conglomerate is towards the southeast, with a gradient of approximately 0.000189. Site investigations to date have predominantly focused on the area within the vicinity of the proposed TSF; however, it is interpreted that recharge to this unit is likely to occur beyond the extent of the proposed TSF footprint to the north and north-northeast of the proposed TSF, where Tertiary Conglomerate occurs at the surface within the Pinal Peak catchment.

Discharge of groundwater from Tertiary Conglomerate is likely to occur downstream of the proposed TSF. It is anticipated that groundwater levels in this unit will become shallower at lower topographic elevations, closer to the Dripping Springs Wash confluence with the Gila River. At these lower elevations, groundwater discharge may occur via hydraulic connection with the overlying Quaternary Alluvium. Within the vicinity of the proposed TSF, the groundwater levels of Tertiary Conglomerate are below the elevation of the Alluvium, therefore, a downward vertical gradient is observed between these units.

7 CLOSING

This report is an instrument of service of KCB Consultants Ltd. The report has been prepared for the exclusive use of Resolution Copper Mining LLC (Client) for the specific application to the Resolution Copper Project, Skunk Camp Site Investigation. The report's contents may not be relied upon by any other party without the express written permission of KCB Consultants Ltd. In this report, KCB Consultants Ltd. has endeavored to comply with generally accepted professional practice common to the local area. KCB Consultants Ltd. makes no warranty, express or implied.

The analyses, conclusions and recommendations contained in this report are based on data derived from available subsurface explorations. The methods used indicate subsurface conditions only at the specific locations where samples were obtained or where in situ tests would infer, only at the time they were obtained, and only to the depths penetrated. The samples and tests cannot be relied on to accurately reflect the nature and extent of strata variations that usually exist between sampling or testing locations.

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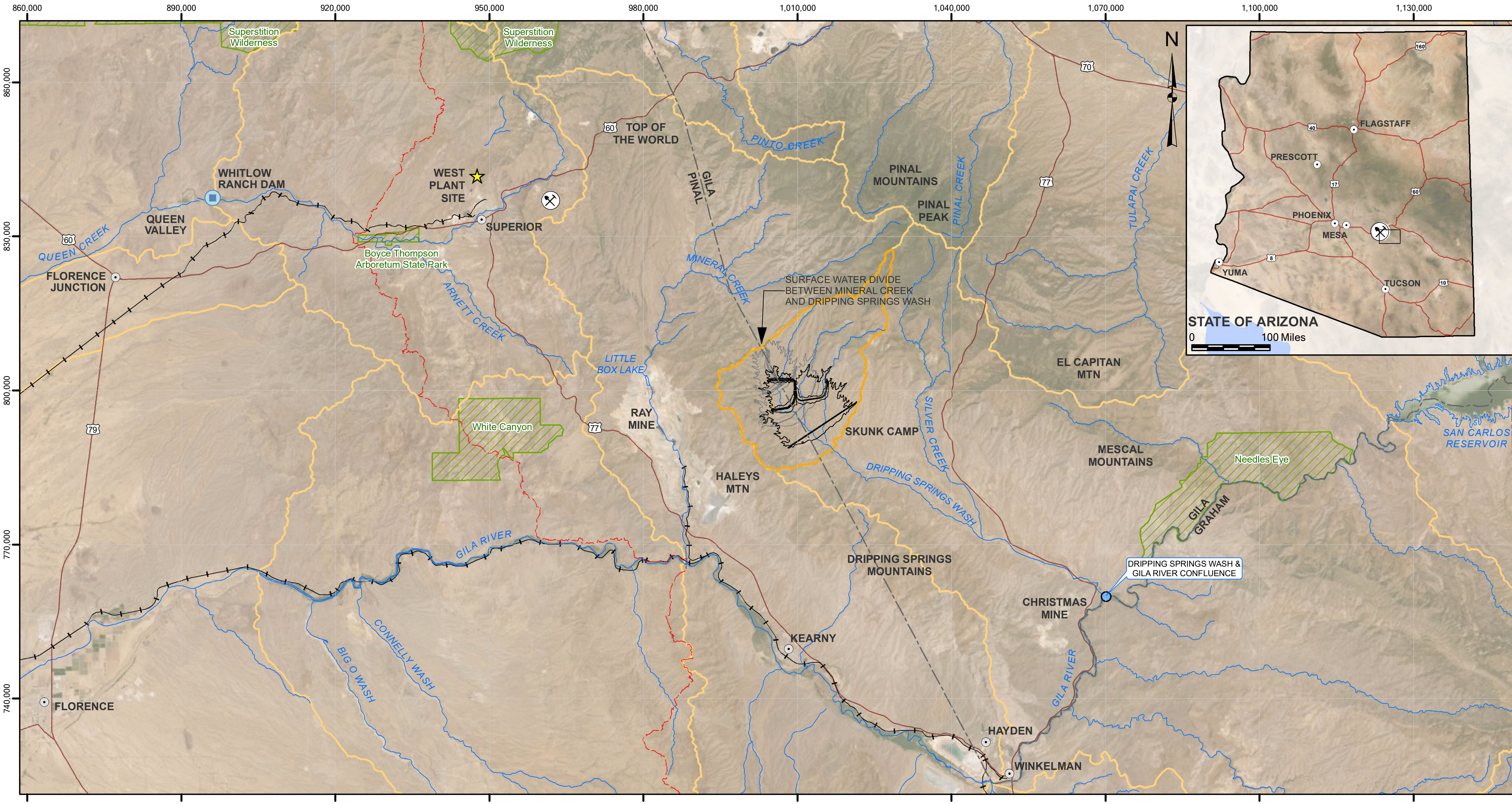
FIGURES



LEGEND

- SKUNK CAMP TAILINGS STORAGE FACILITY - OoM LAYOUT
- SKUNK CAMP TAILINGS STORAGE FACILITY - ALTERNATIVE LAYOUT
- WATERSHED
- TSF CATCHMENT
- RESOLUTION OREBODY
- WHITLOW RANCH DAM
- TOWN OR CITY
- WILDERNESS AREA AND STATE PARK
- COUNTY LINE
- HIGHWAY
- EXISTING RAILWAY
- ARIZONA NATIONAL SCENIC TRAIL (ARIZONA TRAIL)
- RIVER OR MAJOR DRAINAGE

NOTES:
1. NAD83, ARIZONA STATE PLANE CENTRAL
2. IMAGERY PROVIDED BY ESRI/BING AERIAL IMAGERY
3. WATERSHEDS PROVIDED BY NATURAL RESOURCE CONSERVATION SERVICE

