Guidance for Handling Waste Residuals Resulting from Drinking Water Treatment

Idaho Department of Environmental Quality

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Executive Summary

This document presents guidance to assist drinking water system owners on proper disposal of waste residuals from treatment processes for arsenic, nitrate, or uranium. This guidance is not a rule, nor is it rulemaking; it provides assistance and information to drinking water system owners and operators in dealing with drinking water system waste residuals.

Purpose

Because of the expense that may be involved with disposal of certain types of wastes that exceed regulatory limits, the most cost-effective treatment may be a compromise between treatment optimization and maintaining the characteristics of the waste stream below specified levels. The information in this guidance should help with making such decisions.

Scope

This guidance outlines disposal options specific to the following drinking water waste residuals:

- arsenic
- nitrate
- uranium

This guidance does not attempt to provide detailed guidance on treatment train design. Treatment processes must be designed to treat water to required standards and must be adjusted to produce liquid and solid waste streams that comply with regulatory requirements.

Characterization of Waste and Waste Residuals

Characterization of both the waste before treatment and the waste residuals remaining after treatment is a necessary first step in determining disposal options. It may also be necessary to evaluate physical parameters, such as pH, if the water to be treated has been subjected to other treatment processes, such as coagulation-filtration or disinfection by chlorine or other oxidants. Water chemistry may need to be altered or treatment equipment may need to be re-located to ensure that the chemical and physical attributes are optimized for the type of removal technology under consideration.

Summary Guidance for Disposal of Arsenic Waste

Federal statutes and regulations that apply to arsenic in drinking water waste residuals include the following:

- The *Arsenic Rule* (EPA, 2001) lowered the previous maximum contaminant level (MCL) for arsenic from 0.050 mg/L to **0.010 mg/L**. All water community and nontransient noncommunity systems were required to comply with the 0.010 mg/L MCL by January 22, 2006.
- The *Resource Conservation and Recovery Act* (RCRA; EPA, 2005g) specifies that liquid waste streams must have concentrations lower than the Toxicity Characteristic (TC)—**5.0 mg/L** for arsenic—to be classified as non-hazardous (EPA, 2003).

Idaho Rules for Public Drinking Water Systems (IDAPA 58.01.08), which apply to any water system that serves at least fifteen (15) service connections used year-round, defines the MCL for arsenic as **0.010 mg/L**.

In addition, disposal of wastes containing arsenic may be subject to the following *Idaho Administrative Procedures Act* (IDAPA) rules:

- 58.01.03 - *Individual/Subsurface Sewage Disposal Rules.*
- 58.01.05 - *Rules and Standards for Hazardous Waste.*
- 58.01.06 - *Solid Waste Management Rules.*
- 58.01.10 - *Rules Regulating the Disposal of Radioactive Materials not Regulated Under the Atomic Energy Act of 1954, as Amended.* Because processes that remove arsenic may also remove uranium, it is important to be aware of the regulations that apply to uranium-bearing wastes.
- 58.01.11 – *Ground Water Quality Rule.*
- 58.01.17 – *Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater*.

Based on these requirements, the disposal options for arsenic-bearing waste residuals are as shown in Figure 1, page 16.

Summary Guidance for Disposal of Nitrate Waste

Federal statutes and regulations that apply to nitrate in drinking water waste residuals include the following:

- *Safe Drinking Water Act* (SDWA; EPA, 2005h), which established a nitrate MCL of **10 mg/L**.
- *Clean Water Act* (CWA, 2002). Waste residuals that are to be discharged to a stream or other water body require a National Pollution Discharge Elimination System (NPDES) permit from Region 10 of the U.S. Environmental Protection Agency, 1200 Sixth Avenue, Seattle, WA 98101. Telephone (206) 553-1200.

Additional information about the NPDES program can also be located at the following address:

http://cfpub.epa.gov/npdes/

- *Resource Conservation and Recovery Act* (RCRA; EPA, 2005g):

For Idaho, the *Ground Water Quality Rule* (IDAPA 58.01.11) Section 200, defines the standard for nitrate as nitrogen as **10 mg/L**.

Based on these requirements, the disposal options for nitrate-bearing waste residuals are as shown in Figure 3, page 28.

Summary Guidance for Disposal of Uranium Waste

Federal statutes and regulations potentially applicable to waste streams containing uranium include the following:

- *Atomic Energy Act* (AEA, 1954), including *Standards for Protection Against Radiation* (10 CFR 20) and *Domestic Licensing of Source Material* (10 CFR 40). As long as the quantity of uranium does not exceed **0.05 percent by weight, 15 pounds at any given time**, or **150 pounds over the course of a year**, no special requirements apply:

  > (a) A general license is hereby issued authorizing commercial and industrial firms, research, educational and medical institutions and Federal, State and local government agencies to use and transfer not more than fifteen (15) pounds of source material at any one time for research, development, educational, commercial or operational purposes. A person authorized to use or transfer source material, pursuant to this general license, may not receive more than a total of 150 pounds of source material in any one calendar year.

  (10 CFR 40.22)

- Occupational Safety and Health Administration (OSHA, 2005a) requirements, including:
  - 29 CFR 1910.1096, *Ionizing radiation.*
  - 29 CFR 1910.132-136, *General requirements*, which addresses personal protective equipment (PPE) for the eyes, face, head, and extremities.
  - 29 CFR 1910.146, *Permit-required confined spaces.*
  - 29 CFR 1910.147, *The control of hazardous energy (lockout/tagout).*
  - 29 CFR 1910.1200, *Hazard Communication.*
- *Safe Drinking Water Act* (SDWA; EPA, 2005h), including the revised *Radionuclides Rule*, which became effective on December 8, 2003, and which established the MCL for uranium of **30 µg/L**.
- Title 49, Subtitle B of the Code of Federal Regulations (CFR): *Other Regulations Relating to Transportation.*

Idaho rules applicable to waste streams containing uranium is defined in *Rules Regulating the Disposal of Radioactive Materials Not Regulated Under the Atomic Energy Act of 1954, as Amended* (IDAPA 58.01.10).

Based on these requirements, the disposal options for uranium-bearing waste residuals are as shown in Figure 10, page 51 (liquid waste) and Figure 11, page 52 (solid waste).

1.0 Introduction

This document presents guidance to assist drinking water system owners on proper disposal of waste residuals from treatment processes for arsenic, nitrate, or uranium. This guidance is not a rule, nor is it rulemaking; it provides assistance and information to drinking water system owners and operators in dealing with drinking water system waste residuals.

1.1 Purpose

The purpose of this guidance is to provide information that can be used by responsible parties of drinking water treatment systems who need to properly dispose of a variety of waste residuals from drinking water treatment processes. Because of the expense that may be involved with disposal of certain types of wastes that exceed regulatory limits, the most cost-effective treatment may be a compromise between treatment optimization and maintaining the characteristics of the waste stream below specified levels. The information in this guidance should help with making such decisions.

For example, a responsible party attempting to design a treatment train that will remove uranium from drinking water needs to examine the potential waste stream against several federal and state regulations, such as the following:

- *Atomic Energy Act*
- *Clean Water Act*
- Department of Transportation (DOT) regulations governing the shipping, labeling, and transport of hazardous materials
- *Idaho Hazardous Waste Management Act*
- Idaho *Rules Regulating the Disposal of Radioactive Materials Not Regulated under the Atomic Energy Act of 1954, as Amended*
- *Resource Conservation and Recovery Act*
- *Safe Drinking Water Act*

In such a challenging regulatory environment, drinking water treatment technologies must be chosen not only from the perspective of their effectiveness at removing contaminants, but with a full understanding of how regulations apply to the residual wastes that are created when the contaminants have been removed. For example, uranium removal processes should be thoughtfully managed so that the concentration of uranium in the residual waste does not make disposal more difficult.

Similar tradeoffs exist for other treatment processes, including but not limited to those used for the removal of nitrate and arsenic.

1.2 Scope

This guidance outlines the regulatory requirements that apply to specific drinking water waste residuals and provides information that is intended to assist owners of Idaho drinking water systems needing to determine how a particular waste stream should be handled. Because the need for this guidance is most acute concerning treatment for nitrate, arsenic, and uranium, this version of the guidance has been developed for dealing with these specific wastes.

DEQ recognizes that there are other types of water treatment plant residuals that must be addressed. Until specific guidance is available, those will be handled on a case-by-case basis using available literature, perhaps including pertinent parts of this guidance.

This guidance does not attempt to provide detailed guidance on treatment train design. Treatment processes must be designed to treat water to required standards and must be adjusted to produce liquid and solid waste streams that comply with regulatory requirements.

2.0 Characterization of Waste and Waste Residuals

Regardless of the specific constituent—arsenic, nitrate, or uranium—characterization of the waste before treatment and of the waste residuals remaining after treatment is a necessary first step in determining disposal options.

2.1 Key Water Quality Parameters to Characterize

Table 1 and Table 2 list constituents of raw water to characterize before making decisions about treatment and disposal. Both tables come from EPA guidance for arsenic treatment (EPA 2003), but the list of waste constituents should also provide a good starting point for characterization of other wastes as well.

Ideally, samples should be analyzed several times over a period of six months or more to obtain averages that reflect seasonal variations in the water chemistry. Manufacturers of proprietary treatment media may require analysis of additional constituents (or possibly fewer) to predict the performance of their product.

Instructions for collection and handling of samples may be obtained by contacting an analytical laboratory qualified in the laboratory methods specified. A list of the laboratories certified to perform drinking water analyses in Idaho can be obtained from the DEQ Web site:

http://www.deq.idaho.gov/water/assist_business/pws/labs.cfm

It may also be necessary to evaluate physical parameters, such as pH, if the water to be treated has been subjected to other treatment processes, such as coagulation-filtration or disinfection by chlorine or other oxidants. Water chemistry may need to be altered or, alternatively, treatment equipment may need to be located in advance of other treatment processes to ensure that the chemical and physical attributes are optimized for the type of removal technology under consideration.

Table 1. Key water quality parameters to be monitored for treatment processes.

Parameter	USEPA Method	Standard Method[3]	ASTM[4]
Arsenic, Total [1]	200.8200.9	3113 B 3114 B	D2972-93B D2972-93C
Arsenite {As(III)}		3500-As B	
Arsenate {As(V)}		3500-As B	
Chloride (Cl-) 2	300.0	4110 B 4500-Cl- D 4500-Cl- B	D4327-91 D512-89B
Fluoride (F-) [1,2]	300.0	4110 B 4500-F^- B 4500-F^- C 4500-F^- D 4500-F^- E	D4327-91 D1179-93B
Iron (Fe) [2]	200.7 200.9	3120 B 3111 B 3113 B	
Manganese (Mn) [2]	200.7 200.8 200.9	3120 B 3111 B 3113 B	
Nitrate (NO_3^-) [1]	300.0 353.2	4110 B 4500-NO_3^- F 4500-NO_3^- D 4500-NO_3^- E	D4327-91 D3867-90A D3867-90B
Nitrite (NO_2^-) [1]	300.0 353.2	4110 B 4500-NO_3^- F 4500-NO_3^- E 4500-NO_2^- B	D4327-91 D3867-90A D3867-90B
Orthophosphate (PO_4^{-3}) [1]	365.1 300.0	4500-P F 4500-P E 4110 B	D515-88A D4327-91
pH[1, 2]	150.1 150.2	4500-H^+B	D1293-95
Silica [1]	200.7	4500-Si D 4500-Si E 4500-Si F	D859-95
Sulfate (SO_4^{-2}) [2]	300.0 375.2	4110 B 4500-SO_4^{2-} F 4500-SO_4^{2-} C 4500-SO_4^{2-} D 4500-SO_4^{2-} E	D4327-91 D516-90
Total Dissolved Solids (TDS)[2]		2540 C	
Total Organic Carbon (TOC)	415.1		

Source: Arsenic Treatment Technology Handbook for Small Systems (EPA 2003).
1 U.S. EPA (USEPA) Approved Methods for Drinking Water Analysis of Inorganic Chemicals and other parameters.
2 USEPA Recommended Methods for Secondary Drinking Water Contaminants.
3 18th and 19th editions of Standard Methods for the Examination of Water and Wastewater, 1992 and 1995, American Water Works Association (AWWA).
4 Annual Book of ASTM Standards, 1994 and 1996, Vols. 11.01 and 11.02, American Society for Testing.

Table 2. Other water quality parameters to be monitored for treatment processes.

Parameter	USEPA Method	Standard Method[3]	ASTM[4]
Alkalinity [1]		2320 B	D1067-92B
Aluminum (Al) [2]	200.7 200.8 200.9	3120 B 3113 B 3111 D	
Calcium (Ca^{+2}) [1]	200.7	3500-Ca D 3111 B 3120 B	D511-93A D511-93B
Magnesium (Mg^{+2}) [1]	200.7	3113 B 3120 B 3500-Mg E	D511-53B D511-93B
Turbidity	180.1		
Water Hardness	215.1 242.1		

Source: Arsenic Treatment Technology Handbook for Small Systems (EPA 2003).
1 USEPA Approved Methods for Drinking Water Analysis of Inorganic Chemicals and other parameters.
2 USEPA Recommended Methods for Secondary Drinking Water Contaminants.
3 18th and 19th editions of Standard Methods for the Examination of Water and Wastewater, 1992 and 1995, American Water Works Association (AWWA).
4 Annual Book of ASTM Standards, 1994 and 1996, Vols. 11.01 and 11.02, American Society for Testing.

2.2 Waste Characterization Needed Prior to Discussion With a POTW

When discussing disposal options with a Publicly Owned Treatment Works (POTW), the POTW is likely to need analyses of the constituents listed in Table 3.

Table 3. Analysis of non-domestic liquid waste.

Analyte	Units	Analyte	Units	Analyte	Units
Biological Oxygen Demand	mg/l	Chemical Oxygen Demand	mg/l	pH	std units
Total Suspended Solids	mg/l	Fats, Oils, and Grease *	mg/l	Total Nitrogen	mg/l
Total Phosphorus	mg/l	Fecal Coliform	#/100 ml	Total Coliform	#/100 ml
Nitrate(N-NO3)	mg/l				
Heavy Metals (Species/Concentration) [See Table 4. Characteristics of solid waste residuals needed for land application analysis.]					
Residual Ions (Species/Concentration) [See Table 4. Characteristics of solid waste residuals needed for land application analysis.]					

***** Not generally applicable to drinking water treatment residuals.

2.3 Characterization of Waste Residuals for Land Application

When considering treatment options involving land application of solid waste residuals, the analyses of the constituents shown in Table 4 will be needed.

Table 4. Characteristics of solid waste residuals needed for land application analysis.

Analyte	Units	Analyte	Units
Total Solids	Percent	Total Chromium	mg/kg
pH	Standard units	Total Copper	mg/kg
Organic-Nitrogen	Percent	Total Iron	mg/kg
Total Ammonia-N	Percent	Total Lead	mg/kg
Nitrate-Nitrite N	Percent	Total Mercury	mg/kg
Total Phosphorous	Percent	Total Molybdenum	mg/kg
Total Potassium	Percent	Total Nickel	mg/kg
Total Aluminum	mg/kg	Total Selenium	mg/kg
Total Arsenic	mg/kg	Total Zinc	mg/kg
Total Cadmium	mg/kg	Total alpha activity	pico-curies/g

3.0 Treatment and Disposal of Arsenic

Disposal of waste residuals containing arsenic are subject to both federal and state requirements. These requirements are described in the following, preceded by a brief discussion of the physical characteristics and health concerns associated with arsenic. There is also a discussion of available treatment technologies and several decision flowcharts designed to help you choose the treatment plan that will provide the most economical method of compliance.

