Corrective Measures Assessment
Hunter Power Plant

Castle Dale, Utah

June 2019

Prepared For:
Hunter Power Plant
Highway 10, S of Castle Dale
Castle Dale, UT 84513

PacifiCorp
1407 West North Temple, Suite 280
Salt Lake City, Utah 84116

Prepared By:
Water & Environmental Technologies
480 East Park Street
Butte, Montana 59701
406.782.5220

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

AACE	Association for the Advancement of Cost Engineering International
bgs	Below Ground Surface
BLM	Bureau of Land Management
CCR	Coal Combustion Residuals
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMS	Corrective Measures Study
COPC	Constituent of Potential Concern
EPA	U.S. Environmental Protection Agency
FGD	Flue-Gas Desulfurization
ft/day	Feet/day
HPP	Hunter Power Plant
MCL	National Public Water Supply - Maximum Concentration Limit
MNA	Monitored Natural Attenuation
RCRA	Resource Conservation and Recovery Act
RPB	Reactive Permeable Barrier
SAP	Sampling and Analysis Plan
TDS	Total Dissolved Solids
UDEQ	Utah Department of Environmental Quality
USFS	U.S. Forest Service
WDEQ	Wyoming Department of Environmental Quality
WET	Water & Environmental Technologies

1.0 PURPOSE & SCOPE

This report provides the findings of an investigation to determine the nature and extent of the release and an assessment of corrective measures for the Coal Combustion Residual (CCR) Landfill, at the Hunter Power Plant (HPP) near Castle Dale, Utah. It was prepared for PacifiCorp by Water and Environmental Technologies (WET) to comply with the requirements detailed in *Code of Federal Regulations* (CFR) § 257.95(g)(1) and 257.96 (*Final Rule*).

Detection monitoring was conducted between September 2015 and October 2017. The results of detection monitoring revealed statistically significant levels above background for the following Appendix III constituents: boron, calcium, chloride, fluoride, pH, sulfate and total dissolved solids (TDS).

As a result, the CCR Landfill monitoring program was transitioned to assessment monitoring in 2018. The results of two rounds of sampling completed between February and May of 2018, revealed Appendix IV constituents - lithium and molybdenum exceeded the groundwater protection standards established for the CCR Landfill.

CFR § 257.95(g)(1) requires the owner of a CCR unit in which one or more constituents in Appendix IV are detected at statistically significant levels above the site-specific groundwater protection standards, to characterize the nature and extent of the release and any relevant site conditions that may affect the remedy ultimately selected. CFR § 257.95(g)(3)(i) requires the owner of the CCR unit, to assess corrective measures as required by 257.96. In compliance with these requirements, PacifiCorp conducted, in parallel, an investigation to assess the nature and extent of the release and an assessment of corrective measures for the CCR Landfill.

1.1 Organization

This report is organized to address the requirements of CFR § 257.95 and CFR § 257.96 under the *Final Rule* as follows:

- Site Background & History
- Nature & Extent of Release
- Assessment of Corrective Measures

2.0 SITE BACKGROUND & HISTORY

The HPP is located approximately three miles south of Castle Dale, Utah (Figure 1). The physical location is Township 19 South, Range 8 East, Section 16 in Emery County. HPP is a three-unit coal-fired electrical generation plant owned by PacifiCorp. All three units are equipped with a cloth filter bag house to control particulate emissions, and wet lime scrubbers to control sulfur-dioxide emissions. After dewatering and treatment, the Flue Gas De-sulfurization (FGD) waste, fly ash and bottom ash are disposed in the CCR Landfill. As a result, it is considered a CCR unit.

The plant expanded the combustion waste site in 1997, extending its life through 2027. Storm water is diverted around the CCR Landfill with run-on/run-off controls. Water is diverted above the landfill and directed to facility drainages. Stormwater occurring inside the landfill footprint, is directed to a stormwater pond east of the landfill. This 23-acre storm water pond is lined with 18 inches of impermeable clay and is designed to retain a 6-hour, 100-year storm water equivalent, or 1.8 inches (UDEQ, 2015). There is no discharge from this pond.

2.1 Site Conceptual Model

The site conceptual model for the HPP was developed to summarize site information that is currently available and provide the background information needed to assess corrective measures for the site. As defined in Section 2 of this report considerable historic information and environmental data are available to characterize site conditions. These data have been collected, evaluated and organized into the conceptual site model described below.

2.2 Physiography

The HPP is located along Utah State Highway #10, east of South Horn Mountain and North Horn Mountain of the Manti LaSal Mountain Range. The Community of Castle Dale, with a 2010 population of 1,630, is located approximately three miles north of the plant. Castle Dale is located on Utah State Highway #10, approximately 100 miles southeast of Salt Lake City, Utah. The plant site is located in the Castle Valley and includes approximately 2,000 acres of property. The facility elevation is ~5,600 feet above mean sea level. Other nearby communities include the Communities of Huntington (pop. 2,129), Orangeville (pop. 1,470) and Clawson (pop. 163). The region is rich in coal, oil and natural gas, and mineral deposits which have undergone exploration and extraction since the 1890s. Non-industrial private lands in the area, as well as large units of Bureau of Land Management (BLM) and U.S Forest Service (USFS) lands distributed throughout the regional landscape support cattle grazing, agriculture, recreational use, oil and gas development, and mining. Facility land is zoned for mining, grazing, and industrial use. Land west of the plant is generally zoned for agriculture purposes.

The climate at the plant area can be classified as semi-arid (steppe). Utah steppe lands occur between desert and high mountain regions in areas where the average annual precipitation is less than the potential evapotranspiration. The climate in the area is dry due to the effective barrier to moisture from the Pacific Ocean offered by the Cascade and Sierra Nevada ranges. Average precipitation is between six and ten inches per year, with the highest precipitation occurring in late July through October during the monsoon season. Ten to 20 inches of snow can be expected in the winter, representing between one and two inches of the annual precipitation. Average temperatures range from a low of 10°F in January to a high of 90°F in July (Western Regional Climate Center, 2015).

Native soils beneath the landfill consist of Chipeta Series soils underlain by Mancos Shale. The Chipeta Series soils are calcareous, well drained and moderately fine saline silty clay loam texture, approximately 10 to 20 inches deep. The underlying Mancos Shale is a gray, consolidated, fissile, calcareous mudstone with interbeds of thin sandstone and siltstone (WET, 2006).

Indigenous vegetation generally consists of cheatgrass, ricegrass, blackbrush, greasewood and atriplex. Greasewood and atriplex grow in areas of high soil salinity, due to their tolerance for salt concentrations in excess of 10,000 ppm (Skougard & Brotherson, 1979). The power plant is surrounded by cultivated land in the drainages to the north, west and south, as well as the area surrounding Castle Dale. The Hunter Research Farm surrounds the plant to the north, west and east and grows crops such as alfalfa, barley, wheat, oats, hay, grass, trees and safflower (UDEQ, 2015). The dominant plant species east of the plant is Castle Valley Clover, whereas further to the west, vegetation is dominated by Utah Juniper, Pinyon Pine and Sagebrush.

2.3 Surface Water

Rock Canyon Creek is an ephemeral stream that flows from west to east through the HPP. The CCR Landfill is approximately ¼-mile south of Rock Canyon Creek. South Wash (locally known as Buzzard Bench Creek) is a tributary to Rock Canyon Creek located along the northern power plant boundary, about 1 mile north of the CCR Landfill. It drains into Rock Canyon Creek about one mile east of the plant. Rock Canyon Creek flows into Cottonwood Creek, a tributary of Huntington Creek, about 3.8 miles east of the CCR Landfill.

Huntington Creek is a tributary of the San Rafael River, which in turn flows into the Green River, a chief tributary of the Colorado River. Another unnamed tributary to Rock Canyon Creek is visible on aerial photographs 1.5 miles northeast of the CCR Landfill. It is separated from the landfill by a small drainage. This tributary flows into Rock Canyon Creek about 1.5 miles northeast of the CCR landfill. Rock Canyon Creek and South Wash provide stock water for area agricultural enterprises. A search of Utah water rights revealed no active groundwater users within several miles downgradient of the landfill.

2.4 Geology

HPP is located in the northwestern portion of the Colorado Plateau physiographic province and within the Mancos Shale Lowlands (Stokes, 1986). The Mancos Shale Lowlands are characterized by sloping, gravel-covered pediments, rugged badlands and narrow, flat-bottomed alluvial valleys. The CCR Landfill is located on the Bluegate Member of Mancos Shale (Figure 2).

The Mancos Shale was deposited in offshore and open-marine environments of the Cretaceous Interior Seaway. It is 3450 to 4150 feet thick where exposed in the southern part of the Piceance and Uinta Basins and geophysical logs indicate it is approximately 5400 feet thick in the central part of the Uinta Basin (Hettinger and Kirschbaum, 2002). The upper portion of the Mancos grades into and interfingers with the Mesaverde Group and the shale tongues typically have sharp basal contacts and gradational upper contacts.

Lithologic logs developed for facility monitoring wells, completed in the shale note a light gray to dark gray or gray-black shale in various stages of weathering from very weathered to consolidated and un-weathered or competent shale.

2.5 Hydrogeology

The water table aquifer beneath the Hunter CCR Landfill is present in the Bluegate Member of the Mancos Shale, more specifically in the competent shale fractions. Because the thickness of Mancos Shale is in excess of 5,000 ft (Hale and Van De Graaff, 1964) and undergoing various stages of weathering, groundwater migrates through the more permeable zones and no discernable bottom of the water bearing zones is present.

The low permeability of the Mancos Shale and the arid high desert climate result in a discontinuous aquifer with multiple perched layers that may be locally de-watered seasonally and/or by sampling activities. Further downgradient of the CCR Landfill, water is present at the colluvial/shale contact. Infiltration of precipitation in the uplands moves down through the colluvium and accumulates in a water table aquifer at the colluvium/Mancos shale contact. Groundwater flows along the contact following the topography of the shale and, in some areas, infiltrates into the fractured Mancos shale.

