

## **EXHIBIT D**

### **DEQ/DMME URANIUM STUDY:**

### **SURFACE WATER AND GROUNDWATER MONITORING PLANS AND STANDARDS ADEQUACY ASSESSMENT**

# Uranium Study: Surface Water and Groundwater Monitoring Plans and Standards Adequacy Assessment

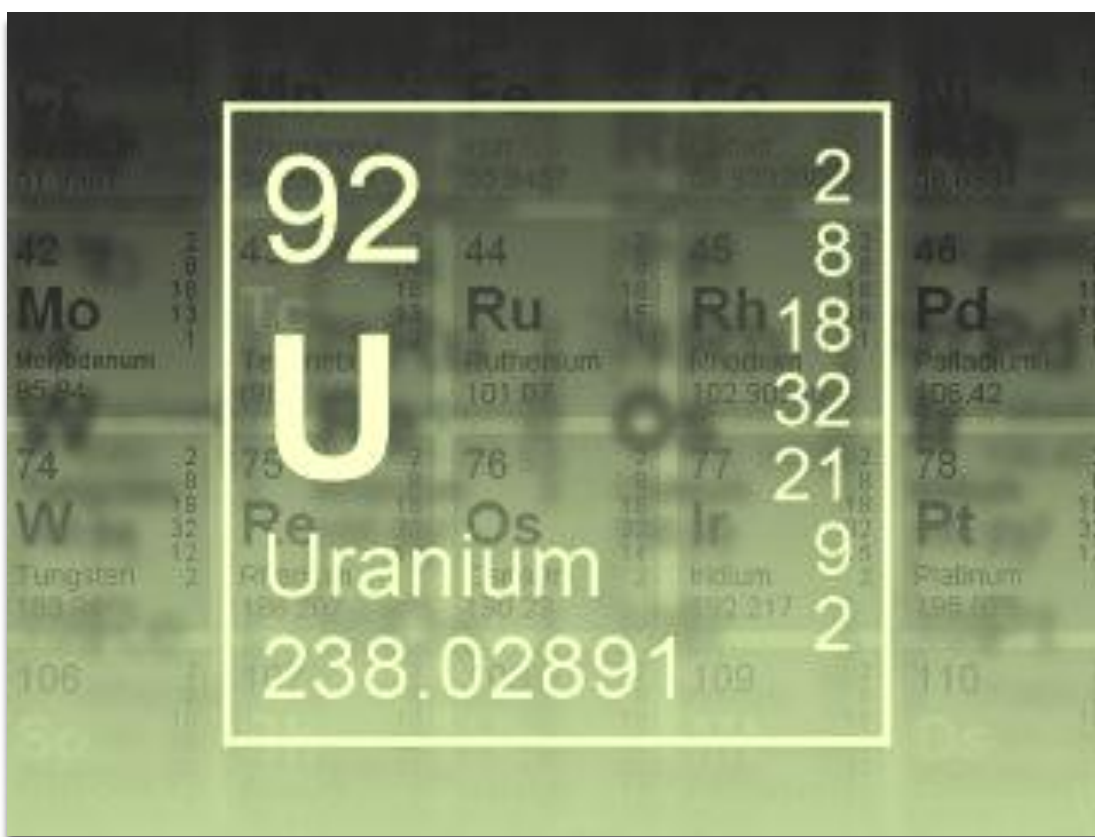
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Department of Mines, Minerals and Energy

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## ABBREVIATIONS

ACL	Alternative Concentration Limit
ALARA	As Low As Reasonably Achievable
ASCM	Alternate Sediment Control Measure
BADT	Best Available Demonstrated Technology
BAT	Best Available Technology Economically Achievable
BCT	Best Conventional Pollution Control Technology
BMP	Best Management Practice
CCR	Colorado Code of Regulations
CDPHE	Colorado Department of Public Health and the Environment
CDPS	Colorado Discharge Permit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHI	Cumulative Hydrologic Impact
COC	Constituents of Concern
COD	Chemical Oxygen Demand
CRS	Colorado Revised Statutes
CWA	Clean Water Act
DMO	Designated Mining Operation
DOGAMI	Oregon Department of Geology and Mineral Industries
DOW	Division of Wildlife
DRMS	Colorado Division of Reclamation, Mining, and Safety
Eh	Oxidation/reduction potential
EPA	U.S. Environmental Protection Agency
EQA	Environmental Quality Act
HUT	Hydrologic Unit Testing
ISR	In Situ Recovery
LQD	Wyoming Land Quality Division
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
MLRA	Mined Land Reclamation Act
mrem/yr	millirems per year
MOU	Memorandum of Understanding
MSHA	Mine Safety and Health Administration
NAS	National Academy of Science
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission



NSPS	New Source Performance Standard
NUREG	Nuclear Regulatory Guide
OAR	Oregon Administrative Rule
ODOE	Oregon Department of Energy
ODEQ	Oregon Department of Environmental Quality
ORS	Oregon Revised Statute
OSM	Office of Surface Mining Reclamation and Enforcement
pCi/L	Picocuries per Liter
PHC	Probable Hydrologic Consequences
PMF	Permanent, Maintenance-Free (Diversion Design)
PPC	preparedness, prevention and contingency
QA/QC	Quality Assurance and Quality Control
RCRA	Resource Conservation and Recovery Act
RFP	Request for Proposal
R&R	Rules and Regulations
SDWA	Safe Drinking Water Act
SIC	Standard Industrial Classification
SPCC	Spill Prevention, Control, and Countermeasure
SU	standard units
SWMP	Storm Water Management Plan
SWPPP	Storm Water Pollution Prevention Plan
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
TOC	Total Organic Compounds
UIC	Underground Injection Control
U.S.	United States
USGS	United States Geological Survey
UWG	Uranium Working Group
VAC	Virginia Administrative Code
VDEQ	Virginia Department of Environmental Quality
VDH	Virginia Department of Health
VDMME	Virginia Department of Mines, Minerals, and Energy
WQCD	Water Quality Control Division
WDEQ	Wyoming Division of Environmental Quality
WPCF	Water Pollution Control Facility
WQD	Water Quality Division
W.S.	Wyoming Statute
WYPDES	Wyoming Pollution Discharge Elimination System

## 1.0 GENERAL INTRODUCTION

On January 19, 2012, the Governor of the Commonwealth of Virginia (Virginia) directed members of his cabinet to form a Uranium Working Group (UWG) with staff from the Virginia Department of Mines, Minerals and Energy (VDMME), the Virginia Department of Environmental Quality (VDEQ), and the Virginia Department of Health (VDH). This UWG was established to provide a scientific policy analysis to help the General Assembly assess whether the moratorium on uranium mining in Virginia should be lifted, and if so, how best to do so.

Recent studies on uranium mining in Virginia have identified important issues related to the protection of public and occupational health and safety, as well as associated environmental and socioeconomic impacts. Consequently, the UWG has sought to develop a conceptual regulatory framework that would address these issues and any other issues identified by the UWG, the public, or other stakeholders. This conceptual regulatory framework will form part of the Departments' policy analysis and will be one of the many pieces of information the General Assembly will consider while deciding whether or not to lift Virginia's moratorium on uranium mining. The information within this report is intended to assist the UWG in developing a scientific policy analysis related to potential future uranium mining in Virginia.

Specifically, this report addresses surface water and groundwater monitoring requirements and assesses the current Virginia water quality standards. The following report sections present a compilation of information, summarized from other state programs (Colorado, Wyoming, Oregon) and federal agencies (i.e., U.S. Nuclear Regulatory Commission [NRC] and U.S. Environmental Protection Agency [EPA]), with respect to protection of water quantity and water quality for uranium mining and milling. States with both high and low levels of precipitation were included in this compilation. This information includes a review of statutes, rules and regulations, as well as a summary of relevant guidance for the UWG to an applicant who intends to prepare a uranium mine permit or mill license application within Virginia.

This report is organized according to the sequence of mining operations or, more simply, the actions generally required by a mining company to achieve regulatory compliance under a Permit to Mine or License to Mill application. This generally starts with an effort to achieve pre-mining/milling data collection requirements, followed by hydrologic control practices during construction and operations, and then hydrologic protection standards associated with closure and final reclamation. Also addressed are siting criteria, monitoring, compliance, well construction, and assessment of Virginia's water quality standards. Within each of these topics, this report is organized by state and associated statutes, rules, and regulations. In report sections that necessitate state-by-state regulatory comparisons, Wyoming is explored first, with Colorado and Oregon serving only to expand on Wyoming statutes, rules, regulations, and guidance as applicable. Wyoming is not an NRC Agreement State and NRC maintains authority over uranium processing operations such as milling and in-situ recovery. An NRC Agreement State is

a state with delegation from the NRC to a qualified state agency for regulatory authority over radioactive materials through an agreement as permitted under Section 274 of the Atomic Energy Act. Colorado and Oregon are NRC Agreement States and as such, have assumed authority over milling operations with NRC oversight.

The creation of state statutes and rules is a legislative process. Although subject to amendment, state statutes and rules are generally fixed for a period of time. Such statutes and rules are promulgated to ensure the protection of water resources and may or may not directly pertain to uranium mining. Standards related to siting, construction, operation, and decommissioning of uranium mills directly address public health and safety, as well as protection of water resources. These are specifically addressed both in state rules and regulations (NRC Agreement States) and through the NRC rules (Non-Agreement States) as promulgated under the Atomic Energy Act of 1954, as amended. Often the state rules directly cite NRC and/or EPA rules, methods and assumptions. Where in-situ uranium recovery (ISR) is addressed, rules and regulations specific to uranium ISR have been developed in accordance with applicable NRC and EPA standards. In all cases, surface water and groundwater monitoring requirements address not only the standard water quality parameters necessary to ensure public and environmental health, but also those parameters specific to uranium mining and milling.

To varying degrees, state and federal regulatory authorities have prepared guidelines to assist the applicant in the preparation of a mining/reclamation permit or mill facility license. Some examples of these types of documents that are specific to uranium mining and milling include but are not limited to: Wyoming Department of Environmental Quality (WDEQ) Land Quality Division (LQD) Guideline 8 (Hydrology), the Colorado Code of Regulations (CCR) Rules 6 and 7 of 2 CCR 407-1; and NRC Regulatory Guide 3.46 (June 1982), Nuclear Regulatory Guide (NUREG)-1748 (August 2003) and NUREG-1569 (June 2003). The following sections will not provide comparative detail on any state-specific or federal guidelines but will rather provide an outline of guidance drawn from several state and federal guidance documents that will ensure a complete permit/license application as it relates to surface and groundwater protection.

Conventional uranium mining, like most types of mining, may include either open pit or underground mining. Some mines involve both types of operations at the same site. The mining process will generate and temporarily store topsoil, mine waste (spoils, overburden), and ore. Uncontrolled runoff can transport these mine materials off site both in dissolved, suspended and bed load form. Bed load is defined as coarse materials transported along the stream or drainage bottom or streambed. Leaching of these mine materials can contaminate the groundwater of the Commonwealth.

Mining regulations require that the operator protect water resources. Protection is typically accomplished by isolating the disturbed area from offsite run-on (via diversions) and treatment of runoff before it leaves the disturbed area (Figure 1-1). Typical treatment includes sediment ponds, containment berms, Alternative Sediment Control Measures (ASCM), all of which result

in the deposition of sediment and the mineral assemblage associated with this sediment. Additional treatment techniques which are specific to uranium mines include the use of barium chloride in settling ponds to precipitate radium, which may be dissolved in the water.

Non-conventional uranium mining includes ISR, which results in minimal surface disturbance while extracting uranium from groundwater wells. ISR is a uranium recovery process regulated by the NRC or NRC Agreement States. It utilizes a chemical process (injection of a carbonate lixiviant and gaseous oxygen) to release the uranium from the mineral matrix of an aquifer and dissolve it into the groundwater. The uranium enriched groundwater is then pumped to the surface and piped to a process facility for uranium removal. Except for a small percentage of water (known as recovery bleed) that must be disposed as a regulated material (either through evaporation or deep formation injection via an Underground Injection Control [UIC] Permit), the water from which the uranium has been removed is refortified with other agents (i.e. carbonate and oxygen) and is re-injected into the aquifer to recover additional uranium. In other words, the waters which are removed from the aquifer during the mining process are recycled and replaced for use in further mining efforts. This type of uranium recovery operation results in minimal disturbance to the surface water system but may result in a permanent quality and quantity disturbance to the local groundwater regime.

On a regulatory basis, uranium mining, like other types of mining, is fully contained within a mine permit area (Figure 1-1). This permit area is all-encompassing and includes the mining area (open pit or underground facilities), stockpile areas, ore storage facilities, mine facilities, roads, conveyors and other facilities used in the mining process. In addition to the mining facilities, such environmental protection facilities such as diversions, sediment ponds and ASCM's are generally contained within the mine permit area. The mined uranium ore is not considered an NRC regulated material for the purpose of radiation protection and health and safety (beyond the occupational radiological health and safety requirements of the Mine Health and Safety Administration [MSHA]). The uranium ore is a natural material, and has not yet been "beneficiated" by removal and concentration techniques, which makes it a licensed material under the Atomic Energy Act, as amended.

Uranium ore processing (uranium mills, ISR well fields, heap leach operations, mill tailings facilities, etc.), on the other hand, are regulated to protect human health and safety and the environment and are contained within what is called a license area. The license area is the regulated portion of a uranium recovery (processing) project area subject to NRC or NRC Agreement State rules governing activities at such facilities. Within the licensed area, there may be an unrestricted area, a controlled area, and a restricted area (see Figure 1-1). The unrestricted area is that portion of the licensed area where access is neither limited nor controlled by the licensee (10 Code of Federal Regulations [CFR] 10.1003). Relatively free movement of materials, personnel, and the public is allowed within the unrestricted area. A controlled area is an area within the site boundary but outside of a restricted area (i.e., within the unrestricted area),

access to which can be controlled by the licensee for any reason (10 CFR 20.1003). The restricted area is an area to which access is limited by the licensee for the purpose of protecting employees and the public against undue risks from exposure to radiation and radioactive materials (10 CFR 20.1003). The mill area, including the processing facility and the waste disposal area(s) are within the restricted area and all employees or equipment, including trucks, must be scanned for radioactivity when they exit the mill area. Uranium ore, once it enters the mill area, becomes licensed material. The ore in the mill area is considered source material (>0.05% natural uranium by weight) before processing and the wastes of processing, including tailings, are considered Byproduct Material under section 11e.(2) of the Atomic Energy Act, as amended. The milling wastes are often call 11e.(2) Byproduct Material or simply 11e.(2), for short.

With respect to water resources, the Licensee is responsible to ensure that process water, including dewatered resources, and storm water (both disturbed and undisturbed storm water) meet permitting requirements as detailed in Section 2.5.

The National Academy of Science (NAS) study presents a more detailed discussion of uranium mining and milling practices (NAS, 2011; Chapter 4) that may add to a reader's understanding of these activities.

## **1.1 Procurement Summary**

On March 2, 2012, the VDEQ issued Request for Proposal (RFP) # 12-06-PJ (Uranium Study). The purpose of the procurement was to acquire contractor services to provide information and expert analysis of uranium mining and milling issues in Virginia relevant to the statutory jurisdictions of VDEQ and VDMME. The Contract identifies two major work Tasks (A and B). Work Task A involved the development of an initial report based on: 1) a review of studies related to uranium mining and milling in Virginia, 2) a comparison of other existing regulatory programs for uranium mining and milling, and 3) a review of emerging standards from international organizations.

Work Task B involved ongoing technical advice and assistance to the Uranium Working Group. The efforts of Work Task B have resulted in a series of interim reports analyzing a range of issues identified in the RFP (Task B2).

## **1.2 Purpose and Objective**

The purpose of this Report is to respond to the Work Task B.2.a, B.2.b, and B.2.d requirement in Contract EP881027 as described above. The objective of this report is to assess water quality monitoring plan components for surface water and groundwater related to uranium mining and milling.

## **2.0 POTENTIAL WATER QUALITY PARAMETERS AND STANDARDS (MINING AND MILLING) FOR SURFACE WATER AND GROUNDWATER**

### **2.1 Potential Water Quality Parameters and Standards**

The potential water quality parameters and standards for uranium mining and milling typically reflect those standards promulgated by the EPA to ensure protection of the surface waters and groundwater of the United States. In Canada, Health Canada on behalf of the Federal-Provincial-Territorial Committee on Drinking Water ([www.healthcanada.gc.ca/waterquality](http://www.healthcanada.gc.ca/waterquality)) promulgates similar standards and guidance. In general, water quality standards are developed to address those parameters for which:

- Exposure to the contaminant could lead to adverse health effects;
- The presence of the contaminant could lead to adverse impacts to the ecosystem or agricultural practices;
- The contaminant is frequently detected or could be expected to be found in a large number of water supplies; and
- The contaminant is detected, or could be expected to be detected, at a level that is of possible health or agricultural significance.

Water quality standards can be separated into use categories to include: drinking water standards; aquatic standards; agricultural (irrigation) standards; livestock standards; and in some cases several subcategories of industrial use. The drinking water standards are often, but not always, the most stringent standards and are based on human health risk. For certain metals, aquatic standards can be more stringent than drinking water standards to ensure the protection of species that are more susceptible to changes in the biochemical ecosystem. Typically, livestock standards and industrial standards are less stringent than drinking water standards. Tables 2-1 and 2-2 compare these different standards for both surface and groundwater.

Potential water quality parameters for mining and milling of uranium are based on the protection of these same resources (human health and safety, aquatic life, agriculture, and industrial use) as discussed above. In addition to the standard monitoring parameters on which drinking water standards are based, several states, the NRC, and Health Canada include the following list specific to uranium mining and milling:

- Radium-226 (Picocuries per Liter [pCi/L]);
- Radium-228 (pCi/L);
- Gross Alpha (pCi/L);



- Gross Beta (pCi/L);
- Uranium (milligrams per liter [mg/L]);
- Vanadium (mg/L);
- Polonium-210 (pCi/L);
- Lead-210 (pCi/L); and
- Thorium-230 (pCi/L).

Each ore body is unique and a robust characterization of the ore and associated mine waste and milling wastes should be performed. This characterization should include all of the associated metals, radionuclides, organic and inorganic compounds, or elements to ensure baseline and compliance monitoring programs are designed to identify any significant release of pollutants from a uranium project site.

## **2.2 Restoration Requirements**

Water quality protection of the surrounding surface and groundwater resources is paramount. A proposed mining and/or milling operation should be designed, operated, and closed or decommissioned in a manner that ensures the protection of the waters of Virginia. Should contamination be detected through the monitoring program in place at the facility, remedial action would be required. Such actions may include, but are not limited to characterization and additional monitoring, containment and disposal, containment and treatment, removal and treatment, disposal, and in-situ treatment (e.g., chemical or biological remediation). The selection of the appropriate action will depend on site-specific conditions on a case-by-case basis. Whereas, water quality restoration to baseline or better is required by all states and the federal government prior to the end of mining and reclamation, the meaning of baseline and reclamation standards are often state specific. For example, some states (e.g., Colorado) and the NRC require restoration to baseline on a parameter-by-parameter basis, while others require restoration to the pre-mining class of use (e.g., Wyoming).

## **2.3 Definitions and Criteria including Sampling Protocol**

Many states provide guidance for sampling protocol and testing for water quality parameters. In general these regulatory programs reference EPA approved methods of analysis according to 40 CFR 136, as amended, "Guidelines Establishing Test Procedures for the Analysis of "Pollutants" under the Clean Water Act." For groundwater, the Resource Conservation and Recovery Act (RCRA) Ground-Water Monitoring Technical Enforcement Guidance Document (EPA, 1986) and the subsequent RCRA Ground-Water Monitoring: Draft Technical Guidance (EPA, 1992) provide sampling guidance. Sample holding times are the maximum times that samples may be held before analysis. Chains-of-Custody to track sample handling and

transportation to the laboratory are generally required. Laboratory certification to complete the required analyses is also required. Some states require that the laboratory completing the analyses have a state certification. References for sample collection and analyses include the following:

- American Public Health Association. 1985. Standard methods for the examination of water and wastewater. 16th Edition. Published jointly by: American Public Health Association, American Water Works Association, and Water Pollution Control Federation.
- Code of Federal Regulation, Title 40 Part 136. Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act. Environmental Protection Agency. U.S. Government Printing Office. Washington.
- EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA - 600/4-79-202.
- EPA. 1982. Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater. EPA-600/4-82-057.
- EPA. 1986. RCRA Ground-Water Monitoring Technical Enforcement Guidance Document. EPA-530/SW-86/055.
- EPA. 1992. RCRA Ground-Water Monitoring: Draft Technical Guidance.

Typically, most water quality standards are for the dissolved fraction of the sample. The term dissolved can be defined as those particles that pass through a 0.456 micron membrane filter. The NRC requires collection and analysis of certain radionuclides as not only the dissolved fraction, but also the suspended fraction. Suspended fraction can be defined as those particles that pass through a nominal 1-micron filter. Analysis of the suspended fraction provides information on radionuclides that are within the suspended sediment associated with surface water streams and impoundments. Under RCRA, filtering of groundwater samples prior to analysis is discouraged and analysis typically results in total concentrations of constituents to account for both dissolved and suspended constituents (EPA, 1986).

## **2.4 Detailed Fate and Transport Analysis of Constituents of Concern**

Individual state guidelines and federal requirements address fate and transport modeling in groundwater and surface water for both mining and milling operations. Prediction of the geochemical changes to which mined rock will be subjected is a critical concern as oxidation and dissolution of constituents upon material exhumation, including generation of acid mine drainage and acid rock drainage, can impact the post-reclamation environment. The dissolution and movement of metals and radionuclides is subject to changes in water chemistry, such as reduction-oxidation potential (Eh) and acidity/alkalinity (pH). Fate and transport modeling may



include laboratory bench scale studies, column leach studies, weathering cells as well as more theoretically-based models that address surface water and groundwater movement, chemical kinetics and chemical equilibria. The nature of the modeling can be very site-specific and most states establish its relevance following the baseline characterization of the geological environment and a regulatory determination of the potential impacts to the surrounding aquatic resources.

## 2.5 National and State Pollutant Discharge Elimination Standards

The EPA regulates point source discharges of both storm water and non-storm water pollutants into waters of the U. S. through provisions of the Clean Water Act (CWA) known as the National Pollutant Discharge Elimination System (NPDES) program. NPDES is an EPA program overseen by state-level environmental quality and/or water quality agencies, such as the WDEQ/Water Quality Division (WQD). An NPDES permit is required for point sources of discharge into surface drainages but not for non-point discharges (i.e., most alternative sediment control measures). Each NPDES permit requires a monitoring plan, generally requiring that one sample be obtained during each week of discharge. The term point source refers to any discernible, confined and discrete conveyance.

The NPDES regulations classify discharges from mine sites as either mine drainage, process water, storm water or unclassified. Uranium discharges classified as mine drainage or process water are subject to the technology-based effluent limitations set forth in 40 CFR 440. NPDES permits set specific requirements regulating the characteristics of discharged water to meet these national technology-based effluent limitations and applicable water quality standards. Discharges classified as storm water are also permitted pursuant to NPDES permits if they are not mixed with the two former types. The NPDES permits specify monitoring, inspection, and reporting requirements.

### 2.5.1 Mine Drainage and Process Wastewater

There is regulatory overlap and cross-references between the NRC and the EPA because of the possible radioactive nature of storm water associated with uranium processing facilities. The CWA gives the EPA the authority to regulate pollutants, which are defined in 40 CFR 122.2 to include “*radioactive materials (except those regulated under the Atomic Energy Act of 1954, as amended.*” The NRC’s 10 CFR 40 Appendix A states that “*Uranium . . . byproduct materials must be managed so as to conform to the applicable provisions of Title 40 of the Code of Federal Regulations, Part 440*” which sets effluent limitations for radium-226 (total and dissolved) and uranium (in the case of mining only). According to 40 CFR 440.34, “*any new source . . . must achieve the following [new source performance standard] NSPS representing the degree of effluent reduction attainable by the application of the best available demonstrated technology (BADT)*”. Concentrations of pollutants discharged from mines (excluding ISR methods) as outlined in 40 CFR 440.34 for new point source discharges are found in Table 2-3.

Requirements for discharges from new uranium mills are also outlined in 40 CFR 440.34(b), which addresses the discharge of process water. Typically, process water discharge from milling operations is prohibited. However, for areas with higher annual precipitation rates than annual evaporation, such as Virginia, “a volume of water equivalent to the difference between annual precipitation falling on the treatment facility and the drainage area contributing surface runoff to the treatment facility and annual evaporation may be discharged subject to the limitations set forth [in Table 2-3]”.

Additionally, 40 CFR 440.131 (Subpart L) details discharge exemptions for mining and milling facilities in the case of precipitation or snowmelt resulting in an overflow or excess discharge of effluent if the following design, construction, and maintenance criteria are met:

For facilities permitted to discharge: containment of wastewater generated by the facility over a 24-hour period and “the maximum volume of wastewater resulting from a 10-year, 24-hour precipitation event or treat the maximum flow associated with these events.”

For facilities not permitted to discharge: containment of maximum amount of wastewater stored and contained by facility and “the maximum volume of wastewater resulting from a 10-year, 24-hour precipitation event”.

The facilities must also demonstrate reasonable steps to minimize overflow and meet all notification requirements.

The Engineering Designs and Best Management Practices Report developed as part of the VDEQ/DMME Uranium Study explores NRC and other engineering design criteria and best management practices (BMPs). NRC requirements include engineering criteria for storm events larger than the 10-year, 24-hour scenario.

### **2.5.2 Storm Water Discharges**

NPDES regulated storm water discharges fall into three categories: construction activities, industrial activities, and municipal separate storm water systems. Storm water discharges associated with industrial activities are defined in federal regulations 40 CFR 122.26(b)(14)(i)-(xi) through the use of Standard Industrial Classification (SIC) codes. Uranium ore is included in SIC 1094 metallic mineral/ores: uranium-radium-vanadium ores. Discharges classified as storm water may be permitted pursuant to NPDES permits if they are not mixed with mine drainage or process water. The EPA published a table in the September 29, 1995 Federal Register (60 FR 50804) to clarify which discharges from mining areas are subject to the effluent limitations and which may be subject to a general storm water permit (See Table 2-4).