3.1 Background

Arsenic (As) is element number thirty-three in the periodical table of elements (CRC, 1993), with physical characteristics, occurence in nature, and health concerns as described in the following.

3.1.1 Physical Characteristics

Arsenic "is a steel grey, very brittle, crystalline, semimetallic (metalloid) solid. It tarnishes in air, and when heated rapidly oxidises to arsenous oxide which has a garlic odour." (Webelements, 2005)

3.1.2 Natural Occurrence

Although arsenic can originate from manmade sources, most arsenic in water is natural:

> "Typically . . . arsenic occurrences in water is caused by the weathering of and dissolution of arsenic-bearing rocks, minerals, and ores. Although arsenic exists in both organic and inorganic forms, the inorganic forms are more prevalent in water and are considered more toxic."
>
> (EPA, 2003)

Arsenic is "widely distributed throughout the earth's crust" and is "introduced into water through the dissolution of minerals and ores, and concentrations in groundwater in some areas are elevated as a result of erosion from local rocks" (WHO, 2001). Additional sources of arsenic include industrial effluents and the combustion of fossil fuels. (WHO, 2001)

In nature, arsenic is typically found in combination with other elements, such as oxygen, chlorine, and sulfur (NSC, 2005):

> "In combination, such arsenic is referred to as inorganic arsenic. Arsenic combined with carbon and hydrogen is referred to as organic arsenic. The organic forms are usually less toxic than the inorganic forms."
>
> (NSC, 2005)

Arsenic enters the environment through several paths:

> Arsenic can be released into the environment through natural activities such as volcanic action, erosion of rocks, and forest fires, or through human activities such as pesticide application, improper disposal of arsenic-containing waste chemicals, agricultural applications, mining, and smelting.

(DEQ, 2005a)

Uses of arsenic include the following:

> Approximately 90% of industrial arsenic in the U.S. is used as a wood preservative. Arsenic is a well-known poison used in the manufacture of agricultural chemicals such as pesticides, weed killers, and rodenticides. It is also used in the production of paints, dyes, metals, drugs, soaps, and semi-conductors.

(DEQ, 2005a)

3.1.3 Health and Safety Considerations

Health concerns regarding arsenic include skin damage, problems with the circulatory system, and a potential increased risk of cancer (EPA, 2005d).

The greatest threat arsenic poses to public health comes from its presence in drinking water (WHO, 2001), but exposure in the work place can also be a factor for some industries and locales.

Occupational Safety and Health Administration (OSHA) guidelines for controlling worker exposure to arsenic include the following methods (OSHA, 2005b):

- Process enclosure
- Local exhaust ventilation
- General dilution ventilation
- Personal protective equipment

Regulations that apply to occupational exposures to arsenic are defined in 29 CFR 1910.1018. The exposure limit is defined as follows:

> The employer shall assure that no employee is exposed to inorganic arsenic at concentrations greater than 10 micrograms per cubic meter of air (10 $\mu g/m^3$), averaged over any 8-hour period.

(OSHA, 2005b)

In the event of a release or potential release of arsenic, workers "must be protected as required by paragraph (q) of OSHA's Hazardous Waste Operations and Emergency Response Standard [29 CFR 1910.120]."

3.2 Regulations

Both federal and Idaho state regulations apply to arsenic in drinking water and as a waste.

3.2.1 Federal Statutes and Regulations

Federal statutes and regulations that apply to arsenic in drinking water waste residuals include the following:

- *Safe Drinking Water Act* (SDWA; EPA, 2005h), including the final *Arsenic Rule* (EPA, 2001), which lowered the arsenic maximum contaminant level (MCL) for arsenic from 0.050 mg/L to **0.010 mg/L**. All water systems are required to comply with the 0.010 mg/L MCL by January 2006 (EPA, 2003).
- Because treatment processes used to remove arsenic could affect other drinking water regulation, system owners need to be vigilant to prevent such impacts. System owners need to consider interactions such as the following (EPA, 2003):
  - Optimum pH for minimizing lead and copper corrosion is 7.59, so pH adjustment may be needed before treating for arsenic.
  - Reducing pH enhances biocidal effectiveness, so systems may need to adjust pH before treating for arsenic.
  - Coagulation and flocculation processes are also related to pH , so pH adjustment may be needed before treating for arsenic.
  - Pre-chlorination to convert arsenite As(III) to arsenate As(V) could increase levels of total trihalomethanes and haloacetic acids.
- *Clean Water Act* (CWA, 2002). Waste residuals that are to be discharged to a stream or other water body require a National Pollution Discharge Elimination System (NPDES) permit from Region 10 of the U.S. Environmental Protection Agency, 1200 Sixth Avenue, Seattle, WA 98101. Telephone (206) 553-1200. Additional information about the NPDES program can also be located at the following address:

  http://cfpub.epa.gov/npdes/

- *Resource Conservation and Recovery Act* (RCRA; EPA, 2005g):
  - Liquid waste streams must have concentrations lower than the Toxicity Characteristic (TC)—which is **5.0 mg/L** for arsenic—to be classified as non-hazardous (EPA, 2003).
  - Solid waste streams are subjected to the *Toxicity Characteristic Leaching Procedure* (TCLP) as defining in EPA Test Method 1311 (EPA, 2006), which measures the potential for leaching in a landfill setting (EPA, 2003).

3.2.2 Idaho Statutes and Rules

Idaho Rules for Public Drinking Water Systems (IDAPA 58.01.08), which applies to any water system that "serves at least fifteen (15) service connections used by year-round residents or regularly serves at least twenty-five (25) year-round residents," incorporates 40 CFR 141.11, which defines the MCL for arsenic as **0.010 mg/L**.

In addition, disposal of wastes containing arsenic may be subject to the following *Idaho Administrative Procedures Act* (IDAPA) rules:

- 37.03.03. *Rules and Minimum Standards for the Construction and Use of Injection Wells.*
- 58.01.02. *Water Quality Standards*.
- 58.01.03. *Individual/Subsurface Sewage Disposal Rules*.
- 58.01.05. *Rules and Standards for Hazardous Waste*.
- 58.01.06. *Solid Waste Management Rules*.
- 58.01.10. *Rules Regulating the Disposal of Radioactive Materials not Regulated Under the Atomic Energy Act of 1954, as Amended*. Because processes that remove arsenic may also remove uranium, it is important to be aware of the regulations that apply to uranium-bearing wastes. (For additional information on handling waste streams containing uranium, see Section 4 of this guidance, *Treatment and Disposal of Uranium*, starting on page 33.)
- 58.01.16. Wastewater Rules.

3.3 Treatment Strategies and Processes

This section identifies potential strategies for mitigating arsenic levels, along with treatment processes and disposal options.

3.3.1 Treatment Strategies

Strategies for mitigating problematic arsenic levels in drinking water include the following (EPA, 2003):

- *Abandonment* - The total abandonment of the problematic source(s) and subsequent switch to other source(s) within the system or purchase from a neighboring system.
- *Seasonal Use* - Switching the problematic source(s) from full-time use to seasonal (less than 60 days per year) or peaking use with subsequent blending with other full-time source(s).
- *Blending* - The combination of multiple water sources to produce a stream with an arsenic concentration that is reliably and consistently below the MCL[1].
- *Sidestream Treatment* - The treatment of a portion of the high arsenic water stream and subsequent blending back with the untreated portion of the stream to produce water that that is reliably and consistently below the MCL.

[1] Generally achieved by a concentration goal that is 80% or less of the MCL.

- *Treatment* – The processing of all or part of a water stream to reduce the arsenic concentration to below the MCL. Treatment strategies include the following:
  - *Wellhead Treatment* – Treatment is located at the wellhead location before the water is mixed with water from other sources.
  - *Centralized Treatment* – Water from several sources is piped to a centralized location for treatment before the water enters the distribution system.
  - *Point of Use (POU) Treatment* – Treatment devices are located at the Point-Of-Use within the building or home and treat only the water intended for direct consumption, typically at a single tap.

3.3.2 Treatment Processes

Arsenic treatment processes can be categorized into three classes (EPA, 2003):

- *Sorption Treatment Processes*, including ion exchange (IX), activated alumina (AA), and Iron Based Sorbents (IBS).
- *Membrane Treatment Processes*, including reverse osmosis (RO), typically assisted with coagulant addition.
- *Precipitation/Filtration Processes*, including enhanced conventional gravity coagulation/filtration, oxidation/filtration, and enhanced lime softening.

Typical efficiencies and the associated water losses for various treatments are shown in Table 5.

Table 5. Typical arsenic treatment efficiencies and associated water losses.

Treatment	As(V) Removal Efficiency	Water Loss
Sorption Processes		
Ion Exchange	95%[1]	1-2%
Activated Alumina (Throw-Away Media)	95%[1]	1-2%
Iron Based Sorbents	Up to 98%[1]	1-2%
Iron and Manganese Removal Processes		
Oxidation/Filtration (Greensand)	50-90%[2]	≤2%
Membrane Processes		
Reverse Osmosis	>95%[1]	15-50% [1]
Precipitative Processes		
Coagulation Assisted Microfiltration	90%[1]	5%
Enhanced Coagulation/Filtration:		
With Alum	<90%[1]	1-2%
With Ferric Chloride	95%[1]	1-2%
Enhanced Lime Softening	90%[1]	1-2%

(Source: EPA, 2003)
1. EPA, 2000
2 Depends on arsenic and iron concentrations

For optimal performance, all of the treatment processes assume that reduced trivalent arsenic [As(III)] has been converted to its oxidized pentavalent form [As(V)]. Such conversion can be accomplished by using an oxidizing agent—chlorine, permanganate, ozone, or Filox-R®[2] at the head of the arsenic removal process (EPA, 2003).

Table 6 shows a comparison of the benefits and drawbacks associated with these four oxidizing agents.

Table 6. Comparison of arsenic oxidizing agents.

Oxidant	Benefits	Drawbacks
Chlorine	Low relative cost ($0.50/lb) Primary disinfection capability Secondary disinfectant residual Oxidizes arsenic in less than 1 minute	Formation of disinfection by-products Membrane fouling Special handling and storage requirements
Permanganate	Unreactive with membranes No formation of disinfection by-products Oxidizes arsenic in less than 1 minute	High relative cost ($1.35/lb) No primary disinfection capability Formation of MnO_2 particulates Pink Water Difficult to handle An additional oxidant may be required for secondary disinfection
Ozone	No chemical storage or handling required Primary disinfection capability No chemical by-products left in water Oxidizes arsenic in less than 1 minute in the absence of interfering reductants	Sulfide and total organic carbon (TOC) interfere with conversion and increase the required contact time and ozone dose for oxidation An additional oxidant may be required for secondary disinfection
Solid Phase Oxidants (Filox R®)	No chemical storage or handling required No chemical by-products left in water Oxidizes arsenic with an empty bed contact time (EBCT) of 1.5 minutes in the absence of interfering reductants	Backwashing required Backwash waste is generated Requires dissolved oxygen to work No primary disinfection capability An additional oxidant may be required for secondary disinfection Iron, manganese, sulfide, and TOC increase the contact time and dissolved oxygen concentration required for oxidation

(Source: EPA, 2003)

In the *Arsenic Rule* (EPA, 2001) EPA has identified what it considers to be Best Available Treatments (BATs) and Small System Compliance Technologies (SSCTs) for use in removing arsenic from drinking water (EPA, 2002b):

- BATs are "developed with large systems in mind, [where] removal is much more efficient. . ."
- SSCTs provide a measure of affordability and technical complexity for systems of different size categories.

[2] Filox-R is a registered trademark of Matt-Son, Inc., Barrington, IL.

EPA BATs for arsenic removal are shown in Table 7.

Table 7. EPA Best Available Technologies (BATs) for arsenic removal.

Treatment Technology	Maximum Percent Removal*
Ion Exchange (sulfate <= 50 mg/L)	95
Activated Alumina	95
Reverse Osmosis	>95
Modified Coagulation/Filtration	95
Modified Lime Softening (pH > 10.5)	90
Electrodialysis Reversal	85
Oxidation/Filtration (20:1 iron:arsenic)	80

(Source: EPA, 2001)
*The percent removal figures are for arsenic (V) removal. Pre-oxidation may be required.

EPA SSCTs for arsenic removal are shown in Table 8.

Table 8. Small System Compliance Technologies (SSCTs)[1] for arsenic[2].

Small system compliance technology	Affordable for listed small system categories[3]
Activated Alumina (centralized)	All size categories
Activated Alumina (Point-of-Use)[4]	All size categories
Coagulation/Filtration[5]	501-3,300, 3,301-10,000
Coagulation-assisted Microfiltration	501-3,300, 3,301-10,000
Electrodialysis reversal[6]	501-3,300, 3,301-10,000
Enhanced coagulation/filtration	All size categories
Enhanced lime softening (pH> 10.5)	All size categories
Ion Exchange	All size categories
Lime Softening[5]	501-3,300, 3,301-10,000
Oxidation/Filtration[7]	All size categories
Reverse Osmosis (centralized)[6]	501-3,300, 3,301-10,000
Reverse Osmosis (Point-of-Use)[4]	All size categories

(Source: EPA, 2001)
1 Section 1412(b)(4)(E)(ii) of SDWA specifies that SSCTs must be affordable and technically feasible for small systems.
2 SSCTs for Arsenic V. Pre-oxidation may be required to convert Arsenic III to Arsenic V.
3 The Act (ibid.) specifies three categories of small systems: (i) those serving 25 or more, but fewer than 501, (ii) those serving more than 500, but fewer than 3,301, and (iii) those serving more than 3,300, but fewer than 10,001.
4 When POU or POE devices are used for compliance, programs to ensure proper long-term operation, maintenance, and monitoring must be provided by the water system to ensure adequate performance.
5 Unlikely to be installed solely for arsenic removal. May require pH adjustment to optimal range if high removals are needed.
6 Technologies reject a large volume of water—may not be appropriate for areas where water quantity may be an issue.
7 To obtain high removals, iron to arsenic ratio must be at least 20:1.

A comparison of treatment technologies, showing optimal water quality conditions, level of operator skill required, types of waste generated, and a ranking of costs, is presented in Table 9.

Table 9. Comparison of arsenic treatment technologies.

