SECTION 2: PROCESS DESCRIPTION
ENERGY FUELS RESOURCES CORPORATION
PIÑON RIDGE MILL
PROCESS DESCRIPTIONS
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<tr>
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<tr>
<td>CCD</td>
<td>Counter current decantation</td>
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<tr>
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<tr>
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<td>Piñon Ridge Mill Facility</td>
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<tr>
<td>FRP</td>
<td>Fiberglass reinforced plastic</td>
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<tr>
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<tr>
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1.0 INTRODUCTION

Energy Fuels Resources Corporation (Energy Fuels) is a wholly owned U.S. subsidiary of Energy Fuels Inc., a publicly traded Canadian Corporation based in Toronto, Ontario. Energy Fuels is a Colorado Corporation with offices in Nucla and Lakewood, Colorado and Kanab, Utah. In 2007, Energy Fuels purchased the Piñon Ridge Property (the Property) in Montrose County with the intent to license, construct and operate the Piñon Ridge Mill Facility (the Facility) for processing uranium and vanadium ores. The Property encompasses approximately 880 acres and is located in Paradox Valley on State Highway 90, approximately 12 miles west of Naturita and approximately 7 miles east of Bedrock, along the northeastern edge of Davis Mesa. The Property address is 16910 Highway 90, Bedrock, Colorado 81411.

The Property has been and is currently being used for seasonal cattle grazing. Energy Fuels has also installed geotechnical borings, groundwater monitoring wells, surface water monitoring systems, air monitoring devices, and meteorological stations on the Project site to establish baseline environmental conditions for permitting purposes. The surrounding property consists of rangeland, uranium mines, and undeveloped land. The uranium mines include an open pit operation immediately southeast of the Property and underground mines along the top of the mesa south of the Property. Energy Fuels does not own or operate these mines, which are currently inactive or in the process of reopening. The closest residences to the Property are located 3.22 miles northwest, 3.14 miles southeast, and 1.82 miles southwest of the Property boundary.

The Facility is designed to process uranium and vanadium ore at an initial capacity of 500 tons per day (tpd) with future expansion to 1,000 tpd. The mill is being permitted with the Colorado Department of Public Health and Environment, Air Pollution Control Division for 1,000 tpd to accommodate for the future expansion and to avoid circumvention of air quality rules. The projected operating life of the Facility is 20 years, operating 24 hours per day, 365 days per year at full production of 1,000 tons per day of ore. Construction of the mill and ancillary facilities will commence following full regulatory approval, which is anticipated in early 2011.

The two primary sources of ore to be delivered to the Facility are the Energy Fuels Whirlwind Mine and Energy Queen Mine. These mines are located on the Colorado
Plateau in Western Colorado and Eastern Utah, and are within reasonable truck hauling distance to the Facility. Both of these mines are capable of producing 200 tons per day of uranium and vanadium ore. The balance of the ore feed is expected to come from mines that are controlled and operated by other mining companies in the area. Energy Fuels also has approximately 20 additional uranium properties on the Colorado Plateau in Western Colorado and Eastern Utah that could become future sources of ore.

Consistent with the Mill Design Report, this Process Description categorizes the process components into the following areas:

- Area 100 – Ore Handling and Grinding
- Area 200 – Leaching
- Area 300 – CCD Thickeners and Tailings Disposal
- Area 400 – Uranium Solvent Extraction (SX)
- Area 500 – Uranium Precipitation
- Area 600 – Vanadium Oxidation and Solvent Extraction
- Area 700 – Vanadium Precipitation
- Area 800 – Reagents
- Area 900 – Utilities and Buildings
- Area 1000 – General Plant.
2.0 AREA 100 – ORE HANDLING AND GRINDING

2.1 ORE DELIVERY AND STOCKPILING

2.1.1 Process Description

Ore will be delivered to the facility in transport trucks with a nominal capacity of 24 tons each. On average, 1,000 tons of ore per day will be delivered to the facility. There is one primary haul road at the facility that is used for ore delivery, reagent and water delivery, product shipment, and employee vehicle traffic. The first 150 feet of road length from Highway 90 will be paved, while the remainder of the primary haul road will consist of an aggregate base. The unpaved primary haul road is 22 feet wide with 2 feet of shoulder on each side. Designed per U.S. Department of Interior specifications and taking into account the weight and frequency of vehicle traffic, the unpaved haul road will be constructed with a 17-inch aggregate base. The top 5-inches of aggregate are specified to be Class 6 aggregate with 6-12% of material passing the No. 200 sieve. The shoulders of the unpaved haul road will also have an aggregate base; however, the base of the shoulder will only be 5-inches thick rather than 17-inches.

The ore delivery trucks will dump the ore at the dumping platform, or in some cases, directly onto the ore pad. Ore that is delivered to the dumping platform will be moved to the stockpiles on the ore pad by a front end loader. The dumping platform can hold 20 loads (24 tons each) of ore; thus, the transfer process to the ore pad will be continuous in order to maintain space on the dumping platform for the average 42 daily loads. The ore pad consists of a 1 acre concrete pad and a 5 acre gravel pad with a geosynthetic under liner. The 1 acre concrete pad, adjacent to the feed hopper building, is used for short term storage of ore that is currently being processed while the 5 acre area is for long term storage. Each stockpile in the 5 acre area can contain approximately 10,000 tons of ore and would be 30 feet high with a base area of 0.34 acres. Allowing for space between stockpiles, approximately ten stockpiles can be contained in the 5 acre area.

2.1.2 Process Emissions

The processes involved in ore delivery and stockpiling will be sources of fugitive particulate matter emissions. The processes include: ore delivery truck travel on the
main haul road, unloading the ore from the trucks onto the dumping platform, transferring the ore from the dumping platform to the ore pad, and wind erosion of the ore stockpiles. The paved main haul road will be treated as a public rather than industrial road for emission calculation purposes because the road is directly off of the public highway and not in the mill area of the Facility. Further, vehicle speeds will be low on the paved portion because vehicles entering the Facility will be turning from the public highway, and vehicles exiting will be stopping at the public highway. The slower vehicle speed will act as a mitigation to keep particulate emissions low. The unpaved main haul road will be treated with magnesium chloride with the first application typically in the spring and two to three additional treatments through the fall. Supplemental watering of the road to control fugitive particulate matter emissions may occur during dry and windy periods. Motion sensing water sprays will be located at the dumping platform dump points for emission control. Transferring the ore to the ore pad will be a source of particulate matter emissions both through loader travel on the gravel ore pad and unloading the ore onto the stockpiles. Both the ore stockpiles and the ore pad travel routes will be sprayed with either water or a raffinate solution from the mill. Radionuclides are also emitted during ore handling. The amount of radionuclides emitted will be referenced from the values used in the MILDOS-AREA draft report dated June 2, 2009 (in Curies per year) and converted to pounds per year using the specific activity of the radionuclides.

2.2 FEED SYSTEM

2.2.1 Process Description

Ore is transferred from the ore pad to the feed hopper building with a front end loader. The feed hopper building is a three sided building that contains a grizzly screen with 12 inch openings. The ore is unloaded through the grizzly screen into a coarse ore feed hopper. Oversized ore that does not pass through the grizzly screen is stockpiled and reduced later in time with a hydraulic rock hammer attachment on the back of a loader. Once the ore passes through the coarse ore feed hopper, it falls onto an apron feeder. The apron feeder consists of metal pans attached to a moving track. The speed of the track can be adjusted based on the ore demand from the mill. Ore is transferred from the apron feeder to a conveyor belt, which then transfers the ore through a chute to the vibratory feeder located in the mill area. The coarse ore feed hopper and apron feeder are located below grade. The conveyor belt is enclosed in a tunnel that is
predominantly below grade and constructed of concrete. The above grade portion of the conveyor belt is enclosed in a corrugated metal tunnel so that the entire conveyor system remains completely enclosed.

2.2.2 Process Emissions

The feed system processes that will be sources of particulate matter emissions include: unloading ore into the grizzly screen to the apron feeder, transferring ore from the apron feeder to the conveyor belt, and transferring ore from the conveyor belt to the mill. Emissions at the feed hopper building area are controlled through the use of plastic curtains over the open side of the building as well as water sprays located at the grizzly screen. Further, air from the grizzly screen, coarse feed hopper, and apron feeder area is vented to a dust collecting baghouse and then through a stack to the atmosphere. The capture efficiency of particulate matter from the feed system is anticipated to be high because the system is predominantly below grade and enclosed.

