The Arsenic Rule:

Water Treatment Plant Residuals

Issues in Management and Disposal

- Waste disposal is an important consideration in the treatment selection process. Arsenic removal technologies can produce several different types of liquid and solid wastes, including sludges, brine streams, backwash slurries, and spent media.
- This presentation is designed to provide an overview of applicable portions of federal regulations that affect water treatment plant (WTP) residuals and provide guidelines for determining appropriate management and disposal options.

Treatment of drinking water results in the concentration of arsenic and other co-occurring contaminants in process residuals

- All arsenic treatment technologies, other than zero-treatment options such as alternate source use and blending, create residuals with concentrated arsenic and other contaminants.
- These types of arsenic mitigation processes produce the following residuals:
  - Chemical precipitation processes, such as enhanced lime softening: process water, filter backwash water, and sludge;
  - Sorption processes with disposable media, such as granular ferric hydroxide: backwash water, regeneration liquid, neutralization fluid, rinse water, sludge, and spent media;
  - Sorption processes with reusable media, such as ion exchange: backwash water, regeneration liquid, neutralization fluid, rinse water, sludge, and spent media;
  - Membrane processes, such as reverse osmosis: spent membranes, reject brines, and backwash water;
  - Iron/manganese removal and greensand filtration: filter backwash fluid, sludge, and spent media.
- Because removal technologies frequently remove other contaminants in addition to arsenic, the residual may also have concentrated levels of co-occurring contaminants, such as lead, barium, or radionuclides. The removal of co-occurring contaminants may pose disposal problems even when the arsenic levels in process residuals are not high enough to lead to a hazardous waste classification or interfere with local limits set by publicly owned treatment works (POTWs). Water systems should thoroughly test their wastes prior to making disposal decisions.

Residuals must be managed and disposed of legally, in a manner which does not adversely impact human health and the environment

- Water systems must legally manage and dispose of process residuals in a manner that does not adversely impact human health and the environment.
- Water systems should seek to reduce or eliminate the production of residuals if possible and should attempt to manage their treatment processes to avoid the production of hazardous waste.

Residuals Overview:

- Contaminants impacting disposal alternatives
- Overview of regulations
- Review of arsenic mitigation processes and residuals produced
- Pilot testing considerations
- Case studies
- Goals of residuals management
- Conclusions

- The following topics will be discussed in this presentation:
  - Contaminants impacting disposal alternatives;
  - Overview of federal regulations concerning WTP residual disposal;
  - Review of arsenic mitigation processes and residuals produced;
  - Pilot testing considerations;
  - Case studies of residuals disposal; and,
  - Goals of residuals management.

2 Phases of Residuals Produced from Arsenic Removal Processes

- **Liquid Phase Residuals**
  - **Brines, concentrates, backwash and rinse water, filter to waste etc.**
- **Solid Phase Residuals**
  - **Spent media, membranes, dewatered sludge**

- Regardless of the raw water source and quality and the processes used, WTPs can produce four types of residuals:
  - Liquids, including brines, concentrates, backwash water, rinse water, and filter to waste water;
  - Solids, including spend media, spent membranes, and dewatered sludge;
  - Sludges, which are semi-solid and usually must be dewatered prior to disposal; and,
  - Gases.
- Gaseous residuals, with the exception of radon, are not widely regulated. This training will focus on solid and liquid phase residuals and sludges.
- While all treatment processes will produce one or more types of residuals, the amount of residuals produced is a function of raw water quality, facility design and operating flow, and treatment process employed.

Contaminants Impacting Disposal Alternatives

- **High or low pH**
- **High Total Suspended Solids (TSS)**
- **High Total Dissolved Solids (TDS)**
- **High concentrations of heavy metals such as arsenic, lead, and cadmium**
- **High concentrations of competing ions such as fluoride, sulfate, chloride**
- **Radionuclides and daughter products**

- Certain raw water characteristics can impact a system's residual disposal options. One challenge for a system, therefore, is to optimize treatment while not creating residual disposal problems. Raw water characteristics that may impact disposal alternatives include:
  - Excessively high or low pH;
  - High total suspended solids (TSS);
  - High total dissolved solids (TDS);
  - High concentrations of heavy metals, including arsenic, lead, and aluminum;
  - High concentrations of competing ions, including fluoride, sodium, sulfate, chloride, and other salts concentrations; and,
  - High concentrations of radionuclides and daughter products.

Management / Disposal Options and Regulatory Requirements

- Water systems have the following disposal alternatives for the wastes they generate:
  - Land disposal and land application (including surface impoundment, landfill, and underground injection):
    - May require a permit;
    - Wastes must be non-hazardous to be disposed in a solid waste landfill;
    - Hazardous wastes must be disposed in hazardous waste landfills, subject to land disposal restriction requirements (40 CFR 268); and,
    - Liquid wastes may not be disposed in a land disposal unit.
  - Direct discharge to a receiving body:
    - Requires a permit; and,
    - Wastes must be non-hazardous and meet National Pollutant Discharge Elimination System (NPDES) discharge requirements.
  - Discharge to a POTW:
    - Requires a permit;
    - Wastes must meet POTW pretreatment requirements; and,
    - Wastes must not interfere with POTW operations or pass through excessive pollutants to sludge.
  - Wetland/ocean disposal:
    - Requires a permit; and,
    - Wastes must be non-hazardous and meet NPDES discharge requirements.
  - Beneficial reuse:
    - May require a permit; and,
    - Wastes must be non-hazardous.
- Disposal options will be limited by regulation, type of waste (liquid or solid), and the concentrations of contaminants in the waste.
- Each option and the applicable regulations are examined in depth throughout the remainder of this presentation.

Liquid Residual Disposal Options

- **Direct discharge to receiving bodies**
- **Discharge to Publicly Owned Treatment Works (POTW)**
- **Underground injection**
- **Land application**
- **Recycle to facility headworks**

(Intermediate processing may be required)

- Liquid residual disposal options include:
  - Direct discharge to a receiving body;
  - Discharge to a POTW;
  - Underground injection;
  - Land application; and,
  - Recycle to facility headworks.
- Intermediate processing may be necessary prior to disposal by some or all of these alternatives. Most intermediate processing concentrates contaminants into a smaller volume for disposal, usually producing two waste streams: a “cleaner” liquid waste stream and a more concentrated solid waste stream. Economics, disposal alternatives, and regulations will dictate the extent of intermediate treatment.
- Intermediate processing for liquid wastes may include:
  - Flow equalization - Large spikes in flow quantity or contaminant concentration may interfere with POTW treatment. Therefore, detaining and mixing water system wastes may be necessary prior to release to a POTW.
  - Brine recycling - Water systems may be able to reuse brine rinse, reducing the total amount of brine that must be disposed. Systems should use caution, however, because the reused brine streams may contain higher levels of suspended solids and contaminants, which may limit disposal options.
  - pH neutralization - Waste streams with excessively high or low pH may need to adjust the pH before release to a POTW or to receiving bodies.
  - Settling or gravity thickening - Settling basins or mechanical presses may be used to remove suspended solids and contaminants from liquid waste streams, resulting in a sludge and a cleaner liquid waste.
  - Evaporation - In hot or dry climates, evaporation can enhance settling basins by removing water and leaving solids and contaminants.
  - Chemical precipitation - Coagulants can be added to remove contaminants from liquid waste streams and precipitate them as sludges.

Solid Residual Disposal Options

- **Land disposal:**
  - **Non-hazardous waste landfill**
  - **Hazardous waste landfill**
  - **Land application**
    - **A State permit may be required**

(Intermediate processing may be required)

- Solid residual disposal options include:
  - Non-hazardous waste landfill;
  - Hazardous waste landfill; and,
  - Land application.
- Intermediate processing may be necessary prior to disposal by some or all of these alternatives.
- Intermediate processing for solid wastes may include:
  - Mechanical dewatering processes, including centrifugal filter presses, vacuum-assisted dewatering beds, belt filter presses, and plate-and-frame filter presses. Mechanical dewatering techniques can require a large capital and operating investment and therefore may only be an option for larger systems.
    - Filter presses can increase the solids content of lime softening sludges from 3% to 40-70% and can increase the solids content of alum sludges after modification to pH 11 from 1% to 35-50%.
  - Non-mechanical dewatering processes, including lagoons, settling basins, gravity thickening, evaporation ponds, drying beds, etc.
  - Thermal processing, including incineration (aerobic) and pyrolysis (anaerobic). Applicable regulations may include the Resource Conservation and Recovery Act (RCRA) Subtitle C and the Clean Air Act National Emission Standard for Hazardous Airborne Pollutants (NESHAPS) program. These processes may produce an ash that will need further disposal.

Regulations Governing Residuals Management and Disposal

- **The Resource Conservation and Recovery Act (RCRA)**
- **Clean Water Act (CWA)**
- **Safe Drinking Water Act Underground Injection Control (SDWA UIC)**

- Three federal regulations provide the bulk of requirements applicable to residuals management and disposal include:
  - RCRA, which governs the management of "solid" and hazardous wastes (note that a RCRA "solid" waste may be liquid or gaseous) and covers land disposal and land application (42 U.S.C. §§ 321 *et seq*.).
  - The Clean Water Act (CWA), which covers direct discharge to receiving bodies and discharge to a POTW (33 U.S.C. §§ 1251 *et seq*.).
  - The Safe Drinking Water Act (SDWA), which covers underground injection under the Underground Injection Control (UIC) program (42 U.S.C. §§ 300f *et seq*.).
- Other federal regulations that may affect WTP residual disposal include:
  - The Atomic Energy Act (AEA), which covers high and low level radioactive waste disposal (42 U.S.C. §§ 2011 *et seq.*).
  - The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), which established prohibitions and requirements concerning closed and abandoned hazardous waste sites, provided for liability of persons responsible for releases of hazardous waste at these sites, and established a trust fund to provide for cleanup when no responsible party could be identified (42 U.S.C. §§ 9601 *et seq.*).
  - The Toxic Substances Control Act (TSCA), which was enacted by Congress to give EPA the ability to track the 75,000 industrial chemicals currently produced or imported into the United States (15 U.S.C. §§ 2601 *et seq*.).
  - The Marine Protection, Research, and Sanctuaries Act (MPRSA), which governs permits for and otherwise prohibits (1) transportation of material from the US for the purpose of ocean dumping, (2) transportation of material from anywhere for the purpose of ocean dumping by US agencies or US-flagged vessels, and (3) dumping of material transported from outside the US into the US territorial sea (16 U.S.C. §§ 1431 *et seq*.).
- This presentation focuses on RCRA, CWA, and SDWA requirements.