Factors	Sorption Processes			Membrane Processes			Precipitative Processes		
	Ion Exchange	**Activated Alumina**	**Iron Based Sorbents**	**Reverse Osmosis**	**Enhanced Lime Softening**	**Enhanced (Conventional) Coagulation Filtration**	**Coagulation Assisted Micro Filtration**	**Coagulation Assisted Direct Filtration**	**Oxidation Filtration**
	IX	**AA**	**IBS**	**RO**	**LS**	**CF**	**CMF**	**CADF**	**OxFilt**
USEPA BAT	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes
USEPA SSCT	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes
System Size	25-10,000	25-10,000	25-10,000	501-10,000	25-10,000	25-10,000	500-10,000	500-10,000	25-10,000
SSCT for POU	No	Yes	No	Yes	No	No	No	No	No
POU System Size	—	25-10,000	25-10,000	25 -10,000	—	—	—	—	—
Removal Efficiency	95%	95%	up to 98%	> 95%	90%	95% (w/ $FeCl_3$) < 90% (w/ Alum)	90%	90%	50-90%
Total Water Loss	1-2%	1-2%	1- 2%	15-75%	0%	0%	5%	1-2%	1-2%
Pre-Oxidation Required	Yes	Yes	Yes	Likely	Yes	Yes	Yes	Yes	Yes
Optimal Water Quality Conditions	pH 6.5 - 9 < 5 mg/L $NO3^-$ < 50 mg/L SO_4^{2-} < 500 mg/L TDS < 0.3 NTU Turbidity	pH 5.5 - 6 pH 6 - 8.3 < 250 mg/L C < 2 mg/L F < 360 mg/L SO_4^{2-} < 30 mg/L Silica < 0.5 mg/L Fe^{+3} < 0.05 mg/L Mn^{+2} < 1,000 mg/L TDS < 4 mg/L TOC < 0.3 NTU Turbidity	pH 6 - 8.5 < 1 mg/L PO_4^{-3} < 0.3 NTU Turbidity	No Particulates	pH 10.5 - 11 > 5 mg/L Fe^{+3}	pH 5.5 - 8.5	pH 5.5 - 8.5	pH 5.5 - 8.5	pH 5.5 - 8.5 >0.3 mg/L Fe Fe:As Ratio > 20:1
Operator Skill Required	High	Low	Low	Medium	High	High	High	High	Medium
Waste Generated	Spent Resin, Spent Brine, Backwash Water	Spent Media, Backwash Water	Spent Media, Backwash Water	Reject Water	Backwash Water, Sludge (high volume)	Backwash Water, Sludge	Backwash Water, Sludge	Backwash Water, Sludge	Backwash Water, Sludge
Other Considerations	Possible pre & post pH adjustment. Pre-filtration required. Potentially hazardous brine waste. Nitrate peaking. Carbonate peaking affects pH.	Possible pre & post pH adjustment. Pre-filtration may be required. Modified AA available.	Media may be very expensive. O Pre-filtration may be required.	High water loss (15-75% of feed water)	Treated water requires pH adjustment	Possible pre & post pH adjustment	Possible pre & post pH adjustment	Possible pre & post pH adjustment	None
Centralized Cost	Medium	Medium	Medium	High	Low	Low	High	Medium	Medium
POU Cost	—	Medium	Medium	Medium	N/A	N/A	N/A	N/A	N/A

(Source: EPA, 2003)

3.4 Waste Characterization and Disposal

Table 1 and Table 2 (pages 4 and 5, respectfully) list the constituents of raw water that should be characterized prior to making decisions about arsenic treatment.

3.4.1 Analysis of Waste Residuals

Waste streams generated by arsenic removal processes must be characterized chemically, so that decisions may be made about disposal options. Disposal options (Figure 1) are limited and potentially expensive, which may affect the choice of treatment method and the manner in which the treatment process is operated.

As an example, treatment with adsorptive media may turn out to be more economical if the media is not backwashed and reused, but is instead disposed of in a landfill when it is fully saturated with arsenic on a one-time basis. This approach avoids creation of a liquid waste stream composed of backwash and rinse waters, which may require further handling and treatment to remove arsenic and any other contaminants that may be present.

3.4.2 Determination of Waste as Liquid or Solid

An initial step in the characterization of the waste is to determine if the waste is liquid or solid. Solid residuals are considered dry enough to landfill when they pass the *Paint Filter Liquids Test* (PFLT) as defined by EPA Test Method 9095B (EPA, 2006). During this test, a measured sample is placed on #60 filter paper, suspended in a funnel, and, if no liquid passes through in five minutes, the residuals are classified as *solid*.

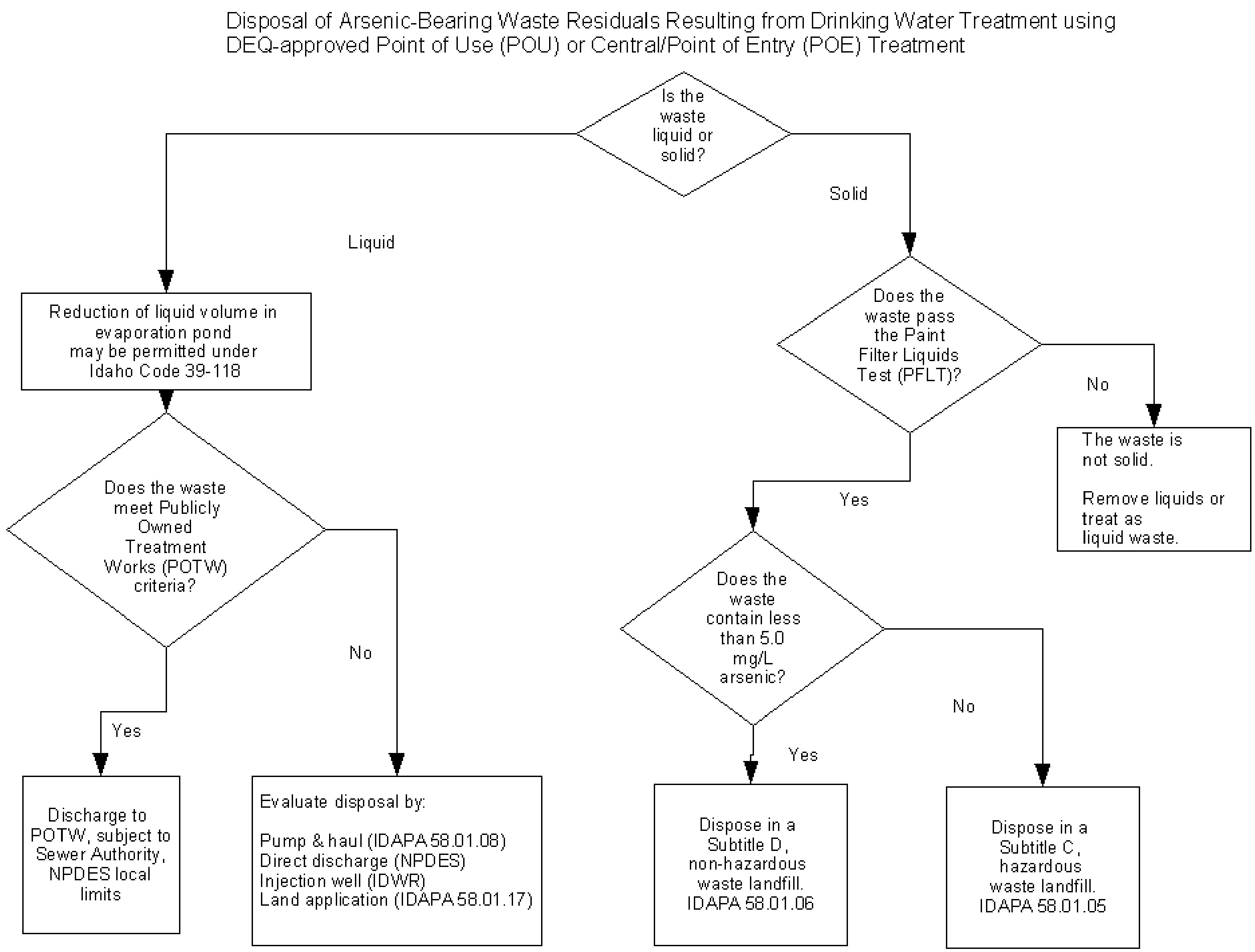

Figure 1. Disposal options for arsenic-bearing waste residuals.

3.4.3 Disposal of Liquid Waste Residuals

Disposal of liquid wastes is generally more problematic than disposal of solid residuals. The options given in the flow chart of Figure 1 are discussed in the following, with suggestions on how to characterize the materials to determine which disposal strategy may be viable.

Storage and handling of liquids in properly constructed lagoons may be used as a means of removing solids and reducing liquid volume by evaporation. However, solids will eventually need to be dewatered and disposed of permanently.

Currently, disposal of liquid residuals containing arsenic to the subsurface is not considered a practical option because the movement and fate of arsenic in the subsurface would be difficult to predict with any accuracy.

a. Total Containment Evaporation Lagoon (Idaho Code Section 39-118 Plan & Specification Review)

A water quality engineer at a DEQ Regional Office will need to approve the design and construction of the lagoon(s). Considerations include sizing to accommodate flows plus a safety margin for heavy precipitation events or snowmelt, lining of the lagoon to prevent percolation of contaminants into underlying groundwater, and proper design and construction of containment structures to prevent the escape of impounded liquids. Lagoons must be capable of being dewatered at appropriate intervals so that sediments can be dried and characterized (as described in the following section on solid residuals) to determine what type of ultimate disposal is appropriate.

Contact: DEQ Water Quality Engineer at the appropriate DEQ Regional Office—see Appendix A, page 59.

b. Connection to a POTW (Clean Water Act—NPDES Program and 40 CFR 503(b) standards for land application)

If a POTW is available, the water system may obtain permission to dispose of liquid wastes by this route. The POTW will need to demonstrate that the waste stream will meet the requirements of its industrial pretreatment program, will not impact the operation of its treatment processes, will not violate the terms of its NPDES discharge permit, and will not exceed standards for the composition of any biosolids that are land-applied after drying.

Analysis of the constituents listed in Table 3 (page 4) may be adequate as a starting point for discussions with the POTW. However, each POTW has unique contaminant challenges and specific discharge criteria that may dictate further analyses of the treatment residuals. Total flow to the POTW and the distribution of flows through time will be required for the POTW to estimate the impact of receiving the wastes. Systems pursuing this and the following disposal option should expect fees, as there is no other incentive for a POTW to increase the load on their treatment facility.

Contact: A POTW to which a direct connection is present or feasible.

c. Pump and Haul to a POTW

This disposal strategy is a variation on the previous one, the difference being that the water system temporarily stores the liquid residual onsite, with the temporary storage tank design and construction to be approved under 39-118 plan and specification review by a DEQ water quality engineer. (Belowground tanks are not allowed).

Characterization of the waste residuals may proceed as in option b. The POTW may request additional analyses. Total volumes and data describing the projected frequency and volume of individual deliveries may be needed.

Contact: Any nearby POTW to which wastes could be economically transported.

d. Direct Discharge to Surface Water (Clean Water Act, NPDES Program)

EPA Region 10 administers the NPDES program in Idaho. Water systems that wish to pursue a permit for direct discharge will need to contact EPA and obtain instructions on how to apply. Requirements for chemical and physical characterization of liquid waste residuals will vary in accordance with the attributes of the proposed receiving waters.

As part of the NPDES permit process, DEQ will conduct a *401 certification*, but this will only occur if EPA is prepared to issue a permit. It is important to be aware that the time required for issuance of an NPDES permit can exceed three years from the date of application. DEQ's 401 certification is for the NPDES discharge and is issued when the NPDES permit meets the state water quality standards.

Contact: Unit Manager, NPDES Permits Unit, US EPA Region 10, 1200 Sixth Avenue, OWW-130, Seattle, WA 98101. Telephone (800) 424-4EPA or (206) 553-1200.

e. Disposal to an Injection Well (Idaho Department of Water Resources Underground Injection Program)

Injection wells are used to dispose of wastes at a depth well below any aquifers that contain useful water. Existing injection wells are few in number and construction of new ones is very expensive. For these and other reasons, disposal of residuals to an injection well is unlikely to be a viable option for a water system. Information on the injection well program can be obtained from IDWR.

Contact: Idaho Department of Water Resources, Underground Injection Program, 322 E. Front St, PO Box 83720, Boise, Idaho 83720-0098. Telephone (208) 287-4800.

f. Land Application (IDAPA 58.01.17, Rules for Reclamation and Reuse of Industrial and Municipal Wastewater)

It is possible to land apply liquid residuals under a DEQ-issued reuse permit, providing that soils and crops are compatible, runoff is controlled, and long term degradation of the land or contamination of underlying ground water will not occur. Characterization of the waste stream in accordance with the constituents listed in Table 4 (page 6) may be sufficient as a starting point.

Analysis of soils for permeability characteristics, depth of profile, and electrical conductivity of the soil solute will be required, both initially and in subsequent years if a permit is issued. The total quantity of wastewater to be land applied and the distribution of application through the course of the year will need to be characterized.

Contact: DEQ Regional Office and ask to speak to someone about a wastewater reuse permit.

3.4.4 Disposal of Solid Waste Residuals

Disposal of solid residuals may occur, in a sanitary landfill (Subtitle D), in a hazardous waste disposal site (Subtitle C) or by land application. Important considerations related to landfill disposal include the following:

- Arsenic-bearing residuals must be tested for leaching potential using the TCLP procedure (EPA Test Method 1311). The arsenic contained on the adsorption media is tightly bound and will usually pass the TCLP test without difficulty, allowing for disposal in a non-hazardous landfill. Because arsenic bearing residuals subject to anaerobic or low pH conditions can release the bound arsenic and allow it to leach into ground water and migrate offsite, disposal in a lined landfill is recommended. The water system seeking to dispose of solid residuals containing arsenic will want to consider negotiating a long-term agreement with a landfill that is prepared to accept these residuals.
- If disposal is to occur in a sanitary landfill, **arsenic in the leachate must not exceed 5 mg/L** and the disposer must qualify as a *Conditionally Exempt Small Quantity Generator* (CESQG), meaning the quantity of waste generated cannot be greater than 100 kg/month. If your system generates more than 100 kg per month of solid waste that does not exceed the 5 mg/L leachate concentration, contact your local landfill to determine if their license allows them to accept greater quantities. If not, consider disposal at a hazardous waste site, or land application, as described below.
- If the TCLP test yields **greater than 5 mg/L arsenic** in the leachate, disposal to a hazardous waste site is required. The landfill authority will provide instructions on how to handle and deliver such wastes. Transportation and disposal of hazardous waste are highly regulated and likely to be expensive. Unless there are no practical alternatives, design engineers should avoid selecting a treatment strategy that results in residuals classified as hazardous waste.
- Sludge that results from settling or coagulation/precipitation of arsenic and other contaminants from liquid wastes may vary in composition due to chemical and physical changes during treatment and handling. Sludge that experiences low pH conditions or a reducing (low oxygen) environment may contain arsenic that is less oxidized and, therefore, more mobile.
- If the raw water contains radionuclides in addition to arsenic, care must be taken to prevent creation of a *mixed waste*, consisting of radioactive contaminants and arsenic (or other contaminants that exceed RCRA toxicity criteria). If mixed waste is a likely outcome of the treatment process, staged treatment may be required to remove contaminants separately.

- There are few options for disposal of mixed waste, and mixed waste regulatory requirements are extremely challenging. Handling and disposal of mixed wastes are not discussed in this guidance because economics alone make it unlikely that treatment processes resulting in mixed waste residuals will be chosen.

a. Disposal at a Sanitary Landfill

Each landfill authority determines what type of waste the facility will accept. Arsenic residuals may pass the TCLP but be mobilized under landfill conditions, such as anaerobic environments or in low pH environments during biological decomposition processes. Consequently, landfill authorities may develop monofill areas for placement of drinking water residuals. As mentioned above, solids residuals must be dry enough to pass the paint filter test before they may be landfilled.

A list of landfills in Idaho is provided in Appendix B, page 61.

b. Disposal at a Hazardous Waste Landfill

Solids that release more than 5 mg/L of arsenic during the TCLP are hazardous wastes and must be disposed of in a licensed hazardous waste facility. At present, only the American Ecology Grandview operation is licensed in Idaho.

Other facilities are located in Nevada, (American Ecology, Beatty site), and Utah (Envirocare), but there is some question as to whether Idaho-generated hazardous wastes can be disposed of at these locations.

