STATEMENT OF BASIS
WESTERN ZIRCONIUM WASTEWATER EVAPORATION PONDS
Permit No. UGW570002

I. Description of Facility

Western Zirconium is an operating unit of the Nuclear Fuels Business Unit of Westinghouse Electric Company. The facility is located at the eastern base of Little Mountain, approximately 12 miles west of Ogden, Utah. The total Western Zirconium site encompasses 1,100 acres of land. Wastewater evaporation ponds cover approximately 110 acres of the site. The Western Zirconium's wastewater evaporation ponds qualify as an existing facility under the Utah Ground Water Protection Regulations.

Western Zirconium extracts zirconium and hafnium metals from raw materials, and then fabricates these metals into products used primarily by the nuclear fuels industry. The plant process can be divided into three sections; 1) Extraction, 2) Reduction/Melting, and 3) Fabrication.

1. Extraction

The extraction portion of the process produces pure zirconium chloride from the starting raw material, zirconium oxychloride crystals. The first step is to dissolve zirconium oxychloride crystals in water to produce a zirconyl chloride solution. At this point the zirconyl chloride solution contains approximately 10% hafnium, an element that is considered an impurity in zirconium products. The hafnium content must be reduced to below 25 ppm in order for zirconium to be suitable for nuclear use. The zirconium and hafnium are separated in the second step of the extraction process.

In the next step of the extraction process the zirconyl chloride solution, containing significant hafnium, is processed through a multi-stage liquid chemical separation process which utilizes methyl iso-butyl ketone (MiBK), ammonia, nitric acid, and sulfuric acid to separate the zirconium and hafnium. The zirconium, which now exists as a sulfate, is fed into a rotary kiln which produces a zirconium oxide powder which becomes the feed for the final extraction step, Chlorination.

In the chlorination step, zirconium oxide is combined with chlorine gas in a fluidized reactor at high temperature to produce zirconium tetrachloride, which becomes the starting raw material feed for the Reduction/Melting portion of the Western Zirconium process.

Four aqueous waste streams are produced in the extraction process and are eventually sent to the evaporation/holding ponds. The first stream is produced in the separation step and contains ammonia chloride, zirconium, hafnium, and methyl isobutyl ketone (MiBK). This stream is first sent to an elementary neutralization station where pH correction is made utilizing liquid ammonia prior to entering the Plant Ammonia Drain (PAD) and eventual discharge into either Ammonia Chloride pond #1 or #2 (A1, A2). The second stream is produced by the air pollution control equipment scrubbing the offgas of the rotary kiln where zirconium sulfate is changed to zirconium oxide. This stream is a sodium sulfate solution that is discharged through the Plant Upset Drain (PUD) to the Upset Pond (U1). The third and fourth aqueous waste streams are produced from the air pollution control equipment scrubbing offgas from the chlorine fluidized reactors. The first of the scrubbers use water to remove zirconium particulate from the offgas and this stream is sent to an elementary neutralization until where the pH is adjusted using lime. This stream is then discharged through the Plant Calcium Drain (PCD) to evaporation/holding ponds Calcium Chloride #1 and #2 (C1, C2). The second scrubbers use sodium hydroxide to remove residual chlorine from the offgas stream. This aqueous sodium hypochlorite stream is discharged through the Plant Sulfate Drain (PSD) to the Sodium Chloride Pond (S1).

2. Reduction/Melting

In the reduction process, zirconium tetrachloride powder from the separation process is placed in a vessel with magnesium metal. The vessel is then heated until the magnesium melts and the zirconium powder turns into a gas. A reaction then occurs where the chlorine is transferred from the zirconium to the magnesium producing zirconium metal and magnesium chloride salt. This zirconium metal is then melted into ingots to serve as the raw material for the fabrication process.

Offgas from the reduction vessels is scrubbed with water to remove zirconium particulate. The effluent from the scrubbers is first sent to the lime elementary neutralization unit for pH adjustment and then discharged through the PCD drain to evaporation/holding Ponds C1 and C2.