RCRA Background

- **RCRA was passed to encourage waste minimization, recycling and reuse of wastes wherever possible**
- **Defines solid and hazardous wastes and establishes standards for appropriate management**

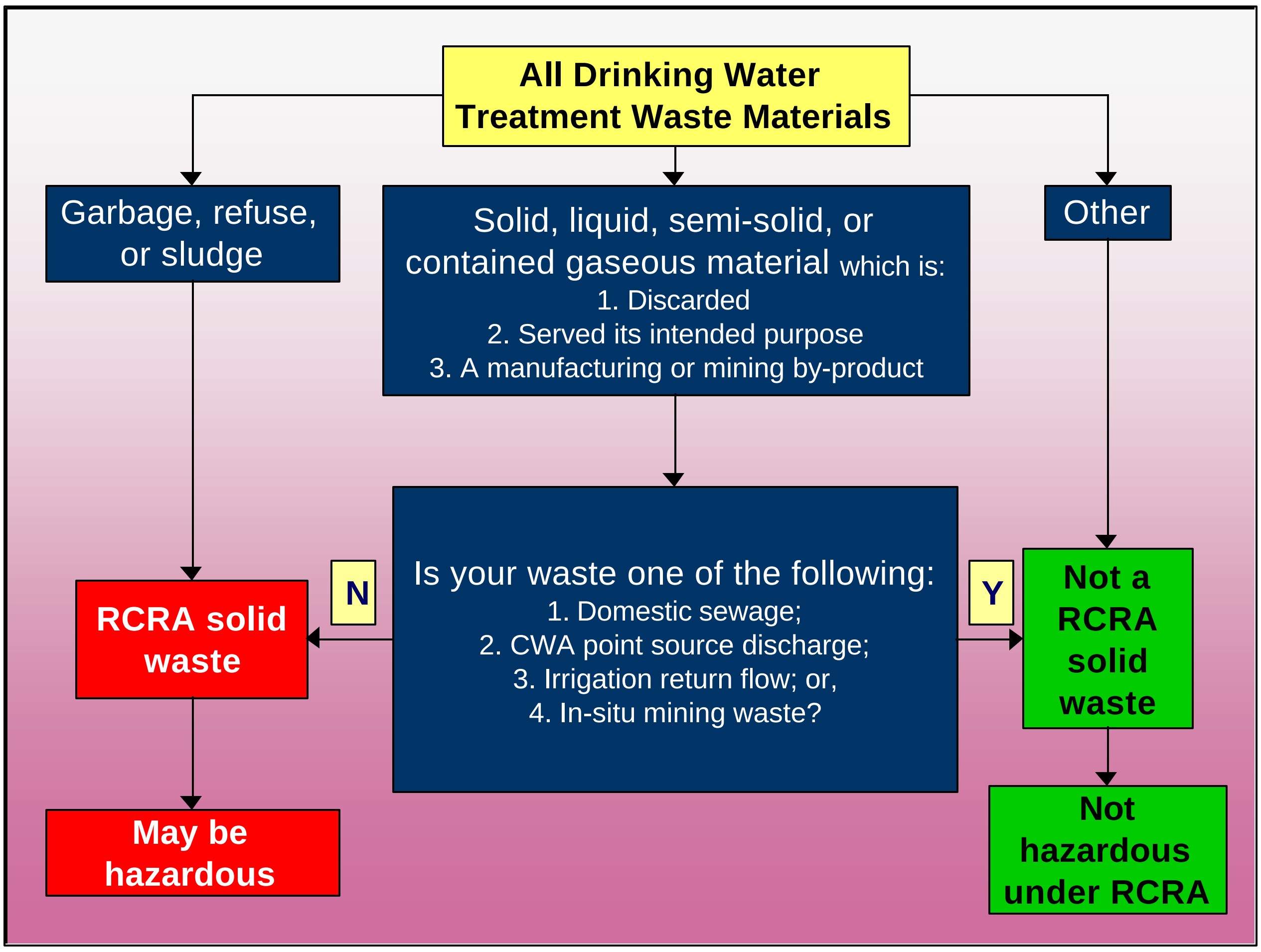
- RCRA establishes a framework for national programs to achieve environmentally sound management of both hazardous and non-hazardous wastes.
- RCRA also promotes resource recovery techniques and methods to reduce the generation of hazardous waste. RCRA is designed to:
  - Protect human health and the environment;
  - Reduce/eliminate the generation of hazardous wastes; and,
  - Conserve energy and natural resources.
- RCRA gives EPA the authority to control hazardous waste from the cradle to grave. This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also establishes a framework for national programs to achieve environmentally sound management of both hazardous and non-hazardous wastes.
- RCRA focuses only on active and future facilities and does not address abandoned or historical sites.
- RCRA provides definitions of waste, solid waste, and hazardous waste.

RCRA: Determining Waste Characteristics

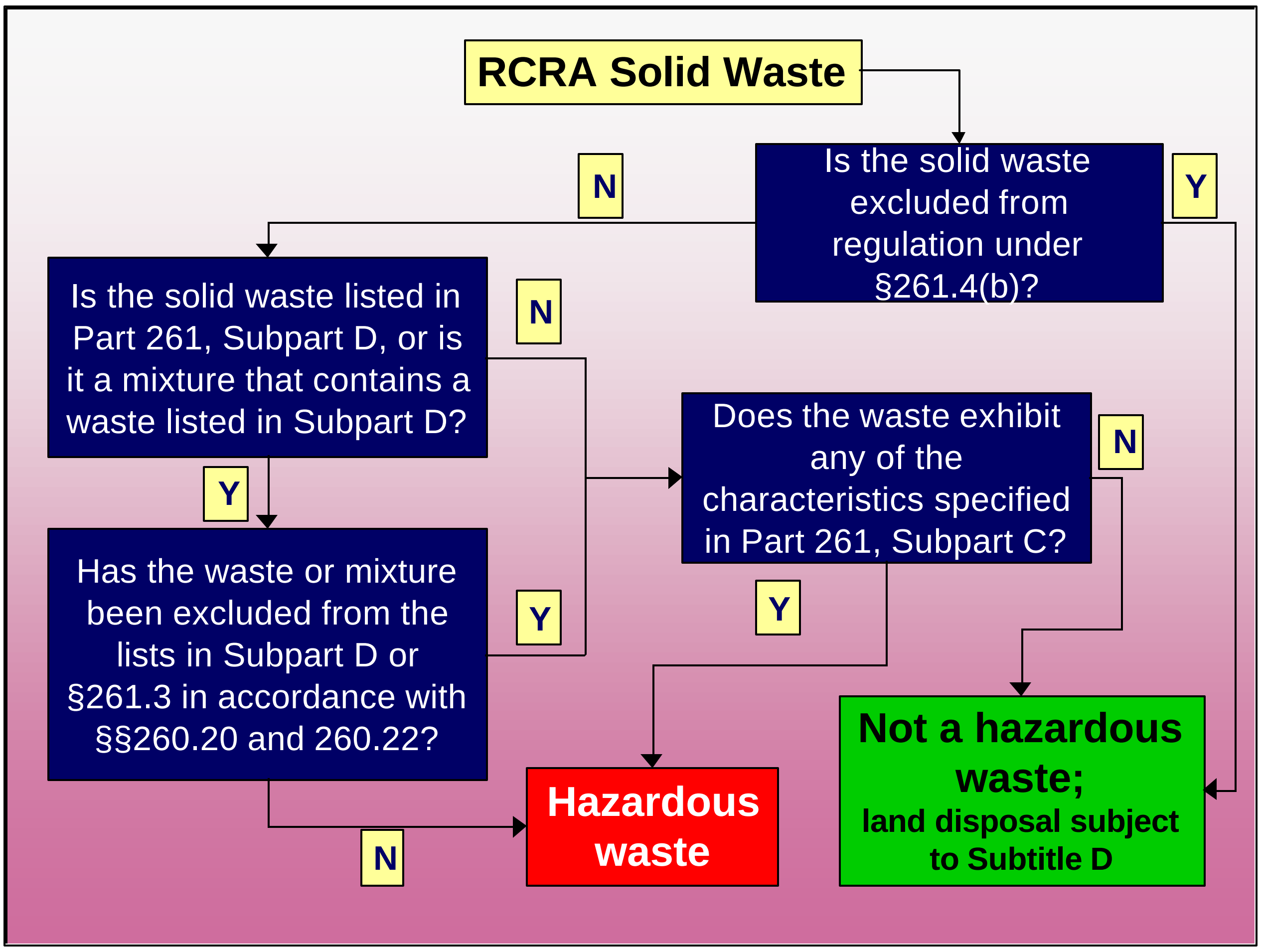
– A person who generates a ***solid waste*** **must** determine if that waste is a hazardous waste (40 CFR 262.11)

- Listed wastes
- Characteristic wastes
- Excluded wastes

- According to the hazardous waste determination regulations in 40 CFR 262.11, any person who generates a solid waste (as defined in 40 CFR 261.2) must determine if that waste is a hazardous waste.
- There are two ways that a waste can be considered hazardous:
  - The waste can be, or contain material ***listed,*** in Subpart D of 40 CFR 261. This subpart contains several lists that enumerate various hazardous wastes. Note that any mixture or derivative of a listed hazardous waste is considered to be hazardous.
    - Note: Even if the waste is listed, a generator still has an opportunity under 40 CFR 260.22 to demonstrate to the Administrator that the waste from his or her particular facility or operation is not a hazardous waste.
  - The waste can have one or more of the ***characteristics*** of hazardous waste: reactivity, corrosivity, toxicity, ignitability. There are specific definitions for each of these in 40 CFR 261.21-261.24.
- If the waste is determined to be hazardous, the generator must manage and dispose of the waste in accordance with the stringent regulations of RCRA Subtitle C.
- However, some types of waste have been excluded and are not considered hazardous even if they are listed or have the characteristics of hazardous waste. Under 40 CFR 261.4, these excluded wastes include:
  - CWA point source discharge;
  - Direct discharge or discharge to a POTW; and,
  - Atomic Energy Commission source, special nuclear, or by-product material.
- WTP waste, if it is determined to be hazardous, is most likely to be considered hazardous under the toxicity characteristic (TC). Wastes that contain high levels of readily leachable arsenic, barium, lead, and other toxic compounds (see 40 CFR 261.24) may be considered hazardous unless accepted by a POTW or covered under a CWA discharge permit. Water systems with extremely high levels of hydrogen sulfide in their source waters may also be considered hazardous under the reactivity characteristic.