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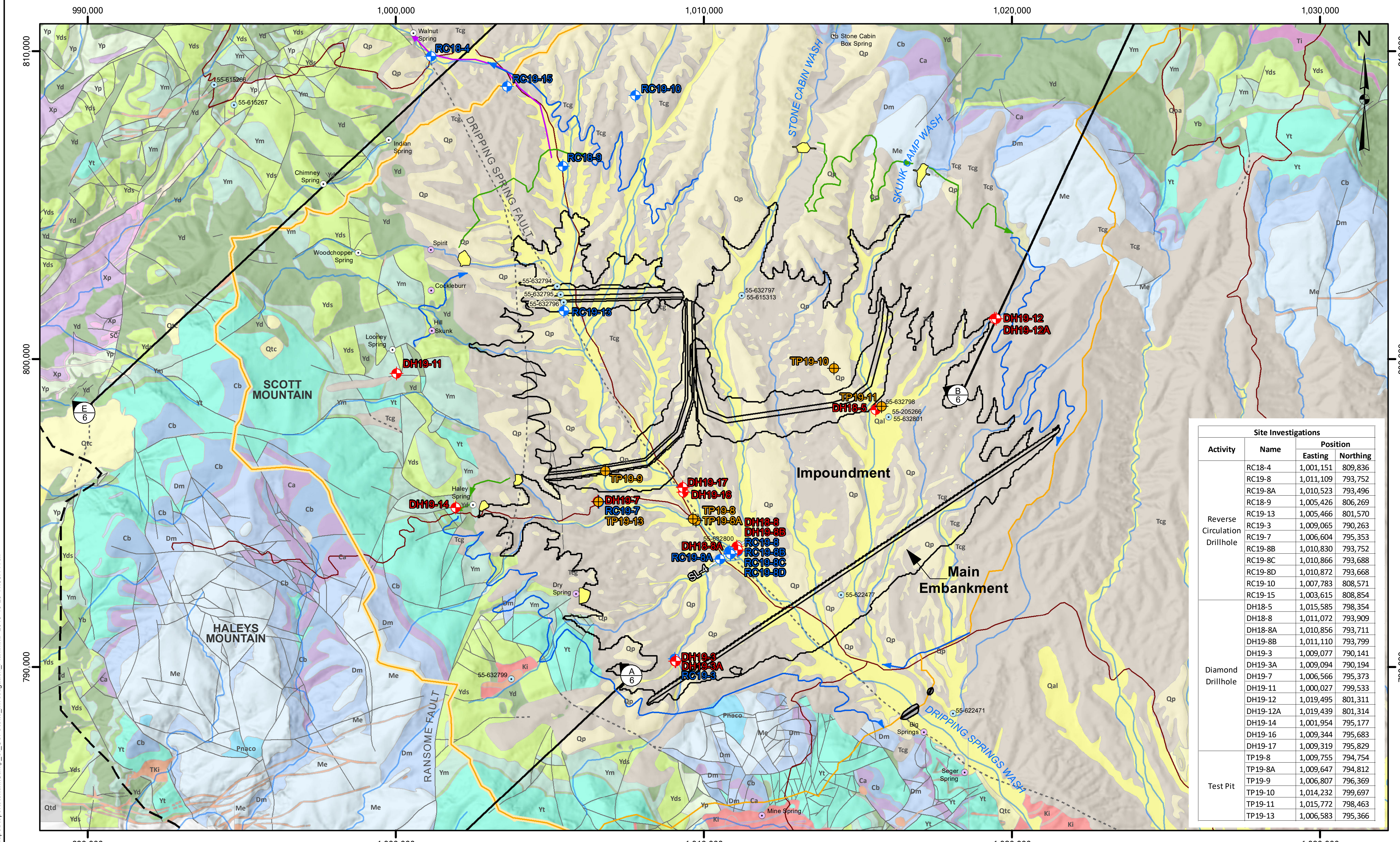
TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED: NOVEMBER 2019

0 5 Mile

CLIENT	RESOLUTION COPPER / KCB Consultants Ltd.
PROJECT	RESOLUTION COPPER PROJECT SKUNK CAMP SITE INVESTIGATION
TITLE	REGIONAL LOCATION PLAN
PROJECT No.	UM09441A21
FIG No.	1



Site Investigations			
Activity	Name	Position	
		Easting	Northing
Reverse Circulation Drillhole	RC18-4	1,001,151	809,836
	RC19-8	1,011,109	793,752
	RC19-8A	1,010,523	793,496
	RC18-9	1,005,426	806,269
	RC19-13	1,005,466	801,570
	RC19-3	1,009,065	790,263
	RC19-7	1,006,604	795,353
	RC19-8B	1,010,830	793,752
	RC19-8C	1,010,866	793,688
	RC19-8D	1,010,872	793,668
	RC19-10	1,007,783	808,571
	RC19-15	1,003,615	808,854
Diamond Drillhole	DH18-5	1,015,585	798,354
	DH18-8	1,011,072	793,909
	DH18-8A	1,010,856	793,711
	DH19-8B	1,011,110	793,799
	DH19-3	1,009,077	790,141
	DH19-3A	1,009,094	790,194
	DH19-7	1,006,566	795,373
	DH19-11	1,000,027	799,533
	DH19-12	1,019,495	801,311
	DH19-12A	1,019,439	801,314
	DH19-14	1,001,954	795,177
	DH19-16	1,009,344	795,683
	DH19-17	1,009,319	795,829
Test Pit	TP19-8	1,009,755	794,754
	TP19-8A	1,009,647	794,812
	TP19-9	1,006,807	796,369
	TP19-10	1,014,232	799,697
	TP19-11	1,015,772	798,463
	TP19-13	1,006,583	795,366

GEOLOGICAL UNITS

- Qal Alluvium (Quaternary)
- Qp Pediment (Quaternary)
- Qtc Talus (Quaternary)
- Qoa Older Gravel (Quaternary)
- QTls Landslide Deposit (Quaternary)
- Tcg Tertiary Conglomerate (Miocene-Pliocene)
- Ti Teapot Mountain Porphyry (Paleocene)
- TKi Hornblende Andesite Porphyry (Tertiary-Cretaceous)
- Ttm Teapot Mountain Porphyry (Tertiary)
- Ki Rattler Granodiorite (Upper Cretaceous)
- Mzbp Basalt Porphyry (Mesozoic)
- Pnaco Naco Limestone (Pennsylvanian)
- Me Escobrosa Limestone (Mississippian)
- Dm Martin Limestone (Devonian)
- Ca Abrigo Formation (Upper & Middle Cambrian)
- Cb Bolsa Quartzite (Middle Cambrian)
- Yd Diabase (Younger PreCambrian)
- Yt Troy Quartzite (Younger PreCambrian)
- Yb Basalt (Younger PreCambrian)
- Ym Mescal Limestone (Younger PreCambrian)
- Yds Dripping Spring Quartzite (Younger PreCambrian)
- Yp Pioneer Formation (Younger PreCambrian)
- Xp Pinal Schist (PreCambrian)