2.3 ORE GRINDING AND PULP STORAGE

2.3.1 Process Description

Ore that has been transferred by the conveyor belt enters the vibratory feeder along with water and slurry from the oversized classifying screen. The wet ore mixture then enters the rotating semi-autogenous grinding (SAG) mill where the ore is reduced to 28 mesh and smaller as the ore is ground against other ore, steel liners, and grinding balls. The processed ore slurry then exits the mill through a trommel screen where non-ore material is collected and discharged to a hopper while the ore slurry enters a sump. Additional water is added to the ore slurry in the sump such that the slurry now contains 65 percent solids. The ore slurry from the sump is pumped to a system of classifying screens. The oversized ore slurry returns to the vibratory feeder and is mixed with raw ore from the feed system and enters the mill for further processing, while the ore slurry that passes through the classifying screens is pumped into pulp storage tanks. The pulp storage tanks discharge ore slurry to the pre-leach system.

2.3.2 Process Emissions

Ore that enters the vibratory feeder becomes mixed with process water and oversized ore slurry, thus particulate matter emissions are reduced through the process itself.
Particulate matter emissions are considered to be negligible once the ore is mixed with water and ground into slurry. The vibratory feeder area and discharge end of the SAG mill are connected to a dust scrubber with a control efficiency of 99%. The dust scrubber will be vented through a stack into the atmosphere. Emissions are not anticipated from the pulp storage tanks as chemicals are not added to the slurry at this point in the process. Radionuclides are emitted during the ore grinding process. Radionuclide values are referenced from the MILDO-AREA draft report dated June 2, 2009 and converted to pounds per year similar to the stockpile emissions.
Uranium has two common valency states, tetravalent, U(IV) and hexavalent, U(VI). In the hexavalent state, uranium is very soluble, but uranium in the tetravalent state is insoluble and essentially immobile. Sulfuric acid leaching can dissolve the hexavalent uranium, but the addition of sodium chlorate (NaClO₃) is needed to oxidize the tetravalent uranium ion to the hexavalent uranyl ion (UO₂²⁺). The oxidized uranium reacts with the sulfuric acid to form a uranyl sulfate complex in the following chemical reaction:

\[ 3 \text{UO}_2 + 3\text{H}_2\text{SO}_4 + \text{NaClO}_3 \rightarrow 3 \text{UO}_2\text{SO}_4 + \text{NaCl} + 3\text{H}_2\text{O} \]

Vanadium has four common valency states, V(II), V(III), V(IV), and V(V). In the presence of an oxidizer it will form various vanadium oxides, including VO and V₂O₄. The oxidized vanadium reacts with sulfuric acid to form vanadyl sulfate in the following chemical reaction:

\[ \text{V}_2\text{O}_4 + 2\text{H}_2\text{SO}_4 \rightarrow \text{V}_2\text{O}_4(\text{SO}_4)_2 + 2\text{H}_2\text{O} \]

The leaching process dissolves uranium and vanadium minerals from the solid ore material in a two-stage leaching process, which will include pre-leach tanks (Stage-1) before entering the leach tank circuit (Stage-2).

### 3.1 PRE-LEACH CIRCUIT PROCESS DESCRIPTION

The pre-leach circuit (Stage-1) includes two 60,000-gallon steel tanks with rubber liners and rubber coated agitators. Uranium and vanadium slurry pulp is combined with a sulfuric acid solution in the first pre-leach tank and overflows into the second pre-leach tank, where additional mixing occurs.

Overflow from the second pre-leach tank enters the pre-leach thickener, where solid material is separated from the liquid solution. Additional sulfuric acid is added, along with polyacrylamide flocculant to promote settling of the solid particles. This solid material is pumped to the leach circuit, while the liquid portion overflows to the pre-leach clarifier.
The pre-leach clarifier is used to further clarify the liquid solution. Solids are recirculated to create larger particles or are recycled back to the pre-leach thickener. The decanted liquid containing dissolved uranium and vanadium is advanced from the thickener to the solvent extraction system.

3.2 LEACH CIRCUIT PROCESS DESCRIPTION

The thickened solids are advanced to the leaching circuit (Stage-2), with eight 60,000-gallon tanks to process 1,000 tpd. Further leaching is accomplished at this stage by the addition of sulfuric acid, heat (injected steam), an oxidant (sodium chlorate), and oxygen (compressed air). The second-stage leaching tanks are operated in series and the ore remains in contact with the leach solution for several hours. Each tank has an agitator to keep the solids in suspension. The discharge from the leach circuit is a slurry consisting of solids and a sulfuric acid solution with dissolved uranium and vanadium. This slurry is fed to the countercurrent decantation stage.

3.3 PRE-LEACH AND LEACH CIRCUIT PROCESS EMISSIONS

Uranium and vanadium are leached from the uranium ore slurry using a strong sulfuric acid solution. Acid in the leaching process not only liberates the metal content of the ore, but also is consumed in chemical reactions with carbonates and other constituents of the rock.

Within the pre-leach tanks, the slurry pulp is assumed to react completely with the sulfuric acid solution. However, a small amount of sulfuric acid emissions will be generated from this process prior to the reactions going to completion and therefore, these tanks are enclosed and vented to a wet Venturi scrubber. Sulfuric acid has an extremely low vapor pressure and a high boiling point, meaning that sulfuric acid does not readily volatilize to form gaseous \( \text{H}_2\text{SO}_4 \). However, acid mist will be carried within water vapor in the inlet stream to the scrubber. Therefore, emissions are calculated using the EPA Diffusion Equation for volatile substances, with water vapor assumed to be the volatile substance. The fraction of acid in the water vapor is then used as the basis of acid emissions which is based on the aqueous solution in the pre-leach tanks containing 1-5% \( \text{H}_2\text{SO}_4 \), assumed 5% for conservative emission calculations.
The pre-leach thickener and pre-leach clarifier tanks are open tanks and do not generate a significant amount of emissions, since the chemical reaction is anticipated to be at completion prior to entering these tanks. The goal of this system is to separate and clarify and only a small amount of sulfuric acid may be added for additional pH control during restarting of the mill after an extended shutdown, such as during the holidays.

The leach tanks are enclosed and vented to the same Venturi scrubber as the pre-leach tanks. When reagents and heat are added to the leach solutions, sulfuric acid emissions are generated. Therefore, the same calculation method used for the pre-leach tank emissions is used for the leach tank emissions. The fraction of acid emissions in the leach circuit is based on the aqueous solution in the leach tanks containing 11% \( \text{H}_2\text{SO}_4 \). The Area 200 Venturi scrubber (220-GHS-01) will yield 99% control for sulfuric acid emissions.
4.0 AREA 300 – COUNTER CURRENT DECANTATION THICKENERS & TAILINGS DISPOSAL

4.1 COUNTER CURRENT DECANTATIONS THICKENERS

4.1.1 Process Description

The slurry from the leach circuit is gravity-fed to the first of a series of eight Counter Current Decantation (CCD) thickener tanks. The CCD circuit consists of a series of thickeners in which the pulp (underflow) goes in one direction, while the uranium/vanadium bearing solution (overflow) goes in a countercurrent direction. The solids settle to the bottom of the first thickener tank and flocculant is added to each thickener feed to increase the settling rate of the solids. As the pulp is pumped from one thickener to the next, it is gradually depleted of its uranium and vanadium. When the pulp leaves the last thickener, it is essentially barren waste that is disposed of in the tailings cells.

The liquid that overflows the eighth thickener advances to the seventh thickener, and continues through each of the CCDs to the first CCD tank. This countercurrent flow of liquid and solids washes the residual dissolved uranium compounds from the solids, so that the first CCD tank has the highest concentration of uranium/vanadium. The liquid that overflows the first thickener contains excess acid and is collected and pumped to the first-stage leach where the excess acid is consumed by the raw pulp.

4.1.2 Process Emissions

Since there are no reagents added to the CCD thickeners, except flocculant, emissions are assumed to be negligible. The polyacrylamide flocculant is used to thicken and settle out solid materials and does not create emissions. So, since the process streams are in a liquid phase and processing is limited to physical separation, no emissions have been calculated for this process.
4.2  TAILING CELLS

4.2.1  Process Description

Tailings are pumped to the operational tailings cell and distributed over the tailing cell beaches. The solids settle out on the beach while the solution forms a pond. A pump returns the majority of the solution back to the Return Water Tank at the Mill. Although the Facility has designed three 30-acre tailings cells for the life of the project, a minimum of one, but a maximum of two, will be in use at any time. Each tailing cell will be approximately 70 feet deep and is lined with a multiple liner system.