3. Fabrication

The fabrication process takes the zirconium ingots produced by the reduction/melting process and fabricates them into tubes, sheets, and wire for sale in the nuclear power generating industry. Standard metal fabrication processes of forging, extrusion, rolling and wire draw are utilized. Water quenching of heated zirconium as well as acid pickling utilizing nitric and hydrofluoric acid is also performed. Aqueous waste streams from the quenching, pickling, and particulate scrubbers are sent to the lime elementary neutralization unit before being discharged to ponds C1 and C2.

II. Characteristics of Wastewater

All industrial waste water at the plant is presently neutralized and transferred to one of the six operational ponds in the pond system. The operational pond system (shown in Figure 2 of the Evaporation Pond Area Ongoing Monitoring Plan) consists of two

Ammonium Chloride Ponds (A1 and A2), two Calcium Chloride Ponds (C1 and C2), one sodium Chloride Pond (S1), and an emergency or upset pond (U1). Ponds C1 and C2 receive waste waters from the Chlorination, Reduction, and Fabrication processes. Ponds A1 and A2 receive waste water from the Separation Department. Pond S1 receives waste water from the Chlorination process caustic scrubber and blow down from the plant cooling towers. Pond U1 receives waste water from the Separation Process air pollution control pad.

The average daily discharge to the ponds is 166,900 gallons per day (gpd). The largest amount of effluent comes from the Plant Calcium Drain (PCD) which discharges on average 127,072 gpd to ponds C1 and C2. The largest constituents of this effluent stream are calcium chloride salt, nitrate-nitrite, and fluoride. There are also trace amounts of zirconium and hafnium metal, radionuclides, and some trace organics from the chlorination process. The Plant Ammonia Drain (PAD) discharges on average 28,942 gpd to ponds A1 and A2. The largest constituents of this effluent stream are ammonium chloride salt, zirconium and hafnium, and trace amounts of methyl iso-butyl ketone (MiBK). The Plant Sulfide Drain (PSD) discharges on average 9768 gpd to the S1 pond. The largest constituent of this effluent stream is sodium hypochlorite (bleach) from the caustic scrubbing of chlorine gas by the chlorination scrubbers. This drain also receives blow down from the plant cooling towers. The Plant Upset Drain (PUD) discharges on average 1,119 gpd to the U1 pond. The largest constituent of this effluent stream is Sodium Sulfate salt, and some zirconium and hafnium salts.

The ponds were sampled during all four quarters of 2002 and 2003 and in the third quarter of 2004. The analytical data is available in those quarterly monitoring reports, contained in DWQ's files. Only minor changes have occurred to the plant's process since that time, and pond constituents should not have changed since that sampling. Note that effluent is transferred among ponds during the year to keep a constant level across the ponds to promote evaporation.

III. Description of Hydrogeology

The Western Zirconium site is located in western Weber County, in a salt flats area near the shore of the Great Salt Lake and at the eastern foot of Little Mountain, an isolated hill composed of Precambrian bedrock. Little Mountain is almost certainly the surface expression of a Basin and Range fault block, and there are indications that a concealed fault occurs in the subsurface along its eastern base, adjacent to the Western Zirconium site.

In a hydrogeologic sense, the site is part of the East Shore area of the Great Salt Lake. Like most areas along the Wasatch Front, ground water flow is controlled by geologic structure, elevation differences between recharge and discharge areas, and stratigraphy of the thick valley-fill sediments that underlie the East Shore area. Ground water recharge takes place primarily in areas of higher elevation in the Wasatch Mountains and particularly in the coarse-grained sediments that underlie the bench areas at the foot of the mountains. Low-lying areas to the west of the mountain front are underlain by generally fine-grained lake sediments of low permeability. However, coarse-grained alluvial deposits were deposited underneath the lake sediments and they extend far to the west of the mountain front. These coarse-grained sedimentary layers are contiguous with, and at lower elevation than, the coarse-grained mountain front deposits. As a result, they form confined aquifers in the East Shore area that are under artesian pressure because of the higher elevation of the recharge areas. In much of western Weber County, two main confined aquifers are recognized, the Sunset Aquifer and the underlying Delta Aquifer. Near the Great Salt Lake, the aquifers are composed of thin alternating layers of silt, clay and sand, and are difficult to differentiate. (Clark, et. al., 1990)