The EPA has authorized 46 states to implement and monitor the NPDES program at the state-level according to the EPA NPDES State Program Status list ([http://cfpub1.epa.gov/npdes/statestats.cfm?program\\_id=12](http://cfpub1.epa.gov/npdes/statestats.cfm?program_id=12)). All states explored in this analysis have approved state

NPDES permit programs and general permits programs. Oregon and Virginia also have authority to regulate federal facilities and have approved pretreatment programs. Wyoming is also able to regulate federal facilities. Below is a spectrum of various state-level requirements for dischargers who seek state general storm-water permits (every item is not required by every state):

- A U.S. Geological Survey (USGS) topographical map showing the location of the facility and each outfall, the drainage area served by each outfall, the direction of flow within each drainage area and the names of the receiving streams;
- A site plan;
- Documentation demonstrating that the discharge to be covered under the general permit consists entirely of storm water; and
- Documentation demonstrating compliance with water-quality standards and effluent limits, including (at a minimum) the following:
  - A preparedness, prevention and contingency (PPC) plan;
  - An erosion and sedimentation control plan; and
  - Other storm-water management and pollution-prevention measures.

Permit conditions applicable to all NPDES permits (storm and non-storm water discharges) in 40 CFR 122.41, include the following minimum monitoring parameters:

- Flow (in gallons/day or millions of gallons/day);
- Pollutants listed in the terms of the permit conditions;
- Pollutants that could have a significant impact on the quality of the receiving streams, according to the findings of the state or local authority, based on the information provided;
- Pollutants specified as subject to monitoring by EPA regulations; and
- Other pollutants for which the EPA requests monitoring in writing.

The CWA details additional NPDES requirements. CWA Section 304(f) requires that the EPA Administrator to develop “*guidelines for identifying and evaluating the nature and extent of nonpoint sources of pollutants, and processes, procedures, and methods to control pollution resulting from mining activities, including runoff and siltation from new, currently operating, and abandoned surface and underground mines; all construction activity, including runoff from the facilities resulting from such construction; and the disposal of pollutants in wells or in subsurface excavations*”. CWA 402(f) requires that “*the Administrator shall promulgate regulations establishing categories of point sources which he determines shall not be subject to the requirements of . . . this section . . . . The Administrator may distinguish among classes,*

*types, and sizes within any category of point sources.”* The construction of impoundments serving as repositories for tailings and treatment of waste from mining and mineral processing operations are regulated by Section 404 of the CWA and Section 402 in the case of discharges from these impoundments into any waters of the United States (U.S.).

Importantly, the permit requirements of CWA 402(1)(2) exclude discharges of storm water runoff from mining operations *“composed entirely of flows which are from conveyances or systems of conveyances (including but not limited to pipes, conduits, ditches, and channels) used for collecting and conveying precipitation runoff and which are not contaminated by contact with, or do not come into contact with, any overburden, raw material, intermediate products, finished product, byproduct, or waste products located on the site of such operations.”* This is illustrated in 2-1.

CWA Section 404(f)(1)(C-E) further details that the discharge of dredge or fill material for the following purposes are not prohibited:

- For the purpose of the maintenance of drainage ditches within a permit area;
- For the purpose of construction of temporary sedimentation basins on a construction site within a permit area (pre-operational phase) which does not include placement of fill material into the navigable waters; and
- For the purpose of construction or maintenance of temporary roads for moving mining equipment, where such roads are constructed and maintained, in accordance with BMP, to assure that flow and circulation patterns and chemical and biological characteristics of the navigable waters are not impaired, that the reach of the navigable waters is not reduced, and that any adverse effect on the aquatic environment will be otherwise minimized.

In accordance with 40 CFR 122.44(d), each NPDES permit shall include conditions that attain or maintain water quality standards established pursuant to Section 303 of the CWA, including state narrative criteria for water quality.

## **Colorado**

Colorado has been selected as the primary example state with a concomitant effort to note and identify differences and similarities between Colorado and other states. Colorado Department of Public Health and the Environment (CDPHE) requires the following permits for discharges associated with metals mining: 1) industrial individual wastewater discharge permit for process water, 2) metal mining storm water permit including a storm water management plan, and 3) discharges associated with subterranean dewatering or well development permit. Additionally, large (disturbance >1 acre) and small (disturbance <1 acre) construction permits are required during the initial phase of construction or exploration of the permit area. The

process water permit applies to all metal mining process water discharges and the dewatering discharges permit applies to all subterranean dewatering activities. The process water permit sets both technology-based effluent limits and water quality-based effluent limits in addition to sampling, monitoring, reporting, and record keeping requirements, consistent with NPDES standards.

According to the metal mining industrial storm water permit factsheet (Colorado Discharge Permit Number COR-040000) available on the CDPHE Water Quality Control Division (WQCD) Permits website, the metal mining storm water Colorado Discharge Permit (CDPS) applies to the following:

- New and existing discharges composed entirely of storm water from active and inactive mining operations that are within SIC Code 10 - Metal Mining and Milling, at sites that discharge storm water only. Construction storm water permits are required only if more than 1 acre of land is disturbed; if less than 1 acre of land is disturbed, the industrial storm water permit will be sufficient. Most mines will likely fall within the greater than 1 acre of disturbed land.
- Areas which discharge storm water that comes into contact with overburden, raw material, intermediate products, byproducts, finished products, or waste products.
- Existing discharges composed entirely of storm water from other metal or coal mining operations that are currently covered by an individual CDPS permits for discharge of process water.
- Each CDPS permit certification covers only one contiguous area. If a remediation plan identifies disposal of mine waste at a location away from the contiguous permit area, separate permit coverage must be obtained for the disposal site.

CDPS exemptions include the following:

- Pre-operational mines—prior to any disturbances associated with the extraction, beneficiation, or processing of mined materials;
- Uncontaminated storm water--discharges of storm water not in contact any overburden, raw material, intermediate products, byproducts, finished products or waste products located at the mining operation; and
- Reclaimed mines—*“Mines that have met certain reclamation conditions are not required to obtain a stormwater discharge permit. . . . Non-coal mining operations which have been released from applicable state or Federal reclamation requirements after December 17, 1990 are also not required to obtain stormwater discharge permits. However, the Division may designate such reclaimed sites as requiring a*

*stormwater permit if the discharge is a significant contributor of pollutants to waters of the State.”*

The storm water permit monitoring requirements as outlined in the application are as follows:

*“This permit does not require submission of effluent monitoring data in the permit application or in the permit itself. The narrative requirements include prohibitions against discharges of non-stormwater. They require dischargers to control and eliminate the sources of pollutants in stormwater through the development and implementation of a Stormwater Management Plan (SWMP). The plan must include Best Management Practices (BMPs), which may include treatment of stormwater discharges along with source reduction.*

*Discharges of stormwater associated with mining operations must meet all applicable provisions of Sections 301 and 402 of the Clean Water Act. These provisions require control of pollutant discharges to a level equivalent to Best Available Technology Economically Achievable (BAT) and Best Conventional Pollution Control Technology (BCT), and any more stringent controls necessary to meet water quality standards. As per EPA, a fully implemented SWMP will constitute compliance with BAT and BCT. It is believed that BMPs can be adequate to control water quality impacts. If the Division determines that additional requirements are necessary, they may be imposed as follows: 1) at the renewal of this general permit or through an industry special general permit if the issue is categorical; 2) through direction from the Division based on the implementation of a TMDL if the issue is watershed-based; or 3) if the issue is site-specific, through guidance from the Division, based on an inspection or SWMP review or through an individual permit.”*

Process water associated with both uranium mining and milling is eligible for discharge under CRS 25-11-101, 6 CCR 1007-1, and hardrock mining and milling individual discharge permits. Discharge quality parameters required for quarterly monitoring are shown in Table 2-5. 6 CCR 1007-1 requires that management of byproduct materials comply with 40 CFR 440. Therefore, new uranium mills may not discharge *process waste water* as per Part 440.34(b). Storm water from both mine and mills (except storm waters from heap leach pads, tailings ponds and process ponds) is exempt from Part 440 but is subject to the NPDES requirements, unless mixed with discharges subject to Part 440 requirements that are not regulated by another permit prior to mixing.

Further, Subpart L (40 CFR 440.131), identifies that facilities allowed to discharge may be qualified for an exemption from storm overflow discharges in excess of the Part 440 requirements if they meet the specific conditions identified, which are detailed in Section 2.5.1, of this report.



## **Wyoming**

Unlike Colorado, Wyoming requires two separate permits under the Wyoming Pollution Discharge Elimination System (WYPDES) program to authorize: 1) metal mining process water, including dewatering discharge (the WYPDES Industrial Operations, Process Water, Form G permit), and 2) storm water discharges, including a storm water pollution prevention plan (WYPDES general industrial storm water permit [Permit WYR00-0000]). However discharges to Class I waters (surface waters in which no water quality degradation by point source discharges will be allowed) of the state cannot be permitted under the general industrial storm water permit. In this case, facilities may apply for coverage under an individual storm water permit. Similar to Colorado, construction activity storm water discharges are required by WDEQ for new construction/exploration projects. Some ongoing (during operations phase) onsite construction activities do not require separate construction permits if they are deemed integral to the ongoing industrial activity. The Industrial General Permit for Storm Water Discharges (Permit WYR00-0000) Fact Sheet available on the Wyoming Department of Environmental Quality, Water Quality Division, WYPDES Storm Water Program website defines storm water associated with industrial activity (mining is considered an industrial activity) as follows:

*“the discharge from any conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing, processing, or raw materials storage areas at an industrial plant. . . .*

*. . . The term "storm water discharge associated with industrial activity" includes, but is not limited to, storm water discharges from industrial plant yards; immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process waste waters; sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas (including tank farms) for raw materials, and intermediate and final products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water.*

*The term excludes areas located on a plant site separate from the plant's industrial activities, such as office buildings and accompanying parking lots, as long as the drainage from the excluded areas is not mixed with storm water drained from the industrial areas described above.”*

WYPDES requires annual storm water monitoring and benchmark requirements for visual observations (color, clarity, odor, foam, oil sheen, etc.), Chemical Oxygen Demand (120 milligrams per liter [mg/L]), Total Suspended Solids (100 mg/L), and Nitrate plus Nitrite (0.68 mg/L). A parameter exceeding a benchmark is not a violation of the permit, but serves as

an indication to WDEQ that the storm water pollution prevention plan may be ineffective in controlling the constituent exceeding the benchmark.

## **Oregon**

Oregon Department of Environmental Quality (ODEQ) requires three categories of permits similar to Colorado for: 1) mining wastewater discharges, 2) subterranean dewatering, and 3) storm water discharges. ODEQ makes the same large (disturbances >1 acre) and small (disturbances <1 acre) construction disturbance distinctions as other states and requires specific permits for each option during the preoperational and exploratory land disturbance phases. ODEQ requires industrial storm water discharge quarterly monitoring and reporting of pH, total suspended solids (TSS), oil and grease, copper, lead, zinc, e. coli, and visual observations. With respect to the mining industry, the Oregon Department of Geology and Mineral Industries (DOGAMI) administers mining-related storm water permits under a Memorandum of Understanding (MOU) between ODEQ and DOGAMI.

### **2.6 Monitoring, Reporting, and Record Keeping (Mining and Milling)**

Monitoring requirements typically are dictated by state statutes and regulations requiring construction, operation, and reclamation to prevent pollution of surface and groundwater and, in some cases, to restore the land and water to the previous highest use; therefore monitoring typically consists of full life cycle programs including pre-operational baseline, operational, and post-operational (reclamation) monitoring. Monitoring can also include sampling of non-impacted environments to establish appropriate baseline conditions for use as a reclamation standard. As detailed in Section 2.3 above, states generally rely on federal guidance to establish acceptable sampling methods, Quality Assurance/Quality Control (QA/QC) procedures, sample preservation techniques, and chain-of-custody requirements.

Compliance monitoring consists of requirements associated with various permits and programs including but not limited to the following:

- Surface mining operating permits required under state statutes;
- Fill and removal permits required under state statutes;
- Permits to appropriate surface water and impoundment structure approval under state statutes;
- NPDES permits under the CWA;
- Water Pollution Control Facility (WPCF) permit under state statutes;
- Permit for placing explosives or harmful substances in waters of the state under state statutes;



- Hazardous waste storage permit under state statutes;
- Local land use permits;
- Any other state or federal permit required for proposed operations, including ISR;
- Hazardous Waste Management program under the RCRA;
- UIC program under the Safe Drinking Water Act (SDWA);
- State-level NPDES programs (i.e., WYPDES);
- Section 404 of the CWA; and
- Impoundments and/or Appropriation of Surface Water under regulations of the State Engineer's Office.

Reporting and record keeping requirements also vary per program, incident, state, and regulating agency.

## 2.7 Wyoming

Monitoring requirements are addressed in Wyoming State Statutes (W.S.) in numerous sections in very general terms. The WDEQ/WQD derives rulemaking and regulatory authority from Chapter 11, Environmental Quality W.S. §35-11-101 through 1507.

W.S. §35-11-302(a)(i) states that “rules, regulations, standards and permit systems should prescribe water quality standards specifying the maximum short-term and long-term concentrations of pollution, the minimum permissible concentrations of dissolved oxygen and other matter, and the permissible temperatures of the waters of the state.” Furthermore, W.S. §35-11-302(b)(i-ii) dictates that rules, regulations, standards and permit systems should prescribe:

- “A schedule for the use of credible data in designating uses of surface and groundwater consistent with the requirements of the Federal Water Pollution Control Act (33 U.S.C. sections 1251 through 1387). The use of credible data shall include consideration of soils, geology, hydrology, geomorphology, climate, stream succession and human influence on the environment. The exception to the use of credible data may be in instances of ephemeral or intermittent water bodies where chemical or biological sampling is not practical or feasible.
- The use of credible data in determining water body's attainment of designated uses. The exception to the use of credible data may be in instances where numeric standards are exceeded or in ephemeral or intermittent water bodies where chemical or biological sampling is not practical or feasible.”

Because the LQD regulates mining activities and has authority over permitting, LQD authority over monitoring with respect to mining activities is also referenced in the Wyoming Statutes. Below is a compilation of numerous instances of statutes referencing activities, which would require monitoring.

*W.S. §35-11-401(f)(iii), General compliance, states that “in promulgating regulations to implement this section the Administrator and Director shall consider . . . their potential for adverse environmental impacts.”* These potential impacts would likely require quantification and therefore monitoring.

In W.S. §35-11-406(b)(xvi), the mining and reclamation plan applications are required to include *“a statement of the source, quality and quantity of water, if any, to be used in the mining and reclamation operations.”* While W.S. §35-11-406(b)(xviii) explicitly requires *“a plan to minimize the disturbances to the prevailing hydrologic balance at the mine site . . . and to the quality and quantity of water in surface and groundwater systems both during and after mining operations and during reclamation.”* This requirement is specific to surface coal mining operations.

W.S. §35-11-411(a), Annual report: require an operator to *“file an annual report with the administrator on or within thirty (30) days prior to the anniversary date of each permit. The report shall include: A report in such detail as the administrator shall require supplemented with maps, cross sections, aerial photographs, photographs, or other material indicating:*

- *The extent to which the mining operations have been carried out,*
- *The progress of all reclamation work, and*
- *The extent to which expectations and predictions made in the original or any previous reports have been fulfilled, and any deviation there from.”*

Augmenting the annual report requirement is one of the duties of the operator as outlined in W.S. §35-11-415(b)(viii):

*The operator shall “prevent, throughout the mining and reclamation operation, and for a period of five (5) years after the operation has been terminated, pollution of surface and subsurface waters on the land affected by the institution of plantings and revegetation, the construction of drainage systems and treatment facilities including settling ponds and the casing, sealing of boreholes, shafts, and wells so that no pollution is allowed to drain untreated into surface or subsurface waters in accordance with state or federal water quality standards, whichever are higher, as may be required in the approved reclamation plan.”*

Various WDEQ/LQD and WQD rules and regulations chapters refer to monitoring and preservation of water quality without specifically outlining monitoring requirements. LQD Guideline 8, Hydrology (WDEQ, 2005), outlines mine plan and reclamation plan monitoring

programs, including guidelines for surface and groundwater monitoring strategies with emphases on permitting requirements) and monitoring logistics. Water quality monitoring guidelines in Guideline 8 include a discussion of monitoring frequency and constituents based on site-specific factors such as transmissivity, gradient, overall water quality in adjacent aquifers, and proximity of adjudicated water rights in the case of groundwater.

## 2.8 Colorado

Colorado Revised Statutes (CRS) 34-32-112.5 requires pre-operational baseline, during-mining, and reclamation monitoring plans as part of the permit application for designated mining operations while Colorado Rules and Regulations (R&R) 3.1.3, R&R 3.1.7, and R&R 6.4.21 Exhibit U further detail monitoring and emergency response requirements. Colorado state statutes and rules and regulations requiring monitoring of water associated with mining and milling and do not significantly extend beyond Wyoming's monitoring requirements.

## 2.9 Milling in Colorado

CDHPE milling requirements as detailed in 6 CCR 1007-1 Part 18 detail that operators must submit a report to the CDPHE on January 1 and July 1 of every year specifying quantities of radiological materials released in unrestricted areas during the previous 6 months. Part 18 Criterion 7 requires the licensee to:

*“Establish a detection monitoring program needed for the Department to set the site-specific ground water protection standards. . . . A detection monitoring program has two purposes. The initial purpose of the program is to detect leakage of hazardous constituents from the disposal area so that the need to set ground water protection standards is monitored. If leakage is detected, the second purpose of the program is to generate data and information needed for the Department to establish [appropriate standards]. The data and information must provide a sufficient basis to identify those hazardous constituents which require concentration limit standards and to enable the Department to set the limits for those constituents and the compliance period. They may also need to provide the basis for adjustments to the point of compliance. The detection monitoring programs must be in place when specified by the Department in orders or license conditions. Once ground water protection standards have been established . . . , the licensee shall establish and implement a compliance monitoring program. The purpose of the compliance monitoring program is to determine that the hazardous constituent concentrations in ground water continue to comply with the standards set by the Department. In conjunction with a corrective action program, the licensee shall establish and implement a corrective action monitoring program. The purpose of the corrective action monitoring program is to demonstrate the effectiveness of the corrective actions.”*

## 2.10 Oregon

Oregon Revised Statute 517.971 (Consolidated Application) outlines baseline, operational, and reclamation monitoring requirements and highlights possible permitting requirements similar to those required by Wyoming. DOGAMI R&R Division 35 outlines operational monitoring program requirements, including but not limited to *“surface and groundwater monitoring systems within and outside the permit boundary, water balance of the process system, and leak detection systems.”* Additionally, R&R Division 35 explains that *“monitoring may be required after cessation of mining or milling operations to insure compliance with decommissioning performance standards.”*

## 2.11 ISR

Wyoming Statute §35-11-430, Duties of an In Situ Mining Operator, is applicable to groundwater protection but may be interpreted for surface water protection as well. In W.S. §35-11-430, the operator is required to *“submit an annual report containing the general categories of environmental protection and reclamation information pursuant to W.S. §35-11-411.”*

LQD R&R Chapter 11, Noncoal In Situ Mining, goes into great detail regarding groundwater monitoring requirements, including specifics such as proper equipment use and maintenance, intervals and frequency of monitoring, and tests and methods. Injection fluids characterized, injection pressure, and flow rate or volumes are also required. Also required is a description of procedures and schedules used to detect, confirm, and monitor excursions and associated control measures. Section 15 of Chapter 11 details laboratory reporting requirements and equipment validation requirements. In agreement with LQD R&R Chapter 11 Rules, WQD R&R, Chapter 9, Section 10 states that *“whenever the discharge of any pollution or wastes into ground water of the State is caused, threatened or allowed; or the physical, chemical, radiological, biological or bacteriological properties of any ground waters of the State may be altered by man’s actions, a monitoring program shall be required and shall be adequate to insure knowledge of migration and behavior of the pollution or wastes.”*

LQD Guideline 8, Hydrology (WDEQ, 2005), outlines mine and reclamation plan monitoring programs, including guidelines for groundwater monitoring strategies with an emphasis on monitoring well placement. Water quality monitoring guidelines in Guideline 8 include a discussion of monitoring frequency and constituents based on site-specific factors such as transmissivity, gradient, overall water quality in adjacent aquifers, and proximity of adjudicated water rights. Guideline 4 (WDEQ, 1994) further details monitoring well placement, depending on the following: *“gradient consideration, dispersivity of recovery fluids, the initial excursion recovery measures employed by the operator, the normal mining operational flare (the lateral and vertical extent of affected area under normal operating conditions), and the recoverability within the allowable regulatory time frame”*. Guideline 4 also expands on Guideline 8 with

additional in situ guidance including sampling and laboratory procedures, analysis, and upper control limit calculations.

CRS 34-32-112.5 requires the presence of a pre-operational baseline, during-mining, and reclamation monitoring plan as part of the permit application for designated mining operations; R&R 6.4.24 Exhibit X, Monitoring plan for ISR operations, reiterates details of monitoring and outlines emergency response requirements for groundwater and ISR.

ODEQ R&R Division 43 for chemical mining does not substantially add to the requirements of other states, outside of explicitly requiring monitoring plans for leak detection and general post-closure operations.

## 2.12 Points for Consideration

Based on state statutes, rules and regulations, and guidance documents, basic elements for consideration with regard to surface and groundwater monitoring plans are detailed below:

- Documentation of precipitation events and stream flows that occur during the monitoring period. For example, for every surface water quality measurement made, the operator or applicant shall collect data on actual stream flow and precipitation that have occurred during the monitoring period;
- Establishment of a complete list of constituent (parameters) for monitoring, based on applicant's robust characterization of process materials and wastes;
- Establishment of sampling locations and frequency of sampling for baseline, operational, and final post-closure conditions. Continuity between baseline, operational and post-closure monitoring locations is preferable;
- Definition of waterbody characteristics related to water quantity and flow; in the case of groundwater, pressure (head) and extent;
- Definition of baseline water quality: constituent, location, and frequency based on waterbody characteristics and constituent;
- Operational monitoring during mining or milling operations, with the objective of prompt detection of impacts to water quality and/or quantity;
- Continuous real-time monitoring to include real-time warning system in the event of a release and reclamation monitoring to address post-mining and post closure. With respect to ISR reclamation monitoring includes restoration and stability monitoring;
- Compliance monitoring to address excursions, leak detection and all related permit/license requirements including UIC, NPDES among others; and

- Reporting of monitoring data and record keeping to include baseline conditions, accidents, spills, and releases.

Typically, monitoring criteria and protocols are established not only within the state guidance documents, but are generally governed by EPA standards, including Standard Methods. Such criteria should be considered:

- Acceptable sampling methods;
- Sampling QA/QC procedures;
- Sample preservation and packaging;
- Chain-of-Custody;
- Sample transport to laboratory;
- Laboratory QA/QC;
- Data validation; and
- Data Management Plan.

Compliance monitoring is established by the regulatory agency and consideration should be given to:

- Storm water discharge;
- Wastewater treatment facility discharge;
- Up gradient and down gradient groundwater monitoring;
- Upstream and downstream surface water monitoring (may include chemical, biological, fish tissue, and sediment sampling); and
- Other regulated discharges and activities.

Reporting of monitoring data to the regulatory agency is often specified by statutes or regulations, and can be clarified within the guidance documents to include real-time, quarterly, semi-annual and/or annual reporting. Public interest may dictate a shorter and more public presentation of monitoring data and reports. In all cases, an operator should maintain proper record keeping of baseline conditions, licenses, accidents, spills, and releases, permits, contacts, correspondence, and meetings. Record keeping is defined within the permit and annual reporting documents that are submitted to the regulatory agency.



### 3.0 COMPLIANCE INSPECTIONS AND ENFORCEMENT BY REGULATORY AGENCIES

Federal and state agencies are authorized to enforce regulations through a variety of mechanisms including annual or event-based compliance inspections and enforcement duties. In order to perform site inspections or direct corrective actions for both surface water and groundwater protection, site access must be authorized. Corrective actions range from monetary penalties and permit revocation to operator license suspension and termination.

#### 3.1 Wyoming

Duties and authorization of inspectors and inspections are detailed in Wyoming Title 30, Mines and Minerals, Chapter 2, Mining Operations, Article 2, Inspector of Mines. Inspector access to mines is detailed in W.S. §30-2-207, including criminal penalties for refusal of access or obstruction; inspector duties include collecting and recording various mining operation statistics and ensuring safety.

According to W.S. §35-11-406(m)(v), operating permits shall be granted if the applicant demonstrates that the application complies with the requirements of this act and all applicable federal and state laws. The director shall deny a permit *“if the proposed mining operation will cause pollution of any waters in violation of the laws of this state or of the federal government.”* Subsequently, W.S. §35-11-409 (a) details that *“the director shall revoke a mining permit if at any time he determines that the permit holder intentionally misstated or failed to provide any fact that would have resulted in the denial of a mining permit and which good faith compliance with the policies, purposes, and provisions of this act would have required him to provide.”* Furthermore, W.S. §35-11-412(b) authorizes the director to *“suspend the [operator’s] license if he determines the operator is in substantial violation of the terms of the license or of the provisions of this act. The suspension shall be lifted when the violations have been corrected to the director’s satisfaction.”*

With respect to inspections, W.S. §35-11-411(c) dictates that upon receipt of the annual report (referenced in W.S. §35-11-411(a)) the administrator shall conduct an inspection of the site of the operation to gauge compliance with the mining or reclamation plan.