4.2.2  Process Emissions

Emissions from the tailings cells include wind erosion of the tailing cell beaches and evaporation of the tailings cell solution. Because the tailing cells are 70 feet deep and lined, not all of the 30 acre area of each cell is exposed for wind erosion. Thus it was conservatively assumed that 20% of the cell would be covered with solution, and that 80% of the 30 acre cell would be exposed for wind erosion. Wind erosion of the tailing cell beaches would create fugitive particulate matter emissions. During the cooler months, it is anticipated that the beaches will remain moist; however during the hotter months, the beaches will be sprayed with a water or raffinate spray to control particulate matter emissions. Evaporation of the tailing cell solution will emit volatile organic compounds (VOCs), sulfuric acid mist, and radionuclides. It is assumed that all of the solution that remains in the tailing cells will eventually evaporate. Emissions of volatile organic compounds and sulfuric acid were calculated using a Metsim Tailing Stream Analysis, dated March 12, 2008. Radionuclide emissions were calculated using the MILDOS-AREA draft report dated June 2, 2009.

4.3  EVAPORATION PONDS

4.3.1  Process Description

Wastewater (i.e. raffinate) is pumped from the vanadium SX circuit to the evaporation ponds. The majority of the wastewater is allowed to evaporate with a small portion used for dust suppression on the tailing cell beaches. The evaporation ponds consist of two
sets of 10 cells each. Each cell is approximately 6 feet deep and 4 acres in area so that a set of 10 cells covers 40 acres. The cells are lined similar to the tailing cells.

4.3.2 Process Emissions

Emissions from the evaporation ponds include wind erosion of the evaporation pond beaches and evaporation of the solution. Because the evaporation ponds typically contain some solution, not all of the total 80 acre area is exposed for wind erosion. It was conservatively assumed that 50% of the ponds would be covered with solution and 50% of the total 80 acres would be exposed for wind erosion. Wind erosion of the evaporation pond beaches would create fugitive particulate matter emissions. During the cooler months, it is anticipated that the beaches will remain moist; however during the hotter months, the beaches will be sprayed with a raffinate spray to control particulate matter emissions. Evaporation of the evaporation pond solution will emit volatile organic compounds and sulfuric acid mist. It is assumed that all of the solution that enters the evaporation ponds will eventually evaporate. Emissions of volatile organic compounds and sulfuric acid were calculated using a Metsim Tailing Stream Analysis, dated March 12, 2008.
5.0 AREA 400 – URANIUM SOLVENT EXTRACTION

5.1 URANIUM SOLVENT EXTRACTION OVERVIEW

The primary purpose of the uranium solvent extraction (SX) circuit is to concentrate the uranium. This circuit has two functions. First, the uranium is transferred from the aqueous acid solution to an immiscible organic liquid by ion exchange. Alamine 336 is a long chain tertiary amine that is used to extract the uranium compound. Then a reverse ion exchange process strips the uranium from the solvent, using aqueous sodium carbonate. The chemical reactions are as follows:

Extraction:
\[(R_3NH)_2SO_4 + UO_2SO_4 \rightarrow (R_3NH)_2UO_2(SO_4)_2\]
(Tertiary Amine)

Stripping:
\[(R_3NH)_2UO_2(SO_4)_2 + 3Na_2CO_3 \rightarrow Na_4UO_2(CO_3)_3 + 2(NaSO_4) + (R_3NH)_2\]

5.2 POLISHING FILTERS AND FEED TANKS

5.2.1 Process Description

The loaded (pregnant) solution from the pre-leach clarifier is pumped to the polishing filters, which remove fine-grain particles that could potentially contaminate the extraction system. Diatomaceous earth (DE) is used to coat the filtering leaves within the polishing filters to increase their efficiency and to help prevent them from clogging. After filtering, the solution flows into the uranium SX feed tank, while the solids removed by the filters are pumped to the tailings cell.

The DE mixing system provides DE slurry to both the uranium and vanadium polishing filters. The DE Mixing System consists of three seven-ft diameter by 8-ft high fiberglass reinforced plastic (FRP) tanks equipped with steel agitators. The DE is mixed with barren vanadium raffinate to create DE solutions of varying strengths. DE is delivered and stored in bulk bags, and the bags are broken and added in the first tank (preparation tank) where a 30 percent DE solution is created. This concentrated
solution is pumped into the pre-coat tank or body feed tank where it is diluted. The pre-coat tank is diluted to create a 10 percent DE solution that is used to pre-coat filter screens in both the uranium and vanadium polishing filters prior to startup. The body feed tank is diluted to create a one percent DE solution that is slowly fed into the polishing filters during operation to maintain the DE coating on the screens.

The filtered solution from the polishing filters flows into the uranium SX feed tank. This is a 26-ft diameter by 20-ft high rubber-lined steel tank that provides buffering storage capacity between the filter circuit and the uranium extraction circuit. Centrifugal pumps at this location feed the uranium extraction circuit.

### 5.2.2 Process Emissions

Diatomaceous earth is delivered and stored in 100 pound bags. The bags are broken using a bag breaker and added in the first DE mixing tank where a 30 percent DE solution is created. A dust collector with 99% control efficiency is used to control particulate emissions from the bag breaker and mixing tank. Controlled particulate emissions from this process are estimated to be less than 1 pound per year.

No other significant emissions are generated by the polishing filters or feed tanks.

### 5.3 URANIUM SX CIRCUIT

A solvent extraction process concentrates and recovers the uranium from the loaded solution. In the SX process, the loaded solution is filtered and the uranium separated out using a kerosene based organic solution. The resulting pure uranium solution is washed with sulfuric acid and water to remove impurities. After the washing, the uranium is stripped from the solvent using a sodium carbonate solution.

#### 5.3.1 Process Description

In the uranium SX circuit, an organic solution, consisting primarily of kerosene with an amine extractant, is circulated counter current to the pregnant solution. The organic solution selectively removes the uranium from the acid solution and concentrates it by two to three fold in the organic solution. The process starts by pumping the pregnant solution in the uranium SX feed tank to the first of four uranium mixer-settler tanks and pumping the barren organic solution to the fourth mixer settler tank. The pregnant
solution then advances from mixer-settler tanks No. 1 through No. 4 while the barren organic extracts the uranium as it advances from mixer-settler tanks No. 4 through No. 1. The organic is less dense than the acid solution, so it separates from the aqueous solution within the settling portion of each tank and floats on top. The loaded organic is skimmed off the top of mixer-settler tank No. 1 while the acid solution, depleted of uranium, is removed from the base of mixer-settler tank No. 4. The loaded organic is pumped to the loaded organic tank and then to the uranium scrub and strip circuit. The depleted acid solution flows into a raffinate settler to remove residual organics and then is pumped to the uranium SX raffinate tank that feeds the vanadium oxidation and extraction circuit.

There are two trains of mixer-settler tanks (Trains A and B), each containing four mixer-settlers and a raffinate settler. The tanks are constructed of materials resistant to acid and organics (e.g., stainless steel). In the first mixing compartment, the organic solution is fed into the bottom of the tank while the denser, uranium-bearing acid solution is fed in above. After mixing, the mixture passes through a baffle located near the top of the tank into a second mixing compartment where the process is repeated. The mixture then flows through a second baffle into the settling area where the organic containing the extracted uranium separates and floats to the top while the depleted aqueous solution settles to the bottom. The settlers are approximately 20-ft long by 10-ft wide by three to four-ft deep. They contain internal “picket fences” that slow the flows and allow greater time for separation of the aqueous and organic phases.

The raffinate settler is similar in size to the mixer settlers but does not contain mixing compartments. It is located downstream of the fourth mixer settler and is designed to remove the small amount of residual organic remaining in solution at that point.

The mixer-settler system operates via gravity flow between tanks with the lighter organic phase flowing through a weir located at the top end of each tank while the denser aqueous phase flows out the bottom end of each tank. The loaded organic flows from mixer-settler tank No. 1 to a steel centrifugal pump located below the platform that pumps to the loaded organic tank.

Similarly, the barren organic that flows from the raffinate settler is pumped to the uranium SX barren organic tank via a small hose pump. The aqueous underflow from
the raffinate settler is pumped to the uranium SX raffinate tank by a three-inch by four-inch stainless steel centrifugal pump mounted below the settler platform.

The uranium SX barren organic tank is a 24-ft diameter by 19-ft high FRP tank with a closed top. As mentioned above, it receives barren organic from the raffinate settlers. The tank also receives barren organic from the Uranium SX Stripper-Mixer-Settlers. A small amount of makeup organic feed is also added to replenish the organic solution lost during the extraction process. Centrifugal pumps transfer the barren organic to mixer-settler tank No. 4.