Because of its geochemical composition and erodibility, the Mancos Shale, a dark gray to black ridge forming marine shale deposit, provides a natural source of soluble salts. It was deposited in a transgressive/regressive coastal-marine environment and is a known source of halite (NaCl) and calcium and sodium-sulfate minerals (Waddell et al. 1979). These minerals are highly soluble and dissolve readily when in contact with groundwater.

Depth to water near the CCR Landfill varies from 8 ft bgs to 84 ft bgs in wells ELF-8 and ELF-1D, respectively. Wells ELF-1D and ELF-3 generally do not contain sufficient water to support sampling. Recent slug testing indicates that the hydraulic conductivity of the upper most aquifer varies two orders of magnitude from approximately 0.1 to 76 feet/day (ft/day) with a geometric mean of 1.2 ft/day (Table 1).

Per Morris and Johnson, 1967 (in Kresic N. 2007) data on properties of rock and soil, site-specific aquifer porosity and effective porosity are 35% and 12%, respectively. The groundwater flow direction in the vicinity of the CCR landfill is to the east with a hydraulic gradient of approximately to 1.03×10^{-2} to 1.13×10^{-2} ft/ft (Figure 3). The groundwater flow velocity is approximately 0.010 ft/day to 0.011 ft/day.

Table 1. Hunter Power Plant - Slug Test Results

Calculated Hydraulic Conductivity	ELF-2	ELF-4	ELF-8	ELF-11
	1.77E-05	4.41E-04	2.85E-02	9.26E-05
			2.32E-02	1.72E-04
			2.86E-02	1.72E-04
# of Measurements:	1	1	3	3
Mean Conductivity (cm/sec):	1.77E-05	4.41E-04	2.68E-02	1.45E-04
Mean Conductivity (ft/day):	0.1	1	76	0.4
Slug testing was conducted on a facility-wide subset of wells to characterize site-wide hydrogeologic characteristics. Not all of the slug test wells appear on every site-specific map.				

2.6 Aquifer Resource Value

The CCR Landfill is underlain by the Mancos shale, which is a natural source of salts, selenium and trace metals (ESL 2011). As a result of its natural degradation, groundwater quality is generally poor with Mancos monitoring wells exhibiting TDS values in excess of 10,000 mg/l characteristic of Class IV Groundwater also referred to as Saline Groundwater. Water quality may degrade in the downgradient direction due to dissolution of shale constituents and may vary widely from monitoring well to monitoring well due to varying consolidation of the shale (UDEQ 2017).

The Mancos has a relatively low permeability as indicated by the aquifer testing results shown in Table 1. Mean hydraulic conductivities in the shale vary from 0.1 ft/day to 1 ft/day and most wells provide limited, low quality water. Many monitoring wells at this site do not provide enough water to allow for purging before environmental sampling.

Because of the limited quantity and poor quality of the groundwater in the Mancos shale, current and future use of the water is very limited without treatment.

At this arid, high desert site, alternate water supplies are scarce as evidenced by the lack of points of diversion on Figure 4. This map indicates all points of diversion within 5 miles of the plant on a geologic map. The map contains very few points of diversion within the Mancos Shale, because of its limited quantity and poor quality. Most points of diversions are located within the Quaternary alluvium along Canyon creek, Cottonwood Creek or Rock Canyon Creek. Many of the purple "Underground" diversions near the landfill, are monitoring wells for the plant site.

2.7 Previous Investigations

HPP is undergoing groundwater monitoring under two separate programs, one mandated by the Division of Water Quality of the Utah Department of Environmental Quality (UDEQ) as a condition for a Groundwater Discharge Permit and the second to address the requirements detailed in the CCR *Final Rule*.

Assessment of facility groundwater quality was initiated in 1979. Formal groundwater monitoring began in 2003 to coincide with the groundwater discharge permit application. Monitoring was performed quarterly for a period of two years, before transitioning to semi-annual monitoring. Semi-annual monitoring under the discharge permit continued through 2014. The 2015 groundwater permit excluded the landfill from the groundwater permit. UDEQ promulgated CCR regulations that require the permitting of landfills. PacifiCorp has filed a permit application and is waiting for the permit to be issued. CCR monitoring was initiated in 2015 and continues to the present.

Several site-specific environmental investigations have been completed, with an emphasis on hydrogeologic and environmental conditions. These have included the following:

- 2003-2006: Background Water Quality Investigations
- 2005: Hunter Power Plant Site Wide Monitoring Report
- 2005/2010/2015: Groundwater Discharge Permit Evaluations
- 2010 and 2015: Ground Water Analysis Reports
- 2015-2018: PacifiCorp CCR-mandated detection and assessment monitoring

2.7.1 Background Water Quality Site Investigations

In 2003, HPP began a voluntary investigation into potential groundwater discharges. The investigation was completed under the provisions of the UDEQ approved site-wide sampling and analysis plan (SAP). A total of twenty-eight monitoring wells were installed and sampled quarterly for a list of twenty-eight water quality parameters both up and downgradient of potential areas of concern.

Monitoring wells were installed in the immediate vicinity of the landfill. Geochemical analysis showed likely impacts from FGD solutions to shallow groundwater downgradient from the CCR landfill. Based on this data, the plant changed operational practices to no longer place FGD solutions in the landfill containing free liquid. The site investigation and background water quality data were used to develop a Ground Water Discharge Permit.

2.7.2 Groundwater Discharge Permits

The first Groundwater Discharge Permit (UGW150001) was issued in 2005. It was renewed in 2010. The permits contain a brief summary of plant water quality, noting with the exception of higher boron and nitrate concentrations, the quality of plant wastewater is generally better than quality of water in the Mancos Shale.

The statement of basis in the 2015 groundwater discharge permit, states going forward, the CCR Landfill and associated monitoring wells will be regulated under the UDEQ solid waste regulations, by the Division of Solid Waste Management and Radiation Control of UDEQ.

2.7.3 Groundwater Analysis Reports

The groundwater analysis reports were submitted with the renewal applications in 2010 and 2015. These reports summarized the groundwater data acquired during permit period. The data in the 2010 and 2015 reports show groundwater in the up and downgradient wells can be classified as brine, prohibiting its use as a potable water source, for irrigation, or as livestock water. This highly mineralized water originates in the Mancos Shale, which serves as a source of sodium, sulfate, boron and other metals. The composition of the shale water complicates the evaluation of water quality at the facility, as FGD residuals also have as major components sodium, sulfate, boron and other metals.

Trend analysis completed using water quality data compiled from 2004 to 2014, revealed significant improvements in water quality over time, coupled with decreasing groundwater elevations. These improvements include improved operational practices which eliminated the liquid content in CCR materials prior to their placement in the landfill. In 2015, four horizontal wells were installed within the landfill groundwater flow path, to capture groundwater / landfill leachate prior to it migrating downgradient of the landfill. The captured water is placed in a tank located in the facility stormwater pond.

2.7.4 CCR Monitoring

Between 2015 and 2017, initial detection monitoring was conducted at the CCR Landfill to comply with the CCR *Final Rule*. The results of detection monitoring revealed background exceedances for the following Appendix III constituents: boron, calcium, chloride, fluoride, pH, sulfate and TDS.

In accordance with the *Final Rule*, assessment monitoring was initiated at the CCR Landfill in February of 2018. This effort revealed lithium and molybdenum exceeded the groundwater protection standard established for the CCR Landfill (Table 2). These results suggest a release has taken place from the CCR Landfill which has impacted facility groundwater.

Table 2. Summary of Groundwater Quality Comparisons – Assessment Monitoring

Analyte	Upper Tolerance Limit (mg/L)	Maximum Contaminant Level (mg/L)	Ground Water Protection Limit (mg/L)	Downgradient Wells that Exceed Upper Tolerance Limit
Antimony	0.002	0.006	0.002	None Exceed
Arsenic	0.0117	0.01	0.0117	None Exceed
Barium	0.1137	2	2	None Exceed
Beryllium	0.002	0.004	0.002	None Exceed

Analyte	Upper Tolerance Limit (mg/L)	Maximum Contaminant Level (mg/L)	Ground Water Protection Limit (mg/L)	Downgradient Wells that Exceed Upper Tolerance Limit
Cadmium	0.0011	0.005	0.0011	None Exceed
Chromium	0.0201	0.1	0.0201	None Exceed
Cobalt	0.0114	NA	0.0114	None Exceed
Fluoride	4.36	4	4.36	None Exceed
Lead	0.012	0.015	0.012	None Exceed
Lithium	5.205	NA	5.205	ELF-6, ELF-5
Mercury	0.00015	0.002	0.00015	None Exceed
Molybdenum	0.158	NA	0.158	ELF-8
Radium	8.511	5	8.511	None Exceed
Selenium	0.608	0.05	0.608	None Exceed
Thallium	0.002	0.002	0.002	None Exceed

3.0 NATURE & EXTENT OF RELEASE

The following sections describe the nature of the release at the Hunter Power Plant and define its extent.

3.1 Nature of Release

FGD scrubber waste, fly ash, and bottom ash are disposed in the CCR Landfill. These wastes are transported to the landfill by truck via a haul road entering the CCR Landfill from the west. As noted, results of detection monitoring completed between 2015 and 2017, revealed Appendix III constituents boron, calcium, chloride, fluoride, pH, sulfate and TDS exhibited statistically significant levels above background. Assessment monitoring completed in 2018 revealed lithium and molybdenum, both Appendix IV constituents exhibited statistically significant concentrations above groundwater protection standards. Based on these findings, a supplemental investigation was completed in 2018 in an effort to bound the spatial extent of impacted groundwater.