- RCRA only regulates what it defines as a "solid waste." Therefore, even if a material meets the criteria for hazardous waste, if it is not first a solid waste, it is not regulated under RCRA.
- A material is a ***solid waste*** under 40 CFR 261.2 if it is:
  - Garbage, refuse, or sludge, irrespective of whether it is discarded, used, reused, recycled, reclaimed, stored, or accumulated; or,
  - Solid, liquid, semi-solid, or contained gaseous material which is discarded, has served its intended purpose, or is a manufacturing or mining by-product.
- Under 40 CFR 261.4, some waste is not solid waste by specific exclusion. The exclusions include:
  - Domestic sewage or any mixture of domestic sewage and other wastes that passes through a sewer system to a publicly-owned treatment works for treatment. "Domestic sewage" means untreated sanitary wastes that pass through a sewer system.
  - Industrial wastewater discharges that are point source discharges subject to regulation under section 402 of the CWA, as amended. Note that this exclusion applies only to the actual point source discharge. It does not exclude industrial wastewaters while they are being collected, stored, or treated before discharge, nor does it exclude sludges that are generated by industrial wastewater treatment.
  - Irrigation return flow.
  - Source, special nuclear or by-product material as defined by the AEA of 1954, as amended (42 U.S.C. 2011 *et seq.*).
  - Materials subjected to in-situ mining techniques which are not removed from the ground as part of the extraction process.
- ***Sludge*** is defined as "any solid, semi-solid, or liquid waste generated from a . . . water supply treatment plant . . . ." (40 CFR 260.10). Therefore, WTP sludge is a solid waste regulated by RCRA and is not excluded by the 40 CFR 261.4. WTP sludges may also be regulated by section 402 of the CWA.



- A person who generates a ***solid waste*** must determine if that waste is a hazardous waste using the following method (40 CFR 262.11):
    1. First determine if the solid waste is excluded from being hazardous waste under 40 CFR 261.4(b). The wastes excluded by 40 CFR 261.4(b) include:
        - Household waste, including household waste that has been collected, transported, stored, treated, disposed, recovered (e.g., refuse-derived fuel), or reused. "Household waste" means any material (including garbage, trash, and sanitary wastes in septic tanks) derived from households (including single and multiple residences, hotels and motels, bunkhouses, ranger stations, crew quarters, campgrounds, picnic grounds, and day-use recreation areas).
        - Waste discharged to a POTW or receiving body. This waste is not regulated under RCRA but is instead regulated under the CWA.
        - Radioactive waste. This waste is not regulated under RCRA except for applicable provisions of the land disposal restrictions (40 CFR Part 268).
    2. If the waste is not excluded, determine if the waste is ***listed*** on one of the following lists (Subpart D of 40 CFR 261):
        - F Series wastes: Hazardous wastes from non-specific sources (40 CFR 261.31).
        - K Series wastes: Hazardous wastes from specific sources (40 CFR 261.32).
        - P and U Series wastes: Discarded commercial chemical products, manufacturing chemical intermediates, off-specification species, container residues, and spill residues thereof (40 CFR 261.33).
        - Note that for mixture and derived-from wastes:
            - The mixture rule regulates a combination of any amount of non-hazardous solid waste and any amount of a listed hazardous waste as a listed hazardous waste. This provision discourages dilution. Some exemptions apply (40 CFR 261.3(a)(iv)).
            - The derived-from rule states that any material derived from a listed hazardous waste is also a listed hazardous waste (40 CFR 261.3(c)).
    3. If the waste is listed, determine whether any person has successfully petitioned the Administrator to modify or revoke the provisions in Subpart D and Part 261 for the waste or mixture (40 CFR 260.20 and 260.22). If the petition was successful, the waste is not considered to be listed.
    4. If the waste is not listed, determine if the waste is identified in Subpart C of 40 CFR 261 by either:
        - Testing the waste for reactivity, corrosivity, ignitability, and toxicity via standard laboratory test methods (see Appendices II and III to 40 CFR 261); or,
        - Applying knowledge of the hazard characteristic of the waste in light of the materials or the processes used.
- If the waste is hazardous (i.e., listed or having the characteristics of hazardous waste, and not excluded from regulation), it must be managed in accordance with RCRA Subtitle C requirements.
- In addition, if the waste is non-hazardous but is land disposed, it must be managed in accordance with RCRA Subtitle D Solid Waste requirements.

RCRA Regulatory Tests

- **Paint Filter Liquids Test**
- **Toxicity Characteristic Leaching Procedure (TCLP)**

- Water systems, as generators of solid wastes, must determine if the wastes are hazardous.
- Note that, for RCRA requirements, once a listed hazardous waste is produced, any mixture or derivative of that waste is considered to be hazardous.
  - The mixture rule regulates a combination of any amount of non-hazardous solid waste and any amount of a listed hazardous waste as a listed hazardous waste. This provision discourages dilution. Some exemptions apply (40 CFR 261.3(a)(iv)).
  - The derived-from rule states that any material derived from a listed hazardous waste is also a listed hazardous waste (40 CFR 261.3(c)).
- As discussed in previous slides, if the waste is not excluded or listed, the system must determine whether the waste has one or more of the characteristics of reactivity, corrosivity, ignitability, and toxicity. The system may either test the waste or apply knowledge of the waste.
  - Generators that have significant experience or familiarity with a process or waste may choose to use their experience to predict that a given waste will or will not be hazardous. However, if a regulator later determines that the waste was disposed of as non-hazardous waste, testing was not performed, and the waste is hazardous, the fines may be extremely high. Therefore, the knowledge clause is usually only used to assume a material is hazardous and treat it as such without paying for testing.
- There are two tests that water systems most commonly need to perform on solid wastes to determine if the wastes are toxic (hazardous) and to be able to choose appropriate disposal options:
  - The Paint Filter Liquids Test (EPA Method 9095a); and,
  - The Toxicity Characteristic Leaching Procedure (TCLP; EPA Method 1311).

Paint Filter Liquids Test

– **Determines if "free" liquids are present in a waste**

– **Wastes containing free liquids banned from disposal in municipal solid waste landfills and hazardous waste landfills**

– **Liquid wastes must be treated or disposed in an alternative manner**

- The Paint Filter Liquids Test (EPA Method 9095a) is used to determine the presence of free liquids in a representative sample of waste.
    - In brief, the test consists of folding a paint filter into a cone, placing a small representative sample of the solid waste in the filter cone, and seeing if any liquid drips out the bottom of the filter cone.
- RCRA prevents hazardous waste landfills and municipal solid waste landfills from accepting wastes with free liquids, because these liquids may be able to leach out of the landfill relatively easily.
- If the Paint Filter Liquids Test determines that a free liquid is present, intermediate processing or an alternative disposal strategy will be necessary.
- The Paint Filter Liquids Test is published in EPA Publication SW-846, which is available on-line at www.epa.gov/epaoswer/hazwaste/test/sw846.htm

Toxicity Characteristic Leaching Procedure (TCLP)

– **Predicts if hazardous components of a waste are likely to leach out of the waste and become a threat to public health or the environment**
– **8 metals and 32 organics have regulatory levels established**
– **Exceeding regulatory levels result in designation as hazardous**

- The TCLP (EPA Method 1311) is designed to determine the mobility of both organic and inorganic analytes present in liquid, solid, and multiphasic wastes. The procedure attempts to simulate landfill conditions, where water may pass through the landfilled waste and enter ground water carrying hazardous soluble materials.
    - In brief, for liquid wastes, the test consists of analysis of the waste for concentrations of various toxic materials, including arsenic.
    - For solid wastes, the test consists of placing the waste in an acetic acid extraction fluid and mixing for 18 hours and then analyzing the acid for 32 organics and 8 metals that may have leached out of the waste.
    - The concentrations of the toxic materials are compared to published toxicity characteristics (TCs) (see 40 CFR 261.24). If the concentrations in the samples exceed the regulatory concentrations, then the waste is considered hazardous.
- The TC for arsenic is 5 mg/L.
- Some WTP residuals may be considered hazardous because of high concentrations of non-arsenic contaminants, such as cadmium and chromium.
- The TCLP is published in EPA Publication SW-846, which is available on-line at www.epa.gov/epaoswer/hazwaste/test/sw846.htm

Residuals Management Under RCRA

- **Land Disposal**
  - **non-hazardous Wastes**
    - **40 CFR Parts 239-258**
  - **Hazardous Wastes – Subtitle C**
    - **40 CFR Parts 260-273**
  - **Land Disposal Restrictions**
    - **40 CFR Part 268**

- RCRA governs the land disposal of solid wastes. Land disposal is defined as placement in or on the land, and includes, but is not limited to, placement in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, underground mine or cave, or placement in a concrete vault or bunker intended for disposal purposes.
- 40 CFR 239-258 provide the land disposal requirements for non-hazardous wastes.
- 40 CFR 260-273, and especially 40 CFR 268, cover the land disposal of hazardous wastes.
- Under the stringent requirements of RCRA Subtitle C (40 CFR 260-273), all facilities generating hazardous waste must:
  - Identify and quantify all hazardous wastes for purposes of determining generator status (i.e., large, small, or conditionally exempt);
  - Obtain an EPA ID number and ensure that all waste management activities are conducted by permitted entities with an EPA ID number;
  - Comply with accumulation and storage requirements applicable to generator status;
  - Prepare waste for transport according to Department of Transportation (DOT) packaging, labeling, placarding, and transport requirements (49 CFR 100-185);
  - Track the shipment and receipt of waste via manifests and chain of custody documentation;
  - Meet extensive record keeping and reporting requirements including implementation of a waste minimization program to reduce the volume and toxicity of hazardous waste generated; and,
  - Maintain cradle to grave responsibility and liability for the waste.