The barren organic consists of kerosene (carrier) plus amine (collector) and alcohol (phase control). The kerosene is stored in a 38,000-gal tank, while the amine and alcohol are stored in 250-gal liquid totes and/or steel drums within the SX Building. The organics are fed into a small (10-ft diameter by 10-ft high) makeup tank by metering pumps. This tank, which is located between the uranium and vanadium barren organic tanks, provides makeup feed to both.

The uranium SX loaded organic tank is identical in construction and size to the barren organic tank. The tank receives loaded organic from the first mixer-settler in Trains A and B, and provides buffering capacity between the uranium extraction and uranium scrub and strip circuit. This tank feeds the scrub and strip circuit.

The uranium SX raffinate tank is an 18-ft diameter by 18-ft high FRP tank. It receives the uranium-depleted solution from the Train A and Train B raffinate settlers and provides buffering capacity between the uranium and vanadium extraction circuits. Centrifugal pumps transfer the solution from the raffinate tank to the vanadium oxidation tank.

5.3.2 Process Emissions

The uranium SX mixer settler tanks contain an organic solution that is used to selectively remove the uranium from the acid solution and concentrate it. The organic solution consists of kerosene (carrier) plus amine (collector) and alcohol (phase control). Emissions from the mixer settler tanks will be evaporative VOCs. Emissions from this process are estimated using the EPA Diffusion Equation for volatile chemicals.
VOC emissions from the uranium SX loaded organic tank and the barren organic tank were calculated using the TANKS 4.09d software.

5.4 URANIUM SCRUB AND STRIP

In the scrub and strip circuit, the uranium is stripped from the organic carrier in one scrubber-mixer-settler and two stripper-mixer-settlers using a caustic sodium carbonate solution. The uranium is concentrated in the stripping solution by a ratio of approximately 40:1, which is the ratio of the flow rate for the loaded organic to that for the sodium carbonate solution. The stripped organic is pumped back to the barren organic tank for reuse in the extraction circuit while the loaded high-grade strip solution is pumped to the uranium precipitation circuit.

5.4.1 Process Description

The loaded organic solution is pumped from the Loaded Organic Feed Tank to the Scrubber-Mixer-Settler, which is approximately 15-ft long by 8-ft wide by three- to four-ft deep. It is similar in configuration to the mixer-settlers with two agitation compartments and a settling basin. A small volume of raw water and sulfuric acid are added in the first mixing compartment to scrub the organic of entrained contaminants prior to stripping. The acid is removed from the bottom of the settling tank and pumped back to the mixer-settler circuit via a small hose pump, while the scrubbed organic overflows from the settling tank into the first of two stripper-mixer-settlers.

There are two stripper-mixer-settlers that are identical in construction and size to the scrubber-mixer-settler described above. The only difference between the scrubber-mixer-settlers and the stripper-mixer-settlers is their application.

The sodium-carbonate solution, with a pH between 11 and 12, is pumped from the sodium carbonate slurry storage tank to the second of the two stripper-mixer-settlers. There, the concentrated sodium carbonate solution mixes with the organic overflow from the first mixer settler and the two phases then separate in the settling basin. This separation process strips the remaining uranium from the organic solution. The partially loaded strip solution at the bottom of the settling tank flows to the first stripper-mixer-settler while the barren organic is pumped to the barren organic tank.
In the first stripper-mixer-settler, the partially loaded strip solution of sodium carbonate is mixed with the scrubbed loaded organic prior to flowing into the settling basin. The organic overflow, largely depleted of uranium, flows over the tail end of the basin to the second stripper-mixer-settler. The loaded sodium carbonate solution at the base of the tank, now with a near neutral pH of between 7 and 8, is pumped to the uranium precipitation feed tank.

5.4.2 Process Emissions

The uranium SX scrubber mixer settler tank will contain the organic solution from the loaded organic feed tank. Emissions from the scrubber mixer settler tank will be evaporative VOCs. Emissions from this process are estimated using the EPA Diffusion Equation for volatile chemicals.

In the stripper mixer settlers, the organic solution mixes with the high pH inorganic sodium carbonate solution. This inorganic solution strips the uranium product from the organic solution, which becomes barren. The barren organic solution is then pumped into the barren organic tank to be recycled in the process. The organic solution generally remains on top of the stripper mixer settler tanks, and the heavier inorganic solution generally goes to the bottom of the tank. Because the organic remains on top of the tank, emissions from the stripper mixer settler tanks will be evaporative VOCs. Emissions from this process are estimated using the EPA Diffusion Equation for volatile chemicals.
6.0 AREA 500 – URANIUM PRECIPITATION

6.1 URANIUM PRECIPITATION

Loaded sodium carbonate solution from the uranium SX scrub and strip circuit is pumped to the uranium precipitation feed tank. This tank feeds into a series of five agitated tanks where hydrogen peroxide is added to precipitate the uranium as triuranium oxide (U$_3$O$_8$). During precipitation, the uranium solution is continuously agitated to keep the solid particles of uranium in suspension. The tanks are arranged in a cascading pattern so that the solution flows by gravity from uranium precipitation tanks No. 2 through No. 6.

6.1.1 Process Description

Feed tank No. 1 is an eight-ft diameter by 10-feet high rubber-lined steel tank with a capacity of 3,700 gallons. The tank serves as a buffer between the SX and precipitation circuits. Pregnant solution is pumped to uranium precipitation tank No. 2. A small bleed stream of the pregnant solution is pumped into Tank No. 4.

Tanks No. 2 and No. 3 are both five-ft diameter by 6-ft high rubber-lined steel tanks that serve primarily as mix tanks. A small volume of water and sulfuric acid are added to Tank No. 2 to adjust the solution pH while hydrogen peroxide is added in Tank No 3. Hydrogen peroxide is a strong oxidizing agent and its addition initiates the precipitation of uranium oxide.

Tanks No. 4, No. 5, and No. 6 are eight-ft diameter by 8-ft high rubber-lined steel tanks with a nominal capacity of 3,000 gallons each, which provides sufficient residence time for uranium to precipitate with the excess oxygen. A small volume of sulfuric acid and pregnant solution is added in Tank No. 4, as necessary, to control the solution pH level. Reagents are not added in Tanks No. 5 and No. 6.

6.1.2 Process Emissions

Sulfuric acid is added to the uranium precipitation tanks for pH control. However, since the pH is held between 2.5 and 4.5 for optimal precipitation of the solution, the average
amount of free acid in solution is estimated to be about 0.0002 N H₂SO₄ (0.001% H₂SO₄). Therefore, sulfuric acid emissions are assumed to be negligible.

The uranium vent gas scrubber is a wet venturi-type scrubber (530-GHS-01) that receives vent gas from the uranium precipitation Tanks 2-6. No particulate emissions are anticipated from the precipitation tanks, since it is a wet process.

6.2 URANIUM DEWATERING

Uranium leaves precipitation tank No. 6 as solid particles in suspension and is pumped to the uranium thickener where the precipitate is thickened and partially dewatered. The thickener underflow containing the precipitate is pumped to a filter press where a pressure system removes additional water and produces a filter cake containing approximately 35 percent moisture. The filter cake then drops through a chute into a decant tank where the precipitate settles and excess water is decanted off the top. The overflow from the thickener is pumped back to the process water tank where it is used as makeup water for the SAG Mill.

6.2.1 Process Description

The solution containing the suspended uranium precipitate is pumped from precipitate tank No. 6 to the feed box of the uranium thickener. The feed box is a small (two-ft cubed) rubber-lined steel box, in which a number of inflows are mixed together prior to flowing into the thickener. Flocculent is added at the feed box to accelerate the settling process within the thickener. Recycled uranium-bearing solutions from the filter press, decant tank, and the sump in the uranium packaging area are also pumped to the feed box.

The uranium thickener is a 32-ft diameter by 12-ft high rubber-lined steel tank with a sloped bottom. Rotating rakes near the bottom of the tank assist in the separation of the yellowcake precipitate from the less-dense barren solution. The uranium precipitate settles to the bottom of the thickener where hose pumps feed the yellowcake to the filter press. The uranium thickener has a capacity of approximately 100,000 gallons and, because of its relatively large size, can be used to store yellowcake over a number of consecutive operating shifts. This allows the downstream belt filter and yellowcake dryer to be operated in batch mode, rather than continuously.
The barren solution from the thickener overflow enters the uranium thickener overflow pipe, which is a vertical 20-ft high by 2-ft diameter HDPE pipe. From the overflow pipe, a centrifugal pump transfers the barren solution to the process water tank in the central portion of the Precipitation and Packaging Building. The 12-ft diameter by 12-ft high process water tank also receives barren solution from the vanadium circuit. Water from this tank supplies makeup water to the SAG Mill.