The investigation included the installation of three new monitoring wells along the facility boundary (Figure 5), well development, and sampling and analysis of these wells for Appendix IV constituents. The wells were placed at the facility boundary to comply with the requirements in the *Final Rule*, and to determine if the spatial extent of the release extended beyond the facility boundary. In addition to the new monitoring wells, samples of the leachate draining from the landfill were collected. Table 3 summarizes the results from this sampling effort.

Based on the results from source sampling, and detection and assessment monitoring, the composition of the release at HPP consists of those Appendix IV constituents that exceed groundwater protection standards:

- Lithium
- Molybdenum

Table 3. Sample Results – Hunter Source Material

Sample Id:	Analyte:	Result:	Units
Hunter Source Material	Antimony	ND	mg/L
	Arsenic	0.002	mg/L
	Barium	0.059	mg/L
	Beryllium	ND	mg/L
	Boron	30.0	mg/L
	Cadmium	ND	mg/L
	Calcium	911	mg/L
	Chloride	3,010	mg/L
	Chromium	ND	mg/L
	Cobalt	ND	mg/L
	Fluoride	0.117	mg/L
	Lead	ND	mg/L
	Lithium	3.72	mg/L
	Magnesium	1.84	mg/L
	Mercury	ND	mg/L
	Molybdenum	0.890	mg/L
	pH	10.8	s.u.
	Selenium	0.040	mg/L
	Sodium	2,260	mg/L
	Sulfate	2,810	mg/L
	Thallium	ND	mg/L
	Total Dissolved Solids	7,980	mg/L

3.2 Extent of Release

The 2018 sample results from the new monitoring wells placed on the plant boundary are provided in Table 4. The data indicates that the release associated with the CCR Landfill has been bounded spatially (Figure 5), as both lithium and molybdenum are below their established groundwater protection standards (Lithium = 5.205 mg/L and Molybdenum = 0.158) in all of the new downgradient wells. All other Appendix IV constituents are below their respective groundwater protection standards as well. Based on these results, additional wells are not necessary on adjacent lands to bound the release. New wells ELF-12, ELF-13, and ELF-14 will be incorporated into the semi-annual groundwater monitoring program moving forward.

Table 4. New Well Results – Nature & Extent Investigation

Sample Id:	Analyte:	Result:	Units
ELF-12	Antimony	ND	mg/L
ELF-12	Arsenic	ND	mg/L
ELF-12	Barium	0.021	mg/L
ELF-12	Beryllium	ND	mg/L
ELF-12	Cadmium	ND	mg/L
ELF-12	Chromium	ND	mg/L
ELF-12	Cobalt	ND	mg/L
ELF-12	Fluoride	0.26	mg/L
ELF-12	Lead	ND	mg/L
ELF-12	**Lithium**	**0.82**	**mg/L**
ELF-12	Mercury	ND	mg/L
ELF-12	**Molybdenum**	**ND**	**mg/L**
ELF-12	Radium 226+228	5.91	pCi/L
ELF-12	Selenium	ND	mg/L
ELF-12	Thallium	ND	mg/L
ELF-13	Antimony	ND	mg/L
ELF-13	Arsenic	ND	mg/L
ELF-13	Barium	0.06	mg/L
ELF-13	Beryllium	ND	mg/L
ELF-13	Cadmium	ND	mg/L
ELF-13	Chromium	ND	mg/L
ELF-13	Cobalt	0.005	mg/L
ELF-13	Fluoride	ND	mg/L
ELF-13	Lead	ND	mg/L
ELF-13	**Lithium**	**1.72**	**mg/L**
ELF-13	Mercury	ND	mg/L
ELF-13	**Molybdenum**	**ND**	**mg/L**
ELF-13	Radium 226+228	2.26	pCi/L
ELF-13	Selenium	ND	mg/L
ELF-13	Thallium	ND	mg/L
ELF-14	Antimony	ND	mg/L
ELF-14	Arsenic	ND	mg/L
ELF-14	Barium	0.05	mg/L
ELF-14	Beryllium	ND	mg/L
ELF-14	Cadmium	ND	mg/L
ELF-14	Chromium	ND	mg/L
ELF-14	Cobalt	0.01	mg/L

Sample Id:	Analyte:	Result:	Units
ELF-14	Fluoride	0.17	mg/L
ELF-14	Lead	ND	mg/L
ELF-14	**Lithium**	**4.01**	**mg/L**
ELF-14	Mercury	ND	mg/L
ELF-14	**Molybdenum**	**0.005**	**mg/L**
ELF-14	Radium 226+228	3.48	pCi/L
ELF-14	Selenium	0.004	mg/L
ELF-14	Thallium	ND	mg/L

When indications of contamination were first discovered during the voluntary investigations that were initiated in 2003, it was evident that, leachate/impacted groundwater was flowing on the surface and into the stormwater pond. Disposal practices were changed at that time to eliminate free liquids being placed into the landfill which resulted in reduced and then elimination of seepage flowing from the landfill. A collection system was installed within the landfill intercepting the residual liquid/leachate to eliminate additional impacts to groundwater. The remaining contamination is in the vadose zone and aquifer and is expected to attenuate over time since the contamination source has been eliminated. There is no additional seepage from the landfill to groundwater. The evaluation of correctives measures presented in Section 4 address the residual impacts to groundwater presented.

Providing an estimate of the quantity of material released from the CCR unit is required under §257.95(g)(1)(ii). The best available data to estimate the quantity of Appendix IV constituents released from the unit to the groundwater is to utilized concentrations found in the groundwater as depicted in the iso-contour map (Figure 5) and an estimated volume of the aquiver. The volume of the aquifer was calculated by estimating the depth of the aquifer from site wells logs and estimating the aerial extent of the impacted groundwater from the groundwater monitoring data. The effective porosity of the aquifer determined during aquifer testing was then used to calculate the volume of water within the pore space of the aquifer material.

The concentrations were estimated as a gradient across the aquifer. The background concentration for each constituent was subtracted from the concentration detected in the downgradient wells. The volume was then multiplied by the concentration and converted to pounds to estimate the quantities of Appendix IV constituents released to the environment as dissolved compounds. The estimated quantities are only approximations due to the different geochemical characteristics of each analyte: absorption, dispersion and attenuation (i.e. some metals readily react, degrade or adsorb to the aquifer matrix, while other compounds are conservative and remain in solution).

Parameters that exceed groundwater protection standards at the Hunter Power Plant are lithium and molybdenum. The mass detectable in the aquifer, based on current data for each of these constituents is 282 pounds, and 4 pounds, respectively.

3.3 History of Corrective Measures

In 2007, operational changes were implemented to reduce groundwater impacts at the CCR Landfill by eliminating free liquids in the landfill. This has significantly reduced the liquid entering the landfill, which has in turn reduced landfill leachate. The landfill was constructed with stormwater run-on controls were placed upstream of the landfill to divert surface water. This effectively eliminates the majority of surface water infiltration into the landfill. Stormwater (rain) that falls inside the landfill footprint, is directed to the stormwater pond east of the landfill. The 23-acre stormwater pond is lined with 18 inches of impermeable clay and is designed to retain a 6-hour, 100-year storm water equivalent, or 1.8 inches (UDEQ, 2015). There is no discharge from the stormwater pond.

In 2014 horizontal wells were installed in the landfill within the groundwater flow path. These wells capture groundwater and landfill leachate before it can migrate downgradient of the landfill. The captured water is collected in a tank located in the landfill and then utilized for dust control on the landfill.

The 2010 and 2015 Groundwater Analysis Reports have documented the effect of improved waste management practices and installation of the horizontal wells in the landfill, with decreasing water levels and improved groundwater quality observed since 2007. The hydrographs show that since 2014, water levels in landfill monitoring wells have continued to decline. TDS concentrations in downgradient wells have either remained stable or decreased slightly during this same period (PacifiCorp, 2019).

3.4 Potential Risks to Human Health & Environment

Constituents of potential concern (COPCs) found in groundwater at the HPP, include those Appendix IV constituents that exceed health-based guidelines (MCLs) established under the *National Primary Drinking Water Regulations* and/or updates to the *Final* Rule issued in July 2018. These constituents include - lithium and molybdenum. Human health effects associated with these constituents are as follows (ATSDR 2019):

- Lithium: None
- Molybdenum: Kidney, Liver, Lungs

In order for COPCs to pose a risk to human health, complete exposure pathways must be present, whereby human receptors regularly come into contact with elevated concentrations of the COPCs. Potential exposure routes include:

1. Dermal exposure or ingestion of collection system water.
2. Dermal exposure or ingestion of impacted water during dust control.
3. Ingestion of impacted groundwater through wells.

Collection System Water. Trace concentrations of both metals are confined to facility groundwater immediately downgradient of the landfill. As a result, the potential for exposure to unsafe levels of either metal is limited to contact with groundwater. The majority of groundwater originating in the landfill, is captured in the current water collection system that consists of 4 horizontal wells designed to serve as a sump at the base of the landfill. Captured groundwater and landfill seepage are collected in a tank. The water is used for dust control on the landfill. Captured water is hard-piped to the tank. As a result, contact with impacted groundwater collected by the horizontal wells is not a complete exposure route for human receptors.

Dust Control. Workers could be exposed to impacted waters via dermal contact or ingestion should they come into contact with water sprayed on the landfill. However, spraying of the water is carefully controlled and is applied so as to not form puddles so no exposure pathways are formed. In addition, personnel that access the landfill is limited. At the concentrations present in the water elevated risks to human health would not be expected.

Little or no impact on wildlife is expected from captured waters at the plant, as the only complete exposure pathways for wildlife would include ingestion of water from dust control activities. Should they occur, exposures to wildlife (e.g. deer) are not expected to pose significant risks to their long-term health.

Ingestion of Groundwater. There are no potable water wells downgradient of the landfill or within the impacted area of the plant. As a result, ingestion of impacted groundwater is not a complete exposure route for receptors.