It may be necessary to confine these wastes to containers before removal from the water treatment facility. Transportation of hazardous waste in all but the smallest quantity is regulated under the *Hazardous Materials Transportation Act*, which requires all shipments to be manifested and tracked. For this reason, water systems that create hazardous wastes will probably find it economically necessary to contract with service providers that specialize in this type of transport. Some manufacturers of arsenic treatment equipment offer waste handling and disposal as part of equipment leasing arrangements. Small systems may find such arrangements beneficial from both an operational and regulatory standpoint.

c. Land Application of Solid Residuals

Water treatment plant residuals are exempt from the Clean Water Act 503(b) provisions, but these materials may be regulated under IDAPA 58.01.16 (*Wastewater Rules*) or 58.01.06 (*Solid Waste Rules*). It will be necessary to characterize the waste residuals chemically and determine if:

- Land application confers a benefit in respect to crop production and related soil characteristics (or is at least neutral in these effects) or;
- Land application is primarily for disposing of the waste residuals.

For example, if the residuals contain nutrients, while at the same time having arsenic and other contaminant levels that are unlikely to cause environmental damage, then a benefit may be derived from land application.

The criteria for beneficial reuse provided in RCRA may serve as a guideline for land farming of solid residuals. The water system would need to own or control any land to be used for this purpose or be prepared to negotiate a fee-based agreement with a nearby landowner.

A detailed chemical characterization of the solids would be needed to determine toxicity characteristics and potential effects on soil chemistry and on the crops to be grown on the treated land. Under RCRA, solids containing up to **41 mg/kg** of arsenic may be land applied without any requirement to track the total amount of arsenic applied over time (EPA, 2003). Tracking is required when the solids contain arsenic in the range of 41-75 mg/kg, and total long-term arsenic accumulation must not exceed 41 kg of arsenic per hectare.

There are containment requirements (no runoff) and restrictions on the types of crops that can be grown. Tests for soil permeability and conductivity of the soil solute will be necessary prior to initiation of sludge application and at appropriate intervals thereafter.

Contact: DEQ Regional Office. Ask to talk to someone about a sludge management plan under Section 650 of the wastewater rules, or, alternatively, a solid waste disposal permit under IDAPA 58.01.06 and 40 CFR Part 257, Criteria for Classification of Solid Waste Disposal Facilities and Practices.

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4.0 Treatment and Disposal of Nitrates

Disposal of waste residuals containing nitrates are subject to both federal and state requirements. These requirements are described in the following, preceded by a brief discussion of the physical characteristics and health concerns associated with nitrates. There is also a discussion of available treatment technologies and several decision flowcharts designed to help you choose the treatment plan that will provide the most economical method of compliance.

4.1 Background

Although the quality of ground water in Idaho is generally good, ground water quality monitoring shows that, in specific areas of the state, Idaho's ground water has been significantly degraded. This localized degradation negatively impacts water quality and potentially threatens domestic water supplies, aquaculture, agriculture, mining, industrial, and other ground water beneficial uses (DEQ, 2005b).

Nitrate is one of the contaminants responsible for this degradation, and it is one of the most widespread ground water contaminants in Idaho (DEQ, 2005b).

4.1.1 Physical Characteristics

Nitrate is a vital component of foods and fertilizers and an essential nutrient for plant growth. Nitrate comes from a variety of sources, such as plants and other organic matter that return nitrate to the soil as they decompose (Figure 2). Septic systems and waste from animal feedlots discharge nitrates to the environment. Application of nitrogen-based fertilizers is another avenue for adding nitrates to the environment (DEQ, 2005b).

Both nitrate and nitrite (which can be formed from nitrate) are compounds of nitrogen:

> Nitrate is an inorganic compound that occurs under a variety of conditions in the environment, both naturally and synthetically. Nitrate is composed of one atom of nitrogen (N) and three atoms of oxygen (O); the chemical symbol for nitrate is NO_3. Nitrite (NO_2) can be formed from nitrate by a chemical process called reduction. Nitrate does not normally cause health problems unless it is reduced to nitrite.

(McCasland, et al.)

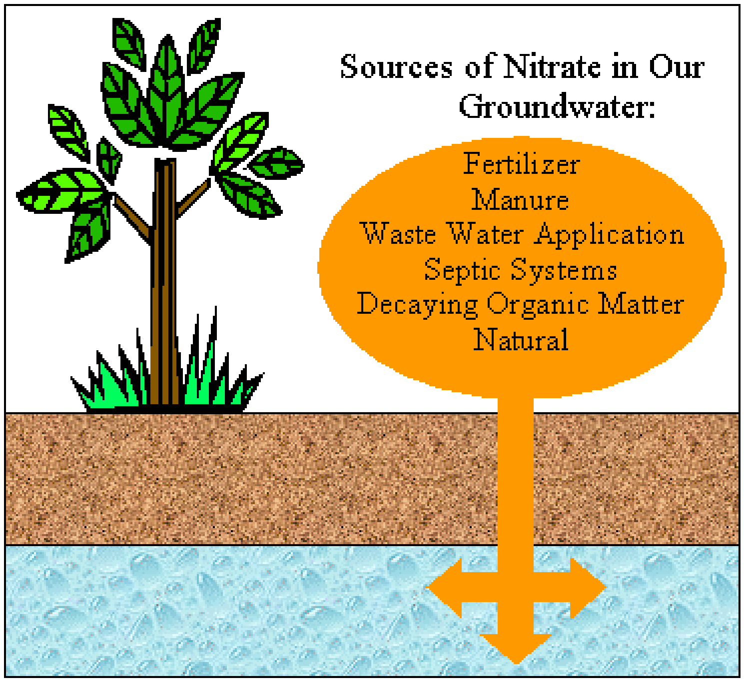

Figure 2. Sources of nitrate. (Source: IDWR, Nitrate)

Nitrate not used by plants can build up in and move through the soil. Precipitation, irrigation, and sandy soils allow nitrate to move around and find its way into surface water and ground water (DEQ, 2005b).

4.1.2 Health and Safety Considerations

If nitrate (NO_3^-) is converted to nitrite (NO_2^-) in the digestive system of the person or animal that consumes it, a condition called *methemoglobinemia* can ensue, reducing the oxygen supply in the bloodstream:

> The principal mechanism of nitrite toxicity is the oxidation of the ferrous iron (Fe^{2+}) in deoxyhemoglobin to the ferric (Fe^{3+}) valence state, producing methemoglobin. Methemoglobin cannot reversibly bind or transport circulating oxygen. Depending on the percentage of total methemoglobin in oxidized form, the clinical picture is one of oxygen deprivation with cyanosis, cardiac dysrhythmias and circulatory failure, and progressive central nervous system (CNS) effects. CNS effects can range from mild dizziness and lethargy to coma and convulsions.
>
> (ATSDR, 2001)

The effects of methemoglobinemia are most pronounced in infants, whose digestive systems tend to have the higher pH levels conducive to conversion of nitrate to nitrite (ATSDR, 2001):

> Short-term exposure to drinking water with a nitrate level at or just above the health standard of 10 mg/l nitrate-N is a potential health problem primarily for infants. Babies consume large quantities of water relative to their body weight, especially if water is used to mix powdered or concentrated formulas or juices. Also, their immature digestive systems are more likely than adult digestive tracts to allow the reduction of nitrate to nitrite. In particular, the presence of nitrite in the digestive tract of newborns can lead to a disease called methemoglobinemia.
>
> http://pmep.cce.cornell.edu/facts-slides-self/facts/nit-heef-grw85.html

The result can be "blue baby syndrome," a condition marked by a bluish discoloration around the infant's lips, nose, and ears. If untreated, the condition can be fatal:

> The first reported case of fatal acquired methemoglobinemia in an infant due to ingestion of nitrate-contaminated well water occurred in 1945. Since then, about 2,000 similar cases of acquired methemoglobinemia in young infants have been reported worldwide; about 10% of such cases result in fatality. The most recently reported U.S. case of infant mortality due to this source was in 1987.
>
> (ATDSR, 2001)

4.2 Regulations

Both federal and Idaho state regulations apply to nitrate in drinking water and as a waste. Applications of these regulations are described in the following sections.

4.2.1 Federal Statutes and Regulations

Federal statutes and regulations that apply to nitrate in drinking water waste residuals include the following:

- *Safe Drinking Water Act* (SDWA; EPA, 2005h) and regulations promulgated thereunder, which established a nitrate MCL of **10 mg/L**.
- *Clean Water Act* (CWA, 2002). Waste residuals that are to be discharged to a stream or other water body require a National Pollution Discharge Elimination System (NPDES) permit from Region 10 of the U.S. Environmental Protection Agency, 1200 Sixth Avenue, Seattle, WA 98101. Telephone (206) 553-1200. Additional information about the NPDES program can also be located at the following address:

  http://cfpub.epa.gov/npdes/
- *Resource Conservation and Recovery Act* (RCRA; EPA, 2005g)

4.2.2 Idaho Statutes and Rules

- IDAPA 58.01.11, *Ground Water Quality Rule*, Section 200, defines the standard for nitrate as nitrogen as 10 mg/L.

4.3 Treatment Strategies and Processes

Three methods of removing nitrates have been approved by EPA (EPA, 2005c):

- Ion exchange
- Reverse Osmosis
- Electrodialysis

4.4 Waste Characterization and Disposal

Table 1 and Table 2 (pages 4 and 5, respectively), may serve as a good starting point for raw water analysis when nitrate removal is the aim of the treatment process.

It may be possible to reduce the number of analytes, depending upon previous monitoring history and the specific requirements of the treatment technique under consideration. For example, if a system has not detected arsenic in prior sampling, analysis for the various ionic species of this element will not be necessary. If there is any question about arsenic occurrence, it would be advisable to determine concentration levels so that the characteristics of projected waste residuals may be anticipated.

Other constituents listed in the tables may be similarly examined for exclusion/inclusion.

If disposal of residuals to the subsurface through an existing septic system is contemplated, the contaminants listed in the *Ground Water Quality Rule* (IDAPA 58.01.11), pp. 6-9, should be reviewed against the system's prior monitoring results to determine if any contaminants are present in amounts that could compromise ground water quality. For a current list of these contaminants, see the *Ground Water Quality Rule* at the following:

http://adm.idaho.gov/adminrules/rules/idapa58/58index.htm

Any of these constituents that have occurred during past monitoring should be included in the raw water analysis.

The presence of radionuclides in the source water has the potential to complicate the choice of treatment strategies and residuals disposal options (see page 33). Radionuclides may need to be removed by a separate treatment process prior to addressing nitrate removal.

4.4.1 Nitrate Removal Options

A variety of nitrate removal processes, each of which produces different residuals, are briefly discussed in the following. The design engineer will encounter much more specific detail when investigating different treatment techniques.

- *Membrane processes*, such as reverse osmosis, may have reduced efficiency due to the similar size of water molecules and nitrate ions. However, the reject water from a membrane process will not contain brines, which opens the possibility of using the waste water for irrigation of crops under a land application permit, or disposing of the water through a septic system (as long as flows and nitrate loading do not compromise the treatment capability of the system).

- An *ion exchange process* that uses a sodium chloride regeneration cycle can be quite efficient, but the backwash and rinse waters will contain high levels of sodium and chloride ions along with the nitrate and any other negative ions that are concentrated through the exchange medium (sulphate, as an example). These constituents would probably eliminate subsurface disposal or land application of the residuals, unless secondary treatment to coagulate or precipitate offending constituents is undertaken. The result of secondary treatment would be essentially uncontaminated water and a sludge that could be land filled. The use of holding and processing lagoons may be warranted. Direct or indirect disposal to a POTW may be an option.
- A *carbon dioxide regenerated ion exchange process* is available, which removes neutral salts from the treated water and liberates carbon dioxide. This process requires precise management—operator skill level and time demands will need to be considered as part of long-term operating costs. The backwash and rinse waters from this process are free of serious contamination and may be disposed of without regulatory hurdles.
- Various types of *biological denitrification processes* are available. In one type of process, ethanol, methanol, or acetic acid is added to provide a carbon source for bacterial growth. Phosphate may also be needed in trace quantities. Carbon dioxide is introduced to the raw water to replace oxygen and create the anoxic conditions required for the denitrification process. Because organic carbon and bacterial biomass is added to the water during treatment, a polishing stage, involving aerated filtration is required. The waste residual from this type of treatment consists of varying quantities of biomass (which is environmentally benign). Again, operator skill and time demands are a key consideration with this type of treatment. The scheme described here is only one of several biological treatment options that have been used to remove nitrates.

As with any treatment process, the design engineer is likely to rely on technology vendors for initial assessments of process complexity and operator requirements, as well as projections of the chemical characteristics and volume of waste residuals. Pilot testing may be needed to verify site-specific efficiencies.

4.4.2 Analysis of Waste Residuals

Disposal options for nitrate residuals (Figure 3) will first depend upon whether central or Point-of-Use (POU) treatment is used. For centralized treatment, the options available will depend upon whether the waste is liquid or solid.

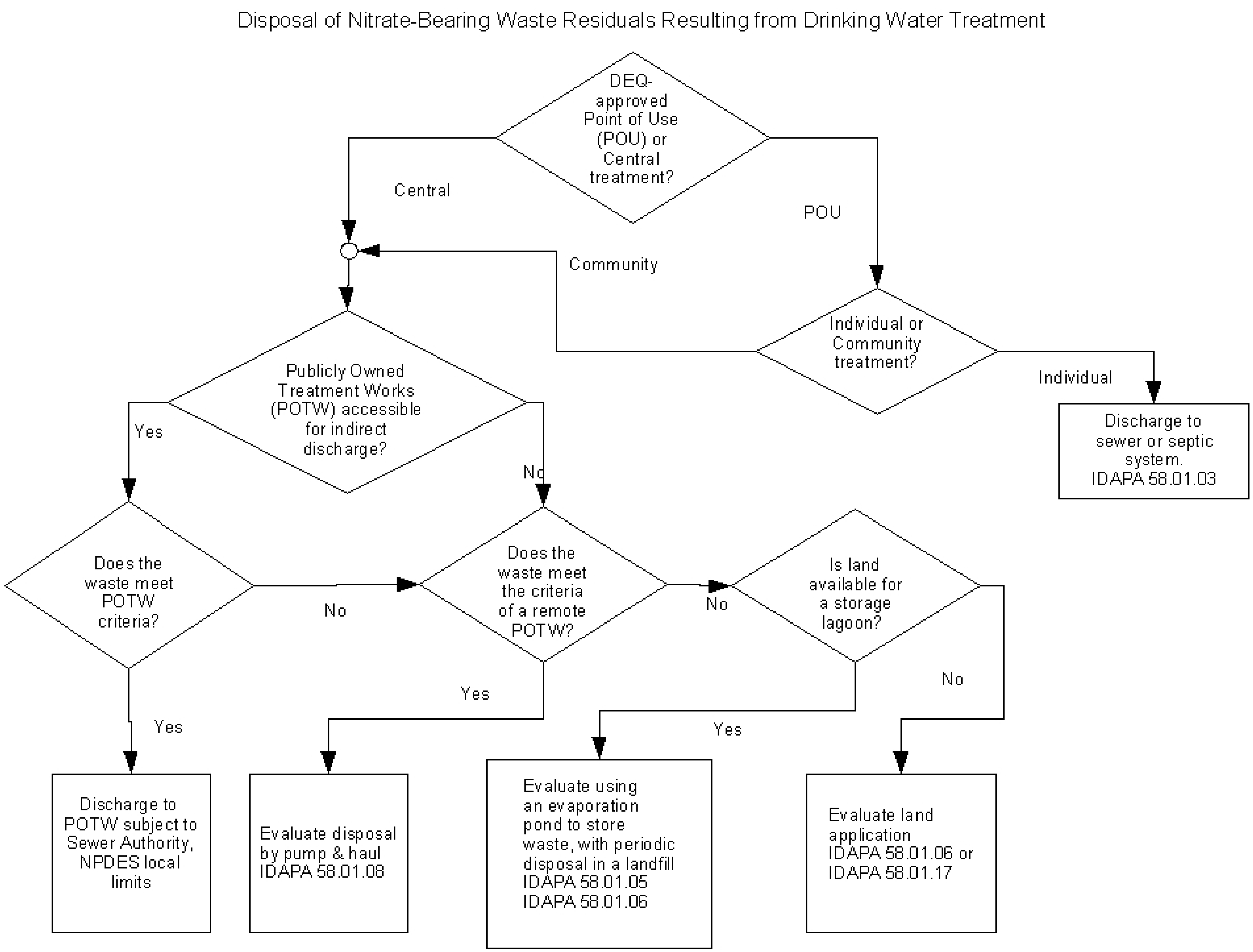

Figure 3. Disposal options for wastewater containing nitrates.