The ground water affected by the facility is a shallow, unconfined aquifer contained in the fine-grained lake sediments immediately underlying the evaporation ponds. The sources of the ground water in this aquifer are upward leakage from deeper confined aquifers, infiltration of precipitation and possibly recharge from Little Mountain. Ground water at the site occurs at depths ranging from 0 to 20 feet below ground surface. Ground water from the shallow unconfined aquifer is not used due to its high dissolved solids concentration, poor quality and low yield. (Western Zirconium RFI Phase I Report, 2003) Ground water elevations are higher on the western side of the site, near Little Mountain, possibly from enhanced upward flow from deeper confined aquifers due to the concealed fault in the subsurface along the base of Little Mountain. Leakage from the evaporation ponds has resulted in a ground water mound centered on the ponds, which is documented in potentiometric contour maps contained in Western Zirconium's quarterly monitoring reports.

Ground water movement in the fine-grained sediments of the shallow unconfined aquifer is very slow, as seen by the fact that significant contamination has not reached the "sentry" monitor wells located approximately 700 to 1000 feet from the perimeter of the evaporation ponds after over thirty years of pond operation. However, because the water table is very shallow and intersects the land surface at times, the shallow ground water can discharge to and become surface water in the salt flats environment east of the plant site. Partial erosion of the sedimentary surface east of Little Mountain has produced knob-and-swale topography. The swales were former erosional channels that have been modified by construction of the wastewater ponds, embankments and other features at the plant site. These swales often hold surface water bodies, particularly during the colder part of the year. The main source of the surface water is storm runoff and snowmelt, but water quality has been affected by upwelling shallow ground water and possibly by leaching from contaminated soils. Overland flow of contaminated surface water is the dominant contaminant migration pathway to areas away from the ponds. (Western Zirconium Phase II RFI Report, 2004). This contaminated surface water may also recharge shallow ground water at locations far away from the ponds.

Because of the limited usefulness of shallow ground water at the site, the primary threat posed by Western Zirconium's wastewater evaporation ponds to waters of the state is the discharge of contaminated surface water to the Great Salt Lake ecosystem.

IV. Discharge Minimization Technology

The existing evaporation ponds were constructed in the late 1970s and early 1980s, under a Construction Permit issued on June 22, 1978 by the Bureau of Water Pollution Control. As such, they are considered "existing facilities" under the Utah Ground Water Protection Regulations, adopted in 1990. Initially, the first ponds had flexible membrane liners (FMLs) installed to line the ponds, but because of upwelling ground water under the site, large bubbles or "whales" formed under the FMLs and the liners had to be removed. The existing ponds were constructed by building 12 foot high dikes upon the existing ground surface forming the ponds. The ponds are surrounded by a dike system that is mostly composed of silty sands and gravels, and with a gravel-surfaced road with little if any surface vegetation. The dike crest ranges from a minimum width of about 12 feet to a maximum width of about 16 feet. The original pond drawings and specifications called for 1 to 2 feet of compacted impervious silt to line the bottom of the ponds and to extend to form the body of the dikes. A 3 foot wide cutoff trench constructed of the same material was to extend from the bottom of the dike into the existing gumbo clays underlying the dike.

Since 1992, monitor wells located adjacent to the ponds have shown significantly elevated levels of ammonia, radium and other constituents found in the pond water. As a result of this, on June 14, 1999 the Division of Water Quality issued a Notice of Violation and Order to Western Zirconium. The Order required Western Zirconium to conduct a Contaminant Investigation, according to the provisions of UAC R317-6-6.15(D), and to repair the pond and liner to come into compliance with UCA 19-5-107(2) and the 1978 Construction Permit.

After investigation and consideration of alternatives, Western Zirconium has proposed a subsurface barrier wall surrounding the evaporation ponds to minimize discharge to ground and surface water. In combination with a low-permeability clay layer underneath the ponds, this wall should significantly cut off subsurface flow of wastewater from the ponds. Existing contamination outside the wall should decrease by natural attenuation over time. This subsurface barrier is classified as a new facility under the Ground Water Protection Regulations, and this ground water discharge permit is required to operate it. Construction of the barrier began in October, 2012 after Western Zirconium received approval from the Army Corps of Engineers to fill wetlands in the project area. DWQ issued a Construction Permit for the subsurface barrier on May 18, 2012.