CCR monitoring completed between 2015 and 2018, coupled with an evaluation of the nature and extent of releases from the CCR Landfill in 2018, indicate the magnitude of impact to shallow groundwater is limited to elevated Appendix III constituents and Appendix IV metals concentrations downgradient of the CCR Landfill. The results also indicate impacted groundwater is contained within the plant boundary, between the waste unit boundary, and new wells ELF-12, ELF-13, and ELF-14 along the eastern boundary of the landfill.

Based on these findings, current site use, and facility water management practices, risks to human health and the environment at the HPP are negligible and are fully manageable with current operational procedures and interim remedies.

The mean concentrations for wells exhibiting the highest concentrations are provided in Table 5. Their corresponding background concentrations are also included. The results illustrate that contributions from HPP operations represent, in most cases, incremental increases in groundwater concentrations, when compared with naturally occurring levels in facility groundwater.

The *Final Rule* also mandates an examination of potential damage to physical structures should the implementation of remedies take substantial time. No impacts to facility structures have been observed due to the trace levels of metals found in captured landfill seepage / impacted groundwater at the plant. Based on this, no long-term damage to plant operations or structures are expected to occur in the future.

Table 5. Mean versus Background Concentrations

Analyte	Well Id#	Mean Concentration (mg/L)	Background Concentration (mg/L)
Lithium	ELF-6	9.26	5.21
Molybdenum	ELF-8	0.42	0.16

Overall, risks to human health and the environment are minimal to negligible at the HPP, due to confinement of impacted groundwater in the subsurface. The only complete exposure pathways are contact or ingestion with captured groundwater used for dust control. These exposures are infrequent, and likely would not result in elevated risks to human or ecological health.

Additional remedial action may be implemented based on the evaluation of corrective measures and selection of remedy under the CCR Final Rule to address the residual groundwater impacts.

3.5 Clean Up Levels / Attainment Criteria

The *Final Rule* prescribes what clean-up levels will be implemented and what will constitute attainment at all CCR units as follows:

> *Compliance with the groundwater protection standards established under § 257.95(h) has [have] been achieved by demonstrating that concentrations of constituents listed in appendix IV to this part have not exceeded the groundwater protection standard(s) for a period of three consecutive years using the statistical procedures and performance standards in § 257.93(f) and (g).*

The *Final Rule* dictates the clean-up levels for the selected remedy at the CCR Landfill as the groundwater protection standards established in 2018 and as updated using semi-annual groundwater data. Table 6 lists the groundwater protection standards developed based on 2018 monitoring data, coupled with guidance provided in the July 2018 modification to the *Final Rule* (EPA 2018).

3.6 Point(s) of Compliance

The *Final Rule* prescribes points of compliance for CCR units where groundwater protection standards have been exceeded, as follows:

> *The owner or operator of the CCR unit demonstrates compliance with the groundwater protection standards established under § 257.95(h) has been achieved at all points within the plume of contamination that lie beyond the groundwater monitoring well system established under § 257.91.*

The *Final Rule* also mandates that groundwater monitoring must be conducted at the waste unit boundary under *§ 257.91*. This means, all groundwater impacted by a release beyond the waste unit boundary must be addressed as part of the selected remedy. The selected remedy will be considered complete when concentrations of Appendix IV constituents in all CCR landfill groundwater monitoring wells are below the groundwater protection standards for three years. Site-specific groundwater protection standards were established as part of assessment monitoring completed in 2018 and are provided in Table 7.

Table 6. Hunter CCR Landfill Groundwater Protection Standards

Analyte	Groundwater Protection Standard (mg/L)
Antimony	0.006
Arsenic	0.012
Barium	2
Beryllium	0.004
Cadmium	0.005
Chromium	0.10
Cobalt	0.011
Fluoride	4.36
Lead	0.015
Lithium	5.205
Mercury	0.002
Molybdenum	0.16
Radium	8.5
Selenium	0.61
Thallium	0.002

4.0 ASSESSMENT OF CORRECTIVE MEASURES

As noted, risks to human health and the environment are considered low. Currently the horizontal wells installed in 2015 are providing protectiveness by capturing the majority of impacted groundwater along the flow path from the CCR Landfill. However, the current measures do not meet attainment criteria in the *Final Rule*. Additional corrective measures may be needed to satisfy these criteria.

As required by CCR regulations, various potential corrective measures for the CCR Landfill were evaluated. They were screened based on several factors including the specific elements defined in § 257.96 and § 257.97 and their ability to reduce residual risks associated with migration of impacted groundwater from the CCR Landfill. Specific criteria include the following:

- Performance
- Reliability
- Ease of Implementation

- Potential Safety Impacts
- Cross-Media Impacts
- Exposure Control to Residual Contamination

Corrective measures to address residual groundwater impacts will likely include - extracting groundwater and using and/or treating the extracted water and treating the impacted water in situ. Two pump and treat and five in situ treatment options were evaluated. Table 7 provides a summary of the evaluation. In addition, three options involving landfill relocation/removal were evaluated and are included in Table 7. The corrective measures evaluated are listed below and discussed in the following sections.

1. Maintain Current Operations with Groundwater Monitoring
2. Pump and Treat
3. Impermeable Barrier with Pumpback
4. Reactive Permeable Barrier
5. In Situ Injection of Reactive Compound
6. Phyto-Technologies
7. Electro-Kinetics
8. Beneficial Use of Ash
9. In-Place Closure
10. Closure by Removal

4.1 Maintain Current Operations

Normally the no action alternative is included as a baseline to compare the benefits of more active remedial measures. However, for HPP the no action alternative includes existing corrective measures already implemented to address impacted groundwater: 1) ensuring all wastes placed in the landfill do not contain free liquids, and 2) operation of the horizontal wells installed in the landfill to collect leachate and impacted groundwater. Four horizontal wells were installed at the base of the landfill, to capture groundwater along the flow path. The wells capture impacted groundwater and leachate before it can migrate downgradient of the landfill. The captured water is placed in a tank located within the facility stormwater pond. The collected water is then used for dust control on the landfill.

The reduction of impacts to groundwater relies on natural processes to decrease or attenuate concentrations of contaminants in soil and groundwater. This approach has been effective since the source of leachate has been reduced or eliminated. Natural processes such as soil adsorption and dispersion will likely facilitate attenuation of contaminants or reduce their mobility in the environment.

Performance. The current measures have been successful in preventing trace metals defined in Appendix IV of the *Final Rule*, from migrating offsite. Based on assessment monitoring data (2015-2018), only Appendix IV constituents - lithium and molybdenum exhibited statistically significant levels above groundwater protection standards at the waste unit boundary. Both metals are below these standards at new wells ELF-12, ELF-13, and ELF-14. Available data indicates the current interim remedy is sufficient to contain impacted groundwater migration.

Reliability. Waste dewatering and the existing run-on/run-off controls have significantly reduced the quantity of leachate formation in the CCR Landfill. These surface water controls require little to no maintenance, and waste dewatering has become part of routine plant operations. The existing horizontal wells are removing impacted groundwater and leachate from the landfill before it can leach into the groundwater preventing offsite migration. Overall, the current measures at the site are reliable.

Implementability. The current system has been implemented and will continue to operate.

Potential Environmental / Safety Impacts / Exposure Control. The current system has already been implemented, so no adverse impacts to the environment are expected due to its continued operation. No heightened safety concerns of plant personnel or the public are expected, since no additional work would be completed that would create potential exposures to the environment, plant personnel, or the members of the public. As discussed above, exposure to impacted media is minimal and is being addressed under the current corrective measures and safe work practices.

Time to Implement / Complete. No time is required to implement the current measures, as they are in place and operating. Based on the timing of the decrease in surface water downgradient of the landfill, removal of liquids from the ash waste has showed a marked decrease in liquid in the whole ground water/surface water system. The remaining constituents in ground water are most likely residual and will attenuate over time. It is expected that groundwater concentration will decrease to protection standards within 15 to 20 years.

Permits & Public Health Requirements. The current operation is already permitted through State and local agencies, as required by State and Local rules. No additional permitting is required to maintain the existing system. No special measures would be required with respect to public health requirements.

Summary. Maintaining the existing system is fully implementable, reliable, and poses no risks to public health and safety by its continued operation. This alternative has demonstrated effectiveness in reducing the quantity of water migrating downgradient of the CCR Landfill. Alone, this alternative will likely meet attainment requirements by meeting groundwater protection standards at the waste unit boundary. However, it will require many years to reach the standards. To shorten the duration of time to meet the groundwater protection standards, additional corrective measures would be required.

4.2 Pump and Treat

The pump and treat alternative involves the physical extraction of impacted groundwater to either remove contaminant mass from the subsurface and/or to hydraulically control plume migration. The extracted water is then treated through a variety of methods, depending on the contaminant characteristics and volume of material recovered to reduce contaminant loading in the groundwater, while containing / remediating recovered groundwater in a controlled setting.

Performance. The pumping aspect of this alternative is included in several other proposed corrective measures. It is a proven technology in use for a variety of similar applications at the CCR Landfill, and with performance monitoring and optimization, can be successfully applied at HPP. This alternative actively addresses the impacted groundwater and would reduce the time required to reach attainment standards in facility groundwater, by removing impacted groundwater in recovery wells as they pass the CCR Landfill boundary.

Reliability. Pump and treat technologies are widely used in the industry to capture / collect contaminated groundwater and contain or treat it to meet discharge standards. Recovery wells, pumps and piping would make up the recovery network, which in general, are low maintenance items. Periodic maintenance of each will be required to remove scaling that will eventually build up due to contact with shale water. These activities can be built into a regular schedule at low costs and without disruption to plant operations.

Implementation. Installation of the pumping system is not complex. Based on an understanding of site hydrogeology and informed by pilot testing, a series of wells will be installed to capture groundwater as it passes the CCR Landfill boundary. System optimization requires frequent performance monitoring early-on, to ensure effective groundwater recovery. Pump and treat is fully implementable at the HPP.