While W.S. §35-11-437(a) is specifically tailored to enforcement for surface coal mining operations, it may be applied to non-coal mining operations as well. The director is authorized to *“issue a cessation order covering that portion of the operation relevant to the violation or hazard and impose any necessary affirmative obligations if:*

- *On the basis of an inspection, it is determined that a condition or practice exists, or violation is occurring, which creates an imminent danger to the public or which is*

*causing or may reasonably be expected to cause significant, imminent environmental harm to land, air or water resources; or*

- *Any violation of this article, land quality division regulations or permit conditions has not been abated within the time specified in the notice for abatement described in subsection (b) of this section, which period shall not exceed ninety (90) days.*”

### 3.2 Colorado

CRS §34-32-115 and §34-32-120 through 124 detail authority to inspect permit areas, ensure compliance, and enact enforcement in the event of noncompliance. CRS 34-32-115, action by the board, authorizes the board to deny a mining permit if:

*“the applicant, an affiliate, officer, or director of the applicant, the operator, or the claim holder has demonstrated a pattern of willful violations of the environmental protection requirements of this article, rules promulgated pursuant to this article, a permit issued pursuant to this article, or an analogous law, rule, or permit issued by another state or the United States.”*

Colorado Division of Reclamation, Mining, and Safety (DRMS) R&R 3.2.1-3.3.4 explain procedures for inspection, communication, decision making, and penalties.

### 3.3 Oregon

Oregon clearly outlines inspection and enforcement details throughout numerous state statutes and rules and regulations. Oregon Revised Statue (ORS) §517.850 authorizes DOGAMI inspection of the permit area *“to determine if the operator has complied with the operating permit, reclamation plan, this chapter and the rules of the department.”* ORS §517.860 details the possible effects of noncompliance with the operating or reclamation permit as determined by inspections pursuant to ORS §517.850 or any other source.

- Written notice of the violation. The notice shall specifically outline the deficiencies;
- A compliance order. The order may specify a date by which the operator shall rectify any deficiencies; and
- The department may recover against the bond or alternative form of financial security and reclaim the area affected by surface mining if the department determines that an operator:
  - Has failed to comply with a department compliance order;



- Fails to complete reclamation in conformance with the reclamation plan on any segment of the permitted site or fails to complete reclamation in a timely manner, or
- Fails to maintain an operating permit and pay all fees required.

Specific operating permit consequences are outlined in ORS §517.862, revocation, termination, or refusal to renew operating permit. The department may revoke, terminate, or refuse to renew an operating permit if the operator:

- Requests termination, provided that all reclamation requirements in the operating permit and reclamation plan have been satisfied;
- Fails to pay a fee as required by state statute;
- Fails to provide or maintain a bond or security as required by state statute;
- Fails to comply with an order issued under state statute, or
- Fails to comply with a suspension order issued under state statute.

In the case of operations without a valid permit, ORS §517.880 authorizes DOGAMI to issue orders to suspend operations and the Attorney General can initiate any legal proceedings necessary. Possible civil penalty rules are outlined in ORS §517.992, including minimum and maximum violation amounts according to type of violation. Furthermore, ORS §517.992 details that *“a reclamation fund shall be established into which funds not used as described [above] shall be deposited. This money shall be used by the DOGAMI for the purpose of the reclamation of abandoned mine and drill sites.”*

DOGAMI R&R Division 30 authorizes possible rationale for an inspection, including but not limited to:

- Determining existing environmental conditions;
- Reviewing the proposed mine operation;
- Reviewing the proposed reclamation plan;
- Collecting data to calculate the amount of the reclamation bond;
- Reviewing operating permit compliance;
- Investigating complaints; and
- Evaluating the adequacy of the amount of the bond or alternative form of security.

Oregon R&R Division 30 further details conditions under which both the department and the permittee can request termination of a permit. Oregon R&R Divisions 30, 35, and 37 outline

steps taken for penalty warnings and civil penalties. Civil penalties are organized according to classification of violations.

### 3.4 ISR

Specifically related to ISR, Wyoming LQD R&R Chapter 11, Noncoal in situ mining, Section 12 addresses issues of noncompliance and excursions, beginning with notification to LQD in the event of any noncompliance which may endanger public health or the environment. Section 13 details the adequacy of corrective actions associated with excursion or other noncompliance, specifically in determining additional steps needed to prevent fluid movement into an unauthorized zone, the following criteria and factors shall be considered by the Administrator:

- Nature and volume of injected fluid;
- Nature and volume of native groundwater;
- Compatibility of injected fluid and native groundwater;
- Potentially affected population;
- Geology;
- Hydrology;
- Proposed method of operation or history of the injection operation if the corrective action is needed in response to amending new wells into an existing operation;
- Completion and plugging records;
- Plugging procedures in effect at the time the well was abandoned; and
- Hydraulic connections with unauthorized zones.

Below is an outline of Oregon R&R Division 37, Chemical process mining, violations and the associated penalty amounts.

- Class 1. Potential threat to human health or safety: warning to \$10,000;
- Class 2. Immediate threat to human health or safety: warning to \$25,000;
- Class 3. Potential threat to the environment: warning to \$10,000;
- Class 4. Immediate threat to the environment; warning to \$25,000;
- Class 5. Failure to comply with laws, rules, Governing Board orders or permit conditions, with no threat to human health, safety or the environment: warning to \$10,000;
- Class 6. Damage to health, safety or the environment: \$1,000 - \$50,000; and

- Failure to comply with prior warning or penalty (continued or repeat violation) within the following classes:
  - Class 1: \$200 - \$10,000;
  - Class 2: \$200 - \$50,000;
  - Class 3: \$200 - \$50,000;
  - Class 4: \$200 - \$50,000;
  - Class 5: \$200 - \$50,000; and
  - Class 6: \$2,000 - \$50,000.

### **3.5 Points for Consideration**

Each state's compliance and enforcement statutes and rules and regulations contain provisions for the following:

- Site access for compliance inspection;
- Notice provisions;
- Penalties; and
- Enforcement and corrective actions.

In all cases, the regulatory agency has a right of entry for all compliance inspections and maintains the ability to levy fines and enforce the environmental protection standards of the state. Most states allow latitude in the definition and timeliness of corrective actions, which are adjusted based on the severity of the issue. Oregon allows the state to revisit the permit conditions in the event of a natural event (catastrophic flood or earthquake) that may have an unintended consequence or could potentially threaten the success of the proposed mine operations or milling plan.

## **4.0 APPROPRIATE HYDROLOGIC SITING CRITERIA FOR MINING AND MILLING: REGULATORY CONSIDERATIONS**

Several states and the NRC have developed siting criteria for uranium milling. While criteria for the siting of uranium mines are mainly dependent upon the spatial distribution of the ore, siting criteria encompass preoperational to post-closure and reclamation considerations. As a result, this section will be organized to cover general topics of siting criteria not addressed in subsequent sections or the Engineering Design Report (WES, 2012).

In general, siting criteria for any mill processing facility should consider the standards promulgated for such uranium milling facilities under 10 CFR Part 40, Appendix A. In an effort to protect public health and safety, uranium mine facilities should consider the items outlined in the following sections.

### **4.1 Water Quality, Use, and Demands in the Area of the Mine**

The water quantity and water quality hazards associated with uranium mining are not significantly different than with other types of hard rock mining. All states recognize similarities in pollutants (total dissolved solids, dissolved metals, pH changes among others) between types of mining operations. Uranium mines may potentially discharge other pollutants including dissolved uranium and its daughter products e.g., radium-226, radium-228, and polonium-210 among others. These parameters may exist as natural constituents within the baseline groundwater system and as such, will be quantified during the initial data collection. If such constituents are absent from the surrounding waters and underlying aquifer, the mine operation shall be similarly regulated to ensure that there is no degradation of the waters. The construction and operation of a uranium mill and related supporting facilities will result in the concentration of these radioactive constituents to the extent that the release of liquids or solids from the facility may present a risk to public health and safety.

Specifically all waters of Virginia should be protected, but local surface and groundwater use and its demand should be a siting consideration. Similarly, if the aquatic ecosystem could be jeopardized by either discharges to or withdrawals from either groundwater or surface water, this must be addressed in the siting considerations.

### **4.2 Surrounding Aquatic Environment: Watershed Area and Depth to Groundwater Table**

The siting of the mining, milling, and processing facilities should be located in a topographic position where the upstream watershed area is minimized in the case of surface water, and the depth to groundwater is maximized in the case of groundwater. In the case of both the mine and the mill, it is paramount to divert runoff from undisturbed areas around the disturbed area. The smaller the upstream watershed area, the less significant will be the diversion issues. In the case

of a mine, both underground and surface, it is likely that groundwater will be encountered. The effects of dewatering on surrounding uses should be considered. Reclamation of the mine and its impact on groundwater quantity and quality should be considered. Burial of acid forming and toxic materials below the water table must be addressed. Although milling and facilities should not discharge liquid (or solid) wastes to the groundwater table, depth to groundwater should be a siting consideration.

### **4.3 Surrounding Geology and Geomorphology**

The siting of the mine should consider the stability of adjacent streams in the case of surface water and the intervening stratigraphy between the surface and the nearest aquifer. The geomorphology of the area and in particular the mine site's proximity to an unstable stream bank or bed should be an important siting criterion. The siting of the mill facility should not be in the immediate vicinity of a perennial or intermittent stream. Proximity can be addressed by certain engineering setbacks like the 100-year or 500-year floodplain. Ultimately, the Operator's mill tailings facility design considerations shall include no release of tailings under any storm event, including the Probable Maximum Flood. As discussed in Section 2.5, EPA and NRC rules allow discharge, but water quality criteria are protective of the receiving waters. Given the chemical characteristics of process fluids, treatment and discharge is generally not a viable option.

Mining criteria should also consider the proximity of the mine site to unstable slopes that could contribute to sediment loading to the affected area or to an offsite stream. Although not a direct groundwater consideration, the effect of slope stability and settlement on the integrity of liners and mill site stability should be a siting consideration. This consideration will be addressed under a later section addressing catastrophic failures.

The presence of aquitards between the surface and the nearest aquifer should be addressed during project siting. In the case of a mine, disruption of these confining layers may impact from ground water elevation in well or could result in communication between aquifers. In the case of a mill facility, the presence of such impermeable strata may enhance the suitability of the site, depending on thickness and areal extent.

### **4.4 Mine Dewatering Impacts and Protection**

Where mining intersects the groundwater table, dewatering will be required. Mine dewatering is process wastewater regulated under NPDES and 40 CFR 440, if discharged to surface waters. The impacts of such dewatering to surface streams and groundwater uses (water quantity or water quality) should be addressed in siting criteria. In some cases native intercepted ground water may require treatment for naturally occurring radionuclides prior to discharge to a surface stream.

#### **4.5 Impacts of Exploratory Boreholes**

The presence of exploratory boreholes or improperly abandoned drill holes should be considered as a siting criterion. Such boreholes, if not abandoned properly, per state requirements, could result in cross communication and adverse impacts to the surrounding aquifers.

#### **4.6 Predictive Geochemical Studies**

Consideration should be given to the potential for geochemical changes to stockpiled ore and waste rock due to oxidation and contact with precipitation. This can be addressed in advance of the approval of any permit/license via properly executed geochemical testing and modeling efforts to include but not be limited to column leach studies, batch testing and general geochemical modeling efforts.

#### **4.7 Probable Hydrologic Consequences**

The regulatory agency should consider the applicant's portrayal of the Probable Hydrologic Consequences (PHC) of the proposed mining operation on the hydrologic balance. These impacts should be compared to pre-mining, mining, and post-mining conditions of the surrounding waters and should consider both water quantity and water quality. The PHC is not a criterion for a mill.

#### **4.8 Cumulative Hydrologic Impact**

The regulatory agency should consider the cumulative hydrologic impact (CHI) to the hydrologic balance of the proposed mine operation in addition to any existing and reasonably foreseeable development within the area. These impacts should be compared to pre-mining, mining, and post-mining conditions of associated water bodies and consider both water quantity and water quality. Similar to the PHC discussion, the CHI is not a criterion for a mill.

## 5.0 PRE-OPERATIONAL BASELINE CHARACTERIZATION FOR SURFACE WATER (MINING AND MILLING)

The programs and requirements for environmental baseline characterization are very similar between Wyoming, Colorado, and Oregon. All are modeled after or are consistent with national regulations (i.e., National Environmental Policy Act [NEPA]) and federal programs (i.e., Office of Surface Mining Reclamation and Enforcement [OSM], NRC, and EPA). Uranium mine permits are regulated by either a single state agency, or several agencies that effectively require the mine applicant to conduct baseline studies covering surface water, ground water, wildlife, soils and geology, vegetation, meteorology/climatology, and air. Radioactive materials license applicants (milling and ISR) are also required to complete such baseline studies to characterize the pre-disturbance characteristics of the proposed license area. Various aspects of the baseline studies may be required by other cooperating agencies and are commingled with the requirements of the agency that regulates mining. In each state, the following elements are required for water resources systems: watershed description, geologic and geomorphic description, hydrologic description, and water rights.

### 5.1 Wyoming

Most environmental mining requirements in Wyoming are addressed in the Wyoming Environmental Quality Act, Wyoming Statute Title 35-Public Health and Safety, Chapter 11-Environmental Quality, with the WDEQ acting as the lead agency for enforcing and administering the Act. The Wyoming statutes codify land and water baseline characterization for a mining permit, including uranium mining under W.S. §35-11-406(a)(vii) by stating:

*The applicant shall... “provide a general description of the land which shall include as nearly as possible its vegetative cover, the annual rainfall, the general directions and average velocities of the winds, indigenous wildlife, its past and present uses, its present surface waters, and adjudicated water rights and their immediate drainage areas and uses, and, if known, the nature and depth of the overburden, topsoil, subsoil, mineral seams or other deposits”.*

Mapping requirements further detail land and water characterization under W.S. §35-11-406(a)(ix-x) by requiring the following:

*“A map based upon public records showing the boundaries of the land to be affected, its surrounding immediate drainage area, . . . lakes, streams, creeks, springs, and other surface water courses, oil wells, gas wells, and the probable limits of underground mines and surface mines, whether active or inactive, on or immediately adjacent to the land to be affected. The map shall also show: the mineral or minerals to be mined”.*

WDEQ/LQD Non-Coal Rules and Regulations Chapter 2, Section 2: General Application Content, adopts statute W.S. §35-11-406 and provides additional specificity by requiring “a



description of the lands to be affected within the permit area and how the lands will be affected.” This description must include the following:

- Major past and present land uses and priority rankings of those uses in the proposed permit area and adjacent lands;
- Vegetative cover including endangered or threatened species;
- Annual precipitation;
- Average wind direction and velocity;
- Indigenous wildlife including endangered or threatened species;
- Overburden, topsoil, subsoil, mineral seams, or other deposits;
- Identification, classification, and description of surface waters and drainage areas; and
- Water rights on the proposed permit area and adjacent lands.

## 5.2 Colorado

The statutes that govern Colorado DRMS and in particular the Mined Land Reclamation Act (MLRA), C.R.S Title 34-32-112.5, addresses the baseline characterization of Designated Mining Operation (DMO) sites, which includes uranium mining sites utilizing conventional underground, open pit, or ISR technologies. It requires detailed characterization of the affected lands including rivers, streams, springs, lakes, and bodies of water in addition to soils, geology, vegetation, and wildlife. The DRMS Colorado Code of Regulations Rules 6 and 7 of 2 CCR 407-1, hard rock/metal mining, provide further guidance for baseline characterization of the affected land and affected waters. Specifically, Hard Rock Rule 6.3.2 requires the operator/applicant, at a minimum, to include a description of vegetation and soil characteristics in the area of proposed operation, identify any permanent manmade structures within 200 feet of the affected area, a wildlife statement verifying no critical or important wildlife species or habitats will be impacted by the proposed operation, and:

*“a description of the water resources in the area of the proposed operation. Identify any streams, lakes, stock ponds, ditches, and reservoirs that would receive drainage from the affected area. Provide any information from publications or monitoring data on flow rates and water quality conditions.”*

Hard Rock Rule 6.4.21 Exhibit U - Designated Mining Operation Environmental Protection Plan, further outlines specific water quality baseline requirements:

*“surface water quality and flow data collected during a minimum of five (5) successive calendar quarters and such other additional data, or a period specified by the Office, as may be necessary*

*to adequately characterize baseline conditions. This baseline data shall be sufficient to provide for the proper design of facilities, to serve as a basis for the evaluation of reclamation performance standards success, and to insure the adequacy of environmental protection facility design, maintenance and operation. . . . In the case of an in situ leach mining operation, a permit applicant must design and conduct a scientifically defensible . . . surface water and environmental baseline site characterization and monitoring plan for the proposed mining operation which, at a minimum, includes five (5) successive calendar quarters, or the period specified by the Office as necessary to adequately characterize the baseline conditions, of water quality data, prior to submitting the permit application.”*

### 5.2.1 Milling in Colorado

Because Colorado is an NRC Agreement State, it regulates uranium mills as well as mines. CDPHE is the authority with jurisdiction to regulate radioactive materials in Colorado, pursuant to §§25-11-101 through 113. Specifically, CRS §25-11-203 addresses milling and tailings in CDPHE 6 CCR 1007-1 Part 18, Rules and Regulations Pertaining to Radiation Control. CDPHE 6 CCR 1007-1 Part 18 requires the following elements as part of the application process:

- Description of the proposed project or action;
- Area/site characteristics including geology, topography, hydrology and meteorology;
- Radiological and non-radiological impacts of the proposed project or action, including waterway and groundwater impacts;
- Environmental effects of accidents;
- Tailings disposal and decommissioning; and
- Site and project alternatives.

### 5.3 Oregon

ORS §517.915, Additional Operating Permit Requirements for Nonaggregate Mineral Mines, prohibits the DOGAMI from issuing an operating permit without “*environmental baseline information as required by the department.*” DOGAMI’s Administrative Rule (Oregon Administrative Rule [OAR]) 632-035-0025 Requirements for an Operating Permit Application, prescribes procedures for meeting the requirements of the environmental baseline referenced in ORS §517.915. Specifically, the DOGAMI may require environmental baseline information including characterization of the following: vegetation, soil/overburden, climate/air quality, fish and aquatic biology, wildlife, surface water, area seismicity, geology and geographic hazards, mineralogy and chemistry, and noise.

Oregon includes area seismicity and noise into the baseline characterization requirement. A baseline seismic characterization is required by Oregon in accordance with NRC permitting

requirements; however, seismicity is not required by all state agencies for permitting of other facilities. Seismic activity may need to be considered at other points in the permitting process.

## 5.4 ISR

In the case of uranium ISR mining, Wyoming W.S. §35-11-428(a)(i-ii) requires the following:

*“The application shall contain a description of the proposed permit area including the following information relating to the applicable in situ technology: Soils, vegetation, wildlife and surface hydrologic information consistent with the extent and nature of the proposed surface disturbance including descriptions of the soil, indigenous wildlife, natural gamma radiation background for lands to be impacted by radioactive materials, the vegetative cover, meteorological information and a description of any surface water and adjudicated water rights within the proposed permit area or on adjacent lands; Geologic . . . information including a description of the general geology including geochemistry and lithology of the permit area and a characterization of the production zone.”*

Wyoming R&R Chapter 11 Noncoal In Situ Mining Section 3 references the ISR statute (W.S. §35-11-428) and details specific baseline and application requirements. Baseline information must include the following:

- A listing of all permits or construction approvals received or applied for in association with the permit area;
- A soil survey which maps soils within the permit area ;
- A description of the nature and depth of the topsoil;
- A survey of vegetative cover and species diversity ;
- A list of the indigenous vertebrate species (surface waters supporting fish that may be affected by the operation shall be sampled for benthic invertebrates and periphyton);
- A description of climatic conditions of the site; and
- A description of the geology, including cross-sections, geologist/driller’s and geophysical logs, formations and aquifers, areal and stratigraphic position of the production zone, geochemical, lithological, and mineralogical description of the receiving strata.

For surface waters within the permit area and on adjacent lands, the names, descriptions, and a map of all such waters and a list and map of all adjudicated and permitted surface water rights are required.

Colorado DRMS MLRA, CRS §34-32-112.5, which addresses the baseline characterization of designated mining operation, was revised in 2009 to address uranium-specific ISR requirements.

It requires detailed characterization of the affected lands including rivers, streams, springs, lakes, and bodies of water in addition to soils, geology, vegetation, and wildlife.

Oregon ORS §517.969, Chemical Process Mining, requires the collection of baseline data, but designates a technical review team to “*determine the data that should be collected during the baseline data collection phase of the consolidated application process to address the issues identified*” (ORS §517.969(c)). Furthermore, ORS §517.969(c)(3-4) requires that “*the technical review team activated under ORS 517.963 shall determine the specific methodologies to be applied by the applicant in collecting baseline data. The applicant shall collect data according to the methodology established by the permitting and cooperating agencies through the technical review team. The data collected shall be verified by the appropriate agency in accordance with procedures adopted by the agency.*”

## 5.5 NRC

The NRC requires pre-operational baseline data for milling sites for at least one full year prior to any major site construction (10 CFR 40 Criterion 7). Additionally, 10 CFR 40 Criterion 5 discusses compliance based on background concentration of constituents in water. The requirements of baseline data collection are detailed in the NRC Regulatory Guide 4.9 (NUREG-4.9; NRC, 1975) and 4.14 (NUREG-4.14; NRC, 1980), Radiological Effluent and Environmental Monitoring at uranium mills. Preoperational monitoring requirements include water, vegetation, food, fish, soil, sediment, and background radiation sampling; regional land and water use, geology, hydrology, meteorology, and ecology. Table 5-1 details preoperational monitoring requirements for uranium mills with respect to surface waters. Regulatory Guide 1748 (NUREG-1748; NRC, 2003) provides guidance on baseline requirements associated with licensing actions.

## 5.6 Points for Consideration

Based on an evaluation of several state guidance documents for surface and underground mining, the following list summarizes and synthesizes guidance requirements for baseline data from state and federal resources as discussed above. The applicant should provide:

- A watershed description, which may include a description of soils, vegetation, topography, climate, and land use information. All states on a regulatory basis require some degree of characterization of a watershed. The specifics are incorporated into a state guidance document or are left to the applicant and the regulatory agency to come to agreement regarding level of detail, accuracy and precision;
- A characterization of the geology and geomorphology to the extent that they impact or define the stability of the surface streams. For example, resistant geologic stratum

or the absence thereof within a watershed are important baseline parameters that may impact the ability of a stream to resist (or be subject to) excessive erosion; and

- A Characterization of the geochemistry of the bedrock (mine zone and overlying materials). It is increasingly important to develop sufficient information that allows the operator and the agency to predict if acid mine drainage may ensue following the flooding of a mine or following reclamation and final closure:
  - Provide a premining radiological assessment for uranium including a summary and detailed mapping of the natural radioactive background and overburden radiochemistry.

With respect to surface water features within the permit or license area, all guidance documents require that the applicant characterize streams, springs, ponds, impoundments, wetland, tidal flats, bays and drainages within and immediately adjacent to the proposed mine or processing area. This may include, but is not limited to:

- The relationship of surface water to groundwater (i.e., springs, recharge/discharge);
- A geomorphological characterization of the surface water features including stream channels, drainage basin and hillslope morphology (including any upstream rainfall catchment areas that may contribute to potential flooding and erosion);
- Erosion, sediment transport, and depositional conditions of the watershed; and
- Characterization of surface water feature quantity, quality, and flow regimes including extreme events.

The applicant may need to rely not only on public data (gaging stations), but also establish site-specific gaging stations, sampling stations, sampling frequency and develop computer models or analytical approaches to ensure that all bodies of water are characterized. Finally, it is important that the applicant characterize all types and means of surface water use in the area. Such uses may include irrigation and domestic water as well as ecological usages of the water including fresh and, as applicable, saltwater fisheries, shellfish and ecological demands by other species including threatened and endangered species. Within these categories, guidelines may identify the following:

- Surface water use (both permitted and unpermitted) from both public data sources and site surveys;
- Water rights within the permit area and in immediate vicinity; and
- Listing of ecological demands associated with the surface water system.

## **6.0 OPERATIONS (MINING AND MILLING PLAN): ENVIRONMENTAL PROTECTION PLANS FOR SURFACE WATER**

The programs and requirements for operational planning, including hydrologic control and environmental protection plans are similar between Wyoming, Colorado, and Oregon. All are modeled after or are consistent with national regulations (i.e., NEPA) and federal programs (i.e., OSM, NRC, and EPA). It is the goal of all hydrologic control plans to ensure that the surface waters of the state and adjacent water uses are not impacted by mining or milling. Typically, this is accomplished by control and diversion of runoff from undisturbed areas around the mining or milling operation and where undisturbed area water is commingled with disturbed area water, treatment is required prior to discharge as explored in Section 2.5 addressing national- and state-level discharge permitting. In the case of milling operations, while discharges are technically allowed under NRC and EPA regulations when discharge water quality is protective of surface water quality, it is not common industry practice to attempt to treat process water to a level protective of instream water quality. In the case of a mining operation (ISR or conventional), diversion design is often tied to the life of the facility and the probability of exceedance during that life. In the case of a milling operation, diversion design is governed by the concept of no discharge of the process material (solids or liquids) even during catastrophic events (i.e., probable maximum precipitation events or maximum credible earthquakes).

### **6.1 Wyoming**

The Wyoming regulatory program approach for mining projects is full life cycle and applies to mines only, as Wyoming is not an NRC Agreement State. The mine plan must consider the reclamation requirements during the planning process; conversely, reclamation requirements can dictate the mine plan. The mine plan provides details such as method of mining, equipment used, temporary and permanent stockpile areas, environmental protection, and mining sequence. With respect to surface water hydrology, mine plans must account for both storm water and process water. Storm water consists of storm water discharge which is collected and conveyed within the permit area, regardless of whether it is originating in a disturbed or non-disturbed area. Process water is “any water which, during manufacturing or processing, comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, byproduct, or waste product” (40 CFR 122.22). Mine plans typically consist of environmental protection plans, hydrologic control plans, waste rock handling plans, monitoring plans, and mitigative action plans.