The thickener underflow containing the yellowcake is pumped to the filter press. The filter press removes additional water from the yellowcake using a high pressure filtering system and has a water wash cycle that removes impurities from the filter cake. The filter press is approximately 20-ft long by four-ft wide and consists of a series of leaves on a on a hydraulically activated track. Each leaf, which is concave in shape, is covered with a filter cloth and has a central port for inflow of the slurried precipitate and perimeter ports for outflow of the filtrate water. The precipitate is captured in the concave depression between the leaves while the solution is forced out through the filter cloths and exits the filter press through the perimeter ports and is returned to the uranium thickener feed box. After filtering, the press is opened and the solids (or cake) containing 35 percent moisture drop into a chute that discharges into the uranium filter cake decant tank.

The cake is allowed to settle in the decant tank. As the cake settles, water separates out at the top and is decanted through a series of valved nozzles back to the uranium thickener feed tank. The decant tank has a cone bottom that connects to the yellowcake dryer below via a slide gate. After decanting excess solution, the gate is opened and the cake is fed into the yellowcake dryer.

6.2.2 Process Emissions

The uranium thickener will use flocculant to accelerate the thickening and settling of the uranium precipitate. This system is not anticipated to yield significant emissions.

A water wash system is used on the uranium filter press, and the exit material contains approximately 35 percent moisture; therefore, particulate emissions from the filter press are assumed to be negligible. The decant tank also receives the cake with 35 percent
moisture and is directly connected to the dryer; therefore, particulate emissions from the decant tank are assumed to be negligible.

6.3 URANIUM DRYING AND PACKAGING

The wet yellowcake containing 35 percent moisture by weight is transferred from the decant tank to the yellowcake vacuum dryer where the cake is indirectly heated to evaporate the contained moisture. The dried cake is then transferred to 55-gallon drums via a rotary valve and an enclosed packaging system. The drums are moved from the packing system to the storage area by a roller conveyor system.

6.3.1 Process Description

The yellowcake dryer is a horizontal, stainless steel vacuum dryer that can hold up to 150 cubic feet of wet yellowcake. It is located below the decant tank and above the rotary valve/packaging system in the northwest corner of the Precipitation and Packaging Building. The drying chamber has a top port for loading the wet yellowcake and a bottom port for unloading the dry powder. A third port is provided at the top for venting hot air to a condenser. The dryer has a rotating shaft with blades (plows) that continually turn the yellowcake during the drying process.

The dryer system circulates steam through both the heated external jacket and heated shaft. The moisture that evaporates from the cake is drawn off by a vacuum through a filter to a condenser and vacuum/filtrate receiver system. When the yellowcake is dry, as indicated by a low moisture content in the air flow to the condenser, the yellowcake is transferred to the packaging system by a rotary valve.

The rotary valve and transfer hood are located directly below the lower dryer port. The transfer hood lowers directly to the top of an open drum. Filling of the drums is controlled by the rotary valve that is electrically connected and calibrated with a level probe in the transfer hood and a weigh scale located under the drum being loaded. Each drum, when full, contains approximately 900 pounds of yellowcake. After each drum is filled, the packaging operator removes the hood and collects a sample of the yellowcake for lab analyses. The operator then seals the top of the drum with a USDOT-approved lid and clamping ring. The operator also washes down the outside of each drum after sealing to remove any fine dust that may have collected on the surface.
and attaches a label containing a unique identification number, gross weight, and other pertinent information.

A roller conveyor is used to move empty drums from the Empty Drum Storage Area to the feed hopper/packaging system and filled drums from the packaging area to the Packaged Drum Storage Area. The on-and-off controls for the system are operated by the packaging operator. The empty drums are manually placed on the conveyor at the Empty Drum Storage Area. Filled drums weigh approximately 900 pounds and are removed from the end of the conveyor and placed in storage using a forklift.

6.3.2 Process Emissions

The yellowcake packaging area has its own heating, ventilating, and air conditioning (HVAC) system, and two sets of doors (vestibules) remain closed at the exits to provide additional containment of air-borne particles. Only required operations personnel are allowed within the packaging area and they are required to wear appropriate PPE including air-purifying respirators, gloves, and coveralls. A viewing area is provided above the packaging area for guests and non-operations personnel.

The yellowcake dryer is a rotary vacuum dryer and is defined as a 'no emission' dryer. The moist air generated by the dryer is drawn through filter socks that are integral to the dryer. An automatic shaker shakes the sock cage and the particles fall back into the dryer. The air from the filter socks is drawn by a vacuum into a condenser where the water and any remaining particulates are removed and pumped to the uranium thickener feed box. The clean air is vented to the uranium packaging room. Negligible emissions are anticipated for this process area.
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7.0 AREA 600 – VANADIUM OXIDATION AND SOLVENT EXTRACTION

7.1 VANADIUM OXIDATION PROCESS

After the uranium has been removed in the uranium SX circuit, the raffinate from that process is pumped to the vanadium SX circuit for extraction of vanadium. However, before the dissolved vanadium can be extracted from the solution, it must first be oxidized and re-filtered. The oxidation is performed in a series of five agitated tanks where sodium chlorate is added. Ammonia is also added in these tanks to increase the pH level slightly. After oxidation, the solution is filtered to remove suspended solids and pumped to the vanadium SX feed tank.

7.1.1 Process Description

Five oxidation tanks are used in the vanadium oxidation process. Each of the tanks is equipped with a rubber-lined steel agitator. The tanks are set up so that the solution flows by gravity from tank No. 1 through tank No. 5. Tanks No. 1, 2 and 3 are 11-ft diameter by 10-ft high FRP tanks, each containing approximately 7,000 gallons of solution. These three tanks serve primarily as mix tanks as sodium chlorate and ammonia are added to each tank. Tanks No. 4 and 5 are much larger, 23-ft diameter by 23-ft high FRP tanks, with a nominal capacity of 70,000 gallons each. Although some ammonia is added in tank No. 4, these larger tanks are sized primarily to provide sufficient retention time for the chemical reactions to complete.

Downstream of oxidation tank No. 5, the solution flows into an adjacent storage tank of similar size, which feeds the vanadium polishing filter. The feed tank is also FRP, but does not contain an agitator. A three-inch by four-inch stainless steel centrifugal pump feeds the polishing filter.

The vanadium polishing filter is adjacent and identical to the uranium polishing filters. These cylinder-shaped, pressurized leaf filters are four to five feet in diameter by nine-ft long with a stainless steel shell and internals. The polishing filters contain 25 to 30 leaves, each fitted with a woven polypropylene filter cloth. The filter cloths are designed to remove particles down to three microns in size. The filters are precoated with DE to help prevent them from clogging. A one percent DE solution is also trickled into the
filters to maintain their efficiency during the filtering process. When the solids build up on the filter screens, as evidenced by an increase in pressure, internal water (i.e., barren vanadium raffinate) sprays are activated to wash down the filters. The solids are collected in the area sump and then pumped to the tailings collection box. The vanadium polishing filter receives its DE solutions from the same DE mixing system utilized by the uranium polishing filters.

The filtered solution from the polishing filter flows into the vanadium SX feed tank. This 26-ft diameter by 20-ft high rubber-lined steel tank provides buffering storage capacity between the filter circuit and the vanadium extraction circuit. Two pumps at this location feed the two trains of the vanadium SX circuit.

7.1.2 Process Emissions

The vanadium oxidation tanks will use sodium chlorate to oxidize the vanadium product. Ammonia will be added to increase the pH level slightly. However, negligible emissions are generated by these processes, as these reagents are consumed by chemical reactions or to maintain the pH.

7.2 VANADIUM SX CIRCUIT

The vanadium SX circuit is very similar to the uranium SX circuit. An organic solution, consisting primarily of kerosene with an amine extractant, is circulated counter current to the pregnant solution. The organic solution selectively removes the vanadium from the acid solution and concentrates it by two to three times in the organic solution. The process starts by pumping the pregnant solution from the vanadium SX feed tank to the first of five vanadium mixer-settler tanks, and pumping the barren organic solution to the fifth mixer settler tank. The pregnant solution then advances from mixer-settler tanks No. 1 through No. 5 while the barren organic extracts the vanadium as it advances from mixer-settler tanks No. 5 through No. 1. The organic is less dense than the acid solution, so it separates from the aqueous solution within the settling portion of each tank and floats on top. The loaded organic is skimmed off the top of mixer-settler tank No. 1 while the acid solution, depleted of vanadium, is removed from the base of mixer-settler tank No. 5. The loaded organic is pumped to the loaded organic tank and then to the vanadium scrub and strip circuit. The depleted acid solution flows into a raffinate
settler for removal of residual organics and then is pumped to the tailings collection box and/or the evaporation ponds.