SITE INVESTIGATION

- DH DIAMOND DRILLHOLE
- RC REVERSE CIRCULATION DRILLHOLE
- TP TEST PIT
- DIAMOND DRILLHOLE & TEST PIT
- GEOPHYSICS LINE

LEGEND

- SKUNK CAMP TAILINGS STORAGE FACILITY - OoM LAYOUT
- SEEPAGE COLLECTION FACILITY
- SURFACE WATER DIVERSION DAM
- RAY MINE
- SPRING (ALRIS)
- SPRING (ADWR SURFACE WATER)
- SPRING UNKNOWN
- ADWR WELL LOCATION AND IDENTIFIER
- GEOLOGY SECTION
- FAULT - CONCEALED
- FAULT
- SURFACE WATER DIVERSION DAM DRAWDOWN PIPELINE
- SURFACE WATER DIVERSION CHANNEL
- CLOSURE SURFACE DIVERSION CHANNEL
- TSF CATCHMENT
- DRIPPING SPRINGS & GILA RIVER CATCHMENT
- EXISTING ROAD
- EXISTING RAILWAY
- RIVER OR MAJOR DRAINAGE

0 1 Mile

NOTES:
1. NAD83, ARIZONA STATE PLANE CENTRAL
2. TERRAIN DATA SOURCE: ESRI
3. CORNWALL, H.R., AND KRIEGER, M.H. 1978. GEOLOGIC MAP OF THE EL CAPITAN MOUNTAIN QUADRANGLE, GILA AND PINAL COUNTIES, ARIZONA. U.S. GEOLOGICAL SURVEY QUADRANGLE MAP GQ - 1442, SCALE 1:24,000.
CORNWALL, H.R., BANKS, N.G., AND PHILLIPS, C.H. 1971. GEOLOGIC MAP OF THE SONORA QUADRANGLE, PINAL AND GILA COUNTIES, ARIZONA. U.S. GEOLOGICAL SURVEY QUADRANGLE MAP GQ - 1021, SCALE 1:24,000.

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CLIENT: RESOLUTION COPPER

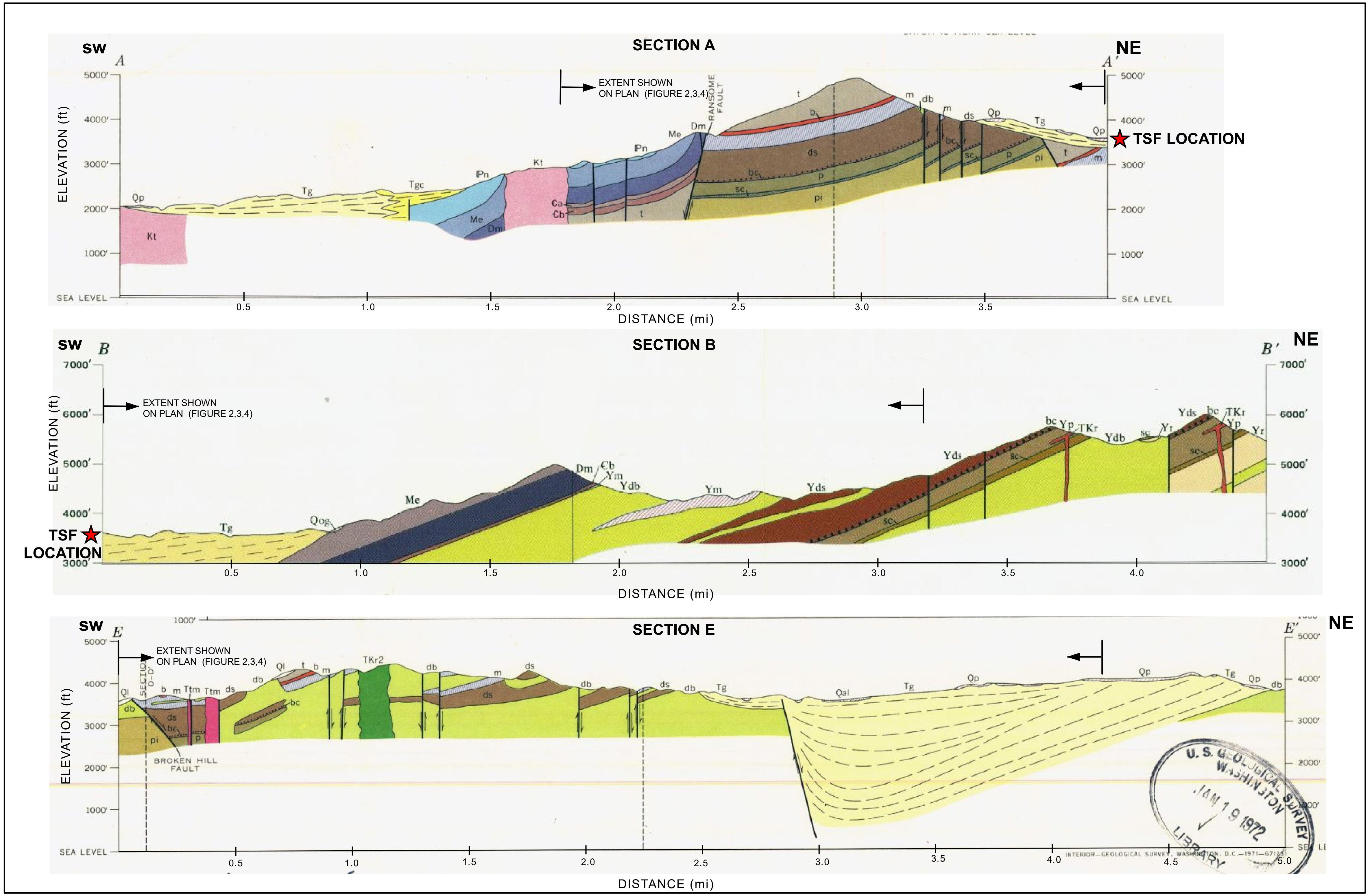
KCB Consultants Ltd.