W.S. §35-11-406(b)(i-v, viii-ix, xiii-xiv, xvi) addresses surface water aspects of conventional mine and reclamation plans while in situ uranium mine and reclamation plans are addressed in W.S. §35-11-428(a)(iii). The relevant WDEQ/LQD R&R are similarly organized with Chapter 2 addressing conventional uranium mining and Chapter 11 addressing ISR. W.S. §35-11-406(b)



requires an applicant to explain “the extent to which the mining operation will disturb or change the lands to be affected.” Specifically, the statute requires that the mining plan include the following:

- Maps showing location and extent of the proposed affected lands, surface drainage area, proposed pits, spoil banks, topsoil conservation areas, refuse or waste areas, all waste water impoundments, any settling ponds, other water treatment facilities, constructed and natural drainways, the surface bodies of water receiving discharge, and set forth the drainage plan;
- The proposed method of protecting and conserving topsoil, subsoil, and spoil piles from wind and water erosion before reclamation;
- A plan for insuring that all acid forming, or toxic materials, or materials constituting a fire, health or safety hazard uncovered during or created by the mining process are promptly treated or disposed of during the mining process in a manner designed to prevent pollution of surface water or threats to human or animal health and safety;
- The procedures proposed to avoid constituting a public nuisance, endangering the public safety, human or animal life, property, wildlife and plant life in or adjacent to the permit area;
- The methods of diverting surface water around the affected lands where necessary to effectively control pollution or unnecessary erosion; and
- A statement of the source, quality and quantity of water, if any, to be used in the mining and reclamation operations.

W.S. §35-11-407 requires that applicants demonstrate the following with regard to water impoundments:

- The size of the impoundment, contouring and revegetation, if any, are suitable for its intended purpose and use;
- Final grading will provide adequate safety and access for proposed water users; and
- The impoundment dam construction will be so designed to insure permanent stability and to prevent safety hazards.

In addressing surface water quality and erosion control, the Wyoming mining regulatory program generally requires erosion to be controlled. The non-coal program relies on the Storm Water Protection Plan of the WDEQ WQD. W.S. §35-11-415 requires sediment control structures to be constructed and functioning prior to an area being disturbed.



W.S. §35-11-406(b) is adopted by the WDEQ/LQD in R&R Chapter 2 Section 2(b)(i)(A)-(b)(iii)(I). Chapter 2 expands on the statute with the following requirements for a mine plan with respect to surface water:

- A plan for topsoil and subsoil storage and protection; and for handling and disposal of all toxic, acid-forming, or otherwise hazardous materials. This plan must include a description with location maps and, where appropriate, typical topographic profiles of the mine facility area, mineral stockpiles, spoil piles, and topsoil and subsoil stockpiles.
- A plan for backfilling, grading and contouring of all affected lands. The plan must include: where terraces or benches are proposed, detailed drawings which show dimension and design of the terraces, check dams, any erosion prevention techniques and slopes of the terraces and their interval; where permanent water impoundments are proposed, contour maps and cross-sections which show slope conditions around the impoundment and the anticipated high and low post mining water level. The plan must also contain a description of erosion control techniques and such other design criteria and water quality and quantity conditions.
- Descriptions, including maps and cross-sections, of any surface water diversion systems.
- Monitoring of surface water conditions may be required during the course of the operation based on the existing water conditions and the nature of the proposed operation. If so required, the application must include a description of the location, construction, and maintenance of such monitoring stations.

W.S. §35-11-406 and WDEQ/LQD R&R Chapter 2 are supported and augmented by R&R Chapter 3, Noncoal Mine Environmental Protection Performance Standards. Chapter 3 Section 2 details General Environmental Protection Performance Standards for the following:

- Diversion systems (unchannelized surface water and ephemeral streams);
- Diversion of intermittent and perennial streams;
- Permanent water impoundments;
- Tailings impoundments, tailings disposal areas, heap leach facilities, and spent ore disposal areas, excluding uranium mill tailings facilities (because in Wyoming, these are regulated by the NRC); and
- Roads and railroads with respect to risk of spills and infrastructure associated with water bodies such as culverts and drainage control.

## 6.2 Colorado

Colorado State Statute Title 34--Mineral Resources, Article 32—MLRA §34-32-116.5, Environmental Protection Plan - DMO requires environmental protection plans for all DMOs and authorizes the DRMS to “*promulgate rules governing the form, content, and requirements of an environmental protection plan for any designated mining operation.*” DRMS Rules and Regulations largely require the same elements as Wyoming Rules and Regulations and guidelines with a few notable areas of expanded requirements. The general requirements for hydrology and water quality disturbances in Rule 3.1.6, states that:

*“disturbances to the prevailing hydrologic balance of the affected land and of the surrounding area and to the quantity or quality of water in surface . . . water systems both during and after the mining operation . . . shall be minimized by measures, including, but not limited to: compliance with applicable Colorado water laws and regulations governing injury to existing water rights; compliance with applicable federal and Colorado water quality laws and regulations, including statewide water quality standards and site-specific classifications and standards adopted by the Water Quality Control Commission; and compliance with applicable federal and Colorado dredge and fill requirements”.*

CDPHE specifically addresses milling and tailings in Rule 6.3.3 Exhibit C by requiring the following:

- **Tailings:** Describe the geochemical constituents of the tailing or leached ore, the chemistry of any leachate, anticipated impacts to surface waters and design details such as embankments, diversions, chemical treatment facilities to be used to control impacts, and surface water monitoring systems.
- **Drainage Control:** Describe the measures used to divert upland drainage away from the site both during and after operation. This must include design details demonstrating the capacity of ditches and impoundment structures to contain operating solutions and the volume of water generated by a 100-year, 24-hour rainfall event.
- **Maps and Plans:** Design drawings must, at a minimum, describe specific design details for tailings ponds and embankments, ponds and ditches, ore and tail transport systems, and surface water monitoring systems.

In addition to locating all water bodies on a map, if an operator may potentially affect surface water systems, Rule 6.4.7 Exhibit G requires the operator to “*submit a brief statement or plan showing how water from dewatering operations or from runoff from disturbed areas, piled material and operating surfaces will be managed to protect against pollution of . . . surface . . . water (and, where applicable, control pollution in a manner that is consistent with water quality discharge permits), both during and after the operation.*” Furthermore, “*the Operator/Applicant*

*shall indicate the projected amount from each of the sources of water required to supply the project water requirements for the mining operation and reclamation.”*

Rule 6.4.21(1)(c) requires details of the manner in which the Operator/Applicant will protect all areas that have the potential to be affected by designated chemicals, toxic or acid-forming materials or acid mine drainage, or that will be or have the potential to be affected by uranium mining. Specifically, the potential for adverse impacts must be evaluated for the following:

- Leach facilities, or heap leach pad;
- Tailings storage or disposal areas;
- Impoundments;
- Waste rock piles;
- Stock piles, temporary or permanent;
- Land application sites; and
- In situ leach operations or conventional uranium operations.

Rule 6.4.21(10) requires design specifications certified by a licensed professional engineer for all Environmental Protection Facilities intended to: convey, transport or divert surface water around or away from acid mine drainage or toxic or acid-forming material; or capture and/or retain surface water run-off from areas affected by the DMO prior to its release from the mine-site into the natural water drainage system.

### **6.2.1 Milling in Colorado**

Specifically, CRS §25-11-203 addresses milling and tailings operational requirements in 6 CCR 1007-1 Part 18, Rules and Regulations Pertaining to Radiation Control, by requiring an explanation of how to conduct milling operations so that all releases are reduced to as low as is reasonably achievable (ALARA) below regulatory limits; daily inspections, at least, of any tailings or waste retention system; notification of the CDPHE in the cases of failures and unusual conditions not previously contemplated; and an operational monitoring program. Discharge requirements were addressed in Section 2.5.

## **6.3 Oregon**

Oregon state statutes §517.760 and §517.956 give authority to DOGAMI to regulate mining and set standards for mining, including chemical process or ISR. Oregon state R&R, Divisions 35 (DOGAMI), 37 (DOGAMI), and 43 (ODEQ) codify the permit and water quality protection requirements for both conventional and chemical process mines. Oregon Department of Energy (ODOE) Division 95 R&R detail construction, operation, and decommissioning rules for uranium mills, though these lack specificity to water. R&R Division 35 presents the water

resource protection requirements for an Operating Permit Application for a conventional mine and is similar to those of both Colorado and Wyoming. Oregon simply organizes those requirements by mine sequence as follows: existing watercourses and ponds; interim watercourses and ponds; and reconstructed watercourses and ponds. R&R Division 35 632-035-025(c)(E) also outlines DOGAMI requirements that “*when appropriate, mine facilities must be designed conceptually as zero discharge/leak facilities. . . .The applicant must provide for the conservation of the pre-mine quantity and maintenance of the pre-mine quality of the surface . . . water resource so as not to degrade the pre-mine use.*” Further requirements associated with conservation of pre-mine quantity and quality of surface water resources from R&R Division 35 632-035-025(c)(F-H) include the following F-H:

A water budget analysis:

- Precipitation/evaporation data;
- Make-up water needs;
- Make-up water source;
- Procedures to dispose of precipitation water in excess of designed capacities;
- Surface water runoff determination for the watershed containing the mine operation; and
- As a minimum, projects designed to handle the 100-year, 24-hour precipitation event.

Seasonal closure procedures if applicable:

- Target seasonal storage volumes;
- Total system storage capacity;
- Procedures to handle volumes of water in excess of seasonal storage capacities; and
- Estimated target dates for closure.

Credible accident contingency plan:

- Accidental discharge scenarios;
- Immediate response strategy;
- Procedures to mitigate impacts to surface water;
- Notification procedures; and
- Chemical constituents representative of ore processing solution.

## 6.4 ISR

While WS §35-11-406(b) is the foundational mine plan statute, ISR Operations Plan requirements are further detailed in W.S. §35-11-428(a)(iii). Additional Operations Plan information required for ISR includes the following:

- Past and present land and surface water use;
- A contour map which locates proposed features necessary to ensure environmental protection; and
- An assessment of impacts to water resources on adjacent lands that may reasonably be expected and the steps that will be taken to mitigate the impacts.

Wyoming DEQ/LQD R&R Chapter 11 adopts noncoal in situ mining statutes at W.S. §35-11-428 and 429. WDEQ/LQD R&R Chapter 1, Chapter 2, Section 1; and Chapter 3, Section 2 expands on the application content requirements of the mine plan. Chapter 11 is intended to detail the content requirements for ISR operations plans in place of Chapter 2, Section 2 for conventional mine plans. ISR operations plans are required to contain the following with respect to surface water:

- Contour maps highlighting the permit area and proposed activities associated with operation including: temporary and permanent drainage diversions, impoundments, stockpiles for topsoil, ore product and waste, all processing facilities, and monitoring sites;
- A description of and design plan for all impoundments;
- A description of all temporary and permanent surface water diversions;
- The composition of all known and anticipated wastes and procedures for their disposal;
- Procedures for ensuring that all acid-forming, or toxic, or other materials constituting a fire or health and safety hazard encountered during or created by the mining process are promptly treated, confined, or disposed of in a manner designed to prevent pollution of surface water, degradation of soils, or vegetation, or threat to human or animal health and safety;
- A description of the mitigating measures developed from the consultations with state game and fish and the U.S. Fish and Wildlife Service;
- Details of a monitoring program and reporting schedule; and

- An assessment of impacts that may reasonably be expected as a result of the mining operation to water resources and water rights inside the permit area and on adjacent lands, and the steps that will be taken to mitigate these impacts.

While Oregon does not have ISR-specific regulations, chemical process mining regulations are addressed in ORS Chapter 517 and DOGAMI R&R Division 37, Chemical Process Mining. R&R Division 37 is similar to Division 35 and expands on alternatives analysis, environmental evaluation, cumulative impact assessments, and best available practicable and necessary technologies requirements. Specifically, the environmental evaluation requirements of 623-037-0085(6)(b) include “an analysis of the causes and impacts of the following types of credible accidents, including the catastrophic consequences of such accidents even if the probability of occurrence is low.” Possible credible accidents include:

- *“Releases of contaminants into the environment as a result of the mine operation or closure;*
- *Precipitation events and other natural events such as earthquakes which exceed the design standards of the mine facilities;*
- *Human error;*
- *Fire;*
- *Unplanned detonation of explosives; and*
- *Equipment failures.”*

Cumulative impact analysis requirements from 632-037-0085(7)(i-iii) “include an assessment of the total cumulative impact on the environment that results from the incremental impact of an action when added with other past, present and reasonably foreseeable future actions,” specifically the following actions:

- *“Similar actions that provide a basis for evaluating their environmental consequences together, such as common timing or geography;*
- *Connected actions which cannot or will not proceed unless other actions are taken previously or simultaneously or are interdependent parts of a larger action and rely on the larger action for their justification; and*
- *Separate actions that affect the same environmental resources including soil, and water resources.”*

DOGAMI explicitly requires that “extraction, processing, and reclamation be undertaken in a manner that minimizes environmental damage through the use of the best available, practicable, and necessary technology to assure compliance with environmental standards.”

ODEQ R&R Division 43 details permitting requirements for chemical mining. Specifically, the permit may manifest itself as a NPDES permit if there is a point-source discharge to surface waters or a WPCF permit if there is no discharge. Additionally, R&R Division 43 details guidelines for the design, construction, operation and closure of chemical mining operations. The following guidelines for control of surface water run-on and run-off and land disposal of wastewater are noteworthy:

- *Surface water run-on and run-off shall be controlled such that it will not endanger the facility or become contaminated by contact with process materials or loaded with sediment” (340-043-0090(1)); and*
- *“To qualify for land disposal of excess wastewater, the permit applicant shall demonstrate to the Department that the process has been designed to minimize the amount of excess wastewater that is produced, through use of water-efficient processes, wastewater treatment and reuse, and reduction by natural evaporation. Excess wastewater that must be released shall be treated and disposed of to land under the conditions specified in the permit” (340-043-0170(1)).*

## 6.5 NRC

10 CFR 40, Appendix A, Criterion 9 and 10 CFR 51 require that licensees submit an environmental report which addresses expected environmental impacts of milling operations, decommissioning and tailings reclamation, and evaluates alternatives for mitigating these impacts. NRC Regulatory Guide 4.9 Chapter 6.1.1 (NUREG-4.9; NRC, 1975) details specific requirements including proposed activities, plant operation, waste confinement and effluent control, the environmental effects of site development and operation, and effluent and environmental measurements and monitoring programs (explored in greater detail in NRC Regulatory Guide 4.14(A) (NUREG-4.14; NRC, 1980)). Table 6-1 details operational monitoring requirements for uranium mills with respect to surface water.

## 6.6 Points for Consideration

In addition to the state statutes, several states offer guidance for a mining and milling applicant’s preparation of their operational plan. Based on evaluation of several state guidance documents for surface and underground mining, the following list summarizes operational data requirements and analysis. The applicant should provide at a minimum:

- A detailed water handling scheme, which addresses storm water and process water, as applicable. Storm water can be defined to include mine storm water from disturbed and undisturbed areas, mill storm water from licensed/restricted and licensed but unrestricted areas. Process water can include mill and other process water. With respect to mining, a third type of water may include “intercepted water,” which could



incorporate water intercepted by the mining process such as from pit and underground mine dewatering.

- The water handling scheme must address all of these type waters, present engineered designs that ensure that there is no offsite discharge that might contaminate the waters of the State. This scheme likely includes elements such as channel, retention pond, treatment system (as needed), discharge and monitoring program designs.
- A water resource and environmental protection plan, which includes a definition of water quantity including source control and mitigation and water requirements for mining and milling. Such a plan should provide sufficient detail that the Applicant can clearly establish a means to protect the water quantity and water uses of the surrounding streams and channels.
- Definition of water quality designed in sufficient detail that the Applicant can clearly establish a means to protect the water quality and water uses of the surrounding streams and channels.
- Evaluation for the potential development of acid rock generation conditions and a means to mitigate this condition should it develop.
- Evaluation of sources of sediment and a means to mitigate this condition should it potentially impact surface streams. Such a sediment treatment may include revegetation and interim stabilization of stockpiles, routing flows away from sources of sediment and water treatment in the event that storm water becomes contaminated.
- Evaluation of sources of chemical contamination including metals, salts or radionuclides. Each applicant should develop a credible plan that mitigates this condition.
- A definition and a plan to protect area water uses (adjacent area and downstream) including irrigation, domestic, industrial, recreational and ecological uses of the surface waters of the state.
- A surface water management plan that clearly defines the probability of exceedance such that the following is addressed:
  - Storm events (magnitude, duration and return interval);
  - Hydrologic protection of the mine and/or mill site;
  - Prevention of offsite discharge of mine or process materials ;
  - Sediment and erosion control; and
  - Outlying areas of unconcentrated flow are contained and/or treated.

This plan should clearly present all hydraulic parameters for engineered designs of diversions, outfalls, spillway design, and riprap as erosion protection, impoundments, and sedimentation or treatment ponds.

- Spill Prevention, Control and Countermeasure (SPCC) plans and procedures, including hazardous waste storage and disposal procedures and procedures for responding to accidents or releases of production or waste fluids and solids.
- A Storm Water Pollution Prevention Plan (SWPPP) that addresses the following:
  - Alternative sediment control measures;
  - Dry wells;
  - Ponds and treatment;
  - Diversions;
  - Ground stabilization of disturbed areas including contemporaneous reclamation and biotechnical slope protection; and
  - A plan for all engineering designs and design assumptions to ensure that there will be no untreated release of liquids or solids from a milling operation. The plan should include diversions, runoff and run on control, liners and leak detection systems.

## 7.0 CLOSURE/RECLAMATION PLANNING (MINING AND MILLING) FOR SURFACE WATER

Reclamation plans are submitted during the initial steps of the permitting application in conjunction with the mine plan. Most state standards require restoration to the level of highest previous use. Reclamation plans typically involve a resource or environmental protection plan encompassing water quality and quantity, and preservation of adjacent area uses. Final site closure and mine reclamation plans generally includes a hydrologic restoration plan that addresses geomorphic restoration and protection of the water quality and water quantity of the waters of the state. In the event of decommissioning of a mill, federal and Agreement State requirements call for long term, essentially maintenance free reclamation. This reclamation or closure plan is designed such that there is no release of solids or liquids for the long term even in the event of a catastrophic event.

### 7.1 Wyoming

Wyoming statutes address mining reclamation plan content in W.S. §35-11-406(b) though timelines, authorization of rules and regulations, and responsibilities are addressed in various statutes: W.S. §35-11-401, 402, and 406. As previously discussed, several state statutes simultaneously address requirements for the mine plan and the reclamation plan; only reclamation plan requirements with respect to surface water will be presented in this section. The reclamation plan required by Wyoming includes the sequence of reclamation, restoration of land and water use, and pollution prevention and stability. W.S. §35-11-103 defines "reclamation" as:

*“the process of reclaiming an area of land affected by mining to use for grazing, agricultural, recreational, wildlife purposes, or any other purpose of equal or greater value. The process may require contouring, terracing, grading, resoiling, revegetation, compaction and stabilization, settling ponds, water impoundments, diversion ditches, and other water treatment facilities in order to eliminate water diminution to the extent that existing water sources are adversely affected, pollution, soil and wind erosion, or flooding resulting from mining or any other activity to accomplish the reclamation of the land affected to a useful purpose.”*

The timeline for commencement of restoration as outlined in W.S. §35-11-401 is within 30 days after either mining operations have ceased. W.S. §35-11-401 also codifies compliance with reclamation and restoration rules and regulations of the WDEQ/LQD.

W.S. §35-11-402 establishes the reclamation standards which the rules and regulations must address and achieve. The surface water-related standards for reclamation of the affected areas include the following:

- Reclamation should restore surface flowing or stationary water bodies to the highest previous use;
- Prevention of pollution of waters of the state from mining operations, substantial erosion, sedimentation, landslides, accumulation and discharge of acid water, and flooding, both during and after mining and reclamation; and
- Establishing such other rules and regulations necessary to insure full compliance with all requirements relating to reclamation, and the attainment of those objectives directed to public health, safety, and welfare.

W.S. §35-11-406 (b) simultaneously establishes the permit application requirements for both the mine plan and the reclamation plan. As mine plan requirements were addressed in Section 2 of this report, only reclamation plan requirements with respect to surface water quantity, quality, erosive potential, and water rights will be addressed below:

*“The application shall include a reclamation plan dealing with the extent to which the mining operation will disturb or change the lands to be affected, the proposed future use or uses and the plan whereby the operator will reclaim the affected lands to the proposed future use or uses. The reclamation plan shall be consistent with the objectives and purposes of this act and of the rules and regulations promulgated.”* The reclamation plan shall include the following:

- Proposed use of the land after reclamation;
- A contour map with the proposed approximate contours after completion of proposed reclamation;
- The proposed method of separating topsoil, subsoil, and spoil piles, protecting and conserving them from wind and water erosion before reclamation begins;
- The methods of diverting surface water around the affected lands where necessary to effectively control pollution or unnecessary erosion;
- The methods of reclamation for effective control of erosion, siltation, and pollution of affected stream channels and stream banks by the mining operations; and
- A statement of the source, quality and quantity of water, if any, to be used in the mining and reclamation operations.

W.S. §35-11-415(b) outlines the duties of operator with an approved reclamation plan. These duties and responsibilities meet the approved reclamation plan requirements, as outlined in W.S. §35-11-406(b) above, in content and language, focusing on prevention of erosion and contamination and restoration to the “highest previous use.” Furthermore, the operator is tasked with the following:

*“Prevent, throughout the mining and reclamation operation, and for a period of five (5) years after the operation has been terminated, pollution of surface . . . waters on the land affected by the institution of plantings and revegetation, the construction of drainage systems and treatment facilities including settling ponds and the casing, sealing of boreholes, shafts, and wells so that no pollution is allowed to drain untreated into surface . . . water in accordance with state or federal water quality standards, whichever are higher, as may be required in the approved reclamation plan.”*

As specified and authorized in W.S. §§35-11-401, 402, and 406 above, the LQD developed reclamation and restoration rules and regulations applicable to uranium mining, specifically R&R Chapter 3 Noncoal Mine Environmental Protection Standards and R&R Chapter 11 Noncoal In Situ mining. In accordance with reclamation standards set forth in W.S. §35-11-402, R&R Chapter 3 *“reclamation shall restore the land to a condition equal to or greater than the ‘highest previous use.’ The land, after reclamation, must be suitable for the previous use which was of the greatest economic or social value to the community area”* and operators are required to restore wildlife habitat. Requirements associated with surface water are listed below.

- Reestablishment of adequate drainage if such a provision is necessary to prevent pollution or diminution of the quantity and quality of the surface water;
- Contouring of affected land to blend in with the topography of the surrounding terrain unless so doing would create an erosion problem or a hazard to man or beast;
- If the reclamation plan provides for a permanent water impoundment and this use has been approved, all sources of possible water contamination within the pit must be covered with overburden or stabilized in such a manner so as not to contaminate the water in the resulting impoundment;
- Except where diversions are authorized by these regulations, all overburden, spoil material, and refuse piles must be located to avoid blocking intermittent or perennial drainages and floodplains in order to minimize loss and spread of material due to water erosion. Ephemeral drainages may be blocked if environmentally sound methods for dealing with runoff control and sedimentation are approved by the Administrator;
- The slopes of all spoil areas must be designed so that they will be stabilized against wind and water erosion. A permanent drainage system must be established consistent with these regulations;
- If it is determined that the spoil material may be a source of water pollution through reaction with leaching by surface water, the operator shall describe proposed procedures for eliminating this condition;

- After backfilling, grading, and contouring and the replacement of topsoil, and/or approved substitutes, revegetation shall be commenced in such a manner so as to most efficiently accommodate the retention of moisture and control erosion on all affected lands to be revegetated;
- Reclamation of tailings impoundments, tailings disposal areas, heap leach facilities, and spent ore disposal areas shall be accomplished by removal and storage of all topsoil present within the affected lands. After termination of operations, the facility shall be reclaimed in accordance with the approved plan using best technology currently available to ensure long term stability, prevent contamination of surface water and facilitate the approved post-mining land uses; and
- If other methods of reclamation and stabilization against wind and water erosion are found to be necessary because of natural conditions, this must be stated and described subject to the Administrator's approval.

## 7.2 Colorado

Colorado does not substantially elaborate beyond the requirements outlined by Wyoming. The Colorado MLRA details duties of the operator and reclamation plan requirements. Colorado MLRA does elaborate on Wyoming reclamation requirements in the area of reclamation needs of wildlife in Rule 6.3.4, which details reclamation plan pond slope requirements and specific future land use requirements. These requirements address where wildlife habitat is the proposed future land use and require that *“shorelines should be irregularly shaped to promote a diverse wildlife habitat. The Colorado Division of Wildlife (DOW) must be consulted where wildlife use is the proposed future land use.”*

## 7.3 Milling in Colorado

CDPHE 6 CCR 1007-1 Part 18.8 outlines decommissioning/reclamation requirements, including planned decommissioning activities, methods used to assure protection of the environment against radiation hazards during decommissioning, and the planned final radiation survey. 6 CCR 1007-1 Part 18 Appendix A Criterion 1D specifies that *“tailings should be disposed of in a manner that no active maintenance is required to preserve the site.”* Criterion 3 details the following requirements:

*“The ‘prime option’ for disposal of tailings is placement below grade, either in mines or specially excavated pits (that is, where the need for any specially constructed retention structure is eliminated). The evaluation of alternative sites and disposal methods performed by mill operators in support of their proposed tailings disposal program (provided in applicants’ environmental reports) must reflect serious consideration of this disposal mode. In some instances, below grade disposal may not be the most environmentally sound approach, such as might be the case if a ground-water formation is relatively close to the surface or not very well*

*isolated by overlying soils and rock. Also, geologic and topographic conditions might make full below grade burial impracticable: For example, bedrock may be sufficiently near the surface that blasting would be required to excavate a disposal pit at excessive cost, and more suitable alternative sites are not available. Where full below grade burial is not practicable, the size of retention structures, and size and steepness of slopes associated with exposed embankments must be minimized by excavation to the maximum extent reasonably achievable or appropriate given the geologic and hydrologic conditions at a site. In these cases, it must be demonstrated that an above grade disposal program will provide reasonably equivalent isolation of the tailings from natural erosional forces.”*

Criterion 4 further details specific tailings and waste disposal criteria including upstream rainfall, topographic, embankment and cover slope, vegetative cover, and impoundment location and design criteria.