Potential Environmental / Safety Impacts / Exposure Control. Captured groundwater would be contained in piping and sent to the facility stormwater pond and/or a new pond pending the volume of recovered water. Worker exposures are possible during active O&M activities. The remainder of the time captured water should be contained before treatment.

Time to Implement / Complete. The pump and treat alternative could be designed and installed in one year. Optimization would be ongoing through performance monitoring, with frequent monitoring during the first year and reduced monitoring once the system has been optimized. Pump and treat will quicken the pace of residual contamination removal and result in compliance over a shorter time horizon. It is estimated that standards attainment could occur within 12-15 years.

Permits & Public Health Requirements. This remedial technology would require permitting and design through the State agencies, which may require significant time in the review and design process. Public health impacts would be minor since site access is controlled.

Summary. The pump and treat technology is fully implementable and reliable and would offer the capability to reach attainment at the waste unit boundary. A pilot study would be required to determine the quantity of water that will be recovered, and if current plant infrastructure can accommodate the volume of captured water for treatment.

4.3 Impermeable Barrier / Pumpback System

An impermeable barrier is a cement/bentonite mix placed in the subsurface as a wall designed to stop groundwater flow and contaminant migration. By itself, an impermeable wall is unlikely to achieve attainment in areas of continuous groundwater flow and therefore this option includes a groundwater pumpback system. The groundwater would be directed to an area where a pumpback system would be optimized.

Performance. An impermeable barrier and pumpback system would offer a long-term containment measure for impacted groundwater. The barrier would direct / contain groundwater in a localized area, allowing for the pumpback system to capture water. Captured water would require long-term management, until a period after landfill closure and capping is complete. This alternative actively addresses the impacted groundwater and would reduce the time required to the attainment of the groundwater criteria at the waste unit boundary. Performance of the system is similar to the pump and treat system utilizing wells for extraction discussed in Section 4.2.

Reliability. While the impermeable barrier technology has been utilized successfully for a number of environmental applications, site-specific considerations will determine whether or not the barrier can effectively serve as an underground dam, directing water to the pumpback system. Significant geotechnical evaluation of drainage downgradient of the landfill would be needed, to determine if the barrier can be constructed and perform its function. The reliability of the impermeable barrier is unknown. If properly designed, the pumpback technology is reliable and effective in capturing impacted groundwater and providing hydraulic control in the aquifer.

Implementation. Implementing this alternative is very invasive. Large excavations are required to accommodate placement of the barrier. Groundwater flow would require evaluation following the barrier installation, to optimize the placement and construction of pumpback wells.

Potential Environmental / Safety Impacts / Exposure Control. Of the available alternatives, impermeable barriers offer some of the highest risks to exposure from workers. Excavations will expose the aquifer and dewatering is required during installation. Workers may be exposed to contaminated groundwater throughout this process. The risk to release of impacted groundwater is very high as well, because the aquifer material is exposed, and groundwater inflow is being actively managed. While dewatering can be done safely and controlled, exposure control will take significant effort to mitigate.

Time to Implement / Complete. The design element of this alternative is likely to be time intensive, for engineering design and installation. Once installed, aquifer evaluation will be required to determine the proper placement and construction of pumpback wells. Performance monitoring will be required to determine effectiveness over the short-term. Installation will likely require one construction season to prepare the site and install the barrier. The combination of an impermeable wall and pumpback system will add efficiency to the capture system, but will not substantially reduce the time to standards attainment, which is estimated at 12-15 years.

Permits & Public Health Requirements. State permits would be required to design and install an impermeable boundary and a pump and treat system. Both DEQ permitting and water rights issues would need to be resolved prior to implementation, which could require up to one year. With respect to public safety, site access control would need to be maintained to limit public exposure to the pumped water.

Summary. An impermeable barrier and pumpback system will allow for active capture and treatment of impacted water. Water management may require the construction of additional storage ponds, unless current infrastructure is sufficient to store captured water. Installation of the barrier will be very invasive and will require special planning.

4.4 Reactive Permeable Barrier

A reactive permeable barrier (RPB) is a placed to intercept contaminants along the groundwater flow path within a contaminant plume. The RPB is designed to react with and/or reduce the toxicity or mobility of contaminant as it passes through the barrier. When properly designed, the contaminant is immobilized in the wall or degraded by compounds used in construction of the wall.

Performance. A reactive permeable barrier can be very effective in treating groundwater where the flow path is well understood or contained, and the quantities of groundwater undergoing treatment are well understood. Treatability testing would be required to determine the optimal composition of an RPB to address impacted groundwater at HPP. It is unlikely an RPB could be installed such that attainment could be reached at the waste unit boundary.

Reliability. RPBs would offer low to moderate reliability. Because they are designed to react with groundwater, several factors affect their ability to function over the long-term, including breakthrough in areas of higher than expected groundwater flow, burnout due to localized flow, and the need to remove and/or replenish the reactive compound due to interactions with contaminants. As a result, RPBs can include long-term O&M and periods of down-time for the system, while maintenance or replacement takes place.

Implementation. Implementing this alternative is very invasive. Large excavations are required to accommodate placement of the barrier, and similar invasive activities are needed to maintain them. Treatability testing would be required to determine if an RPB will effectively support removal of metals from impacted groundwater at the facility.

Potential Environmental / Safety Impacts / Exposure Control. Of the available alternatives, RPBs offer some of the highest risks to exposure from workers. Excavations will expose the aquifer and dewatering is required during installation. Workers may be exposed to contaminated groundwater throughout this process. The risk to release of impacted groundwater is very high as well, because the aquifer material is exposed, and groundwater inflow is being actively managed. While dewatering can be done safely and controlled, exposure control will take the significant effort to mitigate.

Time to Implement / Complete. RPBs will require relatively intensive testing in order to design a barrier that will be effective in treating the metals found in groundwater at HPP. The design element of this alternative is likely to be time intensive, both from an RPB composition perspective, and for engineering design and installation. Once installed, the RPB will begin treating impacted groundwater. Performance monitoring will be required to determine its effectiveness. Installation will likely require one construction season to prepare the site and install the RPB. The installation of a reactive barrier would result in flushing of the downgradient plume with clean water but would not actively treat groundwater between the landfill and the barrier. The lower part of the plume is already below ground water protection standards. As a result, the time to completion would only be marginally faster than maintaining the current interim remedy (15-20 years).

Permits & Public Health Requirements. Additional permits would be required through State agencies to design and construct an RPB. Since the material is reactive, public safety would need to be considered during implementation. Site controls will be required during implementation and operation of the system.

Summary. An RPB offers some very favorable properties, specifically passive treatment of impacted groundwater throughout the year. Implementing this alternative will take 2 to 3 years, and long-term O&M will be required, until landfill closure and capping are complete, and groundwater impacts are reduced to levels below groundwater protection standards. Treatability testing will be required in order to determine the feasibility of this alternative. Based on this, the likelihood of success for an RPB is unknown.

4.5 In Situ Injection of Reactive Compound

In-situ injection involves introducing an agent into the subsurface that physically reacts with the contaminants to degrade, stabilize or immobilize the contaminant in the aquifer. Knowledge of all contaminants and the geochemistry of the aquifer matrix and the water is required to successfully implement this technology.

Performance. Injection of chemicals to residual leachate from the CCR Landfill is unlikely to be successful as a stand-alone alternative. While in situ treatment could result in decreased mobility of metals in the aquifer over the short-term, the depth profile and low permeability of the aquifer, is unlikely to result in the successful placement of chemicals to treat all metals in the groundwater.

Reliability. The reliability of chemical treatment of impacted groundwater will require a pilot study, to determine if chemicals can be effectively applied within the waste or aquifer profile, and if chemical applications immobilize FGD-related constituents sufficiently to support long-term standards attainment objectives. Presently, the reliability of this alternative is unknown.

Implementation. A pilot study would be required to determine if chemical(s) could be applied in the waste across the entire depth profile to effectively immobilize contaminants of concern. The study would also seek to identify which chemical applications have the greatest chance of success to support the cleanup objectives. Because these factors are unknown at this time, the implementability of this alternative is also unknown.

Potential Environmental / Safety Impacts / Exposure Control. In situ application of chemicals to the aquifer would be relatively non-invasive. Likely chemicals would be injected through temporary wells, placed in or downgradient of the pond, based on the pilot study results. Manageable amounts of waste (drill cuttings) would be generated during this process, but safe work practices can mitigate risks to workers. Cuttings can be placed in the pond along with other plant waste to mitigate the potential for releases to the environment during active treatment. Reactions within the waste would be designed to immobilize specific chemicals. The pilot study will be critical to determining if this mitigates risks to mobilization of contaminants to the environment.

Time to Implement / Complete. The pilot study could require up to a year to complete. Vertical profiles of the pond waste would have to be acquired as core samples, followed by batch testing to determine the efficacy of potential chemical amendments. If the pilot test concludes this alternative is viable, chemical injections could begin after the injection well network is developed and installed. Performance monitoring would be frequent during the first year to ensure the effectiveness of the treatment. In-situ injection could be completed within the unit boundary and if the proper substrate is used, this technology would expedite remediation to 10-12 years.

Permits & Public Health Requirements. Remedial activity would require permitting and design documents to be approved by the State Agencies. Public health impacts are not expected since site access is controlled, and the majority of the work will be completed in the subsurface.

Summary. If successful, in situ injection of reactive chemicals would immobilize FGD-related constituents in the groundwater, reducing or eliminating their mobility in the groundwater. Treatability testing is required in order to determine if this alternative can be implemented in the heterogenous waste profile in the impacted area of the aquifer. This alternative does not address the volume of the contaminants, just the mobility.

4.6 Phyto-Technologies

Phyto-remediation is the use of plants or vegetation to uptake contaminants in soil or water and immobilize the contaminant in the cell structures. Specific to groundwater remediation, the selected plant(s) must be in contact with groundwater and thrive while processing the contaminants. Groundwater elevations at the HPP are much deeper than the normal root zones of plants that can survive the arid climate of Utah. Based on these factors, this alternative is not viable to achieve groundwater attainment.