PROJECT: RESOLUTION COPPER PROJECT
SKUNK CAMP SITE INVESTIGATION

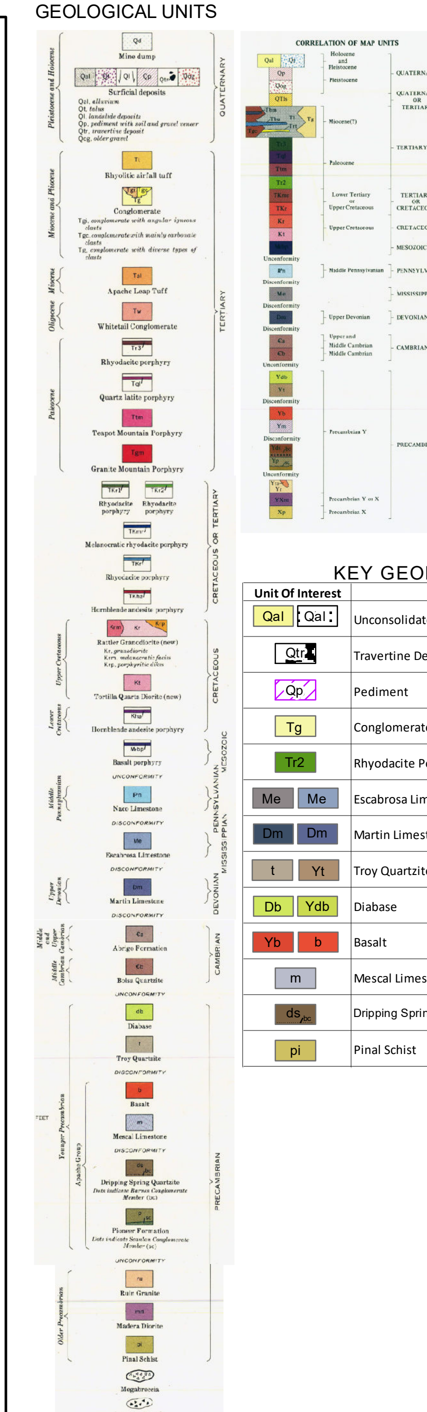
TITLE: SITE INVESTIGATION PLAN

PROJECT No. UM09441A21

FIG No. 2



GEOLOGICAL UNITS



KEY GEOLOGIC UNITS

Unit Of Interest	Description	Age
Qal Qal	Unconsolidated Alluvium	Quaternary
Qtr	Travertine Deposit	
Qp	Pediment	
Tg	Conglomerate	Miocene
Tr2	Rhyodacite Porphyry	Paleocene
Me Me	Escabrosa Limestone	Mississippian
Dm Dm	Martin Limestone	Devonian
t Yt	Troy Quartzite	PreCambrian
Db Ydb	Diabase	
Yb b	Basalt	
m	Mescal Limestone	
ds	Dripping Spring Quartzite	
pi	Pinal Schist	

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED: NOVEMBER 2019

CLIENT

RESOLUTION COPPER

KCB Consultants Ltd.

PROJECT

RESOLUTION COPPER PROJECT
SKUNK CAMP SITE INVESTIGATION

TITLE

SITE GEOLOGY SECTIONS

PROJECT No. UM09441A21

FIG No. 3

NOTES:
1. REFER TO REPORT FOR SOURCE OF GEOLOGY
2. REFER TO FIGURE 2.3 FOR LOCATION OF SECTION
3. SECTION A AND E SOURCE: GEOLOGIC MAP OF THE SONORA QUADRANGLE, PINAL AND GILA COUNTIES, AZ. U.S. GEOLOGICAL SURVEY, 1971.
SECTION B SOURCE: GEOLOGICAL MAP OF THE EL CAPITAN MOUNTAIN QUADRANGLE, GILA AND PINAL COUNTIES, AZ. U.S. GEOLOGICAL SURVEY, 1978.

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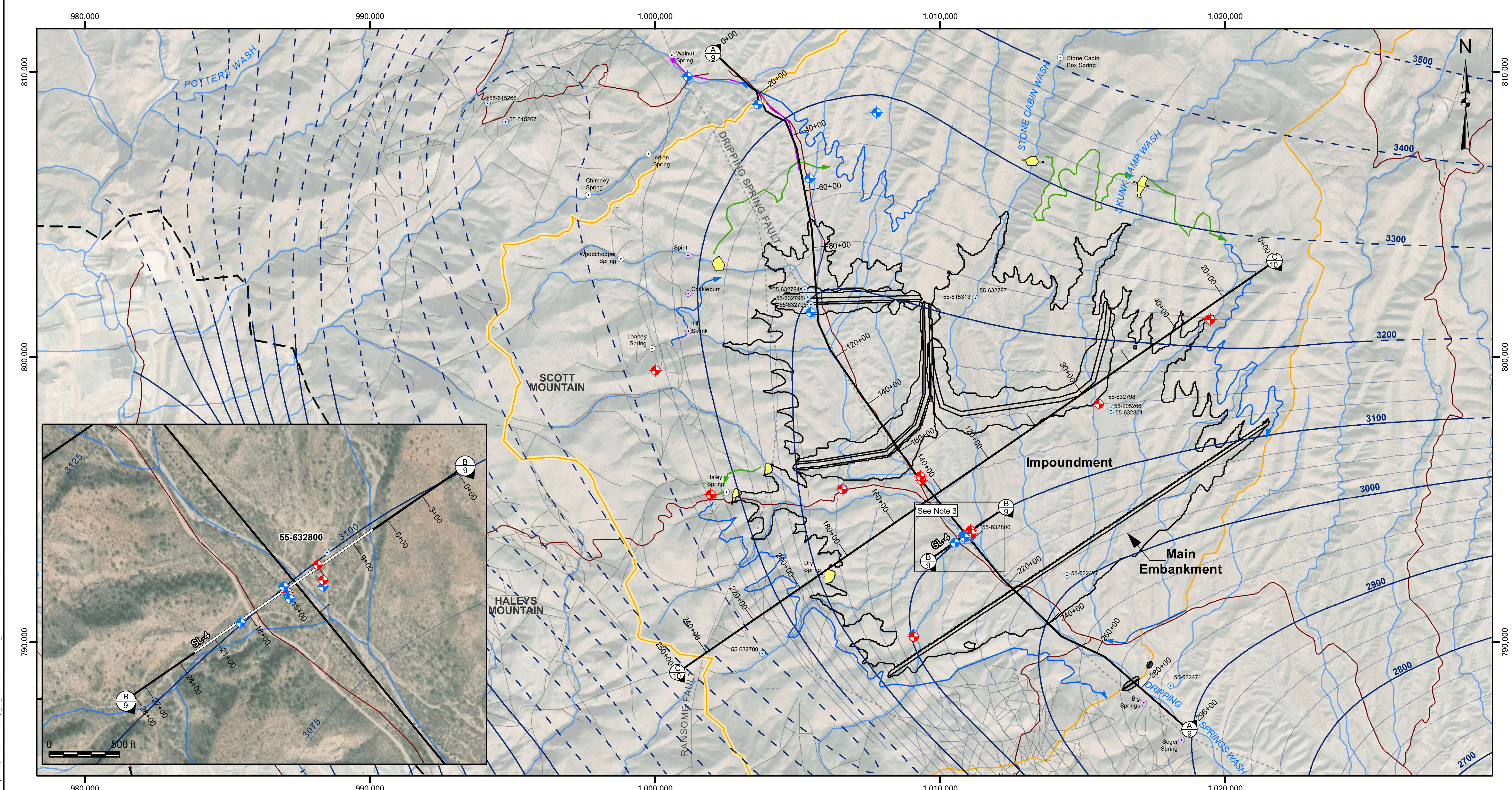