Because of the site's potential to affect ground and surface water, and considering the hydrogeologic conditions and characteristics of the wastewater, Western Zirconium has chosen to construct a composite subsurface barrier wall with hydraulic conductivity of 1×10^{-7} cm/sec or less surrounding the evaporation ponds to cut off the source of discharges to shallow ground water and surface water. Western Zirconium's site investigations have documented the presence of low-permeability clay layers underneath the pond site. (WZ Phase I RFI Report, Sec. 6, Figures 6-1 and 6-2, 2003; WZ Phase II RFI Report, Sec. 2, Figures 2-2 through 2-3, 2004) The impermeable barrier wall will inhibit lateral flow of ground water contaminated by pond seepage; vertical flow will be inhibited by the low-permeability clays and by the upward hydraulic gradient caused by flow from deep aquifers.

New structures constructed as part of this wastewater containment system include a 10,800 foot long, 40 foot wide work pad, a composite subsurface barrier wall, a new dike system and access road surrounding the evaporation ponds. There will be sufficient volume in the space between the new dike and existing pond dikes to provide for secondary containment in the event of a pond dike breach.

Soil improvement will be done under the work pad to provide seismic foundation support for the new exterior dike and wall that are underlain by liquefiable soils. The soil improvement will consist of shallow soil-cement mixing where a Portland Cement grout will be injected underneath the working pad and mixed with the native soils to a depth of approximately 3 to 5 feet.

Following installation of the work pad, the composite barrier wall will be installed using slurry trench technology. A 3-foot wide slurry trench will be excavated through the work pad and underlying soils. The trench will be kept full of slurry during the entire excavation operation to maintain trench stability. The slurry trench will be extended through a minimum of 10 feet to low-permeability soils that underlie the pond area. The trench bottom will range from an elevation of 4180 to 4200 feet above mean sea level (msl), corresponding to a depth of between 15 and 40 feet below the existing ground surface, averaging 25 feet.

Excavated soils will be placed on the work pad and mixed with the slurry and sepiolite clay to produce a low permeability backfill. The backfill will be placed back into the trench in a controlled fashion to displace the slurry and produce a continuous barrier around the evaporation ponds. Following backfill placement, interlocking high density polyethylene (HDPE) sheet piles will be inserted through the soil-sepiolite backfill. The HDPE sheeting will extend about the work pad surface and be incorporated into the new dike section, providing containment of any seepage or ponded water to elevation 4219 feet above msl. This composite barrier wall construction has been shown to meet long-term permeability requirements when subjected to the contaminated pond water.

Following barrier wall installation, a new dike will be constructed along the alignment to elevation 4220 feet above msl, providing 1 foot of freeboard above the elevation 4219 barrier wall. The average height of the dike will be about 5 feet above ground surface, and a 10-foot wide access road will be constructed along its exterior. The interior side of the dike will consist of select low-permeability core material placed and compacted against the HDPE sheet pile to protect above-grade portions of the sheet pile and maintain composite construction similar to that installed in the slurry trench. The exterior of the dike will consist of compacted granular soils with erosion protection rock on the inboard (pond) side. The dike will provide 48 acre-feet of spill containment in the event of a breach of a pond dike, meeting state Dam Safety regulations.

Surface water that has been affected by surfacing shallow ground water flows northward from the evaporation pond site in two swales that are impounded against a railroad grade to form surface water bodies, designated SWB-3 and SWB-9. To prevent contaminated surface water from flowing off the property, Western Zirconium has plugged culverts underneath the railroad grade where it crosses these swales. Contaminated ground water can still flow under the railroad grade, but this will be at a much slower rate than surface water flow.

V. Basis for Permit Issuance

Ground water contamination has already occurred at this site and the permitted facilities are intended to cut off the source of the contamination. Compliance with permit conditions will be demonstrated through monitored natural attenuation in the site's ground water, and no contamination in surface water off of Western Zirconium's property boundary that poses a risk to the Great Salt Lake ecosystem. The compliance monitoring plan is contained in the document "Evaporation Pond Area Ongoing Monitoring Plan", dated February, 2013, which is attached as Appendix A to the permit.