4.7 Electro-Kinetics

Electro-kinetic methods induce a low intensity direct current through the soil or groundwater using a cathode and anode array. The current causes positively charged ions to move toward the cathode and negatively charged ions to move toward the anode where they can be captured or immobilized.

Performance. Electro-kinetic methods can be effective in treating localized or contained contamination, and in relatively homogeneous aquifer settings. It is not clear this alternative can treat groundwater over the spatial area impacted by discharge from the CCR Landfill. A pilot study would be required to determine the viability of this alternative under site-specific conditions.

Reliability. This alternative has been demonstrated as an effective treatment under the right conditions. During active treatment, poles in the system foul over time, due to electro-plating of desired constituents. This results in periods of decreased efficiency and down time to eliminate the effects of fouling. The reliability of the system would be considered moderate.

Implementation. Electro-Kinetic remediation requires a specific contaminant that is attracted to a cathode or anode in an array or a contaminant that can be destroyed by heat. In addition, these methods consume electricity at a very high rate and can only be operated for short periods of time due to the cost. They can be effective if the contaminant is in high concentrations or very limited in extent. As is the case at CCR units, the contaminants are typically dispersed over a large area and in low concentrations once in groundwater. As a result, the implementability of this alternative at the HPP is questionable.

Potential Environmental / Safety Impacts / Exposure Control. Potential exposures to workers could occur during installation of the system, and during periods of maintenance. Because the system treats groundwater in situ, additional exposure to workers or releases to the environment are not anticipated during active operations. The use of electricity does pose a risk to workers.

Time to Implement / Complete. A pilot study would be required to determine if electro-kinetics will serve as a viable alternative to treating impacted groundwater. The pilot study and system design will require a year. Installation could be completed in three months, with system optimization to follow.

Permits & Public Health Requirements. Remediation would require a very specific design and a complicated permitting effort, since the technology is not used extensively. A detailed pilot study would be required to collect the data needed to complete the permitting process. As a result, significant time would be required to obtain the necessary permits. Public health issues are not expected since site access is controlled.

Summary. A pilot study would be required to determine site-specific conditions would lend themselves to effective treatment using electro-kinetics. Based on these findings, an array would be designed and installed to treat impacted groundwater. At present, the viability of electro-kinetics to achieve attainment at the waste unit boundary are unknown.

4.8 Beneficial Reuse

If waste reuse can eliminate environmental concerns while benefitting the end user in a manner that is both economical and protective of the environment, it is generally the preferred alternative.

Performance. Currently the viability of harvesting and use of CCR material (bottom ash, fly ash and FGD waste) is mixed. Mapping of waste disposal practices can make certain parts amenable to beneficial use. However, the manner of placement of the FGD waste in the CCR Landfill has made harvesting usable product not feasible. End users cannot economically utilize the mixed waste in their processes so there is no market/use for mixed waste. Since beneficial use is currently not feasible, the other elements were not evaluated for this option.

4.9 Closure by Removal

This option would involve siting, designing, permitting and constructing a new lined repository, removing all waste from the existing CCR Landfill, and transporting and placing it in the new repository for final disposal. Once removal and compaction are complete, a cap meeting all CCR requirements would be placed on the repository. This alternative does not address the residual impacted groundwater.

Performance. The removal and placement in a lined repository would prevent release of leachate. The new site would be a new CCR Unit and would require long term care and monitoring. The removal would not address impacted groundwater. Over the long-term, natural attenuation would eventually result in attainment, but this period is unknown.

Reliability. A new landfill that meets all of the CCR requirements for liner installation, leachate detection / collection, and an engineered cover would reduce orprevent the release of future leachate. This alternative would not address current conditions in groundwater.

Implementation. Siting a new repository at the HPP would be difficult, as available space suitable to construct a new landfill is very limited. The upper reaches of the plant where the CCR Landfill resides, takes up the majority of available land. If a suitable location can be identified, the design and construction of a new landfill is fully implementable.

Potential Environmental / Safety Impacts / Exposure Control. Increased chances of worker exposure would require mitigation during excavation of existing CCR material, and transport and placement in the new repository. Heightened potential for releases to the environment would also require mitigation, to ensure CCR material is not released as fugitive dust or as a result of spills or accidental dumping. Exposures to workers and releases to the environment can be mitigated through safe work practices and stormwater management.

Time to Implement / Complete. The siting, design, and construction of a new landfill will likely take up to two years to complete. Removal and placement of existing waste to the new repository would also likely require two years. This alternative would not address near-term impacts to facility groundwater. Long-term standards attainment is possible through MNA. Permitting, construction and removal could require up to 5 years and the residual contamination would not be affected by this action. As a result, completion time would be the similar to the current interim remedy (15-20 years).

Permits & Public Health Requirements. A significant permitting effort is expected to site, design and permit a new repository in this location for a large mass of waste. Given the site topography, limited areas are available that are large enough to encapsulate this volume of material. In addition, permits to transport the waste to a new repository may be required depending on the distance from the current landfill and the new repository location. If public haul routes are used, potential public health issues associated with large haul traffic and fugitive dust will need to be mitigated.

Summary. Excavation and placement of existing CCR material in a new onsite repository / landfill, is implementable if a suitable location can be identified and permitted. This alternative will not provide any appreciable benefits to impacted groundwater and would only address the potential for formation of leachate in the landfill in the future.

4.10 Corrective Measures Alternatives

Sections 4.1 through 4.9 presents the evaluation of the ten corrective measures. The evaluations indicate that the current actions implemented under at the site address the concerns at the site. Active treatment of the impacted groundwater would reduce the time by approximately 10 years for the impacted groundwater to meet groundwater protection standards under the *Final Rule*. From the evaluations, a pump and treatment system is the preferred option to actively treat the impacted groundwater. Removal of the landfill would have no impact on contamination already in groundwater. Based on the evaluation, two corrective measures alternatives appear to be the most applicable to address groundwater impacts associated with the Hunter CCR Landfill:

1. Alternative 1 – Maintain Current Operations

2. Alternative 2 – Maintain Current Operations Corrective Measures with a Pump and Treat Groundwater Treatment System

5.0 SELECTION OF THE REMEDY

The CCR Landfill remedy will be selected following public meetings / public comment. The remedy selected will be determined by utilizing the requirements § 257.96 in the *Final Rule*.

Table 7. Alternatives Screening

Regulatory Reference	257.96 (c) (1)						257.96 (c) (2)		257.96 (c) (3)
Corrective Measure – Alternative:	**Performance**	**Reliability**	**Implementation**	**Potential Impacts of Remedy**	**Safety Impacts**	**Control of Exposure**	**Time Required to Begin**	**Time Required to Complete**	**State & Local Permits, Public Health Requirements**
Maintain Current Corrective Actions	=	=	=	=	=	=	=	=	=
Pump & Treat	+	+	+	+	-	-	+	+	-
Impermeable Barrier / Pumpback System	=	-	-	-	-	-	-	+	-
Reactive Permeable Barrier	=	-	-	-	-	-	-	+	-
In Situ Injection of Reactive Compound	-	-	-	-	-	+	-	-	-
Phyto-Technologies	NV								
Electro-Kinetics	=	-	-	-	-	+	-	=	-
Beneficial Reuse	NV								
Closure by Removal	+	+	-	-	-	-	-	+	-

\+ Positive
\- Negative
= Neutral
NV: Not Viable

6.0 REFERENCES

ATSDR, 2019. Agency for Toxic Substances and Disease Registry, Public Health Statements, Lithium and Molybdenum. https://www.atsdr.cdc.gov/phs/index.asp

Hale, L.A. and F.R. Van De Graaff, 1964. Guidebook to the Geology and Mineral Resources of the Uinta Basin: Utah's Hydrocarbon Storehouse. 1964

Hettinger, R.D. and Kirschbaum, M.A. 2002. Stratigraphy of the Upper Cretaceous Mancos Shale (Upper Part) and Mesaverde Group in the Southern Part of the Uinta and Piceance Basins, Utah and Colorado, USGS Geologic Investigation Series I-2764.

Morris, D.A. and Johnson, A.I. (1967). Summary of Hydrologic and Physical Properties of Rock and Soil Materials, as Analyzed by the Hydrologic Laboratory of the U.S. Geological Survey, 1948-1960. USGS Water Supply Paper: 1839-D. In Kresic N. 2007. Hydrogeology and Groundwater Modeling, p 111. CRC Press.

NIH, 2015. Sodium Chloride Toxicity and the Cellular Basis of Salt Tolerance in Halophytes, Annals of Botany, U.S. Department of Health and Human Services, National Institutes of Health, Timothy J. Flowers, Rana Munns, and Timothy D. Colmer. February 2015.

NIH, 2009. The Role of Lithium in the Treatment of Bipolar Disorder, U.S. Department of Health and Human Services, National Institutes of Health, Rodrigo Machado-Vieira, Husseini K Manji, and Carlos A Zarate, Jr. June 2009.

NOAA, 2015. National Oceanic and Atmospheric Administration, Western Regional Climate Center. https://wrcc.dri.edu/

PacifiCorp, 2018. Annual Groundwater Monitoring Report, Hunter Power Plant, Utah. PacifiCorp, December 2018.

Skougard & Brotherson, 1979. Vegetational response to three environmental gradients in the Salt Playa near Goshen, Utah County, Utah. January 1979.

Stokes, W.L. 1986. Geology of Utah. Utah Museum of Natural History and Utah Geological and Minerals Survey.

Utah Department of Environmental Quality, 2015. Groundwater Discharge Permit UGW150001, Statement of Basis, Pacificorps Hunter Plant, Castle Dale, UT. September 2015.