LEGEND

SKUNK CAMP TAILINGS STORAGE FACILITY - OoM LAYOUT
SEEPAGE COLLECTION FACILITY
SURFACE WATER DIVERSION DAM
RAY MINE
SPRING (ALRIS)
SPRING (ADWR SURFACE WATER)
SPRING UNKNOWN
ADWR WELL LOCATION AND IDENTIFIER
FAULT - CONCEALED
FAULT

SITE INVESTIGATION

DIAMOND DRILLHOLE
REVERSE CIRCULATION DRILLHOLE
GEOPHYSICS LINE
GROUNDWATER CONTOUR (100ft)
GROUNDWATER CONTOUR INFERRED (100ft)
GROUNDWATER CONTOUR (25ft)
Groundwater El. (ft) (depth to water (ft))

TSF CATCHMENT
DRIPPING SPRINGS & GILA RIVER CATCHMENT
EXISTING ROAD
EXISTING RAILWAY
RIVER OR MAJOR DRAINAGE

NOTES:
1. NAD83, ARIZONA STATE PLANE CENTRAL
2. IMAGERY SOURCE: ESRI
3. CONCEALED TERTIARY FAULTS ARE INFERRED IN THE SUBSURFACE. GROUNDWATER CONTOURS AS SHOWN DO NOT ACCOUNT FOR THE POTENTIAL IMPACT OF FAULTS ON GRADIENTS.
4. GROUNDWATER CONTOURS PROVIDED BY MONTGOMERY AND ASSOCIATES AND INTERPOLATED TO 25FT INTERVALS.

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED: NOVEMBER 2019

0 1 Mile

CLIENT
RESOLUTION COPPER

KCB Consultants Ltd.

PROJECT
RESOLUTION COPPER PROJECT
SKUNK CAMP SITE INVESTIGATION

TITLE
GROUNDWATER ELEVATION PLAN

PROJECT No. UM09441A21

FIG No. 4

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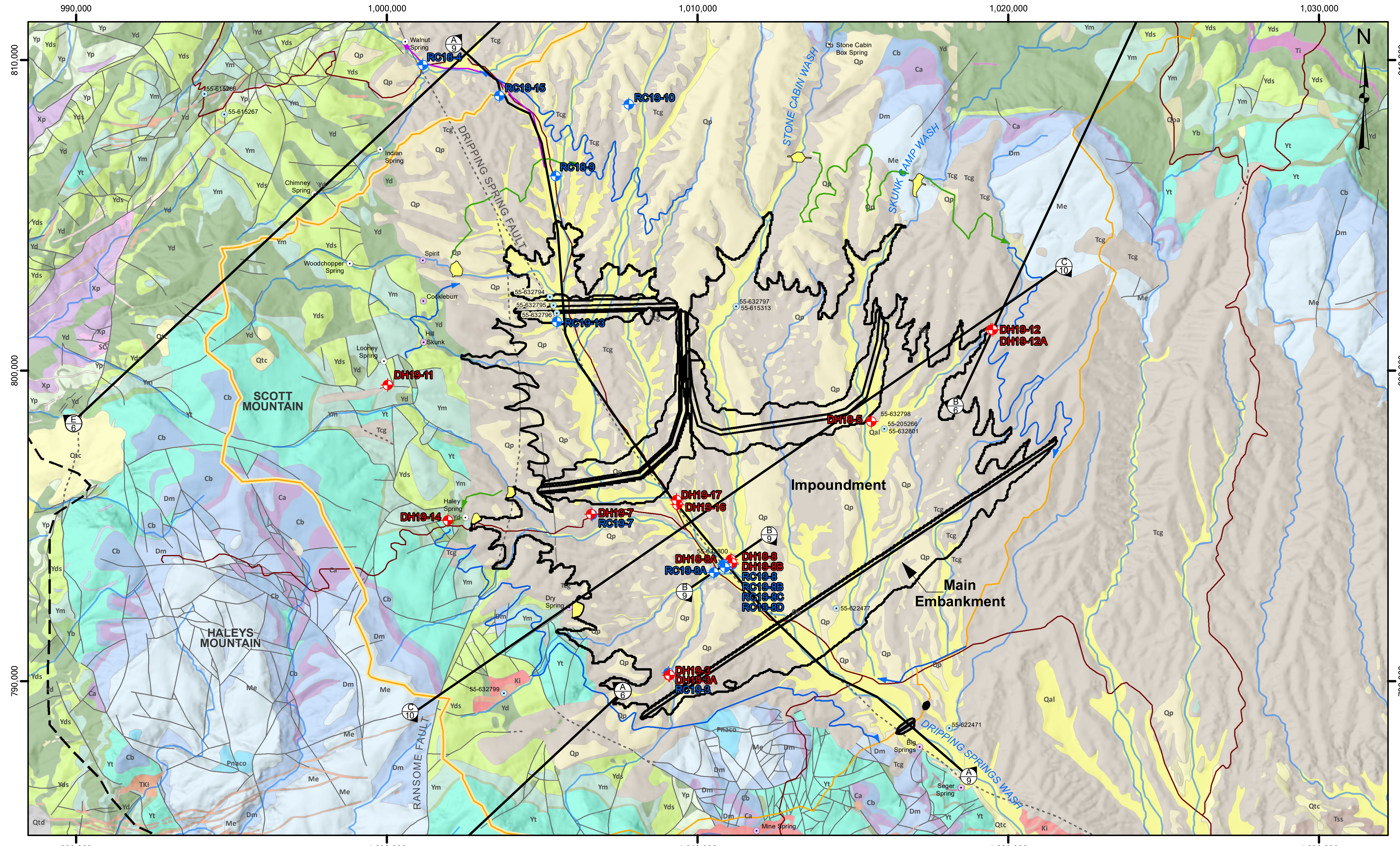