## 7.4 Oregon

As with Wyoming, Oregon mining and reclamation plans are both required as part of initial permitting; therefore, the same state statutes codify both mining and reclamation requirements, including ORS §517.760 (Policy) and ORS §517.790 (Operating permit required for surface mining on certain lands). Oregon statutes require largely the same elements as those of Wyoming and Colorado; however, ORS §517.915 (Additional operating permit requirements for nonaggregate mineral mines) further clarifies that “*if the department finds that reclamation cannot be accomplished, it shall not issue an operating permit,*” specifying that “*the department shall consult with the soil and water conservation district in which the mined land is situated regarding the feasibility of reclamation.*”

ORS §517.832 details emergency operating permit rules and circumstances under which DOGAMI can issue an emergency permit or an amendment to a permit in the event of a natural disaster, including but not limited to a flood, hurricane or an earthquake, or should the effects of a natural disaster threaten significant damage to property or to natural resources. The goal of such a permit is to minimize the impacts of flooding and drainage.

DOGAMI R&R Divisions 30, 35, 37, and 38 adopt and expand upon Oregon State Statutes codifying reclamation requirements. R&R Division 30 details requirements for a reclamation plan including the procedures necessary for surface water, stream, and floodplain protection and post-mine hydrologic controls, including the following:

- “*Procedures to protect surface water quality and to control erosion include the following:*
  - *Detention ponds and sedimentation basins;*
  - *Rock check dams and grade control structures;*
  - *Temporary diversions;*



- *Flocculation systems and/or surface disposal systems; and*
- *Runoff and pond sizing calculations.*
- *Procedures to protect or reconstruct waterways or drainage patterns impacted by mine related disturbances or reclamation by the design and construction of a post-mine drainage control plan to convey storm water and surface water off the property in a manner that will provide long-term stability to the reclaimed land.*
- *Procedures to protect natural resources. The Department may determine it is in the best interest of protection of natural resources and final reclamation to require procedures to integrate flood water passage plans, storm water controls, or fish ingress/egress plans at adjoining mine sites.*
- *Procedures to promote final reclamation and floodplain stability or protection of streams, riparian buffers, and operational setbacks may require detailed engineering and planning for:*
  - *Pond bank and channel bank weirs or other headcut protection plans;*
  - *Floodwater conveyance channels or structures;*
  - *Flood berms;*
  - *Protection of channel migration zone; and*
  - *Protection or stabilization of stream channel buffers.”*

DOGAMI R&R Division 35 adds the following two requirements:

- *“The Department may require the applicant to provide for the prevention of stagnant water.*
- *Final slopes shall be stable.”*

## 7.5 ISR

While ISR has the potential to impact groundwater more than surface water, surface water reclamation should be addressed. Wyoming LQD R&R Chapter 11 Noncoal In Situ mining addresses “*potential impacts to other waters of the state*” in Section 5, Reclamation Plan. Section 5(vi-vii and xi) requires the following be addressed in the reclamation plan:

- *“Procedures for reestablishing any surface drainage that may be disrupted by the mining operation;*
- *Procedures for the reclamation of any temporary diversion ditches or impoundments;*
- *Procedures for permanently disposing of any toxic or acid-forming materials;” and*
- *“Procedures for ground surface preparation, depth of topsoil replacement, erosion control and water conservation practices.”*

In Oregon, R&R Division 37 chemical mining requirements are similar to mine plan requirements; a chemical process mine must comply with reclamation and mine closure standards utilizing the best available, practicable and necessary technology to assure compliance with environmental standards.

## 7.6 NRC

Federal regulations 10 CFR 40 establishes technical and long-term site surveillance criteria relating to reclamation of mills and tailings and associated waste systems. Closure plans must include removal or decontamination of all waste residues, contaminated containment system components, contaminated subsoils, and structures and equipment contaminated with waste and leachate. Under 10 CFR 40 Appendix A, the goal of a closure plan is to “*control, minimize, or eliminate post-closure escape of nonradiological hazardous constituents, leachate, contaminated rainwater, or waste decomposition products to the surface waters or to the atmosphere.*” Reclamation plan requirements include interim stabilization, including dewatering, recontouring and final radon barrier construction. Primary guidance documents include NUREG-1620, -1623, -1748, and -1757. Additional guidance is under review and revision by the NRC including Regulatory Guide 4.1.4 and NUREG-1620 for operational protection standards during reclamation and closure.

## 7.7 Points for Consideration

In addition to state statutes, several states offer guidance for a mining and milling applicant’s preparation of their reclamation or site closure plan. Based on evaluation of several state guidance documents for surface and underground mining, as well as non-conventional mining such as ISR, the following list summarizes operational data requirements and analysis.

- The applicant should provide a final site Hydrologic Restoration Plan that ensures the protection of adjacent area resources and the environment. The plan should address the following:
  - *Protection of water uses, both onsite and offsite;*
  - *Protection of water quantity; and*
  - *Protection of water quality. Water quality considerations must include acid rock generation, sediment and chemical contamination to surface streams and wetlands (metals, salts and radionuclides).*
- The hydrologic restoration plan should include plans and details related to stream channel and drainage system reconstruction. Such a plan should consider: surface water infiltration and runoff on the reclaimed land surface; geomorphic and vegetative stability; restoration to an equal or higher land use.

- In the event of decontamination and decommissioning of a mill, the final hydrologic restoration plan should include: long term stabilization (rock cover, minimum slopes, geomorphic isolation); permanent, maintenance-free diversion (PMF Design); protection of the surface waters of the state during decontamination; and, decommissioning of the mill site.

## 8.0 PRE-OPERATIONAL BASELINE CHARACTERIZATION FOR GROUNDWATER (MINING AND MILLING)

The programs and requirements for environmental baseline characterization are similar in Wyoming, Colorado, and Oregon. Frequently baseline groundwater requirements are not separated from baseline surface water requirements. Both groundwater and surface water baseline characterization requirements are modeled after or are consistent with national regulations (i.e., NEPA) and federal programs (i.e., OSM, NRC, and EPA). Uranium mine permits are regulated by either a single state agency, or several agencies that effectively require the mine applicant to conduct baseline studies covering groundwater, wildlife, soils and geology, vegetation, meteorology/climatology, and air. Uranium license applicants for a mill are also required to complete baseline studies to characterize the pre-disturbance characteristics of the landscape. Various aspects of the baseline studies may be required by other cooperating agencies and are commingled with the requirements of the agency that regulates mining. As discussed in Section 1.0 of this report, statutes and rules provide the framework for environmental baseline characterization while guidance documents provide the more detailed requirements.

### 8.1 Wyoming

Environmental baseline requirements with respect to groundwater are very similar to those requirements related to surface water. Specificity to groundwater in the environmental baseline characterizations required by the statutes and rules of each state is limited; however, Wyoming details baseline characterization/requirements for groundwater in guidance documents, specifically Guideline 8, Hydrology. Environmental baseline requirements for groundwater generally include the hydrogeological setting focusing on stratigraphy and structure, geochemistry and mineralogy, characterization of groundwater quantity and quality, the location of all other wells and septic systems, and groundwater modeling to establish baseline conditions. Most environmental mining regulations in Wyoming are addressed in the Environmental Quality Act (EQA) with the WDEQ acting as the regulating agency. The Wyoming statutes codify land and water characterization for a mining permit under W.S. §35-11-406(a)(vii) simply by saying:

*“The applicant shall provide a general description of the land which shall include as nearly as possible its past and present uses, its . . . adjudicated water rights and their immediate drainage areas and uses, and, if known, the nature and depth of the overburden, topsoil, subsoil, mineral seams or other deposits and any subsurface waters known to exist above the deepest projected depth of the mining operation.”*

Mapping requirements further detail land and water characterization under W.S. §35-11-406(a)(ix-x) by requiring the following:

*“A map based upon public records showing the boundaries of the land to be affected, . . . oil wells, gas wells, water wells, and the probable limits of underground mines and surface mines, whether active or inactive, on or immediately adjacent to the land to be affected. The map shall also show: the mineral or minerals to be mined.”*

In the case of ISR, the above-referenced application requirements W.S. §35-11-406(a)(vii) is replaced with W.S. §35-11-428(a)(i-ii) as follows:

*“The application shall contain a description of the proposed permit area including the following information relating to the applicable in situ technology: Soils, . . . natural gamma radiation background for lands to be impacted by radioactive materials, . . . geologic and ground water hydrologic information including a description of the general geology including geochemistry and lithology of the permit area and a characterization of the production zone and aquifers that may be affected including applicable hydrologic and water chemistry data to describe the projected effects of the mining activities.”*

WDEQ/LQD R&R Chapter 2, Section 2- General Application Content adopt statute W.S. §35-11-406 and provide additional specificity by requiring “a description of the lands to be affected within the permit area and how the lands will be affected.” This description includes the following:

- Major past and present land uses and priority rankings of those uses in the proposed permit area and adjacent lands;
- Overburden, topsoil, subsoil, mineral seams, or other deposits;
- Groundwater “depth, quantity, and quality”; and
- Water rights and existing wells on the proposed permit area and adjacent lands.

## 8.2 Colorado

The Colorado statute that governs pre-operational environmental baseline characterization of applicable mining operations is the MLRA. This authorizes the DRMS to require baseline characterization of DMO sites, which include uranium mining sites utilizing conventional underground, open, or ISR. It requires detailed characterizations of the affected lands including all bodies of water, soils, geology, vegetation, and wildlife. The DRMS CCR Rules 6 and 7 of 2 CCR 407-1 Hard rock/metal mining provide further guidance for baseline characterization of the affected land and waters. The DRMS CCR Rules 6 and 7 requires the operator/applicant to, at a minimum, include a description of soil characteristics in the area of proposed operation, identify any permanent manmade structures within 200 feet of the affected area, and:

*“a description of the water resources in the area of the proposed operation, identify any, aquifers that would receive drainage from the affected area. Provide any information from*

*publications or monitoring data on flow rates, water table elevations and water quality conditions.”*

Hard Rock Rule 6.4.21 Exhibit U, Designated Mining Operation Environmental Protection Plan, further outlines specific water quality baseline requirements:

*“water quality and flow data collected during a minimum of five (5) successive calendar quarters and such other additional data, or a period specified by the Office, as may be necessary to adequately characterize baseline conditions. This baseline data shall be sufficient to provide for the proper design of facilities, to serve as a basis for the evaluation of reclamation performance standards success, and to insure the adequacy of environmental protection facility design, maintenance and operation.”*

### 8.3 Oregon

DOGAMI requires environmental baseline characterization as authorized by the Oregon Mined Land Reclamation Act in ORS §517.915. OAR 632-035-0025 prescribes procedures for meeting the requirements of the environmental baseline referenced in ORS §517.915:

*“The Department may require environmental baseline information including characterization of the following: soil/overburden, ground water, area seismicity, geology and geographic hazards, mineralogy, and chemistry.”*

Oregon includes area seismicity into the baseline characterization requirement. Baseline seismicity characterization is required by Oregon in accordance with NRC permitting requirements; however, seismicity is not required by all state-level agencies. Seismic activity may negatively impact water quality and may need to be considered at other points in the permitting process.

### 8.4 ISR

Wyoming LQD R&R Chapter 11 Noncoal In Situ Mining, Section 3 adopts W.S. §35-11-428 and details specific baseline and application requirements similar to those detailed in LQD R&R Chapter 2 Section 2, above, for conventional noncoal mines. ISR baseline information includes the following from LQD R&R Chapter 11, Section 3 (iii-ix):

- A listing of all permits or construction approvals received or applied for in association with the permit area;
- A soil survey which maps soils within the permit area;
- A description of the nature and depth of the topsoil;
- A description of climatic conditions of the site; and

- A description of the geology, including cross-sections, geologist/driller's and geophysical logs, formations and aquifers, geologic features that could influence aquifer properties, areal and stratigraphic position of the production zone, geochemical, lithological, and mineralogical description of the receiving strata and any aquifers that may be affected by the injection of recovery fluid.

Additionally, for groundwater (aquifers) within the permit area and on adjacent lands, the following elements of baseline characterization are required by LQD R&R Chapter 11 Section 3 (xi-xv):

- Well identifiers, descriptions, and a map of all wells installed for water supply or monitoring and all wells that penetrate the production zone;
- A list and map of all adjudicated and permitted groundwater rights;
- A list and map of all abandoned wells and drill holes, giving location, depth, producing interval(s), type of use, condition of casing, plugging procedures and date of completion for each well or drill hole within the permit area and on adjacent lands to the extent such information is available in public records and from a reasonable inspection of the property;
- A groundwater potentiometric surface contour map for each aquifer that may be affected by the mining process, including overlying and underlying aquifers in which monitoring wells are installed;
- Aquifer characteristics for the water saturated portions of the receiving strata and aquifers which may be affected by the mining process:
  - aquifer thickness, velocity and direction of groundwater movement, storage coefficients or specific yields, transmissivity or hydraulic conductivity and the direction(s) of preferred flow under hydraulic stress in the saturated zones of the receiving strata, the extent of hydraulic connection between the receiving strata and overlying and underlying aquifers, and the hydraulic characteristics of any influencing boundaries in or near the proposed well field area; and
- Tabulated water quality analyses for samples collected from all groundwaters which may be affected by the proposed operation. Sampling to characterize the pre-mining groundwater quality and its variability shall be conducted in accordance with established Department guidelines.

Should an ISR application meet the requirements of LQD R&R Chapter 11, that same application can also be submitted to WQD for underground injection control/Class III well permitting under WQD Chapter 9 (Wyoming Groundwater Pollution Control) Section 6. Such an application shall include:



- A site facility description and engineering and operating data, including:
  - A map locating and identifying the area, the discharge area boundaries, and all wells installed and planned by the owner/operator;
  - Construction and engineering details of the facility; and
  - A description of the special process technique and method of operation to be used and the fluid to be injected;
- The name, geology, description and depth of the receiving aquifer; hydrologic information including direction and rate of water movement in the receiver and fluid chemistry of the receiver, including total dissolved solids;
- The location and identification of each groundwater use in the area of review;
- Water quality information, including background groundwater quality data;
- Plans to monitor:
  - Discharge operations;
  - Quality parameters and fluid levels of groundwater of the state in the vicinity of the discharge operation; and
  - Groundwater flow in the receiver in order to promptly detect the arrival of waste or pollution at a monitor well installed for this purpose;
- Information which shows that the proposed discharge can be controlled and will not migrate into other receivers or to the surface through previously drilled wells and will not migrate into the water source area for any water supply well;
- Methods and procedures for inspection of the facility and operations, and for detecting failure of the well(s) and system; and
- Demonstration or documentation of the mechanical integrity of the well or system and that groundwater pollution which may result from a special process discharge can be eliminated or reduced to an appropriate level, in conformity with provisions and standards of the WQD R&R.

The Colorado MLRA, which authorizes the DRMS to require baseline characterization of DMO sites, was revised in 2009 to address uranium-specific ISR requirements and the Hard Rock Rule 6.4.21 was similarly updated:

*“In the case of an in situ leach mining operation, a permit applicant must design and conduct a scientifically defensible ground water and environmental baseline site characterization and monitoring plan for the proposed mining operation which, at a minimum, includes five (5) successive calendar quarters, or the period specified by the Office as necessary to adequately*

*characterize the baseline conditions, of water quality data, prior to submitting the permit application.”*

ORS §517.969 requires an applicant to collect baseline data and ORS §517.971(5) and (7) further detail requirements, including environmental baseline data, a water budget, and water pollution control permits and plans. However, the data contained in ORS §§517.956-989, Chemical Process Mining, lacks specificity to groundwater characterization.

## 8.5 NRC

The NRC requires pre-operational baseline data for milling sites in 10 CFR 40 Criterion 7 for at least one full year prior to any major site construction. Additionally, 10 CFR 40 Criterion 5 discusses compliance based on background concentration of constituents in water. The requirements of baseline data collection are detailed in the NRC Regulatory Guide 4.9, 4.14, and 4.21. Preoperational monitoring requirements include water, soil, sediment, and background radiation sampling; regional land and water use, geology, hydrology, meteorology, and ecology. Regulatory Guide 1748 (NUREG-1748; 2003) provides guidance on baseline requirements associated with licensing actions.

Regulatory Guide 4.14 (1980) Section 1.1.2, Water Samples, details sampling logistics for groundwater. This guidance is summarized in Table 5.1 and narrative guidance is outlined below:

*“Samples of ground water should be collected quarterly from at least three sampling wells located hydrologically down gradient from the proposed tailings area, at least three locations near other sides of the tailings area, and one well located hydrologically up gradient from the tailings area (to serve as a background sample). The location of the ground-water sampling wells should be determined by hydrological analysis of the potential movement of seepage from the tailings area, and the basis for choosing these locations should be presented when data is reported. Wells drilled close to the tailings for the specific purpose of obtaining representative samples of ground water that may be affected by the mill tailings are preferable to existing wells.*

*Ground-water samples should also be collected quarterly from each well within two kilometers of the proposed tailings area that is or could be used for drinking water, watering of livestock, or crop irrigation.”*

NRC Regulatory Guide 4.21 (2008) Appendix A-2(a) details guidance for minimization of radioactive contamination and waste generation. Regarding baseline characterization for groundwater systems, Regulatory Guide 4.21 advises that applicants:

*“identify potential migration and ground-water transport pathways for potential environmental contaminating events, and assess the effect of construction on the hydrogeological*

*characteristics of the site. The conceptual site model should address both the horizontal and vertical variability of the onsite hydrogeology and the potential effect of the layout of structures, foundations, footings, and backfills. A plan for implementing and updating the conceptual site model should comprise one component of the proposed facility operating procedures. Specifically, following facility construction, any impacts of site construction activities on final site hydrogeological characteristics should be identified. If there are significant changes at the site during the operating life of the facility, the conceptual site model should be reevaluated and adjusted, and appropriate adjustments/changes should be made to the onsite and offsite monitoring program.”*

## **8.6 Points for Consideration**

Based on our evaluation of several state guidance documents for surface and underground mining, the following summarizes recommended baseline data requirements for groundwater. With respect to the various states, Wyoming DEQ/LQD has a relatively comprehensive and frequently updated set of guidelines to ensure that the operator or applicant presents a complete permit application. Especially pertinent to this section, LQD has created Guideline 8--Hydrology which addresses pre-operational baseline characterization guidelines for groundwater. With respect to ISR, Wyoming allows an operator to complete a Hydrologic Unit Testing program following mine permitting but in advance of mine operation. In summary typical guidance documents recommend that the applicant provide the following baseline information as it directly pertains to groundwater:

- Information related to the regional and local hydrogeological setting including: stratigraphy and structure; aquifer hydraulic characteristics; hydrologic boundaries including recharge and discharge areas. Climatological information as it relates to groundwater recharge may be included in this discussion. Aquifer test data and potentiometric surface maps of all potentially affected aquifers should accompany this discussion;
- Characterization of groundwater quantity and quality for all potentially affected aquifers. Data tables should address water quality parameters as established by the regulatory agency and consistent with the existing proposed uses. Seasonal variations in water levels and water quality should be identified;
- Present groundwater use (including springs) information, both on a regional and local basis. These data may include but should not be limited to water rights (public and private) from both public data sources. Locations of private wells and septic systems shall be included on a map. The applicant shall include site surveys and any reasonably available source of information;
- Present laboratory and field information on the related geochemistry and mineralogy of the disturbed subsurface environment. This information may include a description

- of the ore body, waste rock and overburden. Such waste characterization may include leachability, oxidation cells, column leach studies and/or bench scale tests;
- Present a pre-mining radiological assessment for uranium and associated radionuclides and how it may impact the aquifers upon mining-related disturbance. Such information may include the natural radioactive background and overburden radiochemistry;
  - In some cases it may be relevant to include a groundwater model to establish baseline subsurface hydrologic conditions. This becomes particularly important when impacts to aquifers (drawdown) are anticipated as part of the mining or ISR process. In particular where underground or surface mines intersect an aquifer and dewatering is necessary, a predictive model may be appropriate; and
  - An abandoned drill hole list within a given radius of the mining and/or milling operations. These data need to be researched through public and private databases. Any additional information including number of abandoned or exploratory holes not locatable would be helpful as well.

## 9.0 OPERATIONS (MINING AND MILLING PLAN): GROUNDWATER PROTECTION PLANS AND PROCEDURES

The programs and requirements for operational planning, including groundwater protection plans remain similar between Wyoming, Colorado, and Oregon. All are modeled after or are consistent with national regulations (i.e., NEPA) and federal programs (i.e., OSM, NRC, and EPA).

### 9.1 Wyoming

The Wyoming regulatory program approach for mining projects is full life cycle and applies to mines but not mills as Wyoming is not an NRC Agreement State. The mine plan must consider the reclamation requirements during the planning process; consequently, reclamation requirements can influence the mine plan. The mine plan provides details such as method of mining, waste characterization, mine dewatering and recharge, hydrogeology, subsidence analysis, water quantity and quality, procedures for responding to accidents, and mining sequence. Mine plans typically consist of environmental protection plans, hydrologic control plans, monitoring, and mitigative action plans. Due to the importance of monitoring to every step in mining, milling, and reclamation, monitoring is addressed independently in Section 12 of this report.

W.S. §35-11-406(b)(i-v, viii-ix, xiii-xiv, xvi) addresses groundwater aspects of conventional mine and reclamation plans while ISR operating and reclamation plans are addressed in W.S. §35-11-428(a)(iii). The relevant WDEQ/LQD R&R are similarly organized with Chapter 2 addressing conventional uranium mining and Chapter 11 addressing ISR. W.S. §35-11-406(b) mine plan requirements include an explanation of “*the extent to which the mining operation will disturb or change the lands to be affected.*” Specifically, the statute requires that the mine plan include the following:

- Maps showing location and extent of the proposed affected lands, proposed pits, refuse or waste areas, waste water treatment facilities, and shall further set forth the drainage plan including subsurface water above the mineral seam to be removed;
- A plan for insuring that all acid forming, or toxic materials, or materials constituting a fire, health or safety hazard uncovered during or created by the mining process are promptly treated or disposed of during the mining process in a manner designed to prevent pollution of subsurface water;
- A statement of the source, quality and quantity of groundwater, if any, to be used in the mining and reclamation operations; and

- For surface coal mining operations, a plan to minimize the disturbances to the prevailing hydrologic balance at the mine site and in associated offsite areas and to the quality and quantity of water in groundwater systems during mining operations.

W.S. §35-11-406(b) is adopted by the WDEQ/LQD in R&R Chapter 2 Section 2(b)(i)(A)-(b)(iii)(I). Chapter 2 expands on the statute with the following requirements for a mine plan with respect to groundwater:

- A description of the mining operation proposed to be conducted during the life of the mine;
- A plan for handling and disposal of all toxic, acid-forming, or otherwise hazardous materials;
- A plan for backfilling of all affected lands;
- Monitoring of groundwater conditions may be required during the course of the operation based on the existing water conditions and the nature of the proposed operation;
- An estimate of the depth and quantity of any groundwater existing in the proposed permit area down to and including the strata immediately below the lowest mineral seam to be mined; and
- A survey of the pre-mining water levels in existing water wells on the proposed permit area and adjacent lands, including all well fields.

W.S. §35-11-406 and WDEQ R&R Chapter 2 are supported and augmented by Chapter 3—Noncoal Mine Environmental Protection Performance Standards. Chapter 3 Section 2 details General Environmental Protection Performance Standards for the following which may impact groundwater:

- Permanent water impoundments;
- Tailings impoundments, tailings disposal areas, heap leach facilities, and spent ore disposal areas, excluding uranium mill tailings facilities (because in Wyoming, these are regulated by the NRC) to prevent the contamination of groundwater; and
- Adequate through-drainage if necessary to prevent pollution or diminution of the quantity and quality of the groundwater.

## 9.2 Colorado

The MLRA requires environmental protection plans for all DMOs and authorizes the DRMS to “promulgate rules governing the form, content, and requirements of an environmental protection plan for any designated mining operation.” DRMS Rules and Regulations largely require the

same elements as Wyoming Rules and Regulations and Guidelines with a few notable areas of expanded requirements. The general requirements for hydrology and water quality in Rule 3.1.6 are as follows: *disturbances to the prevailing hydrologic balance of the affected land and to the quantity or quality of water in groundwater systems during the mining operation shall be minimized by measures, including, but not limited to: compliance with applicable Colorado water laws and regulations governing injury to existing water rights; compliance with applicable federal and Colorado water quality laws and regulations, including statewide water quality standards and site-specific classifications and standards adopted by the Water Quality Control Commission; and compliance with applicable federal and Colorado dredge and fill requirements.*

Groundwater Rule 3.1.7 details the following specific requirements for groundwater standards and conditions in Colorado, including groundwater that has no specific water quality standard (i.e., unclassified groundwater resource) which must be protected for existing and reasonable future uses. Points of compliance are recognized in Rule 3.1.7 in the case where groundwater quality standards have been established. For existing facilities at which an adverse impact to groundwater quality could occur, the point of compliance will be set as follows:

*“At some distance hydrologically down-gradient from the facility or activity that is causing, or which has the potential to cause, the contamination, and selecting that distance closest to the facility or activity, considering the technological feasibility of meeting the requirements for protecting water quality:*

- A specified distance;
- The hydrologically down-gradient limit of the area in which contamination has been identified; or
- The facility permit boundary.”

In addition to locating all water bodies and aquifers on a map, if an operator is expected to directly affect surface or groundwater systems, the Rule 6.4.7 Exhibit G—Water Information requires the operator to *“submit a brief statement or plan showing how water from dewatering operations or from runoff from disturbed areas, piled material and operating surfaces will be managed to protect against pollution of either surface or groundwater (and, where applicable, control pollution in a manner that is consistent with water quality discharge permits), both during and after the operation.”* Furthermore, *“the Operator/Applicant shall indicate the projected amount from each of the sources of water to supply the project water requirements for the mining operation and reclamation.”*

Colorado Rule 6.4.21(1)(c) requires details of how the operator or applicant will protect all areas that have the potential to be affected by designated chemicals, toxic or acid-forming materials or



acid mine drainage, or that will be or have the potential to be affected by uranium mining. Specifically, the potential for adverse impacts must be evaluated for the following:

- Leach facilities, or heap leach pad;
- Tailings storage or disposal areas;
- Impoundments;
- Waste rock piles;
- Stock piles, temporary or permanent;
- Land application sites; or
- In situ leach operations or conventional uranium operations.