RCRA Land Disposal

- **Options:**
  - **Landfill, land application**
- **May require permit**
- **Must be non-hazardous or RCRA land disposal restrictions apply**

- Under RCRA, solid wastes may be disposed in a landfill or by land application, but hazardous waste:
  - Must be placed in a hazardous waste landfill (or a mixed waste landfill if it also contains radioactive material);
  - May not be disposed by land application (i.e., the spreading of sludge on land for fertilization or other purposes); and,
  - Must be disposed in accordance with the land disposal restrictions in 40 CFR 268. These restrictions require hazardous wastes to undergo physical or chemical changes so that they pose less of a threat to ground water, surface water, and air when disposed. The restrictions also establish waste-specific standards that dictate to what extent or by what process waste must be treated prior to land disposal.
- Certain wastes are excluded from land disposal restrictions, including:
  - Wastes generated by conditionally exempt small quantity generators;
  - Newly identified or newly listed hazardous wastes for which EPA has not promulgated treatment standards; and,
  - Certain waste releases mixed with a facility's wastewater and discharged pursuant to the CWA.
- Water systems cannot:
  - Land dispose hazardous wastes that have not been treated adequately to reduce the threat posed by the wastes (disposal prohibition in 40 CFR 268.40);
  - Dilute wastes as a means of circumventing proper treatment (dilution prohibition in 40 CFR 268.3); or,
  - Store untreated hazardous wastes for reasons other than the accumulation of quantities necessary for effective treatment or disposal (storage prohibition in 40 CFR 268.50).
- Water systems generating hazardous waste and choosing to land dispose it will need to treat the wastes according to 40 CFR 268.42 prior to land disposal. This treatment may include :
  - Neutralization of hazardous waste with high or low pH; and,
  - Removal or treatment of heavy metals.

CWA Background

Clean Water Act (CWA) / National Pollution Discharge Elimination System (NPDES)

- **Created to control, through permit systems, discharge of pollutants into waters of the U.S**
- **Domestic sewage and CWA point source discharges excluded from regulation under RCRA**

- The CWA regulates domestic sewage and discharges from point sources. Under 40 CFR 261.4(a), these types of wastes are specifically excluded from being solid waste and are therefore not regulated under RCRA.
- As authorized by the CWA, the NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the US (40 CFR Parts 122-133).
  - Point sources are discrete conveyances such as pipes or man-made ditches.
- Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.
- In most cases, the NPDES permit program is administered by authorized Primacy Agencies.

Residuals Management under CWA

- **Direct Discharge**
- **Discharge to a Publicly Owned Treatment Works (POTW)**
- **Land Application/Beneficial Reuse**

- Disposal options that are regulated under the CWA include:
  - Direct discharge to a receiving body of water, which includes discharge to a lake, stream, river, wetland, estuary, or ocean;
  - Discharge to a POTW; and,
  - Land application and beneficial reuse.
- Few WTPs are likely to use ocean dumping as a residual management option. This practice, if utilized, would be regulated by the CWA's Dredge and Fill Program (40 CFR Parts 230-233).
  - Dredged or fill material cannot be discharged into the aquatic ecosystem unless it can be demonstrated that such a discharge will not have an unacceptable adverse impact either individually or in combination with known and/or probable impacts of other activities affecting the ecosystems of concern.

Direct Discharge to a Receiving Body

- **Requires NPDES permit**
- **Must meet NPDES discharge requirements**
- **Talk to permitting agency for requirements**

- The CWA requires any person (including water systems) that discharges or proposes to discharge pollutants to a water of the US to apply for a NPDES permit. Exclusions under 40 CFR 122.3 may include:
  - Discharge of dredged or fill material that is regulated under Section 404 of the CWA;
  - Discharge to a POTW (which will set its own limits on contaminant levels); and,
  - Discharge into a privately owned treatment works.
- When applying for a NPDES permit, every applicant must:
  - Provide data on five-day biochemical oxygen demand (BOD5), chemical oxygen demand (COD), total organic carbon (TOC), total suspended solids (TSS), ammonia (as nitrogen, N), temperature, and pH.
  - Indicate whether there is any reason to believe that any pollutant from Table II, III, or IV of Appendix D of 40 CFR 122 is discharged from each outfall. Pollutants of concern to WTPs include total residual chlorine, fluoride, radioactivity (radon, radium 226, radium 228, and uranium), and heavy metals on RCRA's TCLP list (arsenic, lead, cadmium, etc.).
- The permitting agency will then decide whether to grant a permit for discharge and, if so, the limits of contaminants in the discharge. The permitting agency can issue two kinds of permits:
  - An *individual permit*, which is a permit specifically tailored to an individual facility based on the information contained in the permit application (e.g., type of activity, nature of discharge, receiving water quality). The authority issues the permit to the facility for a specific time period (not to exceed five years) with a requirement that the facility reapply prior to the expiration date.
  - A *general permit*, which covers multiple facilities within a specific category. General permits may be written to cover categories of point sources that have similar discharges and are located in the same geographical area.
  - Whether the permitting agency issues an individual or a general permit, it will determine appropriate effluent limits to protect the water quality of the receiving body. Effluent limits take into account the water quality of each receiving body, the nature of the proposed discharge, other existing dischargers into the water body, etc. Effluent limits therefore vary widely and cannot be predetermined. Water systems should contact their permitting agency for more information about requirements for their specific situation.

Discharge to a POTW

- **Requires permit - talk to POTW or Primacy Agency permitting agency**
- **Must meet pretreatment requirements / POTW Technically Based Local Limits (TBLLs)**
- **Must not interfere with POTW operations or pass through excessive pollutants to sludge**

- The CWA controls and prevents the introduction of pollutants that may pass through or interfere with treatment processes or contaminate sewage sludge in POTWs (40 CFR 403).
- As part of the national pretreatment standards, the permitting agency will impose technically based local limits (TBLLs), which determine the concentration of contaminants (including arsenic) that may be discharged to the POTW. The NPDES program requires TBLLs to ensure that the POTW can meet the conditions of its NPDES permit for disposal of its waste products (40 CFR 403.5).
- A WTP that seeks to discharge liquid wastes to a POTW must acquire a permit. The Primacy Agency is likely to be the permitting agency for smaller POTWs, although large POTWs may issue their own permits.
- Dilution is prohibited as a substitution for treatment (40 CFR 403.6(d)).
- The CWA prohibits the following discharges to a POTW (40 CFR 403.5(b)):
  - Any pollutant that causes pass through or interference;
  - Any pollutant that creates a fire or explosion hazard;
  - Any pollutant that will cause corrosive structural damage to the POTW, but in no case with pH less than 5;
  - Solid or viscous pollutants in amounts that will cause obstructions to the flow of the POTW;
  - Heat in amounts that will inhibit biological activity;
  - Petroleum oil, nonbiodegradable cutting oil, or mineral oil products;
  - Pollutants that result in the presence of toxic gases, vapors, or fumes within the POTW; and,
  - Any trucked or hauled pollutants except at the points of discharge designated by POTW.

Arsenic TBLLs

City	Arsenic TBLLs
Albuquerque, New Mexico	51 µg/L
Anchorage, Alaska	1,700 µg/L
Boston, Mass. (Clinton Sewerage Area, MWRA)	1,000 µg/L
Boston, Mass. (Metropolitan Sewerage Area)	500 µg/L
El Paso, Texas	170 µg/L
King County (Seattle), Washington	4,000 µg/L
Lakeland, Florida	120 µg/L
Newark, New Jersey	150 µg/L
Orange County, California	2,000 µg/L
San Jose, California	1,000 µg/L

- POTW TBLLs for arsenic can vary widely among locations depending on, among other factors, the POTWs' NPDES permits (which are ultimately based on receiving water quality) and the discharges of other industrial users.
- This table shows some examples of arsenic TBLLs across the country. Water systems should contact their local POTW and Primacy Agency to determine if TBLLs have been set.
- TBLLs usually take into account the background arsenic level in domestic municipal wastewater. In communities where the drinking water systems will need to install or upgrade treatment for Arsenic Rule compliance, the current drinking water will contain high levels of arsenic. When these communities begin removing the arsenic, the background level of arsenic in domestic municipal wastewater may decrease. As a result, the local POTW's TBLL for arsenic may increase.
  - After a WTP increases the amount of arsenic it removes from drinking water, the POTW is likely to receive less arsenic from domestic municipal wastewater. Therefore, it may be able to treat more arsenic from other sources. As a result, the POTW may be able to increase its TBLL for arsenic, possibly allowing discharge by the WTP.

Land Application/ Beneficial Reuse

- **May require permit**
- **Must be non-hazardous**
- **Some Primacy Agencies use CWA Part 503 sludge land application limits as WTP residuals management guidelines**

- Land application and beneficial reuse of WTP sludges is regulated (and may be prohibited) if:
  - Runoff from the site could reach a body of water (which would trigger the CWA's NPDES requirements); or,
  - The sludge is a hazardous waste (which triggers RCRA requirements).
- Otherwise, land application of WTP residuals is not specifically federally regulated.
- The CWA's NPDES program regulates the final use or disposal of sewage sludge generated during the treatment of domestic sewage in a treatment works (40 CFR 503). Drinking water treatment sludge is specifically excluded from water quality regulations, but the health-based acceptable loading limits established under 40 CFR 503 have been used as guidelines in Primacy Agency programs. These limits are:

Pollutant	Ceiling concentration (mg/kg) [1]	Cumulative pollutant loading rate (kg/hectare)	Monthly avg. concentration (mg/kg) [1]	Annual pollutant loading rate (kg/hectare/365 day period)
Arsenic	75	41	41	2.0
Cadmium	85	39	39	1.9
Copper	4,300	1,500	1,500	75
Lead	840	300	300	15
Mercury	57	17	17	0.85
Molybdenum	75	--	--	--
Nickel	420	420	420	21
Selenium	100	100	100	5.0
Zinc	7,500	2,800	2,800	140

- Primacy Agencies may also regulate WTP sludges to limit hydraulic loading, nitrogen content, or metal content.

SDWA-UIC Background

The Safe Drinking Water Act (SDWA) Underground Injection Control (UIC) program

- **Established to protect the quality of drinking water in the U.S.**
- **Prohibits movement of injected fluids into underground sources of drinking water**

- The SDWA regulates waste disposal through its UIC program (40 CFR 141-149).
- The SDWA established the UIC program to provide safeguards so that injection wells do not endanger current and future underground sources of drinking water.
- Underground injection means the subsurface emplacement of fluids through a well (40 CFR 144.3). A well is defined as:
  - a bored, drilled, or driven shaft whose depth is greater than the largest surface dimension;
  - a dug hole whose depth is greater than the largest surface dimension;
  - an improved sinkhole; or,
  - a subsurface fluid distribution system.