GEOLOGICAL UNITS

Qal	Alluvium (Quaternary)
Qp	Pediment (Quaternary)
Qtc	Talus (Quaternary)
Qoa	Older Gravel (Quaternary)
QTls	Landslide Deposit (Quaternary)
Tcg	Tertiary Conglomerate (Miocene-Pliocene)
Ti	Teapot Mountain Porphyry (Paleocene)
TKi	Hornblende Andesite Porphyry (Tertiary-Cretaceous)
Ttm	Teapot Mountain Porphyry (Tertiary)
Ki	Rattler Granodiorite (Upper Cretaceous)
Mzbp	Basalt Porphyry (Mesozoic)
Pnaco	Naco Limestone (Pennsylvanian)
Me	Escobrosa Limestone (Mississippian)
Dm	Martin Limestone (Devonian)
Ca	Abrigo Formation (Upper & Middle Cambrian)
Cb	Bolsa Quartzite (Middle Cambrian)
Yd	Diabase (Younger PreCambrian)
Yt	Troy Quartzite (Younger PreCambrian)
Yb	Basalt (Younger PreCambrian)
Ym	Mescal Limestone (Younger PreCambrian)
Yds	Dripping Spring Quartzite (Younger PreCambrian)
Yp	Pioneer Formation (Younger PreCambrian)
Xp	Pinal Schist (PreCambrian)

LEGEND

- SKUNK CAMP TAILINGS STORAGE FACILITY
- SEEPAGE COLLECTION FACILITY
- SURFACE WATER DIVERSION DAM
- RAY MINE
- SPRING (ALRIS)
- SPRING (ADWR SURFACE WATER)
- SPRING UNKNOWN
- ADWR WELL LOCATION AND IDENTIFIER
- FAULT - CONCEALED
- FAULT
- SECTION
- SURFACE WATER DIVERSION DAM DRAWDOWN PIPELINE
- SURFACE WATER DIVERSION CHANNEL
- CLOSURE SURFACE DIVERSION CHANNEL

SITE INVESTIGATION

- DIAMOND DRILLHOLE
- REVERSE CIRCULATION DRILLHOLE

- TSF CATCHMENT
- DRIPPING SPRINGS & GILA RIVER CATCHMENT
- EXISTING ROAD
- EXISTING RAILWAY
- RIVER OR MAJOR DRAINAGE

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED: NOVEMBER 2019

0 1 Mile

NOTES:
1. NAD83, ARIZONA STATE PLANE CENTRAL
2. TERRAIN DATA SOURCE: ESRI
3. CORNWALL, H.R., AND KRIEGER, M.H. 1978. GEOLOGIC MAP OF THE EL CAPITAN MOUNTAIN QUADRANGLE, GILA AND PINAL COUNTIES, ARIZONA. U.S. GEOLOGICAL SURVEY QUADRANGLE MAP GQ - 1442, SCALE 1:24,000.
CORNWALL, H.R., BANKS, N.G., AND PHILLIPS, C.H. 1971. GEOLOGIC MAP OF THE SONORA QUADRANGLE, PINAL AND GILA COUNTIES, ARIZONA. U.S. GEOLOGICAL SURVEY QUADRANGLE MAP GQ - 1021, SCALE 1:24,000.

CLIENT: RESOLUTION COPPER

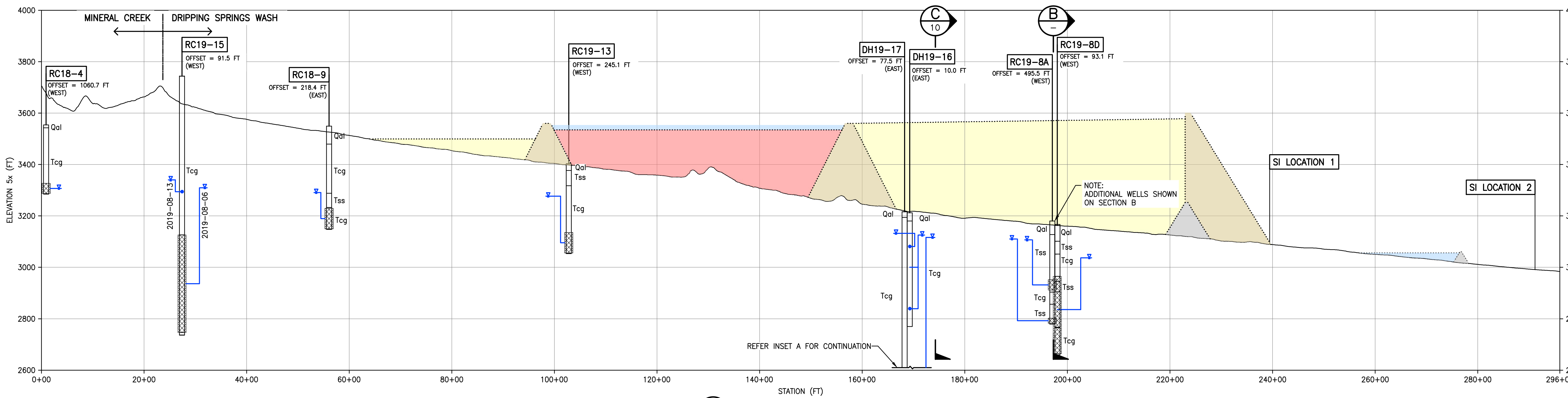
KCB Consultants Ltd.