From Rule 6.4.21(8), groundwater information required for mine plan includes a description of “*all known aquifers and related subsurface water bearing fracture systems within 2 miles of the affected lands*,” including the general direction and rate of flow of groundwater in these aquifers and fracture systems. Section 9 of Rule 6.4.21 includes groundwater quality data needed for operations, beginning with an explanation of “*the existing and reasonably potential future groundwater uses on and within 2 miles down-gradient of the affected lands*.” Rule 6.4.21(10) requires design specifications certified by a licensed professional engineer for all Environmental Protection Facilities intended to: convey, transport or divert surface water around or away from acid mine drainage or toxic or acid-forming material; or capture and/or retain surface water runoff from areas affected by the DMO prior to its release from the mine-site into the natural water drainage system.

### 9.3 Milling in Colorado

Because Colorado is an NRC Agreement State, it regulates uranium mills as well as mines. CDPHE is the authority with jurisdiction to regulate radioactive materials in Colorado, pursuant to §§25-11-101 through 113. Specifically, CRS §25-11-203 addresses milling and tailings in CDPHE 6 CCR 1007-1 Part 18, Rules and Regulations Pertaining to Radiation Control, by requiring an explanation of how to conduct milling operations so that all releases are reduced to as low as is reasonably achievable below regulatory limits; daily inspections, at least, of any tailings or waste retention system; notification of the Department in the cases of failures and unusual conditions not previously contemplated; and an operational monitoring program. Also detailed are requirements resulting from the “*release to the ground water that exceeds the basic standards for ground water as established by the water quality control commission*”; “*until remediation has been completed, the licensee shall provide annual written notice of the status of the release and any remediation activities associated with the release*” to each registered ground water well user within 1 mile of the release. Part 18 Criterion 1-10 detail criteria relating to the operation of mills and the disposition of the tailings or wastes from these facilities.

## 9.4 Oregon

ORS §517.760, Policy; §517.835, Conditions on Operating Permit to Prevent Impact on Groundwater; §517.956, Standards for chemical process mining operation; and §517.971, Consolidated Application give authority to DOGAMI to regulate mining, set standards for mining including chemical process or in situ mining, and outlines requirements for operating permits. Oregon R&R, Divisions 35 (DOGAMI), 37 (DOGAMI), and 43 (DEQ) codify the permit and water quality protection requirements for both conventional and chemical process mines (i.e., ISR). ODOE Division 95 Rules and Regulations detail construction, operation, and decommissioning rules for uranium mills, though these lack specificity to water and ground water. Oregon R&R Division 35 presents the water resource protection requirements for an Operating Permit Application for a conventional mine and is similar to those of both Colorado and Wyoming. Oregon simply organizes those requirements by mine sequence as follows. Oregon R&R Division 35 also outlines DOGAMI requirements that *“when appropriate, mine facilities must be designed conceptually as zero discharge/leak facilities. . . .The applicant must provide for the conservation of the pre-mine quantity and maintenance of the pre-mine quality of the surface and ground water resource so as not to degrade the pre-mine use.”* Further Division 35 R&R requirements associated with conservation of pre-mine quantity and quality of surface and ground water resources include the following:

A water budget analysis:

- Precipitation/evaporation data;
- Make-up water needs;
- Make-up water source;
- Procedures to dispose of precipitation water in excess of designed capacities;
- Surface water runoff determination for the watershed containing the mine operation; and
- As a minimum, projects designed to handle the 100-year, 24-hour precipitation event.

Seasonal closure procedures if applicable:

- Target seasonal storage volumes;
- Total system storage capacity;
- Procedures to handle volumes of water in excess of seasonal storage capacities; and
- Estimated target dates for closure.

Credible accident contingency plan:

- Accidental discharge scenarios;
- Immediate response strategy;
- Procedures to mitigate impacts to surface water;
- Notification procedures; and
- Chemical constituents representative of ore processing solution.

## 9.5 ISR

While Wyoming Statute §35-11-406(b) is the foundational mine plan statute, ISR operating plan requirements are further detailed in W.S. §35-11-428(a)(iii). Additional mine plan information required for an ISR permit include the following:

- A description of the mining techniques;
- Past and present land and groundwater use; and
- Plans and procedures for environmental surveillance and excursion detection, prevention and control programs.

WDEQ/LQD R&R Chapter 11 adopts noncoal ISR statutes §§35-11-428 and 429; R&R Chapter 1; Chapter 2, Section 1; and Chapter 3, Section 2 expands on the application content requirements of the operating plan. Chapter 11 is intended to detail the content requirements for ISR operating plans in place of Chapter 2, Section 2 for conventional mine plans. ISR operating plans are required to contain the following with respect to groundwater:

- Contour maps highlighting the permit area and proposed activities associated with operation including: impoundments, stockpiles for topsoil, ore product and waste, all processing facilities, and monitoring sites;
- Discussion and illustration of the proposed mining schedule, including:
  - A list of the proposed wellfields;
  - A map(s) which shows the proposed sequence for mining of the wellfields;
  - A proposed time schedule for mining each wellfield; and
  - The capacity of the water/waste water treatment systems and correlation of the capacity with the mining and restoration schedules;
- Proposed method of operation including injection rate, average and maximum daily rate and the volume of fluid to be injected, injection pressures with average and maximum injection pressures, proposed stimulation program, type of recovery fluid

- to be used, proposed injection procedure, and expected changes in pressure, native groundwater displacement and direction of movement of injection fluid;
- Production zone fluid pressure, fracture pressure, and physical and chemical characteristics of the receiving strata fluids;
  - The procedure(s) to assure that the installation of recovery, injection, and monitor wells will not result in hydraulic communication between the production zone and overlying or underlying stratigraphic horizons;
  - The procedures utilized to verify that the injection and recovery wells are in communication with monitor wells completed in the receiving strata and employed for the purpose of detecting excursions;
  - The completion details for all monitor wells and a detailed description of the typical proposed well completion for injection and recovery wells;
  - Details of a monitoring program and reporting schedule;
  - A schedule for and description of the procedures to demonstrate and maintain mechanical integrity of wells;
  - Corrective action plan, for such wells that are improperly sealed, completed, or abandoned, consisting of such steps or modifications as are necessary to prevent movement of fluid into unauthorized zones;
  - Chemical reactions that may occur during mining as a result of recovery fluid injection;
  - Subsidence analysis, estimating the effect of subsidence upon the land surface and overlying groundwater aquifers. Subsidence shall be planned and controlled to the extent that the values and uses of the surface land resources and the groundwater aquifers will not be degraded;
  - Measures employed to prevent an excursion, and contingency and corrective action plans to be implemented in the event of an excursion;
  - Assessment of impacts that may reasonably be expected as a result of the mining operation to water resources and water rights inside the permit area and on adjacent lands, and the steps that will be taken to mitigate these impacts:
    - A maintenance plan to ensure that wells are sufficiently covered to protect against entrance of undesirable material into the well, and
    - Monitoring equipment is appropriately serviced and maintained;
  - The composition of all known and anticipated wastes and procedures for their disposal; and

- Procedures for ensuring that all acid-forming, toxic, or other materials constituting a health hazard encountered during or created by the mining process are promptly treated, confined, or disposed of in a manner designed to prevent pollution of groundwater.

WDEQ/LQD Guideline 4 further details and offers guidance on Chapter 11 requirements.

Colorado DRMS Groundwater Rule 3.1.7 details the following specific requirements for groundwater standards and conditions in Colorado, including groundwater that has no specific water quality standard (i.e., unclassified groundwater resource) which must be protected for existing and reasonable future uses. Furthermore, for any in situ leach mining operations:

- Operators of all uranium extraction operations using in situ leach mining or recovery methods shall reclaim all affected groundwater for all water quality parameters that are specifically identified in the baseline site characterization and monitoring plan, or in the statewide radioactive materials standards of the Basic Standards for Groundwater as established by the Colorado Water Quality Control Commission, to either of the following:
  - Pre-mining baseline water quality or better, as established by the baseline site characterization and monitoring plan; or
  - That quality which meets the statewide radioactive materials standards and the most stringent criteria of the basic standards for groundwater as established by the Colorado Water Quality Control Commission;
- Also, in establishing, designing and implementing a groundwater reclamation plan, in situ leach mining operators shall use best available technology. In addition, in situ leach mining operators shall take all necessary steps to prevent and remediate any degradation of preexisting groundwater uses during the prospecting, development, extraction and reclamation phases of the in situ leach mining operation.

Additionally, Colorado Rule, 6.4.22 Exhibit V, Description of ISL Mines, details additional requirements beyond those presented above. The first such requirement is the description of:

*“at least five (5) in situ leach mining operations that demonstrate the applicant’s ability to conduct the proposed mining operation without leakage, vertical or lateral migration, or excursion of any leaching solutions or ground water containing minerals, radionuclides, or other constituents mobilized, liberated or introduced by the mining operation into any ground water outside of the permitted in situ leach mining area.”*

Oregon DOGAMI R&R Division 37 - Chemical Process Mining is similar to R&R Division 35 and expands on alternatives analysis, environmental evaluation, cumulative impact assessments,

and best available practicable and necessary technologies requirements. Specifically, the environmental evaluation includes “*an analysis of the causes and impacts of the following types of credible accidents, including the catastrophic consequences of such accidents even if the probability of occurrence is low.*” Possible credible accidents include:

- *Releases of contaminants into the environment as a result of the mine operation or closure;*
- *Precipitation events and other natural events such as earthquakes which exceed the design standards of the mine facilities;*
- *Human error;*
- *Fire;*
- *Unplanned detonation of explosives; and*
- *Equipment failures.*

Cumulative impact analysis requirements “include an assessment of the total cumulative impact on the environment that results from the incremental impact of an action when added with other past, present and reasonably foreseeable future actions,” specifically:

- *Similar actions that provide a basis for evaluating their environmental consequences together, such as common timing or geography;*
- *Connected actions which cannot or will not proceed unless other actions are taken previously or simultaneously or are interdependent parts of a larger action and rely on the larger action for their justification; and*
- *Separate actions that affect the same environmental resources including soil, and water resources.*

DOGAMI explicitly requires that “extraction, processing, and reclamation be undertaken in a manner that minimizes environmental damage through the use of the best available, practicable, and necessary technology to assure compliance with environmental standards.”

ODEQ R&R Division 43 details permitting requirements for chemical mining. Specifically, the permit may be a NPDES permit if there is a point-source discharge to surface waters or a WPCF permit if there is no discharge. Additionally, R&R Division 43 details guidelines for the design, construction, operation and closure of chemical mining operations. The following guidelines for control of surface water run-on and run-off and land disposal of wastewater are noteworthy:

- *Surface water run-on and run-off shall be controlled such that it will not endanger the facility or become contaminated by contact with process materials or loaded with sediment.*
- *To qualify for land disposal of excess wastewater, the permit applicant shall demonstrate to the Department that the process has been designed to minimize the amount of excess wastewater that is produced, through use of water-efficient processes, wastewater treatment and reuse, and reduction by natural evaporation. Excess wastewater that must be released shall be treated and disposed of to land under the conditions specified in the permit.*

## 9.6 NRC

Federal Regulations 10 CFR 40 Appendix A Criterion 9 and 10 CFR 51 require that licensees submit an environmental report which addresses expected environmental impacts of milling operations, decommissioning and tailings reclamation, and evaluates alternatives for mitigating these impacts. NRC Regulatory Guide 4.9 details specific requirements including proposed activities, plant operation, waste confinement and effluent control, the environmental effects of site development and operation, and effluent and environmental measurements and monitoring programs (explored in greater detail in NRC Regulatory Guide 4.14 and Table 6-1).

## 9.7 Points for Consideration

In our evaluation of several state and federal guidance documents for surface and underground mining, the following summarizes operational requirements and guidance for groundwater protection for consideration by Virginia. With respect to the various states, WDEQ LQD has a relatively comprehensive and frequently updated series of guidelines to ensure that the operator or applicant presents a complete permit application and fully describes their proposed means to protect the groundwater of the state. Especially pertinent to this section LQD has created Guideline 8—Hydrology. With respect to ISR, Wyoming allows an operator to complete a Hydrologic Unit Testing (HUT) program following mine permitting but in advance of mine operation. This testing program allows the operator to collect very site specific and localized data on geologic structure, thickness and continuity of confining beds, aquifer properties and the presence or absence of improperly completed abandoned drill holes. The HUT is well field specific. NRC Regulatory Guide 4.14 (1980) details operational monitoring requirements while Regulatory Guide 4.21 details minimization of contamination throughout the lifecycle of a milling facility. The following should be considered for requirement:

- A detailed plan on how the operator or applicant will protect the groundwater of the state during mining or milling operations including waste characterization and a means to selectively handle backfill and isolate unsuitable, acid-forming or toxic materials from the water table;



- A detailed mine dewatering plan to ensure that natural groundwater doesn't commingle with the mining operation and come into contact with operating equipment including oil and grease. This plan should include dewatering methods, anticipated water quality and quantity of dewatering, impacts of groundwater discharge to surface streams, impacts of dewatering to adjacent uses (groundwater modeling) and where applicable the need to construct a recharge trench to mitigate the impacts of mine dewatering;
- Although addressed in the baseline discussion, the applicant shall generally describe the impacts of the hydrogeology on the operational planning of the mine or mill. This description should clearly address: distance to the groundwater table; hydrogeologic properties including that of intervening stratigraphy;
- Present a subsidence analysis and mining efforts to minimize subsidence and impact to overlying springs and aquifers;
- Groundwater modeling to address impacts to area aquifers in water quantity and in the case of ISR mining, the ability to control excursions in the event that water quality exceedances (flare) should migrate past the monitor well ring. Any groundwater model should be calibrated to real time data, sensitivity analysis performed and the Applicant should validate the model during operations;
- A plan to protect water quality to include: mine discharge water quality (impacts to groundwater if recharged) and an effort to isolate acid forming or toxic materials;
- A plan to protect groundwater at mill sites including a double liner leak detection system and point of compliance monitoring;
- A description of the operators proposed monitor well networks for all potentially affected aquifers, including efforts to monitor nearby wetlands and springs;
- A description of proposed procedures for responding to accidents or releases of production or waste fluids and solids that may impact the local or regional groundwater system;
- A description of proposed mitigative action plans, which may include geologic and hydrologic siting criteria for mill and tailings disposal area and incorporation of best management practices for construction and operation;
- Mill control parameters to minimize spills that could impact groundwater; and
- A plan that describes corrective actions that might include replacement of water wells (water rights), artificial recharge and groundwater remediation.

## 10.0 CLOSURE AND RECLAMATION FOR GROUNDWATER PROTECTION (MINING AND MILLING)

The majority of states address final reclamation and groundwater restoration as part of their operational plan requirements. Reclamation requirements range from returning the land surface and the groundwater aquifers to an equal or higher land use to simply minimizing the impact to natural systems. In the case of returning systems to equal or high use classification, this may require (1) no contamination of groundwater or (2) in the event of contamination, restoration of the aquifer(s) to its pre-mining use characteristics. In the case of processing operations (milling and ISR), restoration includes return of the aquifer water quality to baseline conditions on a parameter-by-parameter basis and in some states on a well- or mine-area basis. In the event of leakage, site restoration is required. ISR facilities are regulated under EPA's aquifer exemption rules and groundwater contamination within the aquifer exemption area is allowed, but groundwater restoration is required to baseline conditions. Surface and underground mines are required to protect the aquifers of the state as well as surrounding water uses. Reclamation of the mining facilities requires groundwater protection and monitoring to ensure that there is no post-mining water quality degradation.

### 10.1 Wyoming

Reclamation plans are submitted during the initial steps of the permitting application in conjunction with the mine plan. Reclamation plans typically involve a resource or environmental protection plan encompassing water quality, quantity, and uses concurrent with a hydrologic restoration plan. Wyoming statutes address mining reclamation plan content in W.S. §35-11-406(b) though timelines, authorization of rules and regulations, and responsibilities are addressed in various statutes: W.S. §§35-11-401, 402, and 406. As previously discussed, several statutes simultaneously address requirements for the mine plan and the reclamation plan. The reclamation plan required by Wyoming includes the sequence of reclamation, restoration of land and water use, and pollution prevention and stability. W.S. §35-11-103 defines "reclamation" as

*“the process of reclaiming an area of land affected by mining to use for grazing, agricultural, recreational, wildlife purposes, or any other purpose of equal or greater value. The process may require . . . water treatment facilities in order to eliminate water diminution to the extent that existing water sources are adversely affected, pollution, or flooding resulting from mining or any other activity to accomplish the reclamation of the land affected to a useful purpose.”*

The timeline for commencement of restoration as outlined in W.S. §35-11-401 is within 30 days after either mining operations have ceased or abandonment of the mining operation. W.S. §35-11-401 also codifies compliance with reclamation and restoration rules and regulations of the LQD of the WDEQ.

W.S. §35-11-406 (b) simultaneously establishes the permit application requirements for both the mine plan and the reclamation plan and requires a statement of the source, quality and quantity of water, if any, to be used in the reclamation operations. W.S. §35-11-415 (b) outlines the duties of an operator with an approved reclamation plan. These duties and responsibilities include the following: comply with the approved reclamation plan, as outlined in W.S. §35-11-406(b) above, in content and language, focusing on prevention of erosion and contamination and restoration of the lands and waters to the “highest previous use.” Furthermore, the operator is tasked with the following:

*“Prevent, throughout the mining and reclamation operation, and for a period of five (5) years after the operation has been terminated, pollution of . . . subsurface waters on the land affected by the institution of . . . treatment facilities including settling ponds and the casing, sealing of boreholes, shafts, and wells so that no pollution is allowed to drain untreated into . . . subsurface water in accordance with state or federal water quality standards, whichever are higher, as may be required in the approved reclamation plan.”*

As specified and authorized in W.S. §§35-11-401, 402, and 406 above, the LQD developed reclamation and restoration rules and regulations applicable to uranium mining, specifically R&R Chapter 3 Noncoal mine environmental protection standards. In accordance with reclamation standards set forth in W.S. §35-11-402, R&R Chapter 3 requires that *“reclamation shall restore the land to a condition equal to or greater than the ‘highest previous use.’ The land, after reclamation, must be suitable for the previous use which was of the greatest economic or social value to the community area”* and operators are required to restore wildlife habitat. Below are requirements associated with groundwater:

- Reestablishment of adequate drainage if such a provision is necessary to prevent pollution or diminution of the quantity and quality of groundwater;
- If it is determined that the spoil material may be a source of water pollution through reaction with leaching by surface water, the operator shall describe proposed procedures for eliminating this condition; and
- Reclamation of tailings impoundments, tailings disposal areas, heap leach facilities, and spent ore disposal areas shall be accomplished by removal and storage of all topsoil present within the affected lands. After termination of operations, the facility shall be reclaimed in accordance with the approved plan using best technology currently available to ensure long-term stability and prevent contamination of groundwater.

## 10.2 Colorado

Colorado DRMS Hard Rock Mining Rule 3, reclamation performance standards, and Rule 6, permit application exhibit requirements both reiterate the statutes' detailed requirements for reclamation plans. While Rule 6 is general, Rule 3 details the following requirements:

- *When backfilling is a part of the plan, the Operator shall replace overburden and waste materials in the mined area and shall ensure adequate compaction for stability and to prevent leaching of toxic or acid-forming materials.*
- *Any drill or auger holes that are part of the mining operation shall be plugged with non-combustible material, which shall prevent harmful or polluting drainage.*
- *No unauthorized release of pollutants to ground water shall occur from any materials mined, handled or disposed of within the permit area.*
- *Hydrology and Water Quality: Disturbances to the prevailing hydrologic balance of the ground water systems after the mining operation and during reclamation shall be minimized by measures, including, but not limited to:*
  - *Compliance with applicable Colorado water laws and regulations governing injury to existing water rights;*
  - *Compliance with applicable federal and Colorado water quality laws and regulations, including statewide water quality standards and site-specific classifications and standards adopted by the Water Quality Control Commission; and*
  - *Compliance with applicable federal and Colorado dredge and fill requirements.*

## 10.3 Milling in Colorado

CDPHE 6 CCR 1007-1 Part 18.8 outlines decommissioning/reclamation requirements, including planned decommissioning activities, methods used to assure protection of the environment against radiation hazards during decommissioning, and the planned final radiation survey.

## 10.4 Oregon

As with Wyoming and Colorado, Oregon mining and reclamation plans are both required as part of initial permitting; therefore, the same state statutes codify both mining and reclamation requirements, including ORS §517.760, Policy and ORS 517.790, Operating permit required for surface mining on certain lands. Oregon state statutes require largely the same elements as those of Wyoming and Colorado; however, ORS §517.915, Additional operating permit requirements for nonaggregate mineral mines further clarifies that “*if the department finds that reclamation cannot be accomplished, it shall not issue an operating permit,*” specifying that “*the department shall consult with the soil and water conservation district in which the mined land is situated*

*regarding the feasibility of reclamation, with particular attention to possible impacts on groundwater aquifers.”*

ORS §517.832 details emergency operating permit rules and circumstances under which DOGAMI can issue an emergency permit or an amendment to an existing permit in the event of a natural disaster, including but not limited to a flood or an earthquake, or should the effects of a natural disaster threaten significant damage to property or to natural resources.

DOGAMI R&R Divisions 30, 35, 37, and 38 adopt and expand upon Oregon State Statutes codifying reclamation requirements. R&R Division 35 details requirements for a reclamation plan including the procedures necessary for groundwater protection and post-mine hydrologic controls, including the following:

- Procedures for ore storage sites to meet decommissioning performance standards for protection of ground water quality and living resources;
- Procedures for tailing disposal facility to meet decommissioning performance standards for long-term stability, protection of ground water quality and living resources and provide for attainment of site land use objectives;
- Removal of all process chemicals;
- Appropriate isolation or removal of waste material; and
- Monitoring system by which the success of the proposed reclamation can be measured for bond release.

Oregon R&R Division 38 is an innovative voluntary reclamation program which outlines incentives for voluntary reclamation. According to Oregon R&R Division 38, a reclamation practice may be considered for an incentive if it demonstrates “*effective reclamation techniques that have broad industry utility and likely will lead to higher quality reclamation.*”

## 10.5 ISR

Wyoming R&R Chapter 11, Noncoal in situ mining Section 5, Application content requirements—Reclamation Plan agrees with and augments W.S. §35-11-428 and 429; LQD R&R Chapter 1, Chapter 2, Section 1, and parts of Chapter 3, Section 2 and requires the following be addressed in the reclamation plan:

- Proposed groundwater restoration schedule including the proposed sequence for restoration of the wellfields and the capacity of the water/waste water treatment systems and correlation of the capacity with the mining and restoration schedules;
- Standards for returning all affected groundwater to the pre-mining class of use or better using Best Practicable Technology:

- The pre-mining background groundwater quality based on a range of factors including the character and degree of injury or interference, the social and economic costs and values of the source of pollution and the impacted aquifer, and the environmental impacts including potential impacts to other waters of the state;
  - The evaluation of restoration of the groundwater within the production zone is based on the average quality over the production zone on a parameter-by-parameter basis. For groundwater affected outside the production zone, the restoration is evaluated separately for each well; and
  - Adjacent aquifers and other waters within the same aquifers must be fully protected to their class of use and to applicable Maximum Contaminant Levels from the EPA Rules (40CFR141);
- A plan for well repair, plugging, and conversion;
  - A proposed time schedule for achieving reclamation;
  - Procedures for permanently disposing of any toxic or acid-forming materials;
  - Procedures for mitigating or controlling the effects of subsidence;
  - Procedures for ground surface preparation, depth of topsoil replacement, erosion control and water conservation practices;
  - The anticipated final water quality of the impoundment and its relationships to the proposed use of the impoundment;
  - Reclamation monitoring plan; and
  - State Engineer's Office approval.

Colorado MLRA details duties of the operator and reclamation plan requirements. The state statutes and rules and regulations requirements do not greatly expand beyond those detailed by Wyoming, except in the area of uranium mining requirements and responsibilities. CRS §34-32-112.5, Designated mining operation rules, specifies the events triggering reclamation, including the detection of subsurface excursion of chemicals outside of the affected area and/or the cessation of production operations.

CRS §34-32-116, Duties of operators - reclamation plans, details uranium mining responsibilities in Section 8 as outlined below:

*“All uranium extraction operations using in situ leach mining or recovery methods, including any injection of any chemicals designed to mobilize uranium resources, shall reclaim all affected ground water for all water quality parameters that are specifically identified in the baseline site characterization, or in the statewide radioactive materials standards or tables 1 through 4 of the*



*basic standards for ground water as established by the Colorado water quality control commission, to either of the following:*

- Pre-mining baseline water quality or better as established by the baseline site characterization conducted pursuant to section 34-32-112.5 (5); or
- That quality which meets the statewide radioactive materials standards and the most stringent criteria . . . . In establishing, designing, and implementing a ground water reclamation plan, the mine operator shall use best available technology.”

Similar to conventional mine plan requirements, Oregon Division 37 Chemical Mining requires that a chemical process mine comply with reclamation and mine closure standards utilizing the best available, practicable and necessary technology to assure compliance with environmental standards.

## 10.6 NRC

NRC 10 CFR 40 establishes technical and long-term site surveillance criteria relating to reclamation of uranium mills, mill tailings and associated waste systems. Closure plans must include removal or decontamination of all waste residues, contaminated containment system components, contaminated subsoils, and structures and equipment contaminated with waste and leachate. The goal of a closure plan is to “*control, minimize, or eliminate post-closure escape of nonradiological hazardous constituents, leachate, contaminated rainwater, or waste decomposition products to water or to the atmosphere.*” Reclamation plan requirements include interim stabilization, including dewatering and recontouring and final radon barrier construction.