4.4.3 Disposal of Liquid Waste Residuals

Based on the treatment process used, the liquid residuals from nitrate treatment can vary widely in composition. The following disposal options apply to concentrated waste residuals that result from membrane treatment or ion exchange processes. (The other treatment processes discussed above, assuming that they are operated with care and precision, do not produce residuals that are subject to regulation.)

a. Total Containment Evaporation Lagoon (Idaho Code 39-118 Plan & Specification Review)

A water quality engineer at a DEQ Regional Office will need to approve the design and construction of the lagoon(s). Considerations include sizing to accommodate flows plus a safety margin for heavy precipitation events or snowmelt, lining of the lagoon to prevent percolation of contaminants into underlying groundwater, and proper design and construction of containment structures to prevent the escape of impounded liquids.

Lagoons must be capable of being dewatered at appropriate intervals so that sediments can be dried and characterized (as described in the following section on solid residuals) to determine what type of ultimate disposal is appropriate.

Contact: DEQ Water Quality Engineer at the appropriate Regional DEQ Office—see Appendix A, page 59.

b. Connection to a POTW (Clean Water Act—NPDES Program and 40 CFR 503, Subpart B standards for land application)

If a POTW is available, the water system may obtain permission to dispose of liquid wastes by this route. The POTW will need to demonstrate that the waste stream will meet the requirements of their industrial pretreatment program, will not impact the operation of their treatment processes, will not violate the terms of their NPDES discharge permit, and will not exceed standards for the composition of any biosolids that are land-applied after drying.

Analysis of the constituents in Table 3 (page 5) may be adequate as a starting point for discussions with the POTW. However, each POTW has unique contaminant challenges and specific discharge criteria that may dictate further analyses of the treatment residuals. Total flow to the POTW and the distribution of flows through time will be required for the POTW to estimate the impact of receiving these wastes. Systems pursuing this and the following disposal option should expect fees to be charged, as there is no other incentive for a POTW to increase the load on their treatment facility.

Contact: A POTW to which a direct connection is present or feasible.

c. Pump and Haul to a POTW

This disposal strategy is a variation on the previous, the difference being that the water system temporarily stores the liquid residual onsite, with the temporary storage tank design and construction to be approved under an Idaho Code Section 39-118 plan and specification review by a DEQ water quality engineer. (Belowground tanks are not allowed).

Characterization of the waste residuals may proceed as in option b. The POTW may request additional analyses. Total volumes and data describing the projected frequency and volume of individual deliveries will be needed.

Contact: Any nearby POTW to which wastes could be economically transported.

d. Direct Discharge to Surface Water (Clean Water Act, NPDES Program)

EPA Region 10 administers the NPDES program in Idaho. Water systems that wish to pursue a permit for direct discharge will need to contact EPA and obtain instructions on how to apply. Requirements for chemical and physical characterization of liquid waste residuals will vary in accordance with the attributes of the proposed receiving waters. As part of the NPDES permit process, DEQ will conduct a *401 certification*, but this will only occur if EPA is prepared to issue a permit. It is important to be aware that the time required for issuance of an NPDES permit can exceed three years from the date of application.

Contact: Unit Manager, NPDES Permits Unit, US EPA Region 10, 1200 Sixth Avenue, OWW-130, Seattle, WA 98101. Telephone (800) 424-4EPA or (206) 553-1200

e. Disposal to an Injection Well (Idaho Department of Water Resources Underground Injection Program)

Injection wells are used to dispose of wastes at a depth in the earth located well below any aquifers that contain useful water. Existing injection wells are few in number and construction of new ones is very expensive. For these and other reasons, disposal of residuals to an injection well is unlikely to be a viable option for a water system. Information on the injection well program can be obtained from IDWR.

Contact: Idaho Department of Water Resources, Underground Injection Program, 322 E. Front St, PO Box 83720, Boise, Idaho 83720-0098. Telephone (208) 287-4800.

f. Land Application (IDAPA 58.01.17, Rules for Reclamation and Reuse of Industrial and Municipal Wastewater or IDAPA 58.01.06, Solid Waste Management Rules)

It is possible to land apply liquid residuals under a DEQ-issued reuse permit, providing that soils and crops are compatible, runoff is controlled, and long term degradation of the land or contamination of underlying ground water will not occur. Characterization of the waste stream in accordance with Table 4 (page 6) may be sufficient as a starting point.

Analysis of soils for permeability characteristics, depth of profile, and electrical conductivity of the soil solute will be required, both initially and in subsequent years if a permit is issued. The total quantity of wastewater to be land applied and the distribution of application through the course of the year will need to be characterized.

Contact: DEQ Regional Office and ask to speak to someone about a wastewater land application permit.

4.4.4 Disposal of Solid Waste Residuals

Unless nitrate residuals also contain potentially toxic contaminants, such as arsenic, solids derived from sediments in containment lagoons are likely to be eligible for land application or placement in a sanitary landfill. Landfill placement will probably require a TCLP to rule out any toxic constituents, although characterization data from the liquid waste residuals may be sufficient to satisfy landfill authorities that the solids lack toxic properties.

The practicality of land application will depend upon constituents other than nitrate. If sodium chloride is present, as would be the case with brine backwashed ion exchange systems, land application is unlikely to be approved unless quantities to be applied are very small and the land surface available is sufficient to allow for very light application rates.

a. Disposal at a Sanitary Landfill

Each landfill authority determines what type of waste the facility will accept. Solid residuals must be dry enough to pass the paint filter test before they may be landfilled.

A list of landfills in Idaho is provided in Appendix B, page 61.

b. Land Application of Solid Residuals

Water treatment plant residuals are exempt from the Clean Water Act 503, Subpart B provisions, but these materials may be regulated under IDAPA 58.01.16.650 (Wastewater Rules) or 58.01.06 (Solid Waste Rules). It will be necessary to characterize the waste residuals chemically and determine if:

- Land application confers a benefit with respect to crop production and related soil characteristics (or is at least neutral in these effects) or;
- Land application is primarily for disposing of the waste residuals.

For example, if the residuals contain nutrients, but also have arsenic and other contaminants at levels that are unlikely to cause environmental damage, then a benefit may be derived from land application.

The criteria for beneficial reuse provided in RCRA may serve as a guideline for land farming of solid residuals. The water system would need to own or control any land to be used for this purpose, or be prepared to negotiate a fee-based agreement with a nearby landowner. A detailed chemical characterization of the solids would be needed to determine toxicity characteristics and potential effects on soil chemistry and on the crops to be grown on the treated land. Tests for soil permeability and conductivity of the soil solute will be necessary prior to initiation of sludge application and at appropriate intervals thereafter.

Table 4 (page 6), may be used as a guide to characterizing solid residuals intended for land application.

Contact: DEQ Regional Office. Ask to talk to someone about a sludge management plan under Section 650 of the wastewater rules, or, alternatively, a solid waste disposal permit under IDAPA 58.01.06 and 40 CFR Part 257, Criteria for Classification of Solid Waste Disposal Facilities and Practices).

5.0 Treatment and Disposal of Uranium

Disposal of waste residuals containing uranium and other *radionuclides* (radioactive nuclides) are subject to both federal and state requirements. These requirements are described in the following, preceded by a brief discussion of the physical characteristics and health concerns associated with uranium. There is also a discussion of available treatment technologies and decision flowcharts designed to help you choose the treatment plan that will provide the most economical method of compliance.

5.1 Background

Uranium is a naturally occurring radioactive metal found in many places. Once thought to be rare, uranium may be more abundant than mercury, antimony, silver, or cadmium (CRC, 1993). For the purposes of this guidance, uranium is defined in terms of the characteristics of uranium-238, the most abundant isotope of this element.

5.1.1 Physical Characteristics

Some important physical characteristics of uranium include the following:

- Naturally occurring uranium consists mostly of the isotope uranium-238 (99.2830%), along with much smaller amounts of the isotopes uranium-235 (0.711%) and uranium-234 (0.0054%) (CRC, 1993).
- Uranium-238 decays slowly, having a half-life—the time required for one half of the atoms to decay—of 4.5 billion years. Decay is by alpha particle emission (CRC, 1993).

5.1.2 Natural Occurrence

Natural concentrations of uranium vary, as shown in Figure 4. Some natural concentrations of uranium can even exceed the **regulatory limit of 30 μg/L** (see *Safe Drinking Water Act*, page 41), but most are below 5 μg/L.

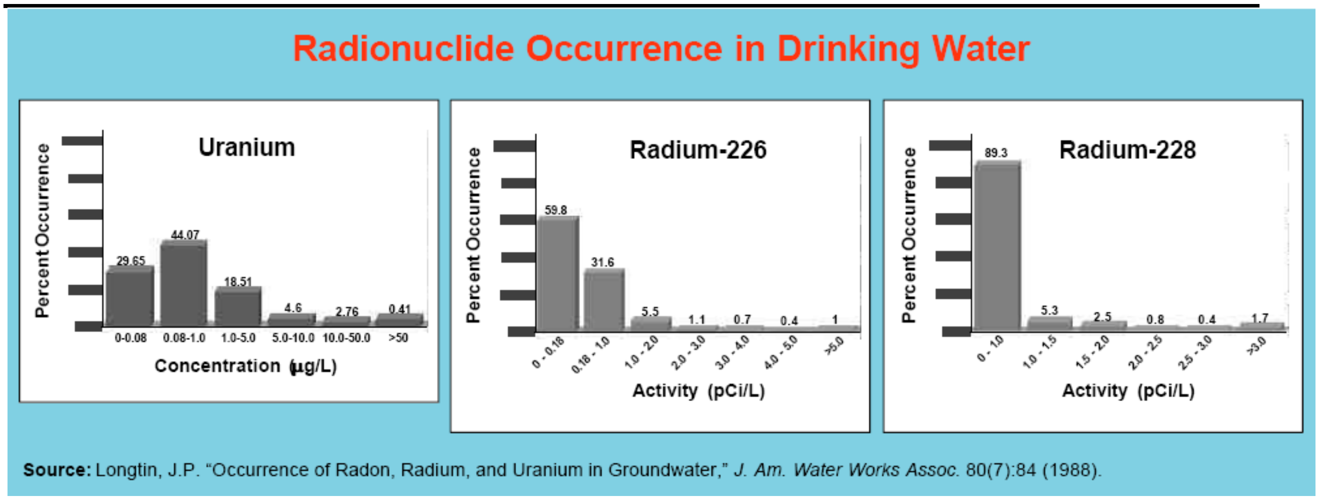

Figure 4. Natural occurrence of radionuclides in drinking water.

5.1.3 Health and Safety Considerations

Uranium poses both a radiological and a toxicological health risk. The radiological health risk stems from uranium's radioactive nature, and, as with many other heavy metals, uranium poses a risk of increased kidney disease. Both of these risks are discussed in the following.

Radiation Concerns

There are two general categories of radiation (INL Oversight, Radiation):

- Electromagnetic waves, which includes gamma rays, X-rays, ultraviolet, visible light, infrared, and radio waves
- Emitted particles, such as alpha particles (the nucleus of the helium atom, stripped of its electrons), beta particles (electrons), and neutrons (the non-charged part of the nucleus)

Alpha radiation is not deeply penetrating: most alpha particles are unable to pass through a sheet of paper (Figure 5) or the layer of dead skin cells on the surface of our bodies (Henry, 1969). Consequently, uranium does not pose a health hazard for external exposures (EPA, 2004).

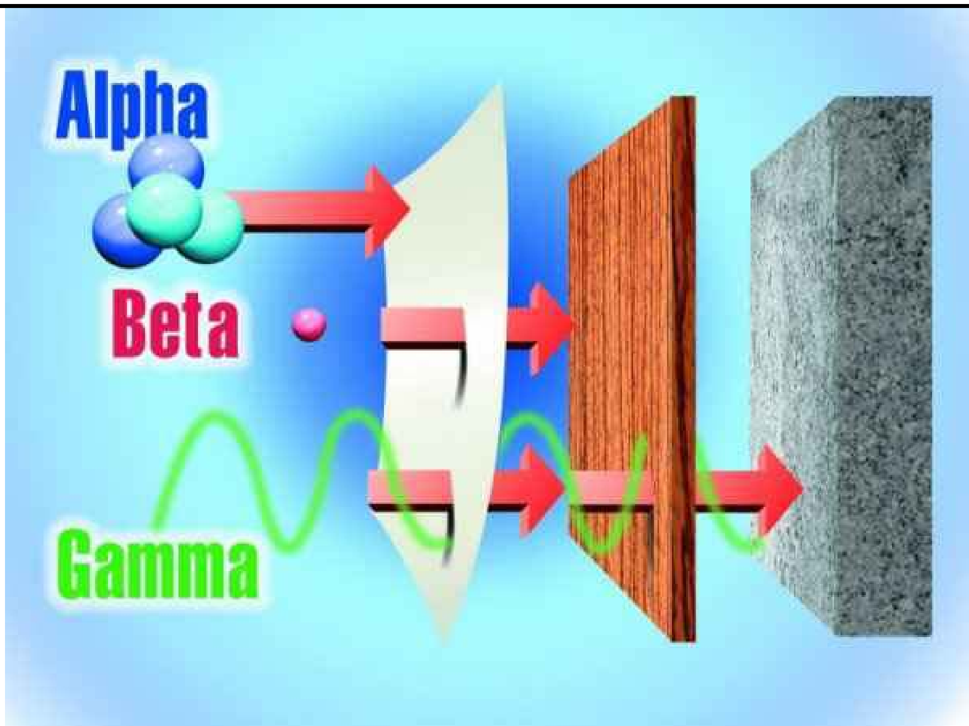

Figure 5. Most alpha particles are stopped by a sheet of paper.

(Source: INL Oversight, http://www.oversight.state.id.us/radiation/rad_penetration.htm)

The main radiological concern regarding uranium involves internal exposure:

> "Uranium can enter the body when it is inhaled or swallowed or through cuts in the skin. About 99 percent of the uranium ingested in food or water will leave a person's body in the feces, and the remainder will enter the blood. Most of this uranium will be removed by the kidneys and excreted in the urine within a few days. A small amount of the uranium in the bloodstream will be deposited in a person's bones, where it will remain for several years."
>
> (EPA, 2002e)

Uranium that remains in the body can present a chronic source of radiation capable of damaging cells and producing genetic damage (EPA, 2002c). At low doses, the effects of radiation are stochastic, involving probabilities rather than direct cause-and-effect relationships. Potential consequences of prolonged exposure include the development of cancers and genetic mutations (Figure 6).