PROJECT: RESOLUTION COPPER PROJECT SKUNK CAMP SITE INVESTIGATION

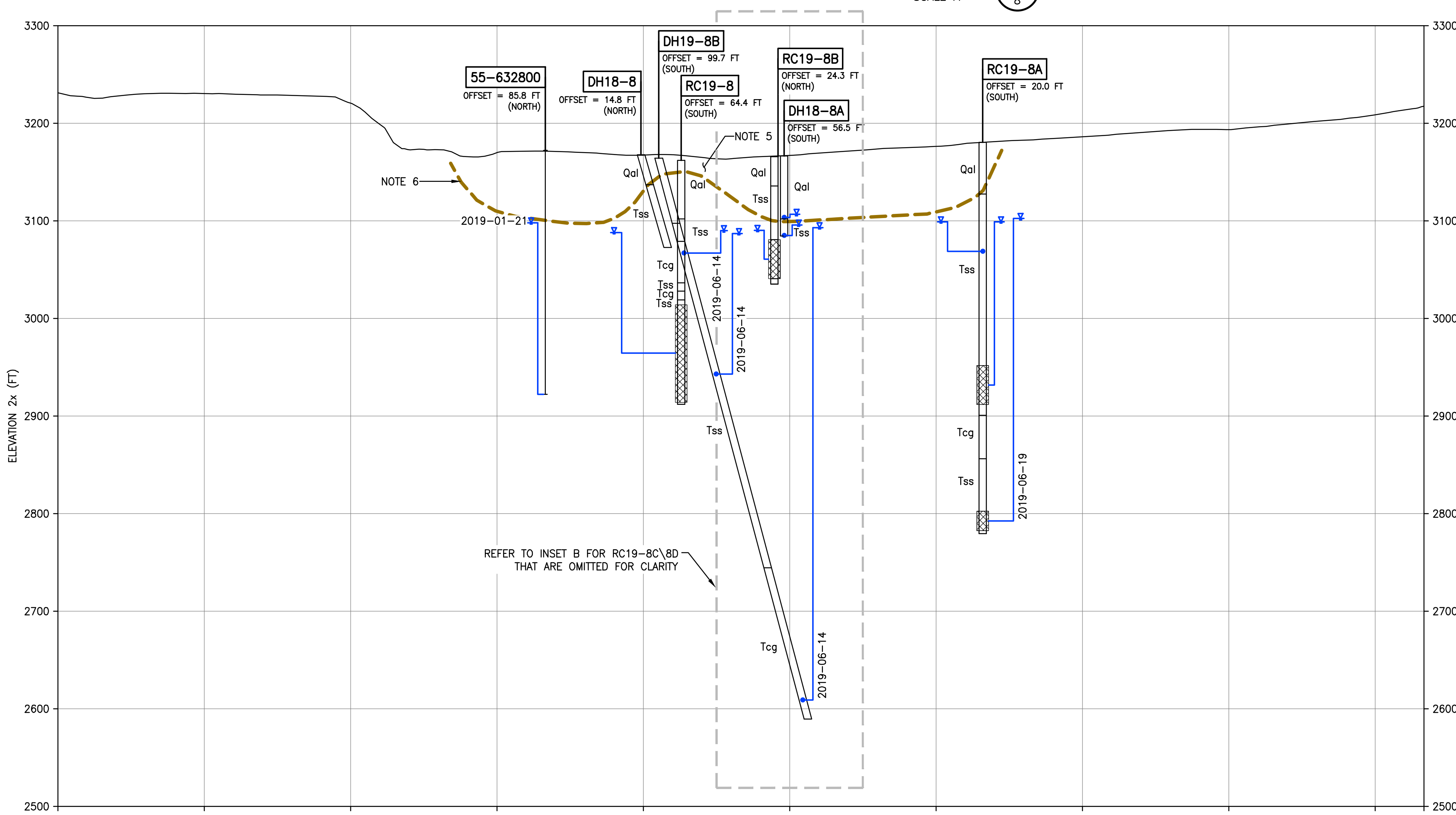
TITLE: SECTION LOCATIONS

PROJECT No. UM09441A21

FIG No. 5

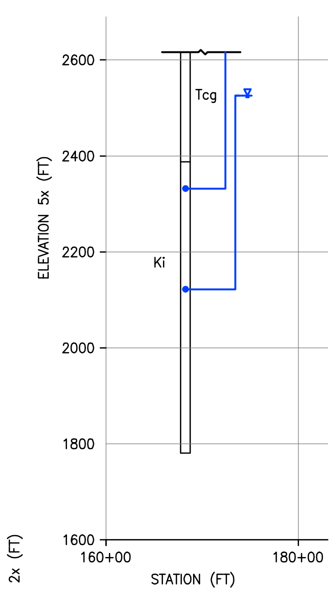


SECTION A DRIPPING SPRING WASH PROFILE
SCALE A

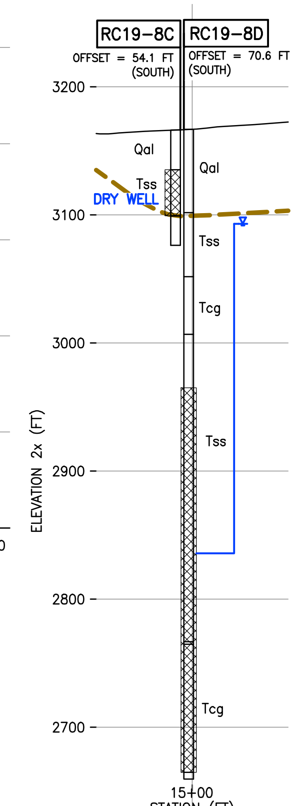


SECTION B DRIPPING SPRING WASH LOCATION 8 SECTION
SCALE B

SCALE A 1000 0 1000 FT
SCALE B 150 0 150 FT



INSET A
SCALE A



INSET B
SCALE B

LEGEND

PROPOSED TSF

- EARTHFILL DAM
- CYCLONED SAND EMBANKMENTS
- SCAVENGER TAILINGS
- PYRITE TAILINGS
- POND

LITHOLOGY

- ALLUVIUM-SANDSTONE CONTACT BASED ON INTERPRETATION OF RESISTIVITY PROFILE AT SL-4.

Qal	QUATERNARY ALLUVIUM
Tss	TERTIARY SANDSTONE
Tcg	TERTIARY CONGLOMERATE
Me	ESCABROSA LIMESTONE
Yd	DIABASE
Ym	MESCAL LIMESTONE
Yds	DRIPPING SPRINGS QUARTZITE
Yp	PIONEER SHALE
Ysc	SCANLAN CONGLOMERATE
Yg	RUIN GRANITE
Ki	RATTLER GRANODIORITE

NOTES

1. PROJECTION AND DATUM: ARIZONA STATE PLANE CENTRAL NAD 83 – INTERNATIONAL FEET.
2. TOPOGRAPHY BASED ON INTERMAP NEXTMAP DSM AND DTM ACQUIRED IN 2004.
3. UNLESS NOTED, WATER LEVELS TAKEN ON JULY 14–16, 2019.
4. VWP WATER LEVELS – ARE STATIC READINGS, TAKEN JULY 11–16, 2019, UNLESS NOTED OTHERWISE.
5. TERTIARY SANDSTONE WAS SEEN BY KCBCL IN EAST BANK OF DRIPPING SPRINGS WASH. OFFSET BOREHOLES SHOW DEEPER ALLUVIUM THAN INTERPRETED ON SECTION.
6. ELECTRICAL RESISTIVITY SHOWED ABSOLUTE DEPTHS OF UP TO 100 FT, HOWEVER THE INTERPRETED CONTACT HAS BEEN SCALED TO OBSERVED THICKNESS OF 64.5 FT IN DH18-8A AND 65.4 FT (VERTICAL) IN DH19-8B.