Residuals Management under SDWA – UIC

- **Requires a permit**
- **Dilution as a substitute for treatment is prohibited**
- **No injection shall be authorized if:**
  - **fluid containing any contaminant moves into underground sources of drinking water**
  - **the presence of that contaminant may cause a violation of any National Primary Drinking Water Regulation (NPDWR) or adversely affect the health of persons**

- The UIC program regulates five classes of wells. Three of these classes may be applicable to WTP residual disposal:
  - Class I (40 CFR 146 Subpart B and G): Wells that inject hazardous, non-hazardous, or radioactive wastes beneath the lowermost formation containing, within a quarter mile of the well bore, an underground source of drinking water.
  - Class IV (40 CFR 146 Subpart E): Wells that inject hazardous waste into or above a formation that has an underground source of drinking water within a quarter mile of the well bore. New wells are prohibited.
  - Class V (40 CFR 146 Subparts F and G): Injection wells that are not included in Classes I-IV, including residential or small cesspools serving fewer than 20 people and receiving only sanitary wastes.
- All injection wells require authorization under general rules or specific permits. The UIC program sets minimum requirements for injection wells, which affect siting, construction, operation, maintenance, monitoring, testing, and, finally, the closure of a well.
- All underground injections are illegal unless authorized by permit or rule, and no injection shall be authorized if it results in the movement of fluid containing any contaminant into underground sources of drinking water, if the presence of that contaminant may cause a violation of any primary drinking water regulation or adversely affect public health.
- The goals of the EPA's UIC Program are to prevent contamination by keeping injected fluids within the well and the intended injection zone, or, in the case of injection of fluids directly or indirectly into an underground source of drinking water, to require that injected fluids not cause a public water system (PWS) to violate drinking water standards or otherwise adversely affect public health.
- Hazardous wastes must be treated to the Universal Treatment Standards established under 40 CFR 268, Subpart D prior to injection. Owners of wells injecting hazardous waste must also comply with RCRA Subpart C requirements for disposal of hazardous wastes. Mixed wastes (which are both hazardous and contain more than 60 pCi/L of radium 226 or radium 228 and more than 300 pCi/L of uranium) are prohibited from underground injection effective April 8, 1998.
- Dilution as a substitute for treatment is prohibited for the owners or operators of Class I hazardous waste injection wells (40 CFR 148.3).

Recycle to facility headworks

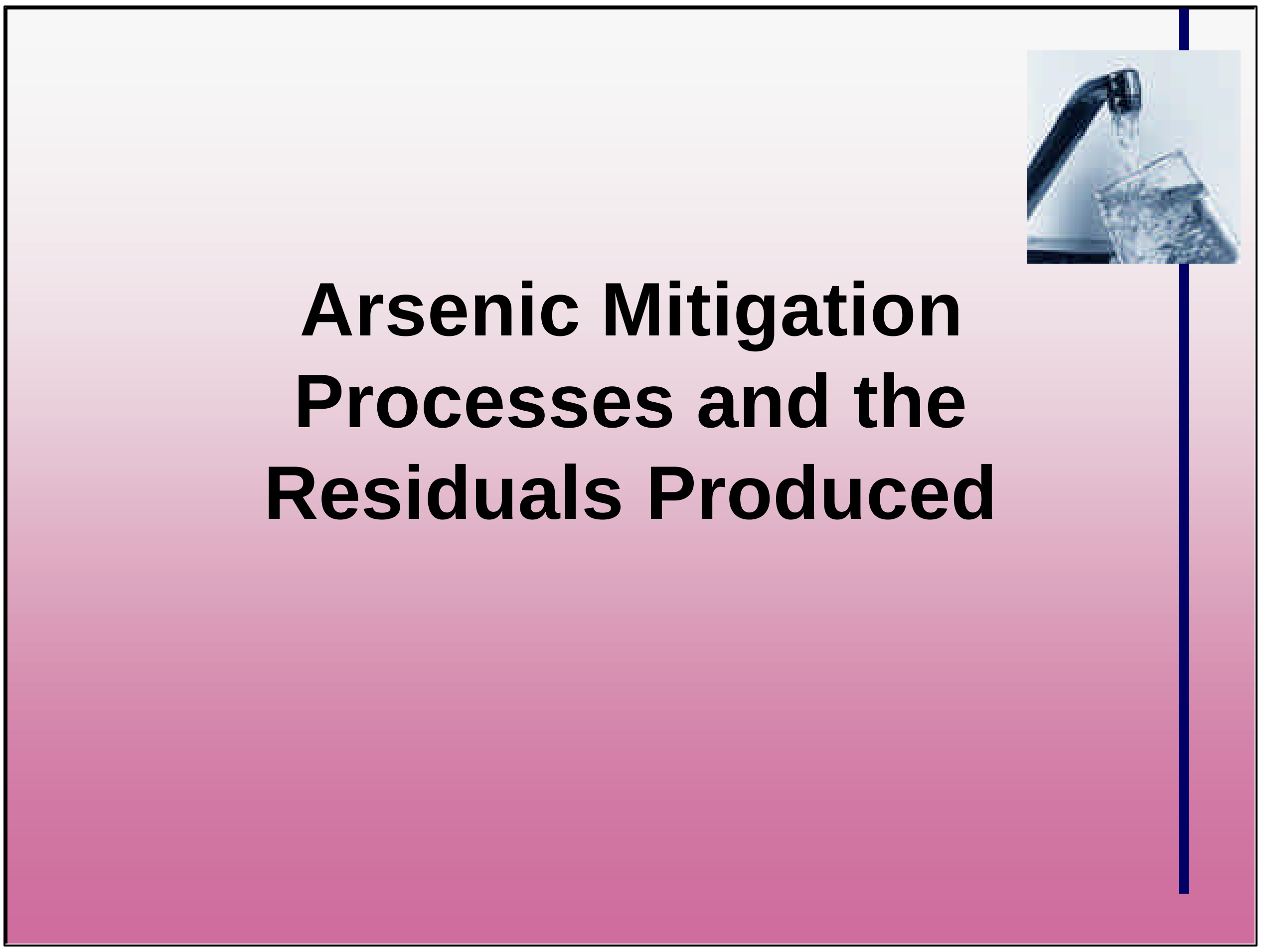
- **Ensure that the system complies with the Filter Backwash Recycling Rule**
- **Ensure that recycling practices do not negatively impact finished water quality**

- Water systems may be able to recycle backwash and other liquid waste streams within their treatment processes.
- The Filter Backwash Recycling Rule (FBRR; 66 FR 31086) reduces the risks posed to consumers by microbial contaminants that may be present in public drinking water supplies. The purpose of the FBRR is to require PWSs to review their recycle practices and, where appropriate, work with their Primacy Agencies to make any necessary changes to recycle practices that may compromise microbial control.
- The FBRR requires that recycled filter backwash water, sludge thickener supernatant, and liquids from dewatering processes be returned to a location such that all processes of a system's conventional or direct filtration, including coagulation, flocculation, sedimentation (conventional filtration only) and filtration, are employed. Systems may apply to the Primacy Agency for approval to recycle at an alternate location.
- The FBRR also requires that systems notify the Primacy Agency in writing that they are recycling.
- Finally, systems must collect and maintain information for review by the Primacy Agency, which may, after evaluating the information, require a system to modify its recycle location or recycle practices.
- More information on the Filter Backwash Recycling Rule can be found on the EPA web site at www.epa.gov/safewater or by calling the Safe Drinking Water Hotline at (800) 426-4791.

Primacy Agency Regulations

- **California uses Waste Extraction Test (WET) to determine toxicity characteristic**
  - **Determination based on total metals analysis as well as extraction analysis**
  - **Some residuals which might pass TCLP for metals may fail California WET for metals**
- **Others ?**

- Primacy Agencies can promulgate regulations that are more stringent than the federal regulations. For example:
  - California requires the use of its own Total Threshold Limit Concentrations (TTLCs) and Soluble Limit Threshold Concentrations (SLTCs) in addition to the federal TC levels to determine whether a solid waste has the characteristic of toxicity and should therefore be identified as hazardous (California Code of Regulations Title 22, Division 4.5, Chapter 11, Article 3, §66261).
    - The TTLCs are compared to the result of a strong acid digestion of a waste that determines the total dry weight concentration of contaminants (i.e., in milligram contaminant per kilogram waste). The presence of a regulated contaminant at a level exceeding the established TTLC is sufficient to determine that the waste is hazardous in California. Use of the TTLC is a measure of persistence and may be more rigorous than the federal TCLP test, which only measures extractable or mobile waste components.
    - If the results of the complete extraction show concentrations that are less than the established TTLC but greater than the established STLC, further analysis must be performed to determine whether an unacceptably high amount of the contaminant may be mobilized.
      - For solid wastes, the results of the complete extraction (in mg/kg) are divided by a factor of 10 prior to comparison with the STLC (in mg/L) because the Waste Extraction Test (WET), which is used to extract the solid wastes, includes a dilution by a factor of 10. If the result of the total analysis divided by 10 is less than the STLC, then it is mathematically impossible for the waste to violate the STLC.
    - The WET is used for solid samples or samples containing greater than 0.5% solids. The test consists of placing the waste in a citric acid extraction fluid for 48 hours and then analyzing the extraction fluid for toxic materials that may have leached out of the waste.
    - Liquid samples containing less than 0.5% solids are compared with the STLC directly.
    - The concentration of the toxic materials in the solid waste extraction or liquid waste is compared to the published SLTC values. If the concentrations in the sample exceed the regulatory concentrations, the waste is considered hazardous in California.
    - Citrate is known to chelate (form a strong bond with) several of the regulated elements, including arsenic. In addition, the greater length of the test may leach more contaminants. As a result, some contaminants (including arsenic) are apparently removed more readily by the WET test, so sludges containing high levels of arsenic may be more likely to be considered hazardous in California.
- Other Primacy Agencies may have requirements that are more stringent than the minimum federal requirements discussed in this presentation. Water systems should consult their Primacy Agencies



- Different arsenic mitigation processes create different waste streams.
- Water systems should seek to reduce or eliminate the production of residuals if possible in order to reduce disposal costs. In addition, because of the stringent and rigorous hazardous waste requirements, systems should attempt to manage their treatment processes to avoid the production of hazardous waste.
- All waste, hazardous or not, should be managed and disposed of legally and safely.