Waddell, K.M. Contratto, P.K. Sumison, C.T. and Butler, J.R. 1979. Hydrologic Reconnaissance of the Wasatch Plateau-Book Cliffs Coal-Fields Area, Utah. USGS Geological Survey – Water Supply Paper 2068.

Water & Environmental Technologies, 2005. Hunter Power Plant Site Wide Monitoring Program – 2004 Annual Monitoring Report. Revision 1 - March 29, 2005.

Water & Environmental Technologies, 2010. Ground Water Analysis – Hunter Power Plant. March 30, 2010.

Water & Environmental Technologies, 2015. Ground Water Analysis – Hunter Power Plant. March 12, 2015.

Water & Environmental Technologies, 2019. Groundwater Monitoring & Corrective Action Report. CCR Landfill – Hunter Power Plant. January 2019.

FIGURES

Legend

MasterWells

N
W E
S

Feet

0 300 600 1,200

PACIFICORP

WET Water & Environmental Technologies

HUNTER POWER PLANT

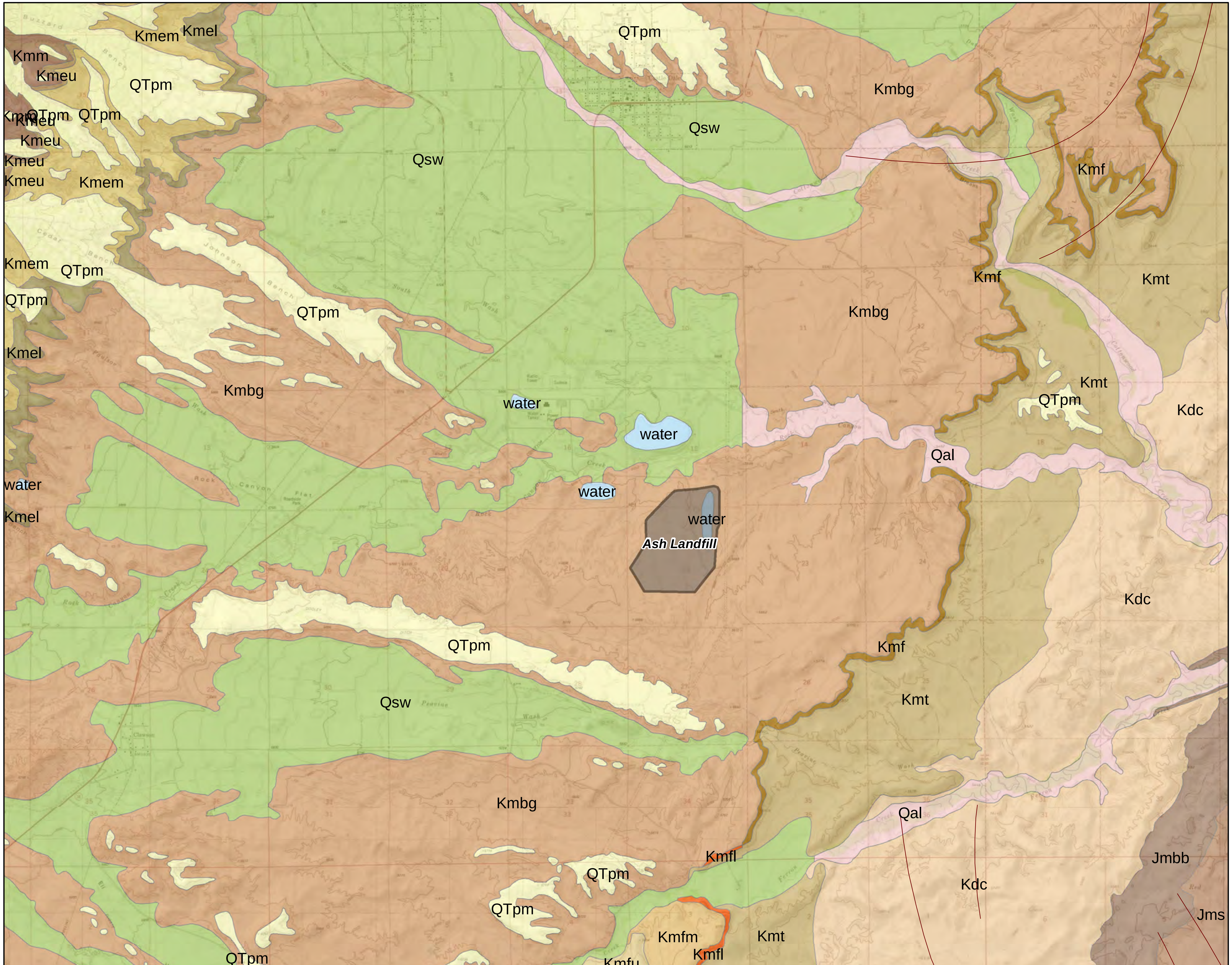
CCR Sample Locations

Job#: PERCM52

Date: 1/21/2019

FIGURE 1

Path: M:\PERC_CCR\Hunter\2018\Moly_53018.mxd, Author: jleprowse



Legend

Folds

Geologic Unit

- Jmbb, Brushy Basin Member of Morrison Formation
- Jms, Salt Wash Sandstone Member of Morrison Formation
- Js, Summerville Formation
- Kdc, Dakota Sandstone and Cedar Mountain Formation
- Kmbg, Blue Gate Member of the Mancos Shale
- Kmel, Lower unit of the Emery Sandstone Member of the Mancos Shale
- Kmem, Middle unit of the Emery Sandstone Member of the Mancos Shale
- Kmeu, Upper unit of the Emery Sandstone Member of the Mancos Shale
- Kmf, Ferron Sandstone Member of Mancos Shale
- Kmfl, Lower unit of the Ferron Sandstone Member of the Mancos Shale
- Kmfm, Middle unit of the Ferron Sandstone Member of the Mancos Shale
- Kmfu, Upper unit of the Ferron Sandstone Member of the Mancos Shale
- Kmm, Masuk Member of the Mancos Shale
- Kmt, Tununk Member of the Mancos Shale
- QTpm, Pediment Mantle
- Qal, Alluvium
- Qsw, Slope wash
- water, water