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED: NOVEMBER 2019

CLIENT: RESOLUTION COPPER	PROJECT: RESOLUTION COPPER PROJECT SKUNK CAMP SITE INVESTIGATION
KCB Consultants Ltd.	TITLE: DRIPPING SPRING WASH SECTIONS
SCALE: AS SHOWN	PROJECT No.: UM09441A21
FIG. No.: 6	

KCB-FIG-D-L

Date: 2019-10-31 Time: 6:46 AM
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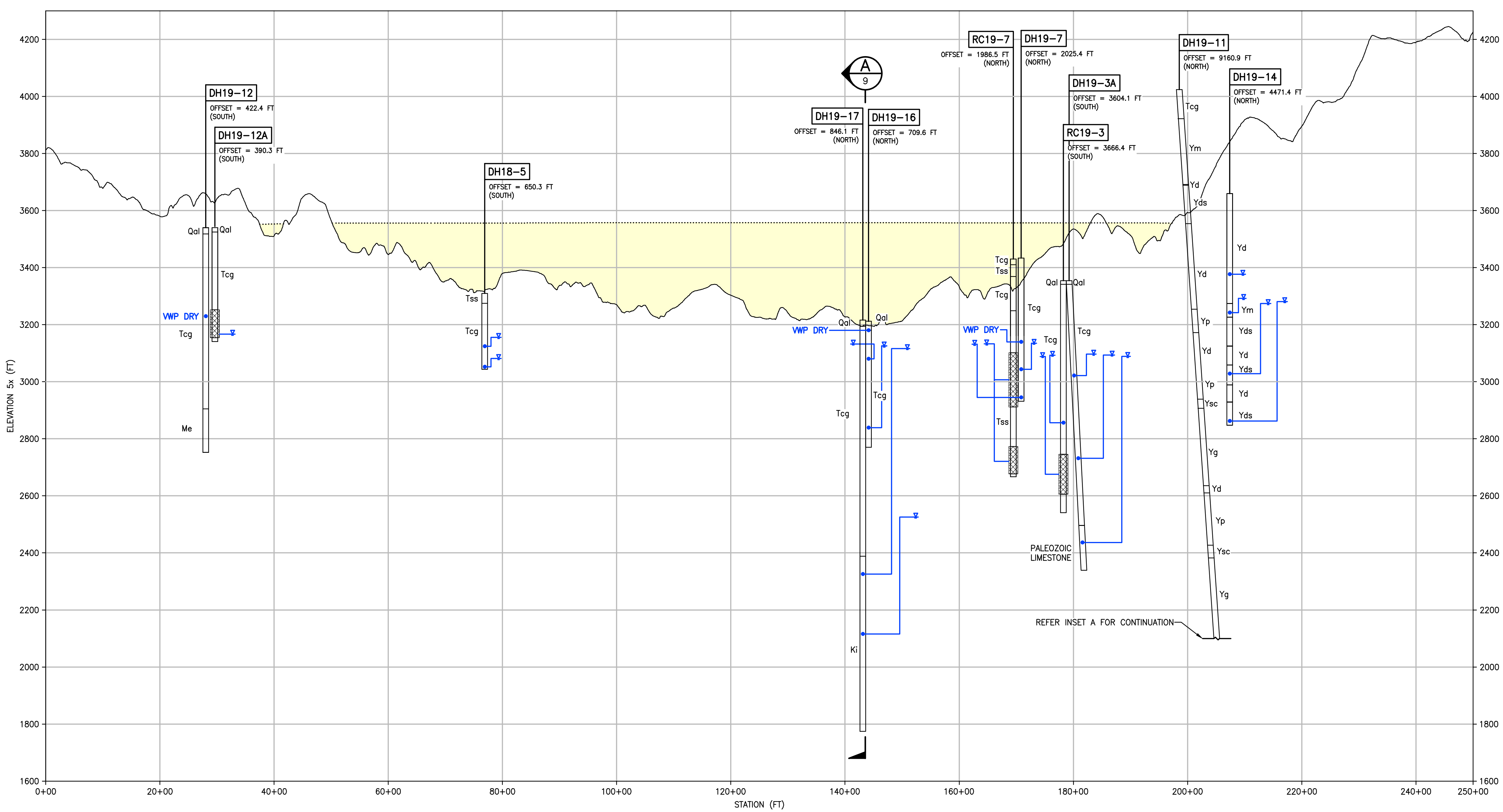

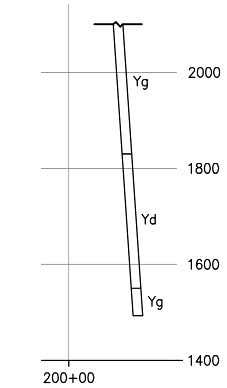

INSET A
SCALE A

SECTION A 8 IMPOUNDMENT CROSS SECTION
SCALE A

LEGEND

PROPOSED TSF

SCAVENGER TAILINGS

LITHOLOGY

Qal	QUATERNARY ALLUVIUM
Tss	TERTIARY SANDSTONE
Tcg	TERTIARY CONGLOMERATE
Me	ESCABROSA LIMESTONE
Yd	DIABASE
Ym	MESCAL LIMESTONE
Yds	DRIPPING SPRINGS QUARTZITE
Yp	PIONEER SHALE
Ysc	SCANLAN CONGLOMERATE
Yg	RUIN GRANITE
Ki	RATTLER GRANODIORITE

NOTES

1. PROJECTION AND DATUM: ARIZONA STATE PLANE CENTRAL NAD 83 – INTERNATIONAL FEET.
2. TOPOGRAPHY BASED ON INTERMAP NEXTMAP DSM AND DTM ACQUIRED IN 2004.
3. UNLESS NOTED, WATER LEVELS TAKEN ON JULY 14–16, 2019.
4. VWP WATER LEVELS – ARE STATIC READINGS, TAKEN JULY 11–16, 2019, UNLESS NOTED OTHERWISE.

SCALE B 150 0 150 FT
SCALE A 1000 0 1000 FT

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED: NOVEMBER 2019

CLIENT RESOLUTION COPPER	PROJECT RESOLUTION COPPER PROJECT SKUNK CAMP SITE INVESTIGATION
KCB Consultants Ltd.	TITLE IMPOUNDMENT CROSS SECTION

SCALE	PROJECT No.	FIG. No.
AS SHOWN	UM09441A21	7

KCB-FIG-D-L

Date: 2019-10-31 Time: 7:03 AM
Drawing File: Z:\M\VCR\M09441A21 – RES-Skunk Camp SI\400 Drawings\CAD\Figure\USFS\A21 – FIG-7 – Impoundment Cross Section.dwg – FIG- (dhu)