Dual Objectives: Meeting the MCL & Waste Minimization

- **Option #1: Change of source**
- **Option #2: Source blending**
- **Option #3: Optimize existing processes for arsenic removal**
- **Option #4: Add unit processes specific to arsenic removal/sidestream treatment**

- When a water system is choosing an arsenic mitigation strategy, it should consider both arsenic removal efficiency and residuals disposal. The system should seek both to produce water with arsenic levels below the MCL and to minimize its waste streams, especially its production of hazardous waste. There are a number of options a system can consider:
  - The system should consider using an alternate source or blending water from a high arsenic source and a low arsenic source to produce finished water with lower arsenic levels. If the system combines these options with treatment, then levels of arsenic in the residuals will be lower. If the system is able to use alternate sources and blending to avoid any treatment, then no residuals will be generated.
  - Systems that choose to optimize an existing treatment process will already be familiar with the residuals they produce and have disposal options in place. However, modification of the treatment process to meet the revised arsenic MCL may result in changes to the residuals, which will require the system to change how the residuals are managed and disposed.
    - Systems must analyze the residuals to determine whether they will now be classified as hazardous waste. Systems may also need to notify their Primacy Agencies of changes to their treatment processes, which may trigger a review of the need for a permit, permit conditions, etc.
  - Systems that install new treatment for arsenic will need to complete engineering feasibility studies. Pilot testing provides an excellent opportunity to test residuals and determine the optimum configurations and operating conditions for meeting drinking water standards while maintaining non-hazardous residuals management options.
    - If treatment is necessary, systems should investigate the use of side-stream treatment: treatment of a portion of the influent water (perhaps only the high arsenic source water, if two sources are being blended) to reduce the quantity of residuals.

Source Management

- Changing the source
- Source blending

No residuals are generated if no treatment is used

- From a residuals-management perspective, systems should attempt to manage their sources by changing the source or blending two or more sources together.
- If the system has no existing treatment, and using alternate sources and blending allows the system to avoid installing treatment, then the system will not generate any residuals.
- If the system treats its water, then using alternate sources and blending will reduce the level of arsenic in the system's residuals.
    - Systems may combine alternate sources and blending with treatment if the system has treatment in place for other contaminants, or if the level of arsenic in the alternate or blended sources is still not reliably below the MCL without treatment.

Optimize Existing Processes

- **Removal of arsenic from drinking water results in increased levels of arsenic in residuals**
- **Changes in residual characteristics trigger requirement to sample and analyze**
- **Results of analyses dictate disposal options**

- Systems that choose to optimize an existing treatment process will already be familiar with the residuals they produce and have disposal options in place.
- However, if modification of the treatment is necessary to meet the revised arsenic MCL, it is likely to result in an increased level of arsenic in residuals.
- Because the characteristics of the waste streams have changed, water systems must, in accordance with RCRA, analyze their residuals again to determine whether they will now be classified as hazardous waste.
- The results of these analyses will dictate disposal options, which may be more limited than prior to treatment modification.

Add Unit Processes for Arsenic Removal

– **Pilot test promising treatment technologies to determine finished water quality, residuals characteristics**
– **Residuals high in arsenic require sampling and analysis to determine characteristics and appropriate management and disposal strategy**
– **Results of analyses dictate disposal options**

- Systems that install new treatment for arsenic should pilot test treatment technologies for three reasons:
    - To determine whether and under what operating conditions the technology can remove sufficient amounts of arsenic to meet the revised MCL;
    - To determine residuals characteristics when the technology is operated to achieve sufficient arsenic removal; and,
    - To determine optimum operating parameters to remove sufficient arsenic while maintaining non-hazardous residual generation.
- Water systems must analyze their residuals to determine their characteristics. The results of these analyses will dictate disposal options.

Arsenic Removal Technologies

- **Sorption Processes**
- **Chemical Precipitation Processes ***
- **Membrane Processes ***

*** Technology in place at existing treatment plants**

- Most arsenic removal technologies will fall into three categories:
  - Sorption processes used on either a throw-away or reusable basis:
    - Ion exchange;
    - Activated alumina; and,
    - Granular ferric hydroxide.
  - Chemical precipitation processes:
    - Iron & manganese removal;
    - Oxidation & filtration;
    - Enhanced coagulation/filtration; and,
    - Enhanced lime softening.
  - Membrane processes:
    - Reverse osmosis;
    - Nanofiltration; and,
    - Coagulation-assisted microfiltration.
- Water systems with chemical precipitation and membrane processes already in place may simply be able to optimize their existing technologies for increased arsenic removal. These water systems will need to reexamine their residuals after changing their processes.
- The next part of the presentation discusses the residuals produced by these three categories of arsenic removal technologies and the options for disposal of each.
- Laboratory analysis will be necessary prior to deciding on a disposal option.
- All of the disposal options assume that the residuals are non-hazardous. Systems must determine residual characteristics in accordance with RCRA.
- Systems should check with their Primacy Agencies to ensure compliance with all applicable regulations.

Sorption Processes-Disposable Media

- **Process:**

  Adsorptive media (GFH etc.) without regeneration

  Activated alumina without regeneration

- **Residuals:**

  Liquid Residuals
  - Possibly backwash and rinse water

  Solid Residuals
  - Spent media

- Sorption processes operated on a throw-away basis could include adsorptive media (such as granular ferric hydroxide) or activated alumina without regeneration.
- These processes will produce the following residuals:
  - Liquid residuals: possibly backwash and rinse water, depending on operations; and,
  - Solid residuals: spent media

Disposable Media Disposal Options

- **Recycle backwash water to facility headworks**
- **Discharge backwash water to receiving body or POTW**
- **Landfill spent media**

- Water systems using sorption processes operated on a throw-away basis may wish to consider the following options for waste disposal:
  - Liquid residuals: recycle to facility headworks, discharge to a receiving body, or discharge to a POTW; and,
  - Solid residuals: landfill.

Sorption Processes-Reusable Media

Process:

Ion Exchange (IX)
- With regeneration

Residuals:

Liquid Residuals
- Backwash and rinse water, regenerant fluids

Solid Residuals
- Spent media
- Sludge from liquids processing

- Sorption processes with reusable media will produce the following residuals:
  - Liquid residuals: backwash, rinse water, and regenerant fluids; and,
  - Solid residuals: spent media and sludge from liquids processing.
    - Some water systems may choose to use intermediate processing to remove solids from liquids prior to disposal. This intermediate processing will produce a sludge, which will also need to be disposed.
- The only media likely to be used with regeneration by small systems is ion exchange.

IX Residuals Disposal Options

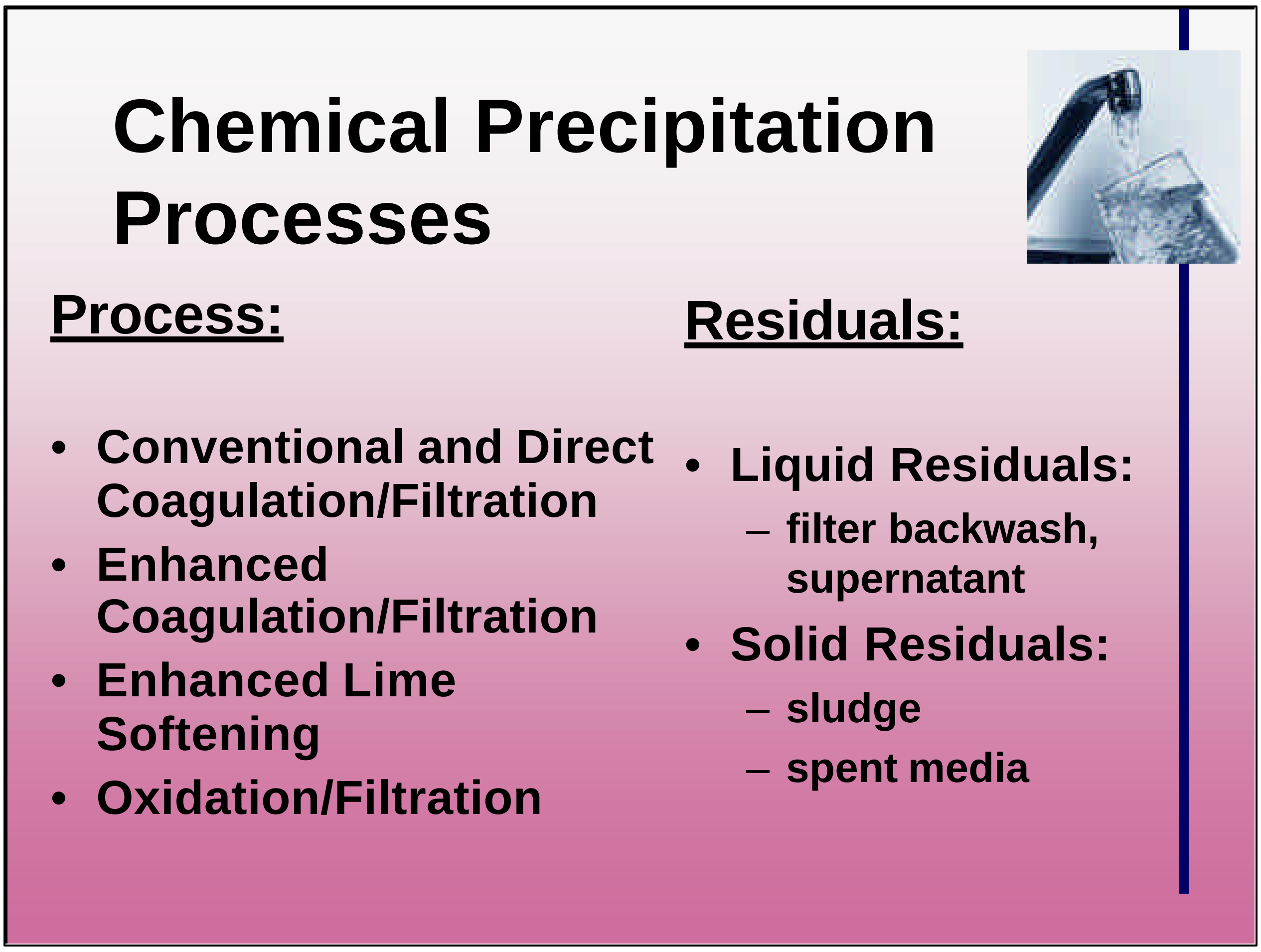
Liquids:

– **Investigate discharge to POTW**
  - **Combine backwash, regenerant, and rinse streams for flow equalization**
  - **Consider pretreatment options**
  - **Apply for pretreatment permit**

Solids:

– **Landfill sludge, spent media**

- Water systems using sorption processes with regeneration (primarily ion exchange) may wish to consider the following options for waste disposal:
  - Liquid residuals: investigate discharge to a POTW. The POTW may require pretreatment, including flow equalization. Combining backwash, regenerant, and rinse streams may assist in flow equalization.
  - Solid residuals: landfill.