The vanadium SX circuit differs in some minor aspects from the uranium SX circuit. In the vanadium SX circuit, the pH is more critical to extraction operations and is measured in the aqueous discharge of the first four mixer-settlers and controlled by sparging ammonia gas into the aqueous feed of these units. Sulfuric acid is added in the fifth mixer-settler to neutralize the barren organic returned from the strip circuit. The organic solution used in the vanadium circuit also contains higher concentrations of the amine extractant (i.e., approximately three percent of the organic solution as compared to one percent for the uranium SX circuit).

7.2.1 Process Description

There are two trains of mixer-settler tanks (Trains A and B), each containing five mixer-settlers and a raffinate settler. The tanks are constructed of acid- and organic-resistant materials (e.g., stainless steel) and are mounted on platforms with the pumps located underneath. In the first mixing compartment, the organic solution is fed into the bottom of the tank while the denser, vanadium-bearing acid solution is fed in above. After mixing, the solution passes through a baffle located near the top of the tank into a second mixing compartment where the process is repeated. The mixture then flows through a second baffle into the settling area where the organic containing the extracted vanadium separates and floats to the top while the depleted aqueous solution settles to the bottom. The 20-feet long by 10-feet wide by three- to four-ft deep settlers contain internal “picket fences” that slow the flows and allow greater time for separation of the aqueous and organic phases.

The raffinate settler is similar in size to the mixer settlers but does not contain mixing compartments. It is located downstream of the fifth mixer settler and is designed to remove the small amount of residual organic remaining in solution at that point.

The mixer-settler system operates via gravity flow between tanks with the lighter organic phase flowing through a weir located at the top end of each tank while the denser aqueous phase flows out the bottom end of each tank. The loaded organic flows from mixer-settler tank No. 1 to a steel centrifugal pump located below the platform that
pumps to the loaded organic tank. Similarly, the barren organic that flows from the raffinate settler is pumped to the vanadium SX barren organic tank. The aqueous underflow from the raffinate settler is pumped to the Vanadium SX raffinate tank.

The 24-ft diameter by 19-ft high FRP vanadium SX barren organic tank is a closed-top tank that receives barren organic from the raffinate settlers and vanadium SX stripper-mixer-settlers. A small amount of makeup organic feed is also added to replenish the organic solution lost during the extraction process. Centrifugal pumps transfer the barren organic to mixer-settler tank No. 5.

The barren organic consists of kerosene (carrier) plus amine (collector) and alcohol (phase control). The kerosene is stored in a 38,000-gallon tank, while the amine and alcohol are stored in liquid totes or drums. Metering pumps feed the organics into a small (10-ft diameter by 10-ft high) makeup tank. This organic makeup tank, which is located between the uranium and vanadium barren organic tanks, provides makeup feed to both.

The vanadium SX loaded organic tank is identical in construction and size to the barren organic tank and is located next to the barren organic tank. The tank receives loaded organic from the first mixer-settler in Trains A and B and provides buffering capacity between the vanadium extraction and vanadium scrub and strip circuit. Centrifugal pumps feed the scrub and strip circuit.

The vanadium SX raffinate tank is located next to the loaded organic tank. It is an 18-ft diameter by 18-ft high rubber-lined steel tank and receives the vanadium-depleted solution from the Train A and B raffinate settlers. The raffinate is either pumped to the evaporation ponds for disposal, or recycled to the tailings collection box and used to dilute the tailings for transport to the tailings cell.

7.2.2 Process Emissions

The vanadium SX mixer settler tanks contain an organic solution that is used to selectively remove the vanadium from the acid solution and concentrate it. The organic solution consists of kerosene (carrier) plus amine (collector) and alcohol (phase control)....
control). Emissions from the mixer settler tanks will be evaporative VOCs. Emissions from this process are estimated using the EPA Diffusion Equation for volatile chemicals.

VOC emissions from the vanadium SX loaded organic tank and the vanadium SX barren organic tank were calculated using the TANKS 4.09d software.

Ammonia and sulfuric acid are used in the vanadium SX circuit to control pH levels, however, inorganic emissions are anticipated to be negligible.

7.3 VANADIUM SCRUB AND STRIP

7.3.1 Process Description

In the vanadium scrub and strip circuit, vanadium is scrubbed in a mixer-settler with an acid solution and then stripped from the organic carrier in three stripper-mixer-settlers using a caustic sodium carbonate/sodium hydroxide solution. The vanadium is concentrated in the stripping solution by a ratio of approximately 25:1, which is the ratio of the flow rate for the loaded organic to that for the caustic solution. The stripped organic is pumped back to the barren organic tank for reuse in the extraction circuit while the loaded strip solution is pumped to the vanadium precipitation circuit.

The loaded organic solution is pumped from the loaded organic feed tank to the scrubber-mixer-settler, which is approximately 15-ft long by 8-ft wide by three- to four-ft deep. It is similar in configuration to the mixer-settlers with two agitation compartments and a settling basin. A small volume of raw water and sulfuric acid is added in the first mixing compartment to scrub the organic of entrained base metals prior to stripping. The acid is removed from the bottom of the settling tank and pumped back to the mixer-settler circuit by a small hose pump, while the scrubbed organic overflows from the settling tank into the first of three stripper-mixer-settlers.

There are three stripper-mixer-settlers, which are identical in construction and size to the scrubber-mixer-settler described above. The only difference being their application. The sodium carbonate/sodium hydroxide solution, with a pH between 11 and 12 standard units, is pumped from storage tanks to the third of the three stripper-mixer-settlers. The concentrated sodium carbonate solution mixes with the organic overflow from the second mixer settler and the two phases then separate in the settling basin.
This separation process strips vanadium from the organic solution. The partially loaded strip solution at the bottom of the settling tank flows to the second stripper-mixer-settler while the barren organic is pumped to the barren organic tank.

In the second stripper-mixer settler, the mixing and stripping process is repeated with the strip solution advancing to the first stripper-mixer settler and the organic solution advancing to the third stripper-mixer settler. In the first stripper-mixer settler, the strip solution is mixed with the organic solution from the loaded organic feed tank and becomes fully loaded. The pregnant solution is then pumped to the vanadium precipitation feed tank while the partially depleted organic solution overflows to the second stripper-mixer settler.

7.3.2 Process Emissions

The vanadium SX scrubber mixer settler tank will contain the organic solution from the loaded organic feed tank. Emissions from the scrubber mixer settler tank will be evaporative VOCs. Emissions from this process are estimated using the EPA Diffusion Equation for volatile chemicals.

In the stripper mixer settlers, the organic solution mixes with the high pH inorganic sodium carbonate/sodium hydroxide solution. This inorganic solution strips the vanadium product from the organic solution, which becomes barren. The barren organic solution is then pumped into the barren organic tank to be recycled in the process. The organic solution generally remains on top during the process, while the heavier inorganic solution goes to the bottom of the tanks. Emissions from the stripper mixer settler tanks will be evaporative VOCs because the organic solution remains on the top of the tank. Emissions from this process are estimated using the EPA Diffusion Equation for volatile chemicals.
8.1 VANADIUM PRECIPITATION

Loaded vanadium strip solution is pumped to the vanadium precipitation tanks. The solution is heated in the tanks with steam and ammonia is added to raise the pH level. The solution is then placed in one of four separate batch precipitation tanks where ammonium sulfate is added and ammonium metavanadate (NH$_4$VO$_3$) precipitates out as the solution cools under mild agitation.

8.1.1 Process Description

The eight-ft diameter by 12-ft high vanadium precipitation feed tank provides buffering capacity between the SX strip circuit and the precipitation circuit. It is constructed of FRP, as the loaded strip solution is not corrosive (pH = 9.2).

Tank No. 1, which serves primarily as a mix tank, is an eight-ft diameter by 10-ft high FRP tank located next to the feed tank. Ammonia is sparged into the tank to raise the pH from 9.2 to 10.8 standard units and steam is added to raise the temperature from ambient levels to 149°F. A rubber-coated steel agitator provides mixing. A hose pump feeds the solution to tanks No. 2, 3, or 4.