After completion of the barrier wall, if discharge of wastewater from the evaporation ponds to the subsurface has been effectively cut off, several changes should be observed in the ground water surrounding the ponds. The existing ground water mound should dissipate, and ground water elevations outside the barrier wall should drop compared to ground water elevations within the area enclosed by the wall. Contaminant concentrations within the existing plume of contaminated ground water should decrease. It may still be possible that the plume boundary could expand outward, but by itself, that would not demonstrate that the contaminant source has not been cut off. Also, because of the very low permeability of the sediments surrounding the evaporation ponds, any changes caused by the cutoff wall may happen very slowly.

This permit is founded on the concept that Western Zirconium has constructed a barrier wall that effectively isolates the evaporation ponds from the surrounding ground and surface water. To demonstrate that the barrier wall is functioning as designed, it will be necessary to review different types of monitoring data from many different points, and get an idea of site-wide conditions. Because of this, permit compliance will not be tied to numeric levels of contaminant concentrations or ground water elevations, but rather on a review of all relevant data needed to demonstrate barrier wall effectiveness.

Western Zirconium has constructed "sentry" monitor wells in uncontaminated ground water immediately outside of the plume of contaminated ground water. Ground water protection levels have been determined for these wells based on past monitoring data. Other monitoring wells ("plume wells") currently exist or will be constructed within the plume.

Under anticipated conditions after the source of ground water contamination has been cut off, contaminated ground water may still migrate to the sites of the sentry wells and affect the water chemistry observed in them. Therefore, if protection levels are exceeded in one of these wells for longer than four consecutive quarterly monitoring events, Western Zirconium shall locate and construct a new sentry monitoring well in uncontaminated ground water as close as practical to the contaminated sentry well. This will monitor any expansion of the contaminated ground water plume, and the old sentry well will continue to be monitored as a plume well. Contamination of a sentry well will not be considered noncompliance with permit conditions, as long as the well is replaced in a timely fashion.

The following sources of information shall be monitored under this permit, and taken into consideration to determine whether Western Zirconium's subsurface barrier wall is performing in such a way as to minimize further releases of process water from the evaporation ponds:

1. Ground water elevation data from paired piezometers on either side of the subsurface barrier should eventually show significantly higher ground water static levels inside the area enclosed by the barrier wall as compared to the levels outside the barrier. Ground water elevations within the existing ground water mound outside the barrier should become lower over time.

2. Levels of contaminant concentrations in plume monitor wells should decrease over time in general, although levels in some wells may increase temporarily due to migration of existing contaminated ground water.

3. Surface water on Western Zirconium's property that is not significantly affected by discharges of contaminated ground water, and surface water beyond Western Zirconium's property boundary, should continue to show levels of contaminants that remain below the standards based on Western Zirconium's 2008 Ecological Risk Assessment. Existing contaminated surface water bodies on Western Zirconium's property located outside of the area enclosed by the subsurface barrier wall and dike should show a decrease in levels of contaminants.

To evaluate effectiveness of the subsurface barrier wall and natural attenuation of the existing ground and surface water contamination, permit conditions will require quarterly sampling of sentry monitor wells, semi-annual sampling of surface water sampling points, annual sampling of plume monitor wells and quarterly collection of ground water elevation data from the monitor wells and also from piezometers associated with the barrier wall.

Several existing plume monitor wells will need to be plugged and abandoned due to construction of the barrier wall. After wall construction is completed, new wells will be constructed to replace the abandoned wells, and the permit will require accelerated sampling from them for eight sampling events to help define variability of ground water chemistry in these wells.

Ground water monitoring wells and surface water monitoring points will be sampled for ammonia, total cyanide, total barium, dissolved cadmium, dissolved selenium, dissolved uranium, total zirconium, nitrate + nitrate, radium 226 + 228, total dissolved solids and pH.