## 10.7 Points for Consideration

In our evaluation of several state guidance documents for surface and underground mining, the following summarizes guidance for the development of reclamation plans that ensure groundwater protection. With respect to the various states, Wyoming DEQ/LQD has a relatively comprehensive and frequently updated series of guidelines to ensure that the Operator/Applicant presents a complete permit application and reclamation plan that addresses the need to protect the groundwater of the state. Especially pertinent to this section LQD created: Guideline 8—Hydrology. With respect to ISR, Wyoming has created Guideline 4, which specifically addresses ISR well field restoration, stability and surface reclamation of ISR facilities. In summary typical guidance documents recommend to the Applicant that they provide the following reclamation information pertinent to groundwater. The Applicant shall provide the following:

- A definition of reclamation goals and objectives, including restoration target values as they pertain to ISR mining. The Applicant must address a complete post-mining and milling aquifer monitoring plan. The monitoring plan for conventional mining should



- be designed and operated to ensure post-mining geologic and hydrologic stability and no impacts to neighboring wells, wetlands or ecosystems.
- Hydrologic restoration of the groundwater resource. In the case of open pit mining the plan should include a detailed backfill and selective handling (isolation) of acid-forming and toxic materials. Recovery of the water table and predictions of post-mining water quality shall be part of the final plan. The applicant shall present information on aquifer recharge and/or continued discharge into pit or underground mine and predictions of the final potentiometric surface.
  - Mineralogical information to ensure that there will not be acid rock generation in pit walls or within the underground mine workings. Guidance documents often address means and methods to allow quantitative and qualitative prediction of post-mining water quality including column leach studies, laboratory bench scale studies, weathering cells and geochemical models. Water quality parameters of interest include, but are not limited to total dissolved solids, sulfates, pH, trace metals and radionuclides. Potential for long-term impacts to springs or groundwater quantity or quality needs to be addressed.
  - A plan to ensure the protection of water uses down gradient of the reclaimed mine/mill complex.
  - A plan to ensure that underground mining will not result in subsidence or negative impacts to overlying aquifers.
  - Procedures for responding to accidents or releases of production or waste fluids and solids. A plan for final surface clean-up and removal of contaminated soils.
  - With respect to decontamination and decommissioning, the Applicant shall present a plan to dewater tailings, capping and final closure (milling). Within the framework of that plan, the Applicant shall present a plan for solid and liquid waste disposal, including regulated licensed materials (evaporation pond liners, contaminated clay and soils, buildings and structures, etc.) that may impact groundwater quality.

## 11.0 WELL CONSTRUCTION AND ABANDONMENT STANDARDS

Well construction and abandonment standards are housed in each state's rules and regulations and guidelines, as applicable.

### 11.1 Wyoming

WQD Chapter 11 and Wyoming State Engineer's Office Rules Part III both explore well construction, well siting, sealing of the annular space, surface construction features, casing, sealing and cementing off strata, well development, and abandonment. Wyoming Guideline 8 provides more detailed guidance for the well construction at all mining operations with the following:

- Casing;
- Well Diameter;
- Screening and Packing;
- Annular and Surface Seals;
- Well Efficiency Tests;
- Well Completion Information; and
- Well Inspection and Maintenance Plan.

Guideline 8 also describes yearly well inspection and maintenance, including total depth measurements, surface seal and casing integrity verification, and historic measurements confirmation for wells with suspected problems.

### 11.2 Colorado

Colorado Department of Natural Resources, DNR Rule 2 CCR 402-2 identifies not only well construction but also borehole and well abandonment requirements. This rule provides minimum construction standards, minimum disinfection standards, well testing, sampling and measuring, standards for plugging and sealing, standards for abandoning wells and boreholes, and reporting requirements. CDPHE also has "Design Criteria for Potable Water Systems" that describes well construction criteria. These rules are referenced by both CDPHE and DRMS in mining and milling regulations.

### 11.3 Oregon

ODEQ R&R Division 78 (690-200 through 690-240) and Division 44 (340-044) detail construction and decommissioning requirements of waste, water, and underground injection activities but they do not expand beyond Colorado and Wyoming regulations.

## 11.4 ISR

For ISR, Wyoming retains the most thorough regulations and will be explored herein. WDEQ/LQD Chapter 11, Noncoal In Situ Mining, Section 6 details well construction requirements. Well siting requirements include the prohibition of wells in perennial drainages. *“If a well must be located in an ephemeral or intermittent drainage, the well shall not be located in the streambed (i.e., the channel) of the drainage and during well construction and use, steps shall be taken to minimize the potential for damage to the channel, such as from erosion and sedimentation, and to protect the well from damage due to erosion and to prevent surface water runoff from entering the well.”* Well development methods must *“not cause damage to the well or cause adverse subsurface conditions that may destroy barriers to the vertical movement of water between water-bearing strata.”*

Additional construction standards are detailed in WDEQ/LQD Chapter 11, Section 6, including top of casing requirements and annular seal standards, procedures, and materials. Annular seals shall be installed to *“protect against contamination or pollution of the well from the surface; and prevent migration of ground water from one aquifer or water-bearing strata to another in accordance with the following requirements.”*

Criteria dictating the number, location, and construction of the monitoring wells and frequency of monitoring, including considerations for the following:

- *The uses for which the ground water in the receiving strata is suitable under pre-mining conditions;*
- *The proximity of the injection operation to points of withdrawal;*
- *The local geology and hydrology;*
- *The operating pressures and whether a negative pressure gradient is being maintained;*
- *The nature and volume of the injection fluids, formation fluids, process byproducts, and recovery fluids; and*
- *The injection well density.*

Mechanical integrity of injection wells must be verified in accordance with WDEQ/LQD Chapter 11, Section 7 that requires standards, schedules, and methods requiring pressure tests and monitored for leaks, unauthorized fluid migration, and other indicators of compromised integrity such as noise logs.

WDEQ/LQD Chapter 11, Section 8 addresses well abandonment and plugging requirements applicable if a well lacks mechanical integrity. As such, *“repair or plugging of the well is*

*required to prevent the movement of fluid into unauthorized zones or onto the surface caused by the lack of mechanical integrity. Repair or plugging of the well must be completed within 120 days of the testing which indicates the well lacks mechanical integrity.”* Section 8 details well plugging materials, methods, procedures, monitoring, and reporting.

## **12.0 WATER QUALITY CONSTITUENTS, SAMPLING, AND TESTING PROTOCOLS**

### **12.1 Virginia's Current Water Quality Standards**

Surface water and groundwater quality from uranium mines and mills is typically monitored for physical properties (i.e., conductivity, TSS, pH, major ions, and common trace metals as well as radium-226, combined radium-226 and 228, gross alpha, gross beta and uranium. The Virginia Water Control Board (Board) provides the majority of surface water and groundwater quality standards for Virginia. Many of the Board's regulations are relevant to uranium mining and milling operations and are summarized in the following subsections.

#### **12.1.1 Surface Water Standards**

The Board's 9 Virginia Administrative Code (VAC) 25-260 regulations contain the general surface water quality standards for Virginia and are administered and enforced by the VDEQ. These standards apply throughout Virginia and are intended to protect surface water resources from contamination by sewage, industrial wastes, agricultural runoff and other types of wastes. These standards address any discharges that may impact the water's quality above the set standards, may interfere with the designated uses of the water, or may make the water harmful to the public or the natural environment.

Surface water standards (numerical criteria provided in 9VAC 25-260-140) vary depending on use such as human health or aquatic life. The human health subcategories further distinguish between public water supply and other surface waters. Standards for human health were developed to protect human health from toxic effects through drinking water and fish consumption, unless otherwise noted. The human health standards generally mirror the EPA SDWA criteria. In addition, acute and chronic toxicity standards are provided for aquatic life.

The Board's standards that are most applicable to uranium mining and milling are summarized in Table 2.1, Surface Water Standards along with applicable Wyoming, Colorado, Oregon, and NRC standards. The Board's criteria include many of the major ions and trace metals that would be expected in waste waters of a uranium mine or milling operation as well as standards for combined radium-226 and -228 (5 pCi/L), gross alpha (15 pCi/L), gross beta (4 millirems per year [mrem/yr]) and uranium (0.03 mg/L). There is no stated surface water standard for radium-226.

The Board, as part of their General Permit Regulation for Industrial Storm Water discharges (9VAC25-151), has developed benchmark limits for several constituents of concern that may be present in storm water discharges from metal mines. These monitoring requirements are provided in Sector G of the regulation and are summarized in Table 12-1. The benchmark

monitoring requirements include numeric values for TSS, turbidity, pH, hardness and 12 trace metals.

Additional monitoring requirements for discharges from metal mines, including uranium mines, are provided in Table 2-1. These additional monitoring requirements do not provide numerical values but include monitoring TSS, pH, chemical oxygen demand (COD), arsenic, radium (dissolved and total recoverable), uranium and zinc.

The VDMME in their Reclamation Regulations for Mineral Mining at 4VAC25-31-490 has one water quality requirement and it establishes a pH limit ranging from 6.0 to 9.0 standard units (SU) for all surface water discharges resulting from the mining of minerals. This pH standard is consistent with standards described in 9VAC25-260-140 and 9VAC25-151-150.

### **12.1.2 Groundwater Standards**

The Board's regulations (9VAC 25-280) contain the general groundwater quality standards for Virginia, which are administered and enforced by VDEQ. These standards apply throughout Virginia and are designed to maintain the quality of Virginia's groundwater resources. Because of regional groundwater differences, Virginia is divided into four physiographic provinces. Additional groundwater quality standards for the four physiographic provinces within Virginia are provided at 9VAC 25-280-50 and 9VAC 25-280-70. Table 2-2, summarizes Virginia's groundwater standards for parameters that are commonly associated with uranium mines and mills. Also included are applicable Wyoming, Colorado, Oregon, and NRC standards.

The Board's regulations provide maximum limits for some of the major ions and common trace metals as well as radium-226 (3 pCi/L), combined radium-226 and 228 (5 pCi/L), gross alpha (15 pCi/L), and gross beta (50 pCi/L). The Board does not provide a standard for natural uranium. The additional groundwater standards provided for the physiographic provinces also do not provide standards for natural uranium (U-nat) or other uranium decay chain radionuclides (e.g. lead-210, polonium-210, thorium-230). A range is provided in Table 2-2 for parameters that vary by the physiographic province.

For groundwater monitoring programs under RCRA, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Commonwealth remediation programs, Virginia also utilizes any applicable EPA Maximum Contaminate Levels, human health risk screening levels and/or site specific standards.

## **12.2 Wyoming Water Quality Standards**

### **12.2.1 Surface Water Quality**

The Wyoming surface water quality standards are contained within WDEQ/WQD R&R Chapter 1 and are authorized by the Wyoming EQA at W.S. §35-11-302(a)(i). Chapter 1 states

that the Wyoming Water Pollution Control Program is designed to serve both the state objectives and policies of the Federal Act. In general, when attainable, the stream water quality should be commensurate with the designated highest and best use including agriculture, fisheries, industry, drinking water, recreation, scenic value, aquatic life other than fish, wildlife, and fish consumption.

Wyoming has four main classes of surface water which are based on water quality. Standards for surface water vary by class. Class I waters are the best quality and are not allowed to be degraded by point source discharges. Examples include surface waters within wilderness areas and national parks. Class II waters are waters, other than those classified as Class I, that are used for drinking water and support or are capable of supporting fish. This class of water includes waters within national forests that are not part of a wilderness area. Class III waters are waters, other than those classified as Class I, that do not support or do not have the potential to support fish because of natural conditions. Class IV waters are waters, other than those classified as Class I, where aquatic life uses are not attainable. Class IV uses may include recreation, wildlife, industry, agriculture and scenic value.

Wyoming surface water standards for Class I and Class II waters are similar to the EPA and Commonwealth criteria. Similar to Virginia, Wyoming has water quality standards that differ for human health and aquatic life depending on beneficial use. The human health standards were also developed to protect against toxicity from drinking water and fish consumption.

Wyoming provides additional numeric values for several major ions and trace metals compared to Virginia (Table 2-1). However, unlike Virginia, Wyoming does not provide any standards for combined radium-226 and 228, gross alpha, gross beta, or uranium. Wyoming has a radium-226 chronic toxicity standard for aquatic life (60 pCi/L), but does not provide a human health standard for radium-226.

### **12.2.2 Groundwater Quality**

Wyoming groundwater quality standards are contained within WDEQ/WQD R&R Chapter 8 and are also authorized by the Wyoming EQA at W.S. §35-11-302(a)(i). Chapter 8 states that all groundwater bodies, including the vadose zone, shall be protected. In general, water should be protected for its intended use and uses for which it is suitable. If the water is not in use, it shall still be protected for the uses for which it is suitable.

There are seven classes of groundwater which vary by use. Numeric standards have been developed for four of these classes including Domestic (Class I), Agriculture (Class II), Livestock (Class III), and Fish and Aquatic Life (Class Special A). Table 2-2, summarizes the Wyoming standards for parameters commonly associated with uranium mines and milling. The additional three classes of groundwater do not have associated numeric standards but are



generally defined as follows: Industrial (Class IV), Hydrocarbon Commercial (Class V), and Unsuitable (Class VI).

Similar to the surface water section, Wyoming has more groundwater criteria than Virginia, but fewer standards for radiological constituents (Table 2-2). Wyoming does have groundwater standards for combined radium-226 and -228 (5 pCi/L) and gross alpha (15 pCi/L), but does not have human health or Class I, II, or III standards for radium-226, gross beta, or uranium. Class Special A standards for fish and aquatic life provide a range for uranium (0.03 to 1.4 mg/L; Table 2-2).

## 12.3 Colorado Water Quality Standards

### 12.3.1 Surface Water Quality

Rule 5 CCR 1002-31 of CDPHE Water Quality Control Commission establishes statewide standards and a system for classifying surface waters of the state. The authorizing legislation is the Colorado Water Quality Control Act. The regulation provides a classification system that combines beneficial use categories with basic state wide standards. Beneficial uses include domestic water supply, aquatic life, agriculture, and recreation. The intent of the standards is to implement the state Act by maintaining and improving the quality of the state's surface water based on beneficial use.

Surface water standards in Colorado vary depending on its use, which is consistent with Virginia, Wyoming and EPA criteria. The two main categories are human health and aquatic life, each of which have further subcategories and associated standards. Human health standards protect against toxins from water supply and fish consumption.

Of the four states being compared, Colorado has the most surface water standards for human health parameters commonly associated with uranium mining and milling (Table 2-1). In addition to the major ions and common trace metals that are regulated, Colorado also has standards for combined radium-226 and 228 (5 pCi/L), uranium (0.0168 mg/L), and gross alpha (15 pCi/L). No standards are present for radium-226 or gross beta (Table 2-1).

### 12.3.2 Groundwater Quality

Rule 5 CCR 1002-41 of the CDPHE Water Quality Control Commission establishes statewide standards and a system for classifying groundwater to protect existing and potential beneficial uses of groundwater. The authorizing legislation is the Colorado Water Quality Control Act.

Similar to the other states, groundwater is classified by use including Domestic Use-Quality, Agricultural Use-Quality, Surface Water Quality, Potentially Usable Quality, and Limited Use and Quality. Water standards vary by use; Domestic Use-Quality and Agricultural Use-Quality generally have the most stringent regulations. Additionally, Colorado provides narrative,

numeric, and statewide standards. Narrative standards generally state that groundwater will be free of pollutants that do not have numeric standards and free of pollutants that, which alone or in combination with, “*are in concentrations shown to be carcinogenic, mutagenic, teratogenic, or toxic to human beings, and/or, a danger to the public health, safety, or welfare.*”

The standards developed by the state of Colorado are very similar in content and value to Wyoming and Virginia and are summarized in Table 2-2. Similar to the surface water criteria, Colorado has more numeric standards for major ions and trace metals than the other three states. Groundwater is regulated for combined radium-226 and -228 (5 pCi/L), gross alpha (15 pCi/L), gross beta (4 mrem/yr), and uranium (0.03 mg/L). There is no standard for radium-226. Colorado as an NRC Agreement State has adopted certain additional radionuclide parameters including thorium-230, polonium 210 and all of the Regulatory Guide 4.14 parameters.

Additional standards for licensing requirements for uranium processing are provided in 6 CCR 1007-1. These standards are summarized in Table 2-2. Standards are available for combined radium-226 and -228 (5 pCi/L) and gross alpha (15 pCi/L).

## 12.4 Oregon Water Quality Standards

### 12.4.1 Surface Water Quality

Oregon’s surface water quality standards are contained within OAR 340-41 and are administered and enforced by the ODEQ. Numeric and narrative statewide criteria to protect surface water resources, human health and aquatic life are provided in this section. OAR 340-41-033 provides information specific to toxic substances. Within this section there are human health criteria as well as acute and chronic aquatic life standards. Human health criteria are designed to protect against potential adverse health effects associated with long-term exposure to toxic substances from the consumption of water and fish.

Oregon’s relevant surface water standards and freshwater guidelines are summarized in Table 2-1. Numeric criteria for radiological constituents are provided as part of the freshwater acute toxicity criteria and include combined radium-226 and -228 (5 pCi/L), radium-226 (2.5 pCi/L), gross alpha (15 pCi/L), and gross beta (50 pCi/L). No regulations are provided for uranium.

### 12.4.2 Groundwater Quality

Oregon’s groundwater quality standards are contained within OAR 340-40 and are administered and enforced by ODEQ. These criteria establish minimum requirement for groundwater quality protection. OAR 340-40-020 contains the general groundwater polices. The numerical reference and guidance levels provided in this regulation were obtained from the SDWA and are for certain organic and inorganic parameters, but exclude radionuclides. Rule OAR 340-40-090 provides interim groundwater standards for groundwater contaminants within designated

groundwater management areas. The standards are essentially the same as what is in OAR 340-40-020, but include some radionuclides and microbiological substances as well as turbidity. Numeric standards for combined radium-226 and -228 (5 pCi/L), gross alpha (15 pCi/L), and gross beta (50 pCi/L) are included. No standards are promulgated for radium-226 or uranium. Table 2.2 summarizes relevant groundwater standards.

## 12.5 NRC Water Quality Standards

NRC generally defers to EPA's Primary Drinking Water regulations 40 CFR Parts 141 and 440, which provide maximum contaminant limits for drinking water and mining effluent and extends the regulation to cover acceptable contaminant concentrations in surface water at uranium facilities and mills. There are examples where NRC regulations (and/or EPA regulations) lag behind each other.

10 CFR 40 Appendix A, Criterion 5A provides the NRC's primary groundwater protection standards for uranium mining and mills. Criterion 5C provides maximum concentrations for several metals and organics that may be found in the wastes of a uranium mill. The relevant numeric standards are summarized in Table 2-2. Criterion 5B addresses potential hazardous materials, including uranium and thorium byproduct materials. These hazardous constituents are listed in Criterion 13 and essentially must not exceed baseline values at the point of compliance (Criterion 5B(5)). If the background value cannot be practicably achieved, Criterion 5B(6) allows the licensee to apply for an alternate concentration limit (ACL). The ACL will be approved only if the licensee can show that the alternative limit will be as low as reasonably achievable, after considering practicable corrective actions, and that the constituent will not pose a substantial present or potential hazard to human health and the environment as long as the proposed ACL is not exceeded.

## 12.6 Gaps in Virginia's Water Quality Standards

Virginia's surface water quality standards for parameters commonly associated with uranium mining and milling are generally comparable to standards in Wyoming, Colorado, and Oregon (Table 2-1). Regulations for beryllium, fluoride, mercury, and silver may be beneficial to develop for regulating uranium mining and milling. Radiological regulations are also comparable between Virginia and the other three states. Virginia does not have surface water standards for radium-226, but maintains a combined radium-226 and radium-228.

Groundwater quality standards in Virginia are relatively comparable to Wyoming, Colorado, and Oregon. Fluoride and silver are the only two parameters in Table 2-2 that for which Virginia does not have a standard although Wyoming, Colorado, and Oregon do have standards for these constituents. In order to address NRC regulations (10 CFR 40), silver would need to be regulated and have a maximum standard of 0.05 mg/L. Virginia does not have a standard for

uranium and developing a uranium standard would be beneficial to protect groundwater resources.

Unlike Wyoming and Colorado, Virginia does not classify groundwater by use. Additionally or alternatively, developing a risk based approach for determining protective concentrations of constituents of concern that do not have numeric standards will likely be valuable, especially for uranium mining operations where such a standard does not currently exist. This could be similar to the groundwater monitoring approach under RCRA where concentrations are compared to background, maximum contaminant levels (MCLs) and/or risk-based screening levels for constituents where MCLs do not exist.

## 13.0 REFERENCES

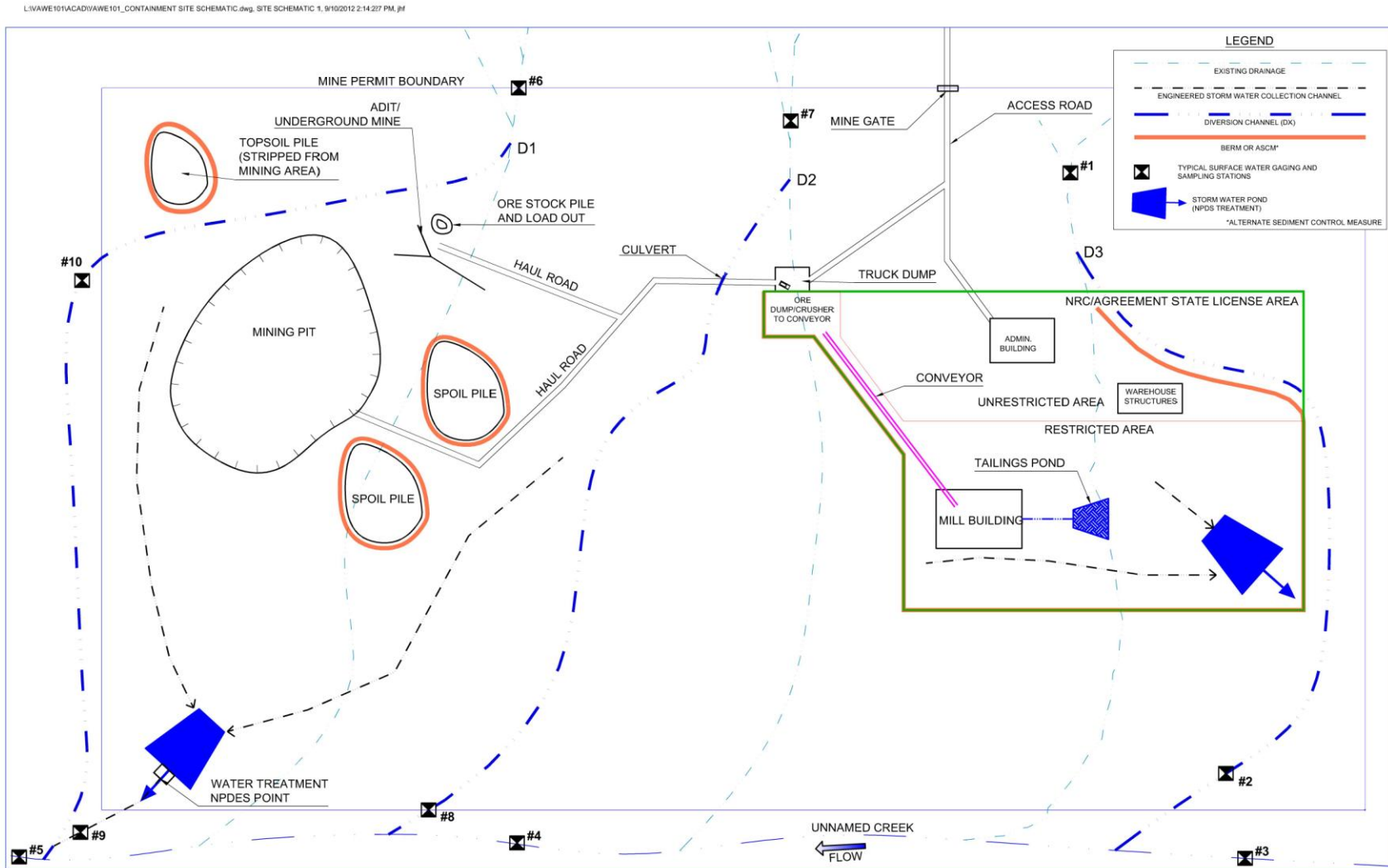
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## FIGURES