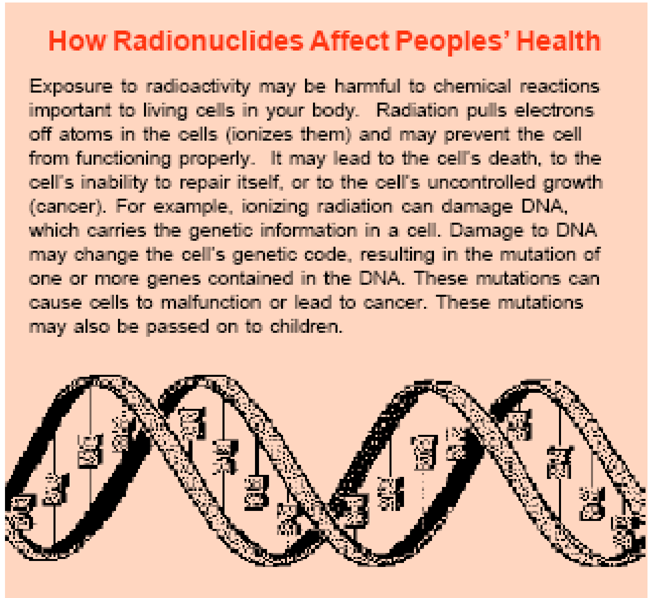

Figure 6. How radioactivity may affect your health.
(Source: EPA, 2002d)

Toxicological Concerns

As with other heavy metals, the presence of uranium can pose an increased risk of kidney disease:

> "In general, heavy metals are attracted to sulfur, often have charged ions that easily bind to other molecules, and result in various oxidation states. The kidney serves as a target organ for toxins due to its extremely high blood flow of 25% of cardiac output. As a result, heavy metals that enter the blood stream will travel to the kidney. The primary function of the kidney is to concentrate waste products, including heavy metals. Transport and binding sites in the kidney are present in proximal tubules and metals may alter the structure of the protein and membrane. These changes may result in longterm residual effects. Waste products filter through the nephrons of the kidney, collect in a duct, travel to the urine and are eventually excreted. The majority of heavy metals elicit adverse effects in proximal tubules. Uranium and mercury cause toxicity in the same portion of the proximal tubules."
>
> (CDC, 2002)

> "A few people have developed signs of kidney disease after intake of large amounts of uranium. Animals have also developed kidney disease after they have been treated with large amounts of uranium, so it is possible that intake of a large amount of uranium might damage your kidneys."
>
> (ATSDR, 1999)

Health and Safety Issues for Workers

Systems should conduct a radiation survey if either of the following applies (EPA, 2005a):

- Analytical results within the past 5 years have approached or exceeded an MCL for a regulated radionuclide.
- Calculations using the SPARRC spreadsheet (see page 48 for more on this tool) indicate potential concentrations of radioactivity in residuals and filters.

In addition to conducting a radiation survey, systems are encouraged to check for radon in buildings holding system equipment (EPA, 2005a). Radon, one of the elements created in the chain of disintegrations that begins with uranium-238 and ends with stable lead, exists as a colorless, odorless gas at standard temperature and pressure. Because radon, an alpha-particle emitter, is readily inhaled, the subsequent decay of radon trapped in the lungs can easily damage sensitive lung tissue.

5.2 Regulations

Both federal and state regulations apply to uranium, as described in the following.

5.2.1 Federal Statutes and Regulations

Federal statutes and regulations potentially applicable to waste streams containing uranium include the following:

- *Atomic Energy Act* (AEA, 1954), including *Standards for Protection Against Radiation* (10 CFR 20)
- *Clean Water Act* (CWA, 2002)
- *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA)
- Occupational Safety and Health Administration (OSHA, 1910) requirements, including:
  - 29 CFR 1910.1096, *Ionizing radiation*
  - 29 CFR 1910.132-136, *General requirements*, which addresses personal protective equipment (PPE) for the eyes, face, head, and extremities
  - 29 CFR 1910.146, *Permit-required confined spaces*
  - 29 CFR 1910.147, *The control of hazardous energy (lockout/tagout)*
  - 29 CFR 1910.1200, *Hazard Communication*
- *Resource Conservation and Recovery Act* (RCRA; EPA, 2005g)
- *Safe Drinking Water Act* (SDWA; EPA, 2005h), including the revised *Radionuclides Rule*, which became effective on December 8, 2003, and which established the MCL for uranium of **30 µg/L**
- Title 49, Subtitle B of the Code of Federal Regulations: *Other Regulations Relating to Transportation*

Atomic Energy Act (Nuclear Regulatory Commission) Requirements

The *Atomic Energy Act* (AEA, 1954), as amended, set up the Nuclear Regulatory Commission[3] (NRC) to regulate civilian commercial, industrial, academic, and medical use of nuclear materials, including what is called *source material*. Source material includes uranium that has not been processed (enriched) to contain more of the isotope uranium-235:

> In general terms, "source material" means either the element thorium or the element uranium, provided that the uranium has not been enriched in the isotope uranium-235. Source material also includes any combination of thorium and uranium, in any physical or chemical form, or ores that contain by weight one-twentieth of one percent (0.05 percent) or more of uranium, thorium, or any combination thereof. Depleted uranium (left over from uranium enrichment) is considered source material.

(NRC, http://www.nrc.gov/materials/srcmaterial.html)

As long as the quantity of source material does not exceed **0.05 percent by weight**, and the total quantity of material does not exceed **15 pounds at any given time** (**150 pounds over the course of a year**) no special requirements apply to the licensee:

> (a) A general license is hereby issued authorizing commercial and industrial firms, research, educational and medical institutions and Federal, State and local government agencies to use and transfer not more than fifteen (15) pounds of source material at any one time for research, development, educational, commercial or operational purposes. A person authorized to use or transfer source material, pursuant to this general license, may not receive more than a total of 150 pounds of source material in any one calendar year.

(10 CFR 40.22)

You can also determine the quantity of a radioactive material by measuring how radioactive it is. The 0.05 percent by weight criterion, for uranium, is equivalent to an activity of **335 pico-Curies per gram** (pCi/g) (EPA, 2005a), where a Curie is 3.7×10^{10} disintegrations (decays) per second (10 CFR 20), and a pico-Curie is one trillionth of that, or 0.037 disintegrations per second.

For additional information on radiation and radioactivity, see the following:

Articles and Information About Radiation, http://www.deq.idaho.gov/inl_oversight/radiation/overview.cfm

Understanding Radiation, http://www.epa.gov/radiation/understand/radiation.htm

and http://www.epa.gov/radiation/understand/curies.htm

Specific requirements placed on uranium-containing waste by the Atomic Energy Act, as enforced by the Nuclear Regulatory Commission, are shown in Table 10. Possession of source material in concentrations or quantities greater than those shown requires compliance with 10 CFR 40, parts 19 (*Notices, Instructions and Reports to Workers: Inspection and Investigations*), 20 (*Standards for Protection Against Radiation*), and 21 (*Reporting of Defects and Noncompliance*).

[3] The original Atomic Energy Act of 1954 established the Atomic Energy Commission, which in 1974 was split into the NRC and the Energy Research and Development Agency (ERDA). In 1977, ERDA became the Department of Energy (OSTI, 2005).

Table 10. Source material quantities exempt from specific licensing requirements.

Means of Measurement	Requirements
Concentration	Less than 0.05 percent, by weight of uranium.
Radioactivity	Less than 335 pico-Curies per gram.
Quantity	Less than 15 pounds at any given time; less than 150 pounds over the course of a year.

Drinking water systems should also be aware of the following important definitions and requirements regarding source material:

- The source material is deemed an **"unimportant quantity"** and is exempt from NRC regulation if the uranium makes up less than 0.05 percent by weight (or approximately 335 pCi/g for natural uranium) of the material. These limits apply to both liquid and solid residuals (EPA, 2005A).
- If the source material contains more than 0.05 percent uranium by weight, but no more than 15 pounds at any time, it is considered a **"small quantity"** and is subject to the general license requirements of 10 CFR 40.22, including disposal at facilities authorized to accept Low Level Radioactive Waste (LLRW)(EPA, 2005A).
- Systems that exceed the unimportant quantity and small quantity thresholds must apply for specific licenses from the NRC or Agreement State (EPA, 2005A).

For liquid waste that is to be disposed of in a sewer system, the concentration of uranium must not exceed **$3\text{x}10^{-7}$ µCi/ml** ($3\text{x}10^{-7}$ pCi/L) (10 CFR 20, Appendix B, Table 2, column 2).

During an August 2004 Webcast, EPA suggested the possibility of an exemption from specific licensing for water treatment facilities:

> Systems that exceed these small quantity thresholds must apply for specific licenses from the Nuclear Regulatory Commission (NRC) or Agreement State and dispose of residuals at facilities authorized to accept LLRW (unless regulators approve another type of disposal). <u>Water treatment facilities that exceed the small quantity thresholds can also apply to the NRC for an exemption from regulatory requirements in 10 CFR Part 40 [underlining added for emphasis]</u>
>
> http://www.epa.gov/safewater/dwa/rules.html

However, the NRC has not yet defined how systems would apply for such an exemption. In a March 2006 recommendation to the Commission (NRC 2006a), NRC staff recommended creating a new interim general license specific to drinking water facilities, but, in April, the Commission ordered staff to follow the normal rulemaking process (NRC 2006b), with the goal of having a rule in place within 20 months (presumably late 2007 or early 2008).

Clean Water Act

The *Clean Water Act* (CWA, 2002, USC 1251 to 1387), establishes requirements for direct discharges of liquid waste or the discharge of a liquid waste to publicly owned treatment works (POTW). Any such discharges must comply with the requirements of the National Pollutant Discharge Elimination System (NPDES).

In Idaho, the NPDES permit program is administered by the U.S. Environmental Protection Agency (EPA), which means that EPA is responsible for issuing and enforcing all NPDES permits in Idaho. The state's role in this process is to certify that NPDES-permitted projects comply with state water quality standards.

For additional information on the NPDES program, see the following Web site:

http://cfpub.epa.gov/npdes/index.cfm

For additional information on Idaho's role regarding NPDES, see the following:

http://www.deq.idaho.gov/water/permits_forms/permitting/401_certification.cfm

Comprehensive Environmental Response, Compensation, and Liability Act

The *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA, 42 USC 9605 et seq.), also known as *Superfund*, provides "broad Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment" (EPA, 2005b).

CERCLA also defines reporting requirements for the release of hazardous substances, including radionuclides.

The *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP, 40 CFR 300) applies to the release or threat of release of hazardous substances (including radionuclides) that may endanger human health and the environment. If disposal of radionuclide-contaminated residuals results in a release or threat of release that endangers human health or the environment, CERCLA may require cleanup of the hazardous substance.

Resource Conservation and Recovery Act

The *Resource Conservation and Recovery Act* (RCRA, 40 CFR 239 to 282) establishes a variety of regulatory programs, addressing both nonhazardous and hazardous wastes (EPA, 2005A):

- Nonhazardous solid waste (Subtitle D), such as that accepted by municipal solid waste landfills (MSWLF). MSWLFs can also receive commercial and industrial wastes. "The Municipal Solid Waste Landfill (MSWLF) requirements (40 CFR 258), establish minimum national criteria for MSWLFs covering landfill location, operation, and design; ground water monitoring; corrective action; closure and post-closure, and financial assurance."

  "Subtitle D landfills that accept nonhazardous waste, but do not accept municipal waste ("industrial landfills"), are also subject to federal regulations (40 CFR Part

257, Subparts A and B). However, state regulations typically have additional requirements that apply to these industrial landfills."

- Hazardous waste (Subtitle C). "Land disposal units that accept hazardous waste are regulated under Subtitle C, and include landfills, surface impoundments, waste piles, land treatment units, and underground injection wells. These disposal units are subject to stringent design and operating standards (40 Parts 264 and 265)."

Safe Drinking Water Act

The *Safe Drinking Water Act* (SDWA, 42 USC 300 et seq.) requires EPA to develop minimum federal requirements to ensure that underground injection does not endanger current and future underground sources of drinking water (40 CFR 144-148).

The SDWA includes the *Radionuclides Rule* (40 CFR 141), which sets the MCL for uranium at 30 µg/L and defines the monitoring requirements shown in Table 11.

Table 11. Key uranium requirements of the *Radionuclides Rule*.

Parameter	Limit
MCL	30 µg/L
Monitoring requirements	1 sample every 3 years for systems above 50% of MCL (15 µg/L) but at or below MCL 1 sample every 6 years for systems above detection limit, but at or below 50% of MCL 1 sample every 9 years for systems below the detection limit
Detection limit	Not yet defined

In summary, *Safe Drinking Water Act* requirements for uranium (and other radionuclides) are as shown in Figure 7.

Radionuclide Maximum Contaminant Levels	
Beta/photon emitters*	4 mrem/year
Gross alpha particle	15 pCi/L
Radium-226 and Radium-228	5 pCi/L
Uranium	30 µg/L
*A total of 179 individual beta particle and photon emitters may be used to calculate compliance with the MCL.	

Figure 7. Radionuclide maximum contaminant levels established by the *Radionuclides Rule* and enforced by EPA.

Initial monitoring under the *Radionuclides Rule* must be completed by December 31, 2007. This date and other key milestones of the rule are shown in Figure 8.

Radionuclides Requirements Dates	
July 9, 1976	1976 Radionuclides Drinking Water Regulation.
June 2000	Under certain circumstances, data collected between June 2000 and December 8, 2003 may be eligible for use as grandfathered data to satisfy the initial monitoring requirements for gross alpha, radium-226/228, and uranium. Information on grandfathering data appears in future sections.
December 7, 2000	The Radionuclides Final Rule.
December 8, 2003	Rule effective date. Systems must begin initial monitoring under a State-specified monitoring plan, unless the State permits the grandfathering of data collected between June 2000 and December 8, 2003.
December 31, 2007	All systems must complete initial monitoring.
2008	Future monitoring frequency and compliance requirements will be determined by the State by this time.

Figure 8. *Radionuclides Rule* milestones.

Monitoring requirements under the *Radionuclides Rule* have changed:

> "One key change in the new Radionuclides Rule is that, rather than monitor at a 'representative' point in your distribution system, you must now monitor at EACH entry point to the distribution system (EPTDS)."
>
> (EPA, 2002d)
>
> EPA has provided States with the flexibility to decide on a case-by case basis whether data collected between June 2000 and December 8, 2003 can be grandfathered (i.e., substituted for the initial quarterly monitoring required by the Revised Radionuclides Rule). States must decide if the data collected by a system during the grandfathering period—in conjunction with historical data, information on geology, and any other criteria the State chooses to use—will provide enough information to ensure that radionuclide activity will remain below the MCLs.
>
> "Systems are required to conduct initial monitoring for gross alpha, radium-226, radium-228, and uranium at each EPTDS by December 31, 2007. You must collect four consecutive quarterly samples at each EPTDS during this initial round of monitoring in order to provide contaminant information during each of the four seasons"
>
> (EPA, 2002d)

After completion of the initial monitoring, monitoring frequency may be reduced under the conditions shown in Figure 9. However, obtaining a monitoring result that exceeds the MCL requires reverting to a quarterly schedule (EPA, 2002d).

Reduced Monitoring for Radionuclides		
If the initial monitoring results are:		Monitoring frequency is reduced to:
< Defined Detection limit	→	1 sample every 9 years
• Defined Detection limit, but • 1/2 the MCL	→	1 sample every 6 years
> 1/2 the MCL, but • the MCL	→	1 sample every 3 years
> MCL	→	Quarterly samples

Figure 9. Reduction of monitoring frequency allowed under the Radionuclides Rule.

Transportation

Other Regulations Relating to Transportation (49 CFR 171 to 180) governs shipping, labeling, and transport of hazardous (including radioactive) materials.

Definitions

Important federal definitions that apply to waste include those shown in Table 12.

Table 12. Federal definitions of waste.