Precipitation tanks No. 2 through No. 5 are FRP tanks equipped with rubber-coated steel agitators. Tanks No. 2, 3, and 4 are the primary precipitation tanks while tank No. 5 is a spare. Each of the primary tanks serves as a batch precipitation unit into which ammonium sulfate solution is added under very slow agitation. The precipitate takes approximately 48 hours to fully form; after which, the remaining solution is decanted and the precipitate is discharged directly onto a belt filter. The decanted solution is pumped back to the process water storage tank.

If precipitation does not occur properly in a precipitation tank, the contents of that particular tank are transferred to tank No. 5 for additional conditioning and precipitation. This spare tank is provided because vanadium precipitation is sensitive to small changes in physical and chemical properties and can be disrupted relatively easily.
8.1.2 Process Emissions

All tanks in the vanadium precipitation circuit are enclosed at the top. Tanks No. 1 through No. 5 are vented to a packed-bed wet scrubber (730-GHS-01) to remove the ammonia fumes and cool the air prior to venting. This scrubber provides 99 percent removal efficiency for particle sizes down to five microns.

The vanadium precipitation process will use ammonia and ammonium sulfate for pH control to maintain optimal precipitation of the vanadium product. Ammonia emissions from this process are calculated using the EPA Diffusion Equation.

8.2 VANADIUM FILTERING AND DRYING

8.2.1 Process Description

The precipitate from the precipitation tanks is inspected by the operator as it is discharged from the bottom of each tank. This inspection is performed from an enclosed observation corridor located between the precipitation tanks and the belt filter. If the precipitate has crystallized properly, it is pumped to the belt filter for water removal and cleaning. If the precipitate is poorly formed, the operator redirects the pumped solution to Tank No. 5 for additional conditioning.

The belt filter removes additional water from the vanadium precipitate using a vacuum filtering system and washes contaminants out of the produced filter cake using a series of water sprays. The belt filter is approximately 30-ft long by eight-feet wide and consists of a synthetic filter cloth placed over a grooved rubber belt. The liquid portion of the underflow is pulled through the filter cloth by a vacuum and directed via a filtrate manifold to a receiver. The vacuum is created by an electrically-powered vacuum pump. The excess liquid that collects in the receiver is pumped to the process water storage tank for reuse. A second receiver and seal tank is included in the system to equilibrate water pressures. The air from the vacuum system is scrubbed in a Venturi scrubber before being vented to the atmosphere.

The filter cake containing approximately 24 percent moisture, drops through a chute at the discharge end of the belt filter into the wet cake conveyor. This conveyor is an
enclosed four-inch diameter steel screw conveyor. The rotating screw transfers the wet filter cake from the belt filter into the vanadium steam dryer.

The vanadium steam dryer consists of a U-shaped steel trough with a screw-type shaft that advances the cake through the dryer. It is approximately 30-ft long by four-ft wide by four-ft high and is powered by a 75-Hp motor. The dryer jacket is heated with steam, which raises the temperature of the cake to 248°F and evaporates most of its remaining moisture. The heated air is drawn through a baghouse and then through a Venturi scrubber to remove dust particles prior to venting to the atmosphere. The vanadium cake, now containing approximately three percent moisture by weight, is transferred to rotary kiln feed hopper via a four-inch diameter steel screw conveyor. Both the dryer and conveyor are completely enclosed.

The four-ft diameter by four-foot high steel feed hopper provides buffering capacity between the steam dryer and rotary kiln. The hopper feeds the kiln through a four-inch diameter steel screw conveyor.

The 30-ft long by 30-inch diameter rotary kiln is constructed of stainless steel. The cake is fed in at one end of the kiln and gradually moves to the other end as the kiln rotates. The kiln is indirectly heated with propane to a temperature of 698°F, which removes the remaining three percent moisture and ammonia in the cake, creating a granular vanadium oxide product. This dry, granular material is then conveyed to the fusion furnace via a four-inch diameter screw conveyor. The kiln and conveyor are completely enclosed.

8.2.2 Process Emissions

The gas emissions from the steam dryer and rotary kiln, along with the vacuum flow from the belt filter, are all directed to the packed bed wet scrubber (730-GHS-01). Ammonia will be driven off in the rotary kiln when heated to 698°F. By mass balance, the amount of ammonia generated by the belt filter vacuum and the rotary kiln is 117 lb/hr, as inlet to the scrubber. The scrubber packed bed wet scrubber is designed with a 99% control efficiency for ammonia emissions.
Vanadium particulate from the belt filter and rotary kiln is estimated to be 10 ppm, as inlet to the scrubber. Again, the scrubber is designed with a 99% control efficiency for particulate emissions.

8.3 VANADIUM FUSION AND PACKAGING

The granular vanadium oxide produced by the rotary kiln is melted in the fusion furnace. The furnace discharges to a casting water wheel where the vanadium oxide melt is solidified into a fused black-flake product. A bucket conveyor then moves the product to a hopper and packaging system where the black-flake is packed, weighed, and sealed for shipment in 55-gallon drums.

8.3.1 Process Description

The granular vanadium oxide is conveyed from the rotary kiln to the 5-ft diameter by 10-ft long fusion furnace. The direct-fired furnace is lined with refractory brick and heated to a temperature of 1,472°F, which causes the product to melt. The molten metal is then discharged to a casting wheel as vanadium pentoxide (V_2O_5) or black flake.

The casting wheel is a 10- to 12-ft diameter horizontal steel plate that rotates on a vertical shaft. The upper surface of the wheel is continually wetted by flowing water as the wheel turns. The molten metal from the furnace is dripped onto the wheel where it cools instantly into a black flake ribbon. The unit has a roller breaker that reduces the ribbon flakes to the appropriate size for shipment. A scraper continuously removes the broken flake product from the wheel into a bin. A suspended hood above the wheel vents gas emissions to the Venturi scrubber.

An enclosed vertical bucket conveyor moves the black flake from the bin to the feed hopper and packaging system. The conveyor consists of a series of steel buckets that are fixed to a rotating roller chain. As each bucket descends into the bin, it scoops up the black flake material. The buckets remain in a carrying position until they reach the apex of the conveyor system, at which point they tip and discharge into the feed hopper. The black flake feed hopper is a small steel bin with a packaging system at its base. The packaging system includes a vibrating feeder and a sealed hood that fits tightly over the top of each drum as it is filled. The packaging system is calibrated by weight through a belt scale (approximately 570 pounds of black flake per drum) so that the
precise quantity of black flake needed to fill a 55-gallon drum is metered out by the vibrating feeder. The hood is also equipped with a level probe that allows the operator to monitor the height of the product in the drum while the hood is down. The hood is vented to the Venturi scrubber. After a drum is filled, the packaging operator collects a sample of the black flake for lab analyses and then seals the top of the drum with a USDOT-approved lid and clamping ring. The operator also washes down the outside of each drum after sealing to remove any fine dust that may have collected on the surface and attaches a label containing a unique identification number, gross weight, and other pertinent information.

A roller conveyor is used to move empty drums from the empty drum storage area to the feed hopper/packaging system and filled drums from the packaging area to the packaged drum storage area. The on-and-off controls for the system are operated by the packaging operator. Empty drums are manually placed on the conveyor at the empty drum storage area. Filled drums, weighing close to 600 pounds each, are removed from the end of the conveyor and placed in storage using a forklift.

8.3.2 Process Emissions

The furnace, casting wheel, and packaging hood are all vented to the wet Venturi scrubber (730-GHS-02) and estimated to yield 200 ppm of vanadium particulate, as inlet to the scrubber. The scrubber is designed to control particulate emissions with a 99% control efficiency.
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9.0 AREA 800 – REAGENT DELIVERY, PREPARATION, AND STORAGE

Reagents that are used in the uranium and vanadium recovery process are delivered by truck to the Reagent Unloading Area during daylight hours using the main haul road. The exception is ammonia, which is delivered directly to a tank near the Solvent Extraction building. Some reagents may be delivered ready to use, while some reagents need on site processing. Potable and non-potable water is also delivered using the main haul road. Approximately 16 reagent delivery trucks, 30 non-potable water trucks, and 1 potable water truck enter the Facility per day.