Several different types of monitoring points will be used to determine compliance with permit conditions:

1. Sentry monitor wells are located around the downgradient periphery of the site immediately outside the current extent of the plume of contaminated ground water. These wells will be sampled quarterly. Analytical results will be compared to protection levels derived from the greater of the mean plus 2 times the standard deviation from background data or from concentrations determined by the 2008 Ecological Risk Assessment. (Most of these wells have been monitored for several years and significant background data has been collected from them.) If analytical values exceed the protection levels for four consecutive quarters, Western Zirconium shall locate and construct a new monitor close to the site of the contaminated well and immediately outside the plume of contaminated ground water, as a means to track expansion of the plume. The old sentry well will continue to be monitored as a plume well.

2. Plume monitoring wells are located within the plume of contaminated ground water originating from the ponds. These wells will be sampled annually in the third quarter. The purpose of monitoring these wells is to track the natural attenuation of the plume. It is expected that following barrier wall construction and cutoff of subsurface discharge from the ponds, contaminant concentrations in these wells will generally not increase and should show a slow decrease over time, due to the low permeability of the site's soils. Analytical results from this monitoring will be compared to those of the last monitoring event before construction of the barrier wall began, the third quarter of 2012, and also to data collected before then. Several in-plume monitoring wells will be plugged and abandoned during barrier wall construction, and new wells constructed to replace them after completion of the barrier wall. Analytical results from these wells will be compared to results of the first monitoring event following well completion. In addition, to better define variability of contaminant concentrations, new plume wells will be monitored quarterly for eight quarters following well completion.

3. Surface water bodies SWB-3, SWB-7, SWB-8, SWB-9, SWB-10, AND SWB-11 (defined in the Evaporation Pond Area Ongoing Monitoring Plan dated February, 2013) will be monitored semi-annually in the second and fourth quarters of the year, for the same parameters as the monitoring wells. Monitoring results for ammonia, total barium, dissolved cadmium and dissolved selenium will be compared to the Ecological Risk-Based Cleanup Goals for the Mud Flat Area as determined in Western Zirconium's January, 2008 Ecological Risk Assessment (ERA). Monitoring results for total cyanide will be compared to the ERA cleanup goal for free cyanide. Monitoring results for nitrate + nitrite will be compared to

the water quality standard of 10 mg/l. It is not expected that these cleanup goals will be met immediately in all monitored surface water bodies, but cutoff of the source of contaminated ground water that affects surface water quality should result in a decrease in contaminant concentrations in surface water over time. Meeting the cleanup goals in all surface water bodies outside of the subsurface barrier wall and dike is the long-term goal of this remedial action and would define successful containment of Western Zirconium's wastewater.

4. Ground water elevations will be measured quarterly in all monitor wells and piezometers. Twelve pairs of piezometers will be installed at equal distances around the barrier wall, with one of the pair inside the wall and the other piezometer immediately outside the wall. Five existing nested piezometers will continue to be monitored to measure vertical hydraulic gradient. If the subsurface barrier wall is successfully containing the evaporation pond wastewater, ground water elevations measured in the monitor wells should show dissipation of the existing ground water mound over time; the paired piezometers around the barrier wall should show significantly higher ground water elevations inside the area enclosed by the barrier wall compared to outside the wall; and the nested piezometers should show an upward vertical hydraulic gradient which would help to contain the contaminated ground water within the barrier wall.

REFERENCES

Evaporation Pond Area Ongoing Monitoring Plan, Western Zirconium, December 2012, DWQ files

Quarterly Monitoring Reports, Western Zirconium, First through Fourth Quarters, 2002; First through Fourth Quarters 2003; Third Quarter 2004; Third Quarter 201 DWQ files

Clark, D.W., Appel, C.L., Lambert, P.M., and Puryear, R.L., 1990, Ground-Water Resources and Simulated Effects of Withdrawals in the East Shore Area of Great Salt Lake, Utah, Technical Publication No. 93, State of Utah Department of Natural Resources

Phase I RCRA Facility Investigation Report for Pond Solid Waste Management Units and Area of Concern Lowlands East of the Plant, Western Zirconium, February 2003, DWQ files

Phase II RCRA Facility Investigation Report for Pond Solid Waste Management Units and Area of Concern Lowlands East of the Plant, Western Zirconium, August 2004, DWQ files

Ecological Risk Assessment, Western Zirconium, January 2008, DWQ files