Waste Type	Definition and Discussion
Hazardous waste	Waste is considered hazardous if it is a solid waste (as defined under 40 CFR 261.2) that is not excluded from regulation as hazardous waste under 40 CFR 261.4(b) and when it meets the criteria listed under 40 CFR 261.3(a)(2) and (b). These criteria can be found at: http://www.access.gpo.gov/nara/cfr/waisidx_99/40cfr261_99.html The presence of radionuclides does not make waste hazardous; hazardous waste generation will most likely be the result of the removal of co-occurring contaminants, such as arsenic, in the waste. Some treatment technologies that are effective in removing radionuclides (e.g., IX) will also be effective in removing other contaminants (e.g., arsenic) that, in high enough concentrations, could make the resulting residuals hazardous or, in some cases, mixed waste. Water systems are required to determine whether the waste they generate is hazardous. This may be done using knowledge of the waste generation process, analytical testing, or a combination of both. Analytical testing may involve leachate tests such as the Toxicity Characteristic Leaching Procedure (TCLP) (Method 1311, as described in U.S. EPA publication SW-846, “Test Methods for Evaluating Solid Waste, Physical/Chemical Methods”), which applies to 40 substances, including metals, pesticides, and other organic compounds. If the waste is hazardous, it must be managed under RCRA Subtitle C requirements.

Low level waste	The *Low-Level Radioactive Waste Policy Act* (42 USC 2021b(9)) defines low-level radioactive waste (LLRW) as "radioactive material that (A) is not high level radioactive waste, spent nuclear fuel, or byproduct material (as defined in section 2014(e)(2)...); and (B) the Nuclear Regulatory Commission classifies as low-level radioactive waste." Generally, LLRW can be thought of as byproduct material as defined in 42 USC 2014(e)(1) (i.e., yielded in or made radioactive by the production or use of special nuclear material) that does not fall into any other category. In addition, LLRW can contain source or special nuclear material. Note that water treatment residuals would not meet the definition of byproduct material as defined under 42 USC 2014(e)(2) (waste from processing uranium or thorium ore).
Mixed waste	Mixed waste "contains both hazardous waste and source...or byproduct material subject to the Atomic Energy Act of 1954" (42 USC 6903(41)). Therefore, although highly unlikely, systems generating waste containing uranium or thorium (source material) as well as hazardous waste could potentially have a mixed waste. If wastes contain licensable amounts of source material (any concentration exceeding the "unimportant quantity" in 10 CFR 40.13 (a)) and hazardous waste, these wastes must be disposed of at a facility authorized to accept mixed waste. A system generating hazardous waste does not have mixed waste if the amount of source material generated is an "unimportant quantity" (uranium or thorium makes up less than 0.05 percent by weight of the material), or if the waste contains only radium (since radium is not considered source or byproduct material when present in water treatment residuals).

(Source: EPA, 2005A)

Because there are limited disposal pathways, generation of a mixed waste should be avoided if at all possible.

5.2.2 Idaho Statutes and Rules

Idaho statutes and rules applicable to waste streams containing uranium include the following:

- *Idaho Hazardous Waste Management Act*
- *Rules Regulating the Disposal of Radioactive Materials Not Regulated Under the Atomic Energy Act of 1954, as Amended*

Idaho Hazardous Waste Management Act

The *Idaho Hazardous Waste Management Act* (Chapter 44, Title 39, Idaho Code) was enacted to protect public health and safety, health of living organisms, and the environment from the effects of the improper, inadequate, or unsound management of hazardous waste. The act directs DEQ to "promulgate rules which are consistent with RCRA and the federal regulations adopted by the administrator of the United States environmental protection agency to implement RCRA."

DEQ Rules

Rules that apply to disposal of waste residuals include the following:

- IDAPA 58.01.10, *Rules Regulating the Disposal of Radioactive Materials Not Regulated under the Atomic Energy Act of 1954, as Amended*, regulates the disposal of radioactive materials not regulated under the Atomic Energy Act of 1954, except for naturally occurring radioactive materials (NORM) or technologically enhanced naturally occurring radioactive materials (TENORM) waste from the production of elemental phosphorus or from the production of phosphate fertilizers.

  TENORM is defined as:

  > Any naturally occurring radioactive materials not subject to regulation under the Atomic Energy Act whose radionuclide concentrations or potential for human exposure have been increased above levels encountered in the natural state by human activities. TENORM does not include source, byproduct or special nuclear material licensed by the U.S. Nuclear Regulatory Commission under the Atomic Energy Act of 1954.

  (IDAPA 58.01.10)

Specific requirements of IDAPA 58.01.10 that apply to this guidance include the following:

- All owners and operators shall conduct operations in a manner consistent with radiation protection standards for occupation workers contained in 10 CFR 20.
- No person, owner, or operator shall dispose of radioactive materials by any method other than at a permitted treatment, storage or disposal facility.

5.3 Treatment Strategies and Processes

In the *Radionuclides Rule*, EPA has identified what it considers to be Best Available Treatments (BATs) and Small System Compliance Technologies (SSCTs) for use in removing radionuclides from drinking water (EPA, 2002B):

- BATs are “developed with large systems in mind, [where] removal is much more efficient. . .”
- SSCTs provide a measure of affordability and technical complexity for systems of different size categories.

Treatment technologies for removing radionuclides include the following:

- Ion exchange
- Point of use ion exchange
- Reverse osmosis
- Point of use reverse osmosis
- Lime softening
- Green sand filtration
- Co-precipitation with barium sulfate

- Electrodialysis/electrodialysis reversal
- Pre-formed hydrous manganese oxide filtration
- Activated alumina
- Coagulation/filtration

Table 13 lists each technology, along with that technology's appropriate designation as a BAT or SSCT, a size recommendation (for SSCT listings only), an assessment of the effectiveness of the technology for dealing with radioactive residuals (radium, uranium, gross alpha particle emissions, and beta/photo radiation), source water suitability, and the level of operator skill required by the technology.

Table 13. EPA Best Available Technologies and Small System Compliance Technologies listed in the Radionuclides Rule.

Treatment Technology	Designation	Customers Served (SSCTs only)	Treatment Capabilities				Source Water Considerations	Operator Skill Required
	BAT and/or SSCT?		Radium (Ra)	Uranium (U)	Gross Alpha (G)	Beta/photon (B)		
Ion Exchange (IX)	BAT & SSCT	25-10,000	√	√		√	All ground waters	Intermediate
Point of Use (POU) IX	SSCT	25-10,000	√	√		√	All ground waters	Basic
Reverse Osmosis (RO)	BAT & SSCT	25-10,000 (Ra, G, B) 501-10,000 (U)	√	√	√	√	Surface waters usually requiring pre-filtration	Advanced
POU RO	SSCT	25-10,000	√	√	√	√	Surface waters usually requiring pre-filtration	Basic
Lime Softening	BAT & SSCT	25-10,000 (Ra) 501-10,000 (U)	√	√			All waters	Advanced
Green Sand Filtration	SSCT	25-10,000	√				Typically ground waters	Basic
Co-precipitation with Barium Sulfate	SSCT	25-10,000	√				Ground waters with suitable water quality	Intermediate to Advanced
Electrodialysis/ Electrodialysis Reversal	SSCT	25-10,000	√				All ground waters	Basic to Intermediate
Pre-formed Hydrous Manganese Oxide Filtration	SSCT	25-10,000	√				All ground waters	Intermediate
Activated Alumina	SSCT	25-10,000		√			All ground waters	Advanced
Coagulation/Filtration	BAT & SSCT	25-10,000		√			Wide range of water qualities	Advanced

Source: EPA, 2005A.

Application of these technologies produces the types of residuals listed in Table 14.

Table 14. Residuals produced by treatment technologies.

Treatment	Types of Residuals							
	Solid			Liquid				
	Spent Resins /Media	Spent Membranes	Sludge	Brine	Backwash Water	Rinse Water	Acid Neutralization Water	Concentrate
Ion Exchange (IX)	√			√	√	√		
Reverse Osmosis (RO)		√						√
Lime Softening	√		√		√			
Green Sand Filtration	√		√		√			
Co-precipitation with Barium Sulfate	√		√		√			
Electrodialysis/Electrodialysis Reversal		√						√
Pre-formed Hydrous Manganese Oxide Filtration	√		√		√			
Activated Alumina (AA)	√			√	√	√	√	
Coagulation/Filtration	√		√		√			

Source: EPA, 2005a.

For a specific treatment technology, the concentrations of radionuclides expected can be estimated using the Spreadsheet Program to Ascertain Radionuclides Residuals Concentration (SPARRC). The program is available for download at the following URL:

http://www.npdespermits.com/sparrc/

For additional information about uranium, regulations regarding uranium, and treatment technologies, see the resources listed in Table 15.

Table 15. Resources for additional Information about uranium.

Issue	Resource	Location of Information
Basic information	EPA	http://www.epa.gov/superfund/resources/radiation/pdf/uranium.pdf
Health and safety issues	ATSDR	http://www.atsdr.cdc.gov/toxprofiles/tp150.html
Regulatory requirements	EPA DEQ NRC	http://www.epa.gov/safewater/rads/radfr.pdf http://www2.state.id.us/adm/adminrules/rules/idapa58/0110.pdf http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/ml022200075-vol1.pdf#pagemode=bookmarks&page=14
Treatment technologies	EPA	http://www.epa.gov/safewater/rads/implement.html

5.4 Waste Characterization and Disposal

An examination of water system monitoring history should reveal whether or not contaminants of regulatory concern co-occur with radionuclides. Table 1 and Table 2 (pages 4 and 5, respectively), may provide a starting point for analysis of contaminants other than radionuclides.

Table 16 lists the analytical methods approved by EPA for characterizing radionuclide levels in raw and finished drinking water.

Table 16. EPA-approved analytical methods for characterizing radionuclide levels in raw and finished drinking water.

Analyte	Methodology	Method
Gross alpha	Co-precipitation	EPA(1)00-02
Uranium Activity	Alpha spectrometry	EPA(1)00-07
Radium-226 Activity	Radon Emanation	EPA(2)903.1
Radium-228 Activity	Radiochemical	EPA(2)904.0

The selection of contaminants to be monitored should be based on prior monitoring results and any available knowledge of contaminants in the area where the source is located. Combinations of toxic and radioactive contaminants could dictate the need for a staged treatment process in which the toxics and radionuclides are removed separately so that mixed waste is not generated.

5.4.1 Analysis of Waste Residuals

The options for disposal of treatment residuals containing radionuclides are very limited in Idaho. Waste classified as TENORM (see page 45 for a definition) must be disposed of in an approved hazardous waste site. Because of this requirement, only solid radionuclide bearing wastes may be generated at a water treatment plant. There is only one hazardous waste site in Idaho:

US Ecology Idaho, Inc.
PO Box 400
(10.5 Miles NW on Hwy 78)
Grand View Idaho, 83624

Office (208) 834-2275
Fax (208) 834-2997
Hours: M-F 7:30 am - 4:00 pm

This facility may be contacted for information about characterization of waste containing radionuclides and requirements for handling and transporting such waste.

5.4.2 Disposal of Liquid Waste Residuals

All liquid waste containing radionuclides will require secondary treatment to remove the radioactive materials (Figure 10). For this reason, treatment strategies are likely to center around the use of techniques that do not generate a liquid residual. This would include one-time use of adsorptive media, followed by disposal of the saturated media at a hazardous waste site.

Design engineers considering a treatment train that generates liquid waste residuals will find it necessary to develop a secondary treatment process to remove uranium or other radionuclides from the waste. Once the radionuclides have been removed by coagulation or precipitation, the remaining liquid residual may be treated exactly as described in the sections on arsenic and nitrate, with the same disposal options available.

5.4.3 Disposal of Solid Waste Residuals

As indicated in the preceding discussion, solid waste residuals resulting from treatment of drinking water for removal of radionuclides are likely to be of three types, all of which, under current regulations, must be disposed of at a hazardous waste site (Figure 11).

a. Exhausted adsorption media

The media removed from a treatment vessel should be placed in a container and removed to a hazardous waste site in accordance with requirements established by the waste site authorities. Care must be taken not to exceed uranium quantity and activity levels specified by the waste site authorities.

b. Sludge produced by secondary treatment

This sludge will contain radionuclides and any other contaminants removed from liquid residuals. The sludge must be dewatered so that it will pass the paint filter test, then transported to a hazardous waste site. Quantity and radioactivity levels specified by the waste site authorities must not be exceeded.

c. Membranes or filters that are removed at the end of their useful lifespan

These materials should be handled as described for exhausted adsorption media (item a.).

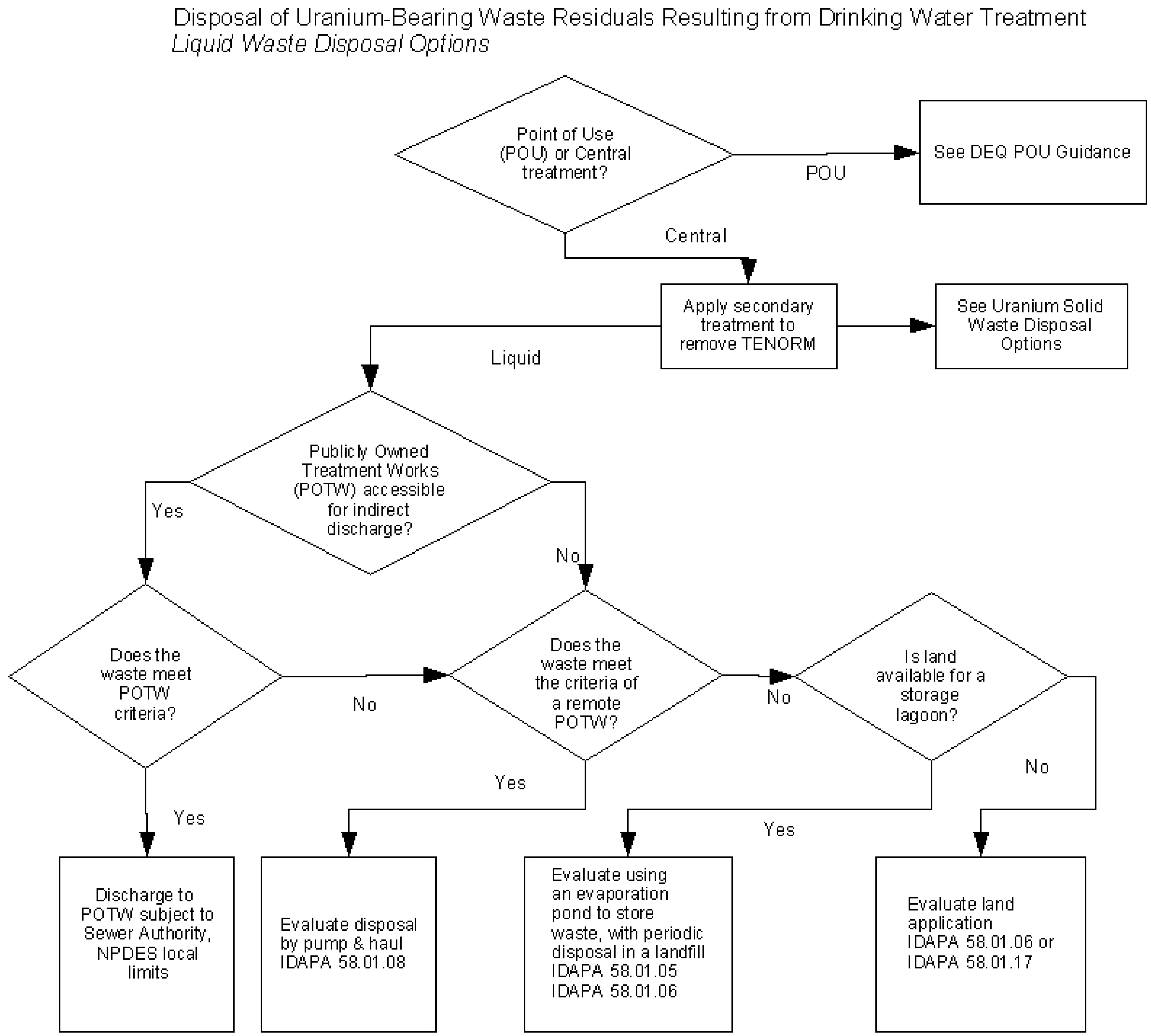

Figure 10. Liquid residuals disposal flowchart for uranium-bearing wastes.