- Chemical precipitation processes used for arsenic removal could include:
  - Conventional and direct coagulation/filtration;
  - Enhanced coagulation/filtration;
  - Enhanced lime softening; and,
  - Oxidation/filtration, including iron and manganese removal plants.
- These processes will produce the following residuals:
  - Liquid residuals: filter backwash water and supernatant from sludge settling; and,
  - Solid residuals: sludge and spent media.

Chemical Precipitation Residuals Disposal Options

Liquids:

- **Direct discharge backwash water/ supernatant**
- **Discharge backwash water/supernatant to POTW**

Solids:

- **Landfill sludge, spent media**

- Water systems using chemical precipitation processes may wish to consider the following options for waste disposal:
  - Liquid residuals: direct discharge to a receiving body or discharge to a POTW; and,
  - Solid residuals: landfill.

Membrane Processes

- Reverse osmosis
- Nanofiltration
- Coagulation-assisted membrane filtration

- Membrane processes used for arsenic removal include reverse osmosis, nanofiltration, and coagulation-assisted membrane filtration.

Membrane Processes Residuals

- **Liquid Residuals:**
  - Reject concentrate
  - Cleaning solution/ backwash water
- **Solid Residuals**
  - Spent membranes
  - Sludge

- Membrane processes will produce the following residuals:
  - Liquid residuals: reject concentrate, cleaning solution, and backwash water; and,
  - Solid residuals: spent membranes and sludge.
- Heavy metals (including but not limited to arsenic), radionuclides, and disinfection by-products (DBPs) are possible in the reject concentrate.

Membrane Processes Residual Disposal Options

- **Liquids:**
  - – **Consider pretreatment/management options**
  - – **Investigate discharge to POTW**
- **Solids:**
  - **Landfill sludge, spent membranes**

- Water systems using membrane processes may wish to consider the following options for waste disposal:
  - Liquid residuals: attempt to minimize using pretreatment or management strategies and then discharge to a POTW; and,
  - Solid residuals: landfill.

Pilot Testing Considerations

- **Consider pilot testing when optimizing existing processes or adding new processes**
- **Plan sampling ports for raw water, finished water, media, liquid and solid waste streams**

- Water systems are encouraged to conduct pilot testing whenever they are modifying their existing treatment processes or adding new processes.
- Sampling ports should be designed for any pilot testing apparatus to allow for easy and frequent sampling of raw water, finished water, media, liquid wastes, and solid wastes.

Sampling

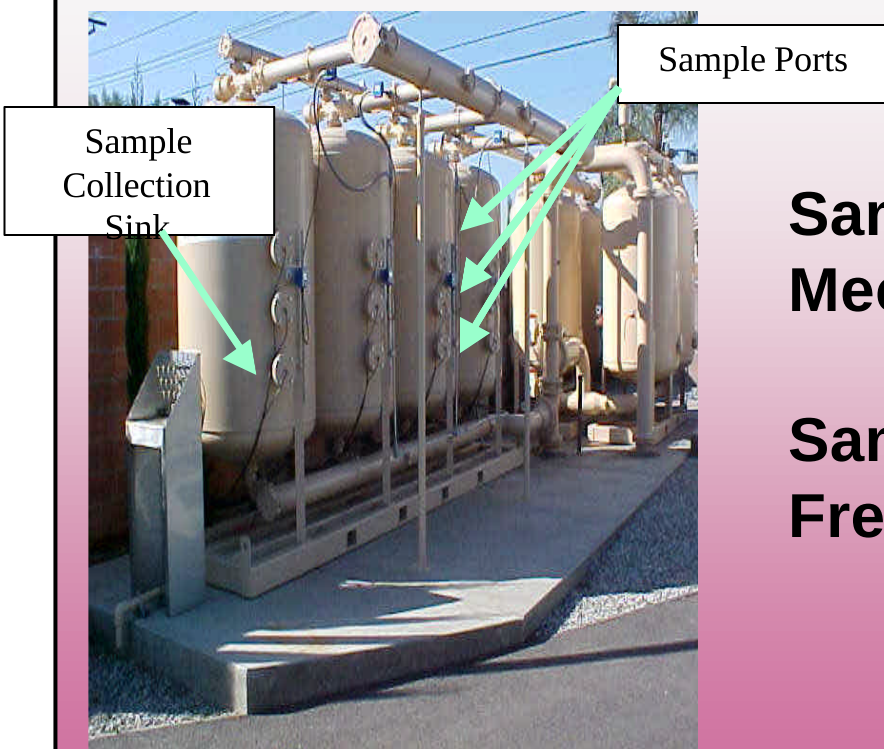
- Obtaining a representative sample is ***critical***
- Consider mixing, compositing, coring or analyzing multiple samples to account for sample variability
- Lab work is only as good as the sample being tested

- It is critical to obtain representative samples of the material or waste stream being tested.
- Media, water, and waste streams often vary significantly. For example, an activated alumina bed is likely to be saturated with arsenic at the top (near the water inlet) but contain a lower concentration of arsenic near the bottom (near the water outlet). Taking a sample one time from one portion of the material is frequently not enough. Systems should analyze samples taken over a period of time and from throughout the material. Strategies such as mixing, compositing, and coring may be useful.
- Even the most accurate laboratory analytical method will not provide useful information if the sample it measures is not indicative of the rest of the material.

Developing a Sampling Plan:

- **Use a certified lab, use approved methods**
- **Determine preservation requirements, holding times, sample container compatibility**
- **Choose grab samples for liquids, composite samples for solids**
- **Obtain equipment and provide for decontamination between samples**

- When sampling, water systems should:
  - Use a certified lab that uses methods approved by EPA or the Primacy Agency.
    - Certified laboratories must analyze performance evaluation samples and are subject to periodic on-site audits to ensure accuracy. These laboratories have therefore proven that they are capable of analyzing samples correctly and accurately. Most Primacy Agencies have a list of local approved laboratories.
  - Determine preservation requirements, holding times, and sample container compatibility.
    - Some materials can change composition over time or if they are held in certain environments (such as high temperatures). The laboratory analysis then does not measure the material as it exists in the water system. Certified laboratories can provide guidance on appropriate sample handling procedures.
  - Choose grab samples for liquids and composite samples for solids. These sampling techniques tend to be more representative than others. Compositing samples over time will also ensure more representative results. Systems should check with their Primacy Agencies for compositing requirements.
  - Obtain the appropriate sampling equipment and ensure that it is used properly. Make sure to decontaminate the equipment between samples so that material from one sample does not inadvertently pass into the next.



Sampling Mechanism

Sampling Frequency

- This water system in Paramount, California, designed this pilot testing unit with sampling in mind. Each pilot testing unit is fitted with three liquid sampling ports and there are also sampling taps on the raw and finished water. Each sampling tap is connected with dedicated plumbing to a sample collection sink located nearby; this sink makes it easy for water system personnel to frequently sample water at each of the five locations associated with each tank.
- For media samples, the top of the beds can be removed and the beds can be cored.
- During pilot testing, the water system should take frequent samples. While not all of these samples need to be analyzed initially, the additional samples may provide greater clarity later (for example, stored samples can be used to to determine precisely when a media became hazardous).

Case Study #1: IX Plant Backwash/Regeneration

Parameter	Units	# Samples	Minimum Conc.	Maximum Conc.	Average Conc.	Arsenic TC
Backwash:						
TSS	mg/L	5	6.0	24.0	14.0	-
Total As	:g/L	5	28.9	74.4	59.4	5000
Brine Rinse:						
TSS	mg/L	5	6.0	13.0	9.0	-
Total As	:g/L	5	1,830	*38,522*	*15,623*	5000
Slow Rinse:						
TSS	mg/L	5	0.5	22.0	9.6	
Total As	:g/L	5	253	3,060	1,332	
Fast Rinse:						
TSS	mg/L	5	0.5	4.0	1.2	-
Total As	:g/L	5	6.9	356	108	5000

Brine rinse arsenic greater than toxicity characteristic

Arsenic Removal from Drinking Water by Ion Exchange and Activated Alumina Plants, USEPA ORD 10/00

- The following two case studies show the character of residuals in plants treating for arsenic at the revised MCL standard. These results cannot be generalized to all water systems; each water system will face a unique combination of source water quality, disposal regulations, and technology operation.
- The first case study shows the arsenic concentrations in various liquid waste streams produced during backwash and regeneration of an ion exchange plant removing arsenic. The plant supplies treated water to a school and is used by approximately 350 students and teachers. The designed average daily demand is 1,200 gallons per day. Over the period of study, the plant reduced total arsenic from an average concentration of 40.6 µg/L in the raw water to an average concentration of 19.0 µg/L in the treated water.
- Four waste streams are created during backwash and regeneration: backwash, brine rinse, slow rinse, and fast rinse.
- Five samples were taken from each waste stream over the course of nearly a full year.
- For liquid samples, the TCLP test requires comparison of the concentration of arsenic to the TC, which for arsenic is 5 mg/L (or 5,000 µg/L). The maximum concentrations of arsenic in the backwash, slow rinse, and fast rinse streams were all below the TC. However, because the majority of the arsenic was removed from the media during the brine rinse stage, the brine rinse contained average and maximum arsenic concentrations well above the TC.
- If this plant disposed of each waste stream individually, the plant would probably have two options for disposal of its brine rinse stream:
  1. Disposal to a POTW, if the waste stream meets the POTW's TBLLs.
  2. Intermediate processing to remove arsenic and solids from the liquid waste stream, resulting in a non-hazardous liquid waste and a potentially hazardous solid waste.
- Alternatively, the plant may be able to combine its waste streams for purposes of flow equalization prior to disposal in a POTW. The equalized liquid waste stream is unlikely to exceed the TC.
- If the ion exchange resin itself is regenerated prior to disposal, the plant is unlikely to produce hazardous solid wastes.