9.1 PROCESS DESCRIPTION

The following reagents are stored and used at the Facility:

- Sulfuric acid is delivered in liquid form directly to the storage tanks. Most of the sulfuric acid is used in the leach circuit.
- Ammonia is received in liquid form and is stored in a horizontal pressure tank. Ammonia is used in the vanadium circuit.
- Ammonium sulfate is received in dry powder form and blown via compressed air to a storage hopper. From the storage hopper, it is conveyed to a solution tank where it is agitated and mixed with water. The storage hopper is equipped with a dust collecting baghouse and screw conveyors are used to move the material to the solution tank. Ammonium sulfate is used in the vanadium precipitation process.
- Sodium chlorate is received in liquid form and pumped to a mix tank where it is diluted with water and then pumped to a storage tank. Sodium chlorate serves as a catalyst in the leach process, and is also used in the vanadium oxidation tanks.
- Sodium carbonate is delivered in dry form and offloaded using a water jet eductor to create a slurry. The slurry is then pumped to a storage tank and further diluted with water, and finally pumped to a dilute storage tank. Sodium carbonate is used in the uranium and vanadium stripper mixer settlers in the Solvent Extraction building.
- Hydrogen peroxide is delivered in liquid form and transferred to a storage tank. Hydrogen peroxide is used in the uranium precipitation process.
Sodium hydroxide is delivered in 275-gallon totes and stored at the Warehouse. As needed, the solution is pumped from the totes and added to a tank where it is mixed with water. Sodium hydroxide is used in the vanadium stripper mixer settlers.

Organic reagents used in the uranium and vanadium solvent extraction processes include kerosene, trimethylamine, and isodecanol. Kerosene acts as a transporting agent, while trimethylamine and isodecanol act as collector agents. Kerosene is delivered and pumped to a storage tank. Trimethylamine and isodecanol are received in 275-gallon totes and stored in the warehouse until they are needed. All three constituents are added to the organic make-up tank for mixing as needed. The organic mixture is approximately 1% Alamine, 3% isodecanol, and the balance is kerosene.

Diatomaceous earth is received in 100 pound bags stored both in the warehouse and at the point of use. The bags are placed in a bag breaker system which contains an integral dust filter. The bags are broken and the powder falls directly into a mix tank where it is mixed with water. Mixing of the diatomaceous earth occurs every other day. The diatomaceous earth solution is used in the uranium and vanadium polishing filters.

Flocculant is received in bulk bags and stored at the warehouse and point of use. The flocculant is emptied into a feed hopper and blown into the mix tank where it is mixed with water. The flocculant solution is then pumped to a storage tank and used in the pre-leach circuit and the CCD thickeners.

9.2 PROCESS EMISSIONS

Most of the reagents are exempt from emissions reporting as the reagents are not listed in the non-criteria reportable pollutant list in Appendix B of Regulation 3. Sulfuric Acid storage tank emissions are calculated using the USEPA Tanks program, version 4.09d as sulfuric acid is a non-criteria reportable pollutant. Ammonia is also a non-criteria reportable pollutant; however, emissions were determined to be negligible from the storage tank because it is a pressure vessel designed to prevent vapor from escaping.

Diatomaceous earth, ammonium sulfate, and flocculant emit particulate matter emissions during their unloading and mixing operations. The diatomaceous earth and ammonium sulfate systems are equipped with dust filters for emission control.
The kerosene storage tank and the organic make-up tank emissions were calculated using the USEPA Tanks program, version 4.09d. Trimethylamine and isodecanol are not listed in the Tanks constituent database and they are only 4% of the total organic solution; thus, the organic make-up tank was considered to be 100% kerosene. Both storage tanks are exempt from emission reporting by Regulation 3, Section II.D.1 because the annual throughput is less than 400,000 gallons.

Fugitive particulate matter emissions from delivery vehicle traffic on the main haul road are calculated along with the ore delivery truck emissions.
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10.1 PROPANE HEATING SYSTEM

10.1.1 Process Description

Liquid propane is delivered by tanker truck and offloaded to a 30,000 gallon horizontal pressure tank located west of the reagent unloading area. A secondary 6,000 gallon liquid propane tank will be located in the administration building area. Both propane tanks have an attached vaporizer. Propane will be used to heat the administration facility and mill buildings, the steam boilers, and the fusion furnace.

Three steam boilers will be located at the Facility; however, only two will be in regular operation with the third as a backup. Each boiler has a capacity to produce approximately 10,000 pounds of steam per hour and is equipped with low NO\textsubscript{x} burners. The boilers provide steam to the leach tanks, the vanadium precipitation tanks, and the uranium and vanadium dryers.

10.1.2 Process Emissions

Both propane tanks are exempt from emissions reporting based on Colorado Regulation 3, Part II.D.1.zz because the tanks have capacities less than 60,000 gallons and the tanks are pressure vessels sufficient to prevent vapor loss (requirements of Regulation 7, Section IV).

Emissions from the boilers will result from propane combustion. All three boilers are connected to a single 100 foot high stack that will vent combustion exhaust to the atmosphere. The boilers employ 30 ppm low NO\textsubscript{x} burners for emission control.

10.2 DIESEL AND GASOLINE STORAGE

10.2.1 Process Description

Diesel and gasoline are delivered to the Reagent Unloading Area and pumped to their respective storage tanks. The main diesel storage tank is a 12,000 gallon tank and feeds diesel to two diesel day tanks. One day tank is connected to the emergency firewater pump and the other to the standby generator. The gasoline tank is a 2,000
gallon tank. Both the diesel and gasoline tanks provide fuel to two adjacent dispenser islands.

10.2.2 Process Emissions

All three diesel tanks are exempt from emissions reporting by Regulation 3, Section II.D.1.fff because the tanks have less than 400,000 gallons annual throughput. Volatile organic compound emissions from the gasoline storage tank were calculated using the USEPA Tanks program, version 4.09d.
11.0 AREA 1000 – GENERAL PLANT

11.1 EMERGENCY RESPONSE SYSTEM

11.1.1 Process Description

The emergency firewater system contains a 207 horsepower diesel firewater pump engine. The Facility also contains an emergency standby generator used in the case of a power failure. The standby generator is a 2,000 kiloWatt generator. Both the firewater pump engine and the standby generator contain their own diesel day storage tanks that were described in Section 10.3. Because the firewater pump engine and the standby generator are used for emergency purposes only, they are required by 40 CFR Part 60, Subpart IIII to limit operational and maintenance use to 100 hours per year. Emergency use is not limited. Both systems would exhaust through a stack into the atmosphere.

11.1.2 Process Emissions

Emissions from the firewater pump engine and standby generator would be generated from diesel combustion. Neither system employ emission controls as the equipment is used for emergency purposes only. Emissions are calculated based on the 100 hours per year maximum that can occur for operation and maintenance purposes only.

11.2 ADDITIONAL VEHICLE TRAFFIC

11.2.1 Process Description

Vehicle traffic in addition to the ore delivery trucks and reagent trucks already mentioned would include product shipment trucks, vehicle worker traffic, and monitoring and security vehicles. Based on a 1,000 ton per day processing schedule, 30 truck loads of uranium yellowcake would be shipped from the Facility per year. Likewise, 100 truck loads of vanadium oxide would be shipped from the facility per year. Shipment of product would occur during daylight hours. Worker vehicles would enter the Facility and travel to either the Administration Building or the Mill Area. Approximately 27 workers would be at the Administration Building and 30 workers would be at the Mill Area during a day shift. Swing shift and graveyard shifts would employ approximately 15 workers.
each at the Mill Area. Both the product shipment trucks and worker vehicles would travel along the main haul road.

Air monitoring stations, production wells, monitoring wells, and the licensed boundary perimeter are monitored using secondary unpaved service roads. These roads are 10 feet wide and will not be graveled, watered, or treated with chemicals for emission control unless necessary. The monitoring road system extends to the perimeter of the Property. While not all portions of the monitoring service roads will have vehicle traffic on a daily basis, some portions may have vehicle traffic multiple times per day depending on circumstances. On a typical day, the anticipated travel would be based on routes to the air monitoring stations and production wells. Additional access to the monitoring wells and other road use would occur on a less frequent basis. It is anticipated that the monitoring activities associated with the air stations and wells will occur during daylight hours only. The secure licensed boundary perimeter will be monitored six times per day and is anticipated to occur over a full 24 hour per day period.

11.2.2 Process Emissions

The worker vehicles and product shipment trucks will emit fugitive particulate matter emissions from traveling on the main haul road. These emissions are calculated based on the vehicle mix that would travel on the main haul road including delivery trucks, reagent trucks and worker vehicles. An emission control efficiency is applied since the main haul road will be stabilized and treated for dust control.

The security and monitoring vehicle emissions from traveling on the secondary service roads are calculated separately from the main haul road because the travel schedule differs and only lightweight trucks are anticipated to be traveling along those roads. No credit for emission control efficiency is taken for the secondary road emission calculations since treatment of these roads for dust control is not planned unless necessary. Because the vehicle traffic on the service roads used for monitoring air stations and wells does not occur on a standard daily schedule, the emissions are calculated assuming three round trips per day using the distance of a typical monitoring route.