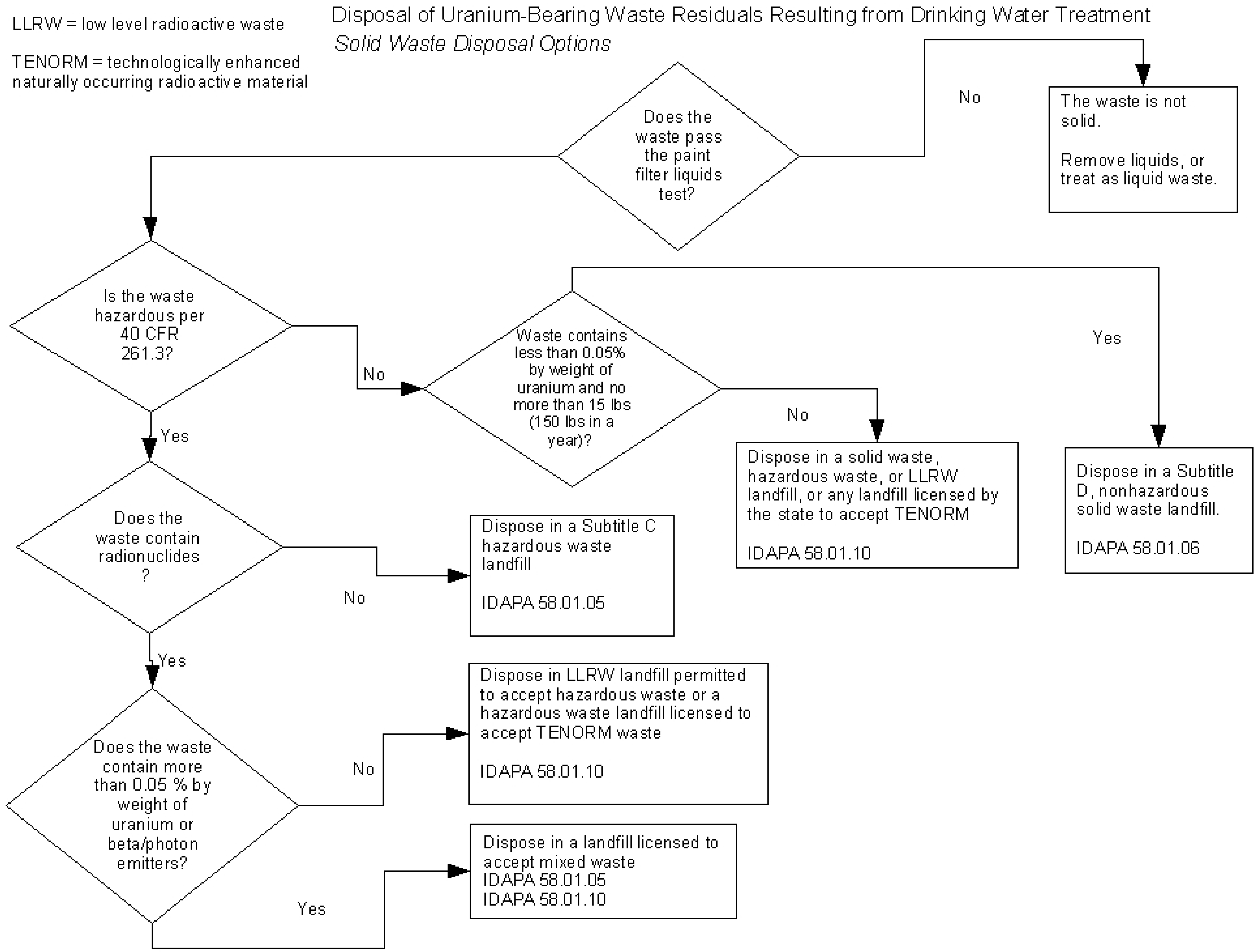

Figure 11. Solid residuals disposal flowchart for uranium-bearing wastes.

Glossary

µg/l	Micrograms per liter, unit of measure.
BAT	Best Available Technology.
Beneficial Uses	Various uses of ground water in Idaho including, but not limited to, domestic water supplies, industrial water supplies, agricultural water supplies, aquacultural water supplies, and mining. A beneficial use is defined as actual current or projected future uses of ground water.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act. Also known as “Superfund.”
Constituent	Any chemical, ion, radionuclide, synthetic organic compound, microorganism, waste or other substance occurring in ground water.
Contaminant	Any chemical, ion, radionuclide, synthetic organic compound, microorganism, waste or other substance which does not occur naturally in ground water or which naturally occurs at a lower concentration.
Contamination	The direct or indirect introduction into ground water of any contaminant caused in whole or in part by human activities.
CWA	Clean Water Act.
CWS	Community Water Systems.
Degradation	The lowering of ground water quality as measured in a statistically significant and reproducible manner.
DEQ	Idaho Department of Environmental Quality.
EPA	U.S. Environmental Protection Agency.
Ground Water	Any water of the state which occurs beneath the surface of the earth in a saturated geological formation of rock or soil.
Ground Water Quality Standard	Values, either numeric or narrative, assigned to any constituent for the purpose of establishing minimum levels of protection.
IDWR	Idaho Department of Water Resources.
Land Application	A process or activity involving application of wastewater, surface water, or semi-liquid material to the land surface for the purpose of disposal, pollutant removal, or ground water recharge.
MCL	Maximum Contaminant Level.
mg/l	Milligrams per liter, unit of measure.
ml	Milliliter, unit of measure.
Natural Background Level	The level of any constituent in the ground water within a specified area, as determined by representative measurements of the ground water quality unaffected by human activities.
NORM	Naturally Occurring Radioactive Material. Any material containing natural radionuclides at natural background concentrations, where human intervention has not concentrated the naturally occurring radioactive material or altered its potential for causing human exposure. NORM does not include source, byproduct, or special nuclear material licensed by the U.S. Nuclear Regulatory Commission under the Atomic Energy Act of 1954.
NPDES	National Pollutant Discharge Elimination System.
pCi/l	Pico Curies per liter, unit of measure.
POE	Point of Entry.
POU	Point of Use.
RCRA	Resource Conservation and Recovery Act.
Responsible Party	An individual, group, corporation or other entity that is accountable for implementation of the approved ground water quality monitoring plan. The responsible party may be the land owner, the operator, the project manager or the benefactor. The responsible party must be identified in the monitoring plan.
SSCT	Small System Compliance Technologies.

TENORM	Technologically Enhanced Naturally Occurring Radioactive Material. Any naturally occurring radioactive material not subject to regulation under the Atomic Energy Act whose radionuclide concentrations or potential for human exposure have been increased above levels encountered in the natural state by human activities. TENORM does not include source, byproduct, or special nuclear material licensed by the U.S. Nuclear Regulatory Commission under the Atomic Energy Act of 1954.

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Appendix A: DEQ and Health District Regional Offices

DEQ maintains regional offices in Boise, Coeur d'Alene, Idaho Falls, Lewiston, Pocatello and Twin Falls (Figure 12). Each region's staff consists of specialists in air quality, water quality, and waste management and remediation issues. They are knowledgeable about environmental issues in their particular regions and work directly with citizens, businesses, and industries to implement the state's environmental policies and programs.

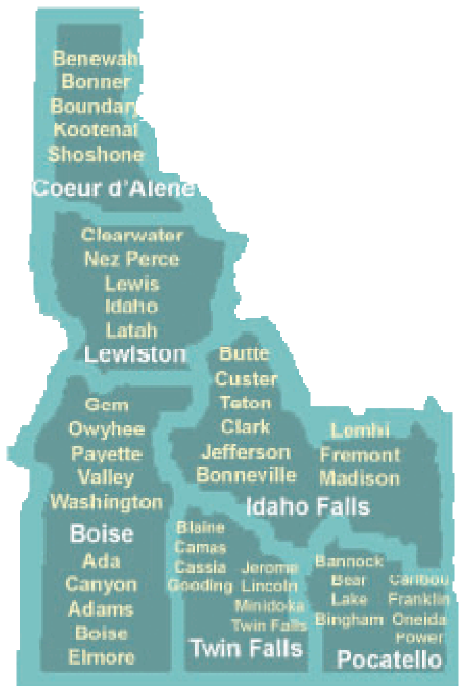

Figure 12. Map of DEQ regions.

Boise Regional Office	1445 N. Orchard	Boise, ID 83706	ph: (208) 373-0550 fax: (208) 373-0287
Coeur d'Alene Regional Office	2110 Ironwood Pkwy	Coeur d'Alene, ID 83814	ph: (208) 769-1422 fax: (208) 769-1404
Idaho Falls Regional Office	900 N. Skyline, Suite B	Idaho Falls, ID 83402	ph: (208) 528-2650 fax: (208) 528-2695
Lewiston Regional Office	1118 "F" Street	Lewiston, ID 83501	ph: (208) 799-4370 fax: (208) 799-3451 toll free: (877) 541-3304
Pocatello Regional Office	444 Hospital Way, #300	Pocatello, ID 83201	ph: (208) 236-6160 fax: (208) 236-6168
Twin Falls Regional Office	1363 Fillmore St.	Twin Falls, ID 83301	ph: (208) 736-2190 fax: (208) 736-2194

For questions regarding *subsurface disposal*, contact the appropriate Idaho Health District:

Idaho District Health Department	Counties Served
Health District I Panhandle Health District 8500 N. Atlas Road Hayden, ID 83835 (208) 415-5200 http://www2.state.id.us/phd1/	Benewah, Bonner, Boundary, Kootenai, Shoshone
Health District II North Central District Health 215 10th Street Lewiston, ID 83501 (208) 799-3100 http://www.ncdhd.us/	Clearwater, Idaho, Latah, Lewis, Nez Perce
Health District III Southwest District 920 Main Street Caldwell, ID 83605-3700 (208) 455-5345 http://www.publichealthidaho.com/	Adams, Canyon, Gem, Owyhee, Payette, Washington
Health District IV Central District Health 707 North Armstrong Place Boise, ID 83704-0825 (208) 327-7450 http://www.phd4.state.id.us/	Ada, Boise, Elmore, Owyhee
Health District V South Central District Health 1020 Washington Street North Twin Falls, ID 83301-3156 (208) 734-5900 http://www.phd5.idaho.gov/	Blaine, Camas, Cassia, Gooding, Jerome, Lincoln, Minidoka, Twin Falls
Health District VI Southeastern District 1901 Alvin Ricken Drive Pocatello, ID 83201 (208) 233-9080 http://www2.state.id.us/phd6/	Bannock, Bear Lake, Bingham, Butte , Caribou, Franklin, Oneida, Power
Health District VII 254 E Street Idaho Falls, ID 83402-3597 (208) 522-0310 http://www2.state.id.us/phd7/	Bonneville, Clark, Custer, Fremont, Jefferson, Lemhi, Madison, Teton

Appendix B: Approved Landfills in Idaho

County	Name	Location	DEQ Region	Household Hazardous Waste?
ADA	HIDDEN HOLLOW LANDFILL	9005 SEAMANS GULCH RD	BOISE	Y
ADA	ADA COUNTY N. RAVINE CELL	10300 N. SEAMANS GULCH RD	BOISE	
ADAMS	GOODRICH LANDFILL	ADAMS COUNTY	BOISE	
BANNOCK	FORT HALL CANYON NEW MSWLF	N FORT HALL MINE RD., POCATELLO	POCATELLO	N
BEAR LAKE	MONTPELIER CANYON LANDFILL	E. OF MONTPELIER	POCATELLO	N
BINGHAM	FIELDING/BINGHAM CO. LANDFILL	715 N 1100 E, SHELLEY	POCATELLO	N
BOISE	IDAHO CITY/WARM SPRINGS RD	NW OF IDAHO CITY (Warm Springs Ridge)	BOISE	N
BONNEVILLE	BONNEVILLE COUNTY LANDFILL	SUNNYSIDE ROAD/BONE ROAD	IDAHO FALLS	N
BOUNDARY	BOUNDARY COUNTY LANDFILL	2 MILES N. OF BONNERS FERRY	COEUR D'ALENE	Y
BUTTE	ARCO MSWLF	2 MI. SE OF ARCO	IDAHO FALLS	N
BUTTE	HOWE LANDFILL	HOWE	IDAHO FALLS	N
CANYON	PICKLES BUTTE LANDFILL	S.OF LAKE LOWELL	BOISE	N
CARIBOU	CARIBOU COUNTY MSWLF	GRACE	POCATELLO	N
CASSIA	S.ID.REG.SWLF - MILNER BUTTE	12.5 MI. W OF BURLEY	TWIN FALLS	Y
ELMORE	BENNET ROAD LANDFILL	NE OF MOUNTAIN HOME	BOISE	N
ELMORE	GLENNS FERRY LANDFILL	NE OF GLENNS FERRY	BOISE	N
ELMORE	MOUNTAIN HOME AFB LANDFILL	MT. HOME AFB	BOISE	N
ELMORE	SIMCO ROAD LANDFILL	13 MI NE OF MOUNTAIN HOME	BOISE	N
FRANKLIN	FRANKLIN COUNTY MSWLF CUP	4 MI. W. OF PRESTON	POCATELLO	N
FRANKLIN	RIVERDALE MSWLF	NEAR RIVERDALE	POCATELLO	
FREMONT	ST. ANTHONY LANDFILL	1 MI. N OF ST. ANTHONY	IDAHO FALLS	N
FREMONT	ISLAND PARK LANDFILL	½ MI. S LANDFILL RD	IDAHO FALLS	N
JEFFERSON	JEFF. CO. LF - CIRCULAR BUTTE	CIRCULAR BUTTE	IDAHO FALLS	N
KOOTENAI	FIGHTING CREEK/FARM LANDFILL	13 MI. S. HWY 95 (#16335 S. HWY 95)	COEUR D'ALEN	Y
LEMHI	LEMHI COUNTY LANDFILL-NORTH RIFLE RANGE	7 MI.SE SALMON	IDAHO FALLS	N
ONEIDA	MALAD LANDFILL	3 MILES N. OF MALAD CITY	POCATELLO	N
OWYHEE	BRUNEAU-GRANDVIEW MSWLF		BOISE	
OWYHEE	RIMROCK LANDFILL	½ MILE EAST OF RIMROCK H.S.	BOISE	
PAYETTE	CLAY PEAK LANDFILL	3 MI E. PAYETTE	BOISE	N
POWER	POWER COUNTY MSWLF	1/2 MILE S.W. AMERICAN FALLS	POCATELLO	N
TETON	DRIGGS LANDFILL	1/2 MILE E. OF DRIGGS	IDAHO FALLS	N
TWIN FALLS	TWIN FALLS CO. - HUB BUTTE	2910 N. 2800 E. TWIN FALLS	TWIN FALLS	

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Guidance Index