Case Study #2: WET Results of Spent Adsorptive Media in CA

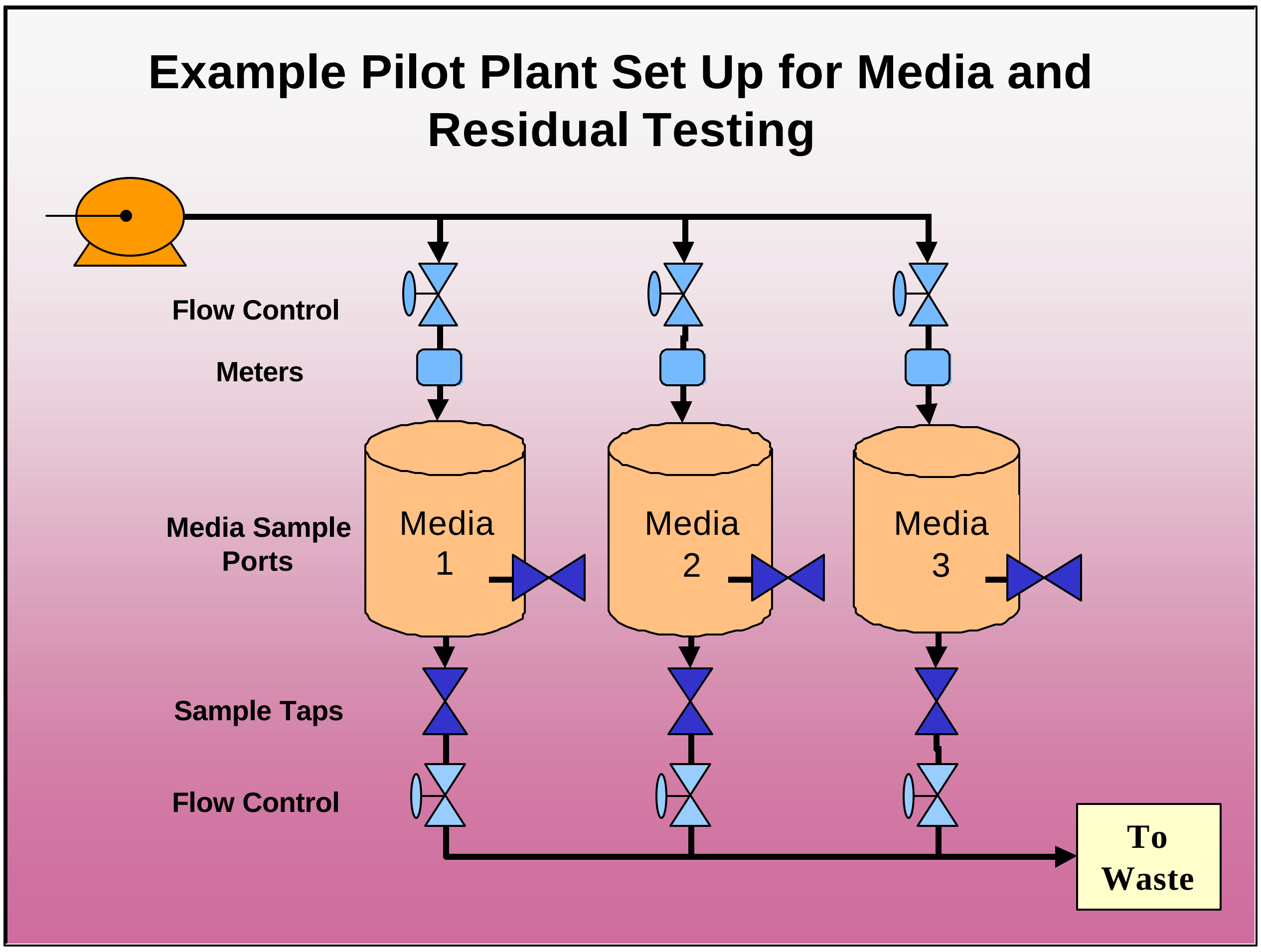
Element	AA Media #1 mg/kg	AA Media #2 mg/kg	AA Media #3 mg/kg	Iron – Based Media mg/kg	Iron-Based Media CA WET Result mg/L	Cal TTLC mg/kg	Cal STLC mg/L
Arsenic	30.8	22.9	15.1	413	2.9	500	5
Barium	149	369	330	622	-	10,000	100
Chromium	ND	ND	20.3	31.1	-	500	5

- The second case study shows the concentrations of various heavy metals in four adsorptive media piloted without regeneration at a water system in California. The plant produces 500 to 600 gallons per minute total flow. The concentration of arsenic in the raw water is 15 to 20 µg/L. Effluent arsenic concentrations range from 2 µg to 15 µg/L, depending on the media used. The iron-based media produces finished water with the lowest arsenic concentration.
- At the time these media samples were taken, the three activated alumina media had reached exhaustion and the iron-based media (granular ferric hydroxide) was approximately 50% to exhaustion. The researcher cored each vessel and mixed the cored material to produce one representative sample per media type. The samples were evaluated for all contaminants regulated under the TCLP and WET tests and only arsenic, barium, and chromium were detected.
- Because this plant is in California, its residuals must be evaluated by both the TCLP test and the California requirements. For solid wastes, California requires that:
  - The total concentration of contaminants be evaluated to determine whether any exceed the total threshold limit concentration (TTLC).
  - When the result of the total analysis is less than the TTLC and the result divided by 10 is greater than the soluble threshold limit concentration (STLC), the WET test must be performed to determine whether leachate from the waste extract exceeds the STLC for any contaminant; and,
  - When results are less than the TCLP, the TTLC, and the STLC, the waste is considered non-hazardous for toxicity.
- The concentrations of arsenic, barium, and chromium in the activated alumina media at exhaustion were well below the TTLC required in California. The concentrations divided by 10 were also below the STLC levels. These media can therefore be disposed to a non-hazardous landfill without undergoing WET analysis (provided the TCLP results are less than the TC values, as is shown on the next slide).
- At 50% to exhaustion, the concentrations of barium and chromium in the iron-based media were well below the TTLC established in California, and the concentrations divided by 10 were also below the STLC levels. The concentration of arsenic was similarly below the TTLC, but the concentration of arsenic divided by 10 was greater than the STLC level. The WET test was therefore performed for arsenic in the iron-based media. The concentration of arsenic in the WET leachate from the iron-based media (2.9 mg/L) was below the established level (5.0 mg/L). However, because 2.9 mg/L is more than 50% of the limit, if the media is used to exhaustion it may exceed the regulatory limit. The water system plans to continue to use the media with more frequent testing to use as much of its available capacity as is possible without producing hazardous waste.

Case Study #2: TCLP Results of Spent Adsorptive Media in CA

Element	AA Media #1 mg/L	AA Media #2 mg/L	AA Media #3 mg/L	Iron – Based Media mg/L	TC mg/L
Arsenic	0.0074	<0.01	<0.01	0.011	5.0
Barium	4.6	3.9	2.6	7.5	100

- The concentrations of arsenic and barium in the activated alumina media at exhaustion and the iron-based media at 50% to exhaustion were well below the TC. (Chromium was not detected in the TCLP extract.) These media would therefore be considered non-hazardous under federal regulations.



- This example pilot plant set-up for media and residual testing shows the testing of several media in parallel. Each media bed is fitted with a meter and flow control to accurately measure and adjust the amount of water flowing through each bed. In addition, each media bed has both media and liquid sampling ports to allow for frequent sampling.

- The goals of WTP residuals management are to:
  - Generate non-hazardous waste.
    - Non-hazardous waste is less expensive to dispose than hazardous waste.
    - Non-hazardous waste does not result in cradle-to-grave liability.
  - Generate as little waste as possible.
  - Dispose of waste appropriately at the lowest possible cost.
- Following these principles simultaneously will result in waste minimization and best management practices.

Why Generate Non-hazardous Wastes ?

- No cradle-to-grave liability
- Management requirements less rigorous
- Disposal of non-hazardous waste is less expensive

- Water systems should avoid generating non-hazardous wastes because:
  - They will avoid cradle-to-grave liability. Under RCRA, a water system is responsible for its wastes from when they are produced to an indefinite point in the future. Even if a water system disposes of its wastes in a hazardous waste site, if that site is poorly managed in the future, the water system may be responsible for cleaning up the site, which is many times more expensive than the initial disposal.
  - The management requirements are much less rigorous for non-hazardous wastes. RCRA stringently regulates the generation, transportation, treatment, storage, and disposal of hazardous wastes.
  - The disposal of non-hazardous waste is less expensive. Because of the management requirements and risk associated with hazardous wastes, it costs several times as much to transport and dispose of them.

But…. Economics

- **Possible trade-off between maximizing use of media and avoiding generation of hazardous waste**

- **Therefore, perform cost-benefit analysis**

- In some situations, media may be hazardous if they are used to exhaustion. Therefore, systems will need to throw away unexhausted media to avoid generating hazardous waste. There may be a trade-off between the costs associated with generating hazardous waste and the costs associated with purchasing new media more frequently.
- Water systems that are considering generating hazardous waste should perform a cost-benefit analysis, considering the life-cycle costs of hazardous waste generation. These costs may include future liability and additional costs for manifestation, storage, transportation, handling, and disposal.

Conclusions

- **Avoid generating a hazardous waste unless it is more cost-effective to do so**
- **Most likely scenarios:**
  - **Ion exchange with discharge to a POTW**
  - **Activated alumina without regeneration**
  - **GFH**
  - **POU systems**
- **Pilot scale testing will be useful for determining operating parameters and residuals characteristics**

- Water systems should avoid generating a hazardous waste unless it is much more cost-effective to do so. When making this determination, they should remember to take the whole waste life-cycle into account.
- Considering both treatment and residuals, the most likely scenarios for small water systems that must install new treatment to comply with the Arsenic Rule are the installation of:
  - Ion exchange, if discharge to a POTW is possible. Because there is likely to be a high concentration of arsenic and suspended solids in the liquid waste stream, waste disposal may be difficult unless the waste stream meets a local POTW's TBLLs.
  - Activated alumina and granular ferric hydroxide without regeneration. Regeneration of these media involves the use of caustics and other chemicals that may compromise operator safety. In addition, regeneration may increase the amount of arsenic in the media, possibly creating a hazardous waste.
  - Activated alumina and reverse osmosis point-of-use (POU) systems. These systems have proved effective for the smallest systems.
- In all cases, water systems should pilot test technologies prior to modification or installation both to ensure effective treatment and to characterize residuals.