Feet

0 2,000 4,000 8,000

N W E S

PACIFICORP

WET Water & Environmental Technologies

HUNTER POWER PLANT

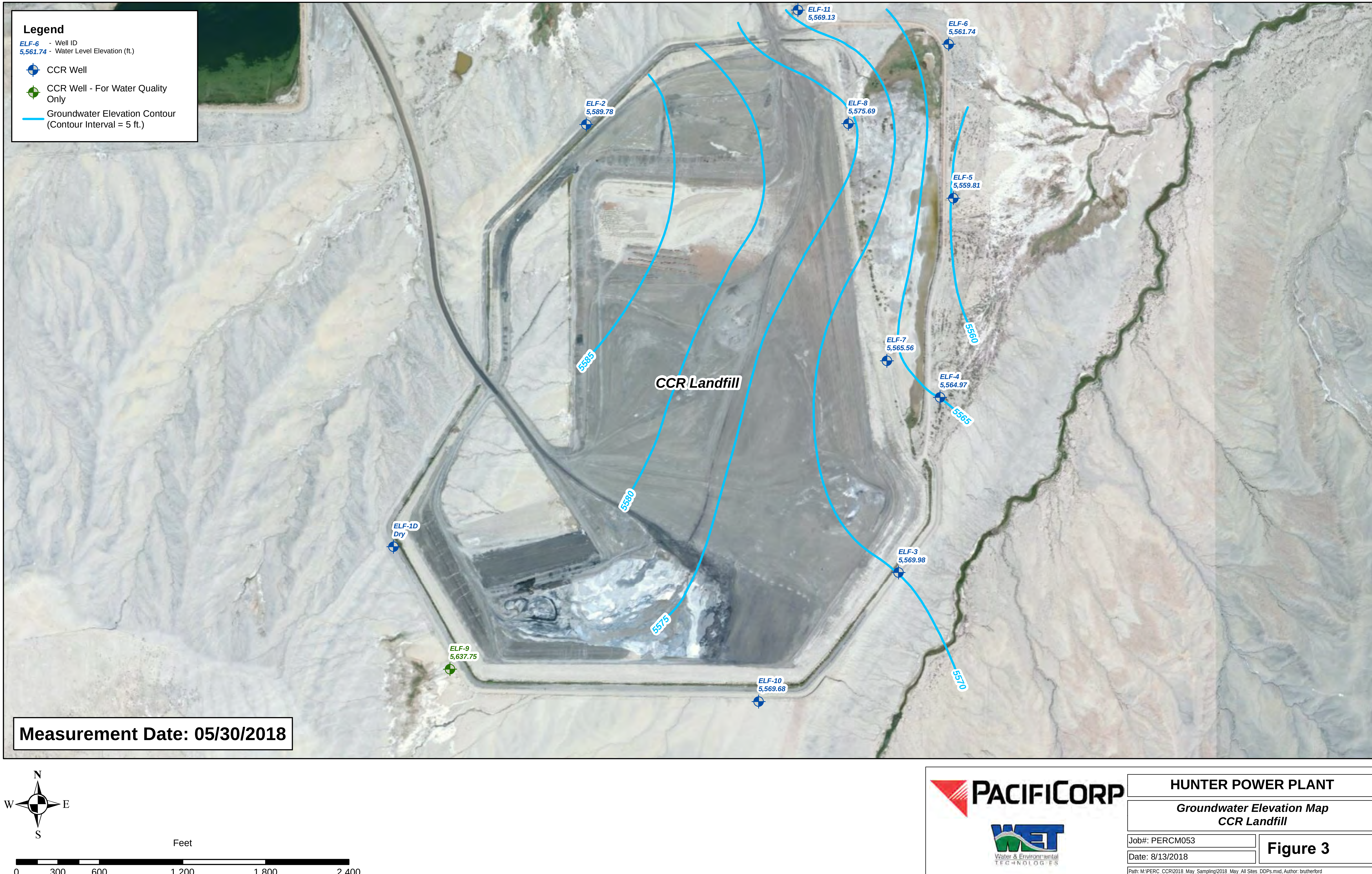
Geologic Map

Job#: PERCM52

Date: 12/20/2017

FIGURE 2

Path: M:\PERC_CCR\Hunter\Figure 2_Geology.mxd, Author: Stefanie

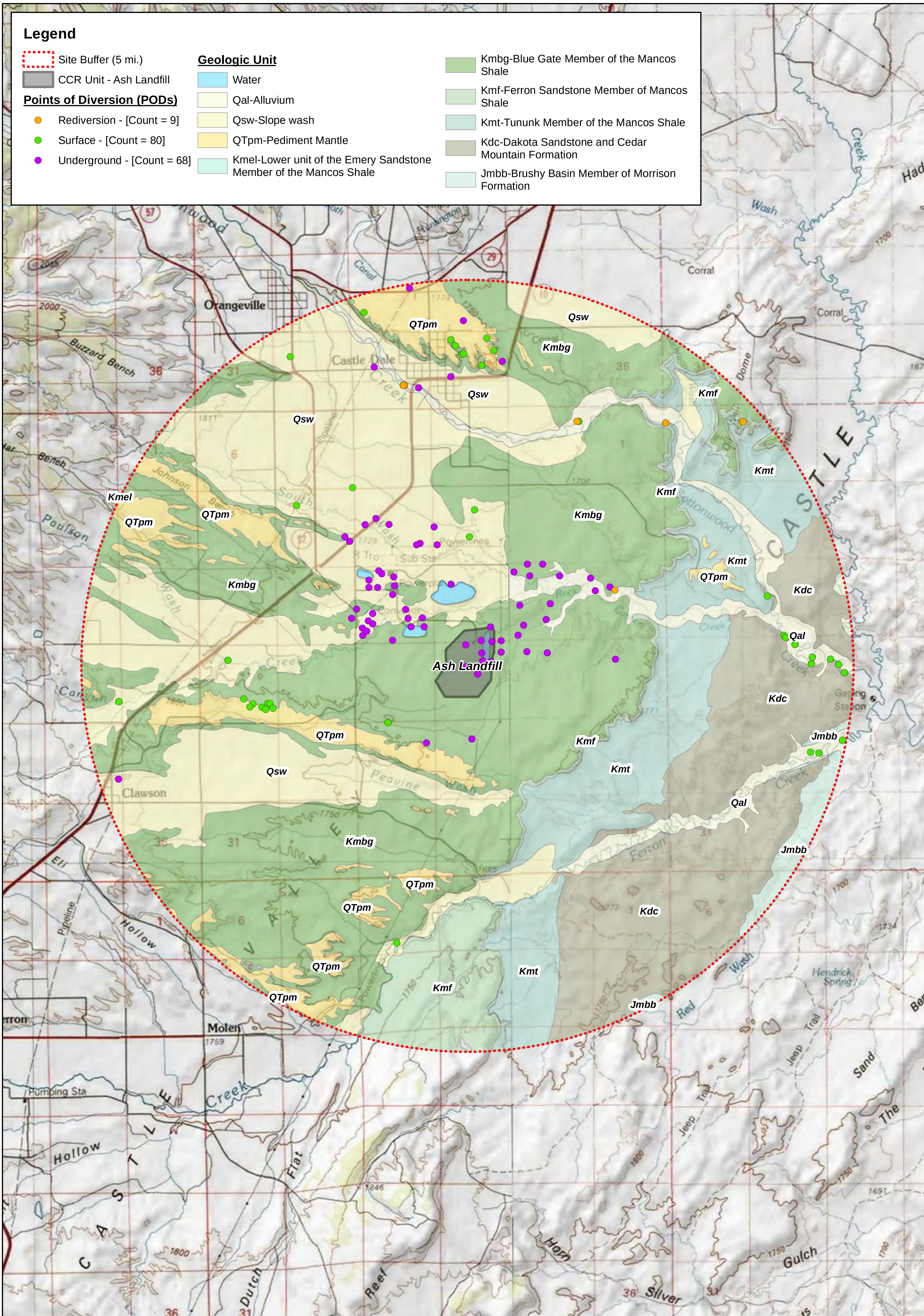


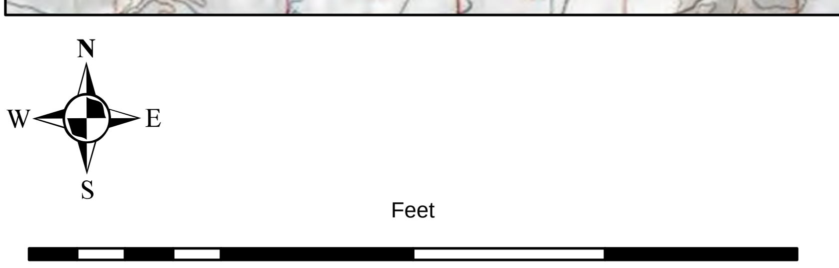
PACIFICORP

Water & Environmental Technologies

HUNTER POWER PLANT	
Groundwater Elevation Map CCR Landfill	
Job#: PERCM053	Figure 3
Date: 8/13/2018	

Path: M:\PERC_CCR\2018_May_Sampling\2018_May_All Sites_DDPs.mxd, Author: brutherford





PACIFICORP

WET Water & Environmental Technologies

Hunter Power Plant

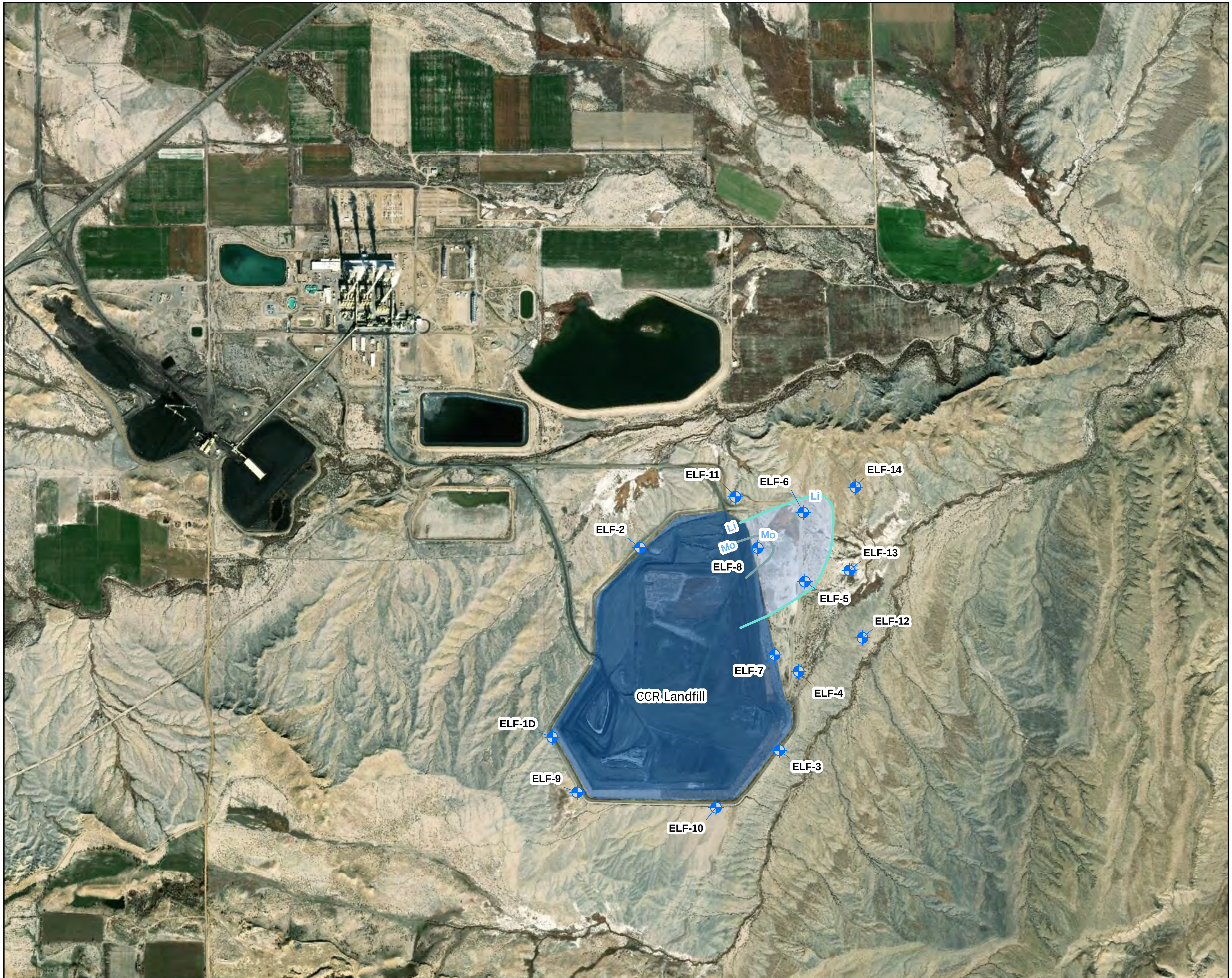
Points of Diversion (PODs) Map

Job#: PERCM052

Date: 3/26/2019

Figure 4

Path: M:\Hunter\2018\Points of Diversion_Geo.mxd, Author: brutherford



Legend

- MasterWells
- Mo - Molybdenum
- Li - Lithium
- Groundwater Plume
- CCR Landfill

N
W E
S

1 Inch = 1,500 Feet

0 750 1,500 3,000

PACIFICORP

WET Water & Environmental Technologies

HUNTER POWER PLANT

Appendix IV - Groundwater Exceedances

Job#: PERCM52	**FIGURE 5**
Date: 2/22/2019	

Path: M:\PERC_CCR\Hunter\2019\AppIV_Figure2.mxd, Author: jslocum