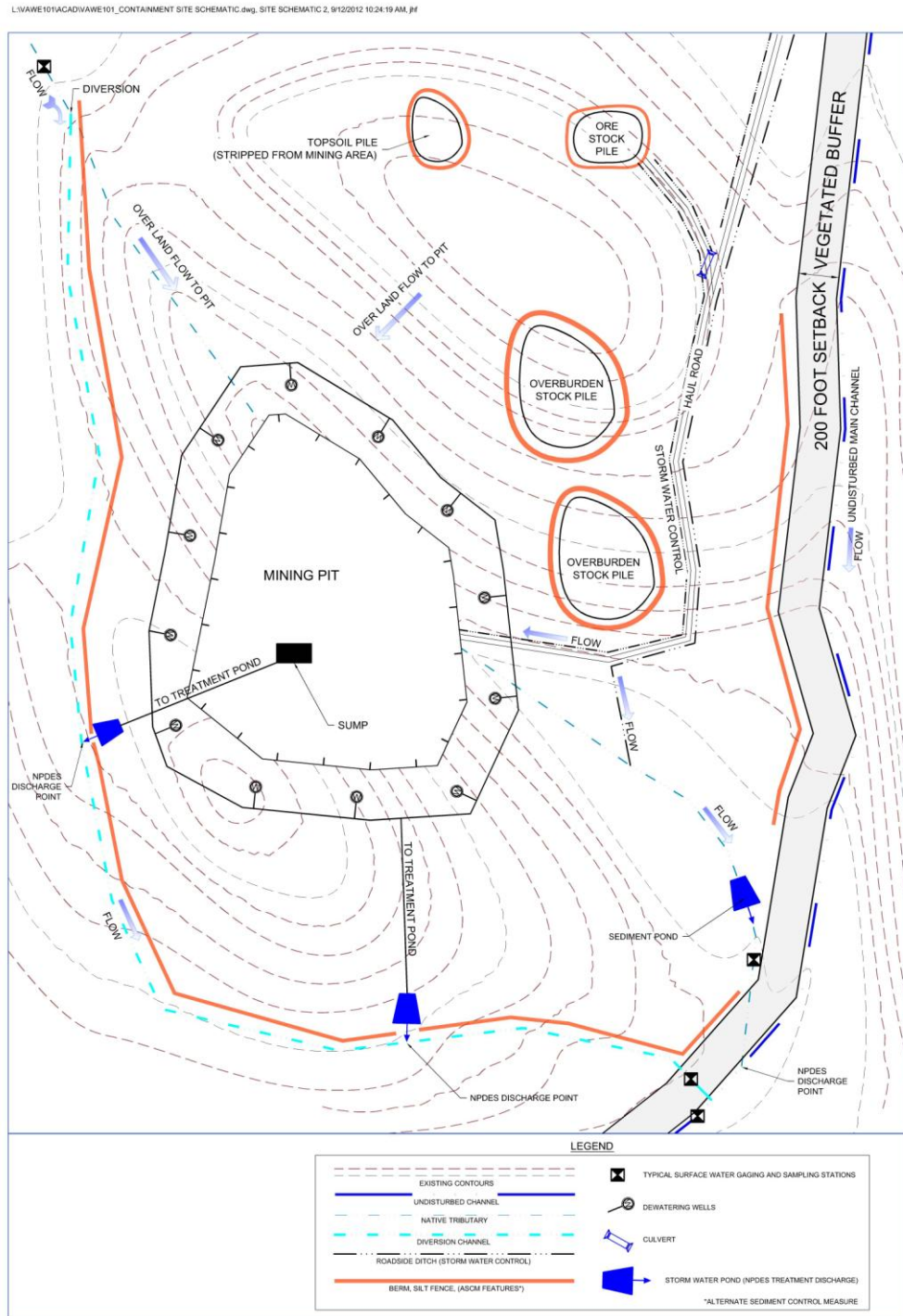


Commonwealth of Virginia  
Uranium Study: Surface Water & Groundwater Monitoring



**Figure 1-1 Conceptual Permit Area Site Schematic**

Commonwealth of Virginia  
Uranium Study: Surface Water & Groundwater Monitoring



**Figure 2-1 Conceptual Storm Water Runoff Site Schematic**

## TABLES

Table 2-1      Surface Water Quality Standards

	Virginia				Wyoming			Colorado				Oregon			
	9VAC25-260-140 Public Water Supply (Water and Fish Consumption)	9VAC25-260-140 Surface Water (Water and Fish Consumption)	9VAC25-260-140 Aquatic Life Acute	9VAC25-260-140 Aquatic Life Chronic	Chapter 1 Human Health (Water and Fish Consumption)	Chapter 1 Aquatic Life Acute	Chapter 1 Aquatic Life Chronic	5 CCR 1002-31 Human Health (Water and Fish Consumption)	5 CCR 1002-31 Aquatic Life Acute	5 CCR 1002-31 Agriculture	5 CCR 1002-31 Recreation	OAR 340-041 Table 40 Human Health for Toxic Pollutants (Water and Fish Consumption)	OAR 340-041 Table 20 Freshwater Acute Criteria	OAR 340-041 Table 20 Freshwater Chronic Criteria	OAR 340-041 Table 33C Freshwater Guidance
Surface Water Constituents	values in mg/L unless otherwise noted														
Alkalinity													20		
Aluminum						0.75	0.087		hardness- dependent						
Ammonia Nitrogen as N		36.1	24.1	5.91		24.1	5.91						pH/temp dependent		
Antimony	0.0056	0.640			0.0056			0.006				0.0051			9
Arsenic	0.01		0.340	0.150	0.01	0.340	0.150	0.00002	0.340			0.0021	0.36	0.19	
Barium	2.0				2.0			1.0				1.0	1.00		
Beryllium					0.004			0.004		0.100					0.13
Boron										0.75					
Cadmium	0.005		0.0039	0.0011	0.005	0.002	0.00025	0.005		0.010			0.0039	0.0011	
Chloride	250		860	230		860	230	250					860	230	
Chromium III	0.10		0.570	0.074	0.10	0.5698	0.0741	0.05		0.10			1.70	0.21	
Chromium VI			0.016	0.011	0.10	0.016	0.011	0.05	0.016	0.100			0.016	0.011	
Copper	1.3		0.013	0.009	1.0	0.0134	0.009	1.0		0.200		1.3	0.018	0.012	
Fluoride					2.0			2.0					4.00		
Total and Dissolved Iron	0.30				0.30 <sup>1</sup>		1.00 <sup>1</sup>	0.30	1.0					1.0	
Lead	0.015		0.120	0.014	0.015	0.0646	0.0025	0.05		0.10			0.082	0.0032	
Manganese	0.05				0.05	3.11	1.462	0.05		0.20			0.05		
Mercury			0.0014	0.00077	0.00005	0.0014	0.00077	0.002					0.0024	0.000012	

Table 2-1      Surface Water Quality Standards

	Virginia				Wyoming			Colorado				Oregon			
	9VAC25-260-140 Public Water Supply (Water and Fish Consumption)	9VAC25-260-140 Surface Water (Water and Fish Consumption)	9VAC25-260-140 Aquatic Life Acute	9VAC25-260-140 Aquatic Life Chronic	Chapter 1 Human Health (Water and Fish Consumption)	Chapter 1 Aquatic Life Acute	Chapter 1 Aquatic Life Chronic	5 CCR 1002-31 Human Health (Water and Fish Consumption)	5 CCR 1002-31 Aquatic Life Acute	5 CCR 1002-31 Agriculture	5 CCR 1002-31 Recreation	OAR 340-041 Table 40 Human Health for Toxic Pollutants (Water and Fish Consumption)	OAR 340-041 Table 20 Freshwater Acute Criteria	OAR 340-041 Table 20 Freshwater Chronic Criteria	OAR 340-041 Table 33C Freshwater Guidance
Molybdenum								0.210		0.30					
Surface Water Constituents	values in mg/L unless otherwise noted														
Nickel	0.610		0.180	0.020	0.10	0.4682	0.052	0.10		0.20		1.40	1.40	0.16	
Total Nitrate+Nitrite as N					10.0										
Nitrate as N	10.0				10.0			10.0		100					
Nitrite as N					1.0			1.0		10					
Dissolved Oxygen								3.0	5.0-7.0	3.0	3.0				
Field Water pH	6.0-9.0				6.5-8.5		6.5-9.0	5.0-9.0		6.5-9.0	6.5-9.0		6.5-8.5		
Selenium	0.170		0.020	0.005	0.05	0.02	0.005	0.05	0.00184	0.02		0.12	0.26	0.035	
Silver			0.0034			0.0034		0.10					0.0041	0.00012	
Sodium	270														
Sulfate	250							250							
Sulfide							0.002	0.05	0.002	0.002				0.002	
Turbidity (NTU)						Increase <10							1.00		
Total Dissolved Solids	500														
Total Suspended Solids (TSS)															
Vanadium (mg/L)					0.10			0.10							
Zinc	7.40		0.120	0.120	5.0	0.1172	0.1181	5.0		2.0		2.1	0.12	0.11	

Table 2-1      Surface Water Quality Standards

	Virginia				Wyoming			Colorado				Oregon			
	9VAC25-260-140 Public Water Supply (Water and Fish Consumption)	9VAC25-260-140 Surface Water (Water and Fish Consumption)	9VAC25-260-140 Aquatic Life Acute	9VAC25-260-140 Aquatic Life Chronic	Chapter 1 Human Health (Water and Fish Consumption)	Chapter 1 Aquatic Life Acute	Chapter 1 Aquatic Life Chronic	5 CCR 1002-31 Human Health (Water and Fish Consumption)	5 CCR 1002-31 Aquatic Life Acute	5 CCR 1002-31 Agriculture	5 CCR 1002-31 Recreation	OAR 340-041 Table 40 Human Health for Toxic Pollutants (Water and Fish Consumption)	OAR 340-041 Table 20 Freshwater Acute Criteria	OAR 340-041 Table 20 Freshwater Chronic Criteria	OAR 340-041 Table 33C Freshwater Guidance
Radiological Constituents	values in pCi/L unless otherwise noted														
Combined Ra 226 and 228	5							5.00					5.00		
Radium 226							60						2.50		
Uranium (mg/L)	0.03							0.0168							
Gross Alpha	15							15					15		
Gross Beta	4 mrem/yr												50		

Table 2-2      Groundwater Quality Standards

	Virginia	Wyoming				Colorado			Oregon			NRC
	9VAC25-280 Groundwater Standards	Chapter 8 Domestic Supply (Class I)	Chapter 8 Agricultural Standards (Class II)	Chapter 8 Livestock Supply Standards (Class III)	Chapter 8 Fish/Aquatic Life (Class Special A)	5 CCR 1002-41 Domestic Supply	5 CCR 1002-41 Agricultural Standards	6 CCR 1007-1 Li. Commencing Requirements for Uranium Processing	OAR 340-40 Groundwater Reference Levels	OAR 340-40 Groundwater Guidance Levels	OAR 340-40 Interim Standards	10 CFR 40 Groundwater Standards (Criterion 5C)
Groundwater Constituents	values in mg/L unless otherwise noted											
Alkalinity	10-500, regional											
Aluminum			5.0	5.0	0.1		5					
Ammonia Nitrogen as N	0.025	0.5			0.02							
Antimony						0.006						
Arsenic	0.05	0.05	0.1	0.20	0.05	0.01	0.10	0.05	0.05		0.05	0.05
Barium	1.0	2.0			5.0	2.0		1.0	1.0		1.0	1.0
Beryllium			0.1		0.011-1.3	0.004	0.100					
Boron		0.75	0.75	5.0			0.75					
Cadmium	0.0004	0.005	0.010	0.050	0.0004- 0.015	0.005	0.010	0.010	0.01		0.01	0.01
Chloride	25-50, regional	250	100	2000		250				250		0
Chromium	0.05	0.10	0.10	0.50	0.05	0.1	0.10	0.05	0.05		0.05	
Copper	1.0	1.0	0.2	0.5	0.01-0.04	1.0	0.2			1.0		
Fluoride		4.0				4.0	2		4.0		4.0	
Hardness	120-300, regional											
Hydrogen sulfide	1.40	0.05			0.002							
Total and Dissolved <sup>1</sup> Iron	0.01-10, regional	0.3	5.0		0.5	0.3	5			0.3		
Lead	0.05	0.015	5.0	0.10	0.004-0.15	0.05	0.10	0.05	0.05		0.05	



Table 2-2 Groundwater Quality Standards

	Virginia	Wyoming				Colorado			Oregon			NRC
	9VAC25-280 Groundwater Standards	Chapter 8 Domestic Supply (Class I)	Chapter 8 Agricultural Standards (Class II)	Chapter 8 Livestock Supply Standards (Class III)	Chapter 8 Fish/Aquatic Life (Class Special A)	5 CCR 1002-41 Domestic Supply	5 CCR 1002-41 Agricultural Standards	6 CCR 1007-1 Li. Commencing Requirements for Uranium Processing	OAR 340-40 Groundwater Reference Levels	OAR 340-40 Groundwater Guidance Levels	OAR 340-40 Interim Standards	10 CFR 40 Groundwater Standards (Criterion 5C)
Groundwater Constituents	values in mg/L unless otherwise noted											
Manganese	0.01-0.5, regional											
Mercury	0.00005	0.002		0.00005	0.00005	0.002	0.010	0.002	0.002		0.002	0.002
Molybdenum						0.035						
Nickel			0.2		0.05-0.4	0.1	0.20					
Total Nitrate + Nitrite				100.0		10.0	100.0					
Nitrate as N	0.5-5	10.0				10.0			10.0			
Nitrite as N	0.025	1.0		10.0		1.0	10.0					
Field Water pH	5-9, regional	6.5-8.5	4.5-9.0	6.5-8.5	6.5-9.0	6.5-8.5	6.5-8.5			6.5-8.5		
Selenium	0.01	0.05	0.02	0.05	0.05	0.05	0.02	0.01	0.01		0.01	0.01
Silver		0.10			0.0001- 0.00025	0.05		0.05	0.05		0.05	0.05
Sodium	25-100, regional											
SAR			8									
Sulfate	25-150, regional	250.0	200.0	3000.0		250				250		
Total Organic Carbon (TOC)	10											
Total Dissolved Solids (TDS)	250-1000, regional	500.0	2000.0	5000.0	500.0- 2000.0		400 or 1.25xbackground				500	
Turbidity (NTU)											1	
Vanadium (mg/L)			0.10	0.10		0.1	0.10					

Table 2-2 Groundwater Quality Standards

	Virginia	Wyoming				Colorado			Oregon			NRC
	9VAC25-280 Groundwater Standards	Chapter 8 Domestic Supply (Class I)	Chapter 8 Agricultural Standards (Class II)	Chapter 8 Livestock Supply Standards (Class III)	Chapter 8 Fish/Aquatic Life (Class Special A)	5 CCR 1002-41 Domestic Supply	5 CCR 1002-41 Agricultural Standards	6 CCR 1007-1 Li. Commencing Requirements for Uranium Processing	OAR 340-40 Groundwater Reference Levels	OAR 340-40 Groundwater Guidance Levels	OAR 340-40 Interim Standards	10 CFR 40 Groundwater Standards (Criterion 5C)
Zinc	0.05	5.0	2.0	25.0	0.05-0.6	5	2			5		
Radiological Constituents	values in pCi/L unless otherwise noted											
Combined Radium 226 and 228	5	5	5	5	5	5		5			5	5
Radium 226	3											
Gross Alpha	15	15	15	15	15	15		15			15	15
Gross Beta	50					4 mrem/yr					50	
Uranium (mg/L)					0.03-1.4	0.03						

**Table 2-3      40 CFR 440.34 New Point Source Effluent Limitations for Conventional Uranium Mines and Mills**

<b>Effluent Characteristic</b>	<b>Maximum for any 1 day (mg/L)</b>	<b>30 day average of daily values (mg/L)</b>
TSS	30	20
COD	200	100
U	4.0	2.0
Zn	1.00	0.5
Ra226 (dissolved)	10 (pCi/L)	3 (pCi/L)
Ra226 (total)	30 (pCi/L)	10 (pCi/L)
pH	6.0-9.0	6.0-9.0

**Table 2-4 Applicability of 40 CFR Part 440 Effluent Limitation Guidelines to Storm Water Runoff from Active Ore (Metal) Mining and Dressing Sites (Uranium, Radium and Vanadium Ores)**

Discharge/source of discharge	Applicable ELG, if any (see key)	Note/comment
Land application area runoff .....	MD	PW—if Process fluids present.
Crusher area .....	MD	PW—if Process fluids present.
Piles (seepage and/or runoff):		
Spent ore .....	MD	PW—if Process fluids present.
Surge/Ore .....	MD	PW—if Process fluids present.
Waste rock/overburden .....	MD	
Topsoil .....	SW	
Drainage:		
Pit drainage (unpumped) .....	MD	
Pit drainage (removed by pumping) .....	MD	
Mine water from underground mines (unpumped), adit discharges.	MD	
Mine water from underground mines (pumped) .....	MD	
Seeps/French drains .....	MD	PW—if Process fluids present.
Roads constructed of waste rock or spent ore:		
Onsite haul roads .....	MD	
Offsite haul/access roads .....	SW	(if off Active Area).
Roads not constructed of waste rock or spent ore:		
Onsite haul roads .....	SW	MD—if dust control with MD water.
Offsite haul/access roads .....	SW	
Milling/concentrating:		
Tailings impoundment/pile .....	PW	
Runoff from tailings dams/dikes when constructed of waste rock/tailings.	MD	PW—if Process fluids present.
Runoff from tailings dams/dikes when not constructed of waste rock/tailings.	SW	PW—if Process fluids present.
Heap leach pile runoff/seepage .....	PW	
Pregnant pond (barren and surge ponds also) .....	PW	
Polishing pond .....	PW	
Concentration building .....	SW	If storm water only, and no contact with piles.
Concentrate pile (product storage) .....	PW	
Mill site .....	SW	Same as concentration bldg.
Ancillary areas:		
Office/administrative building and housing .....	UC	Unless mixed with SW from industrial area, then SW.
Chemical storage area .....	SW	
Docking facility .....	SW	Excessive contact with waste product could constitute MD.
Explosive storage .....	SW	
Fuel storage (oil tanks/coal piles) .....	SW	
Vehicle/equipment maintenance area/building .....	SW	
Parking areas .....	SW	UC if only employee and visitor type parking.
Power plant .....	SW	
Truck wash area .....	SW	Excessive contact with waste product could constitute MD.
Reclamation-related areas:		
Any disturbed area (unreclaimed) .....	MD	SW if inactive area.
Reclaimed areas released from reclamation bonds after Dec. 17 1990.	UC	
Reclaimed areas released from reclamation bonds prior to Dec. 17 1990.	SW	
Partially/inadequately reclaimed areas or areas not released from reclamation bond.	SW	

KEY: UC—Unclassified; Not Subject to Storm Water Program or 40 CFR Part 440 Effluent Limitations Guidelines (ELG); MD—Subject to 40 CFR Part 440 ELG for mine drainage; PW—Subject to 40 CFR Part 440 ELG for mill discharge or process (including zero discharge ELG); SW—Storm water runoff from these sources are subject to the Storm Water Program, but are not subject to 40 CFR 440 ELG unless mixed with discharges subject to the 440 CFR 440 ELG that are not regulated by another permit prior to mixing. Non-storm water discharges from these sources are subject to NPDES permitting and may be subject to the effluent limitation guidelines under 40 CFR 440.

**Table 2-5 Colorado Milling Water Quality Discharge Monitoring Parameters**

**APPLICATION for DISCHARGES ASSOCIATED WITH HARDROCK MINING AND/OR MILLING**

**24. Discharge Quality:** Analytical data for the following parameters, unless waived by the Division, shall be submitted from at least one sampling of each discharge point as well as state waters upstream of each discharge. Upstream data should be from non-runoff periods, to the extent possible. If more than one outfall is to a common body of water, only one analysis of the receiving water upstream of the upper-most outfall will be required. If the receiving stream is dry during portions of the year, so indicate. In the case of sedimentation ponds for stormwater runoff, one outfall can be sampled if it can reasonably be assumed to be representative of all sedimentation pond outfalls. For new mines, please submit a minimum of one years data for those parameters listed below. Such data must have been obtained on at least a quarterly basis and must be reflective of the water quality prior to any mining activity.

PARAMETER	DETECTION LEVEL	PARAMETER	DETECTION LEVEL
Total Dissolved Solids, mg/R	10	Total Recoverable Manganese, mg/R	0.05
Flow, MGD	NA	Dissolved Manganese, mg/R	0.05
pH, s.u.	NA	Total Mercury, mg/R	0.00025
Oil and Grease, mg/R	5	Total Recoverable Nickel, mg/R	0.05
Dissolved Oxygen, mg/R	NA	Potentially Dissolved Nickel, mg/R	0.05
Alkalinity, mg/R	10	Total Recoverable Silver, mg/R	0.0002
Total Suspended Solids, mg/R	10	Potentially Dissolved Silver, mg/R	0.0002
Hardness, mg/R as CaCO <sub>3</sub>	10	Total Recoverable Uranium, mg/R	0.03
Total Ammonia, mg/R	0.05	Total Recoverable Zinc, mg/R	0.05
Temperature, °C Winter	NA	Potentially Dissolved Zinc, mg/R	0.05
Temperature, °C Summer	NA	Total Residual Chlorine, mg/R	0.05
Biochemical Oxygen Demand, mg/R	1	Fecal Coliform, #/100 ml	NA
Chemical Oxygen Demand, mg/R	30	Nitrate, mg/R as N	0.1
Dissolved Aluminum, mg/R	0.1	Nitrite, mg/R as N	0.002
Total Arsenic, mg/R	0.05	Sulfide mg/R as H <sub>2</sub> S	0.1
Total Recoverable Cadmium, mg/R	0.0004	Boron, mg/R	0.05
Hexavalent Chromium, mg/R	0.025	Chloride, mg/R	5
Trivalent Chromium, mg/R	0.05	Sulfate, mg/R	5
Total Chromium, mg/R	0.005	Total Cyanide, mg/R	0.01
Total Recoverable Copper, mg/R	0.005	Total Recoverable Selenium, mg/R	0.002
Potentially Dissolved Copper, mg/R	0.005	Total Cobalt, mg/R	0.006
Total Recoverable Iron, mg/R	0.3	Gross Alpha, pCi/R	0.3
Dissolved Iron, mg/R	0.3	Total Radium 226 + 228, pCi/R	8
Total Recoverable Lead, mg/R	0.005	Total Fluoride, mg/R	0.1
Potentially Dissolved Lead, mg/R	0.005	Weak Acid Dissociable Cyanide, mg/R	0.01
Total Phenols, mg/R	0.100	Total Phosphorus, mg/R as P	0.05
Total Organic Nitrogen, mg/R as N	0.05		

Table 5-1      Preoperational Radiological Monitoring Program for Uranium Mills (NRC Regulatory Guide 4.14, 1980)

Type of Sample	Sample Collection				Sample Analysis	
	Number	Location	Method	Frequency	Frequency	Type of Analysis
WATER						
Groundwater	Six or more	Wells located around future tailings disposal area. At least three wells hydrologically down gradient from disposal area. At least three located on other sides of tailings disposal area	Grab	Quarterly	Quarterly	Dissolved natural uranium, Ra-226, Th-230, Pb-210, and Po-210
	One from each well	Wells within 2 km of tailings disposal area that are or could be used for potable water supplies, watering of livestock, or crop irrigation	Grab	Quarterly	Quarterly	Dissolved and suspended natural uranium, Ra-226, Th-230, Pb-210, and Po-210
	One	Well located hydrologically up gradient from tailings disposal area to serve as control or background location	Grab	Quarterly	Quarterly	Dissolved natural uranium, Ra-226, Th-230, Pb-210, and Po-210
Surface Water	One from each body of water	Larger permanent onsite water impoundments or offsite impoundments that may be subject to direct surface drainage from potentially contaminated areas or that could be affected by a tailings impoundment failure	Grab	Quarterly	Quarterly	Suspended and dissolved natural uranium, Ra-226, and Th-230
					Semiannually	Suspended and dissolved Pb-210 and Po-210
	One from each body of water	Surface waters passing through the site or offsite surface waters that may be subject to drainage from potentially contaminated areas or that could be affected by a tailings impoundment failure	Grab	Monthly	Monthly	Suspended and dissolved natural uranium, Ra-226, Th-230
					Semiannually	Suspended and dissolved Pb-210 and Po-210
SOIL AND SEDIMENT						
Surface Soil	Up to forty	300-meter intervals to a distance of 1500 meters in each of the 8 directions from center of milling area	Grab	Once prior to site construction. Repeat for location disturbed by evacuation, leveling, or contouring	Once	All samples for Ra-226, 10% of samples natural uranium, Th-230, and Pb-210
	Five or more	At same locations used for collection of air particulate samples	Grab	Once prior to site construction	Once	Natural uranium, Ra-226, Th-230, and Pb-210
Subsurface Soil Profile	Five	At center reference location and at distances of 750 meters in each of the 4 directions	Grab	Once prior to site construction. Repeat for location disturbed by construction	Once	Ra-226 (all samples), natural uranium, Th-230, and Pb-210 (one set of samples)
Sediment	Two from each stream	Up and downstream of surface waters passing through site or from offsite surface waters that may be subject to direct runoff from potentially contaminated areas or that could be affected by a tailings impoundment failure	Grab	Once following spring runoff and late summer following period of extended low flow	Twice	Natural uranium, Ra-226, Th-230, and Pb-210
	One from each water impoundment	Onsite water impoundments (lakes, ponds, etc.), or offsite impoundments that may be subject to direct surface runoff from potentially contaminated areas or that could be affected by tailings impoundment failure	Grab	Once prior to site construction	Once	Natural uranium, Ra-226, Th-230, and Pb-210

Table 6-1      Operational Radiological Monitoring Program for Uranium Mills (NRC Regulatory Guide 4.14, 1980)

Type of Sample	Sample Collection				Sample Analysis	
	Number	Location	Method	Frequency	Frequency	Type of Analysis
WATER						
Groundwater	Three or more	Hydrologically down gradient and relatively close to the tailings impoundment	Grab	Monthly (first year), Quarterly (after first year)	Monthly (first year), Quarterly (after first year)	Dissolved natural uranium, Ra-226, Th-230, Pb-210, and Po-210
	At least one control sample	Hydrologically up gradient (i.e., not influenced by seepage from tailings)	Grab	Quarterly	Quarterly	Dissolved natural uranium, Ra-226, Th-230, Pb-210, and Po-210
	One from each well	Each well used for drinking water or watering of livestock or crops within 2 km of the tailings impoundment	Grab	Quarterly	Quarterly	Dissolved and suspended natural uranium, Ra-226, Th-230, Pb-210, and Po-210
Surface Water	Two from each water body	Surface waters passing through the mill site or offsite surface waters that are sufficiently close to the site to be subject to surface drainage from potentially contaminated areas or that could be influenced by seepage from the tailings disposal area. One sample collected upstream of the mill site and one sample collected at the downstream site boundary or at a location immediately downstream of the location of potential influence	Grab	Quarterly	Quarterly	Dissolved and suspended natural uranium, Ra-226, Th-230, Pb-210, and Po-210
	One from each water body	Larger water impoundments (i.e., lakes, reservoirs) near the mill site that are sufficiently close to the site to be subject to drainage from potentially contaminated areas or that could be influenced by seepage from the tailings disposal area	Grab	Quarterly	Quarterly	Dissolved and suspended natural uranium, Ra-226, Th-230, Pb-210, and Po-210
SOIL AND SEDIMENT						
Soil	Five or more	Same as for air-particulate samples	Grab	Annually	Annually	Natural uranium, Ra-226, and Pb-210
Sediment	One or two from each water body	Same as for surface water samples	Grab	Annually	Annually	Natural uranium, Th-230, Ra-226, and Pb-210



**Table 12-1 9VAC25-151-150 Mining Discharge Benchmark Values**

<b>Constituent</b>	<b>Benchmark Value</b>
Antimony (mg/L)	0.640
Arsenic	0.05
Beryllium	0.130
Cadmium	0.0021
Copper	0.018
Total and Dissolved Iron	1.0
Lead	0.12
Mercury	0.0014
Nickel	0.470
Field Water pH	6.0-9.0
Selenium	0.005
Silver	0.0038
Turbidity (NTU)	50
Total Suspended Solids (TSS)	100
Zinc	0.120