U. S. Environmental Protection Agency

Ensuring and Determining Compliance with Land Disposal Restrictions Through RCRA Permits, Waste Analysis Plans and Inspection Sampling Practices

Information Bulletin

April 2022

Introduction and Objectives

This information bulletin is intended to make Resource Conservation and Recovery Act (RCRA) permit writers, inspectors, and the regulated community aware of controls, conditions and sampling practices to ensure and determine compliance with RCRA land disposal restrictions (LDRs). LDRs include testing and recordkeeping requirements, treatment standards, various prohibitions and other conditions that ensure hazardous wastes are adequately treated before disposal, thereby minimizing impact on human health and the environment. This document is based on existing regulatory requirements, longstanding guidance, and formal policy, and provides an overview of the basis of LDR requirements. It focuses on strategies that permit writers and facilities can use to improve RCRA permits and Waste Analysis Plans (WAPs), as well as provides inspectors with tools to better determine compliance with LDRs.[1]

This bulletin follows the Environmental Protection Agency (EPA)'s review of 57 hazardous waste treatment facility WAPs and examination of 14 facility LDR inspection sampling results, which revealed insufficient LDR treatment verification sampling at many facilities and high LDR failure rates in treatment residues. These extensive LDR failures were likely caused by inadequate LDR treatment design and operation in RCRA permit controls, insufficient WAP LDR treatment verification sampling, or both. Protective waste disposal is achieved where permit writers and facilities incorporate into permits both well-designed and operated LDR treatment permit controls and adequate WAP conditions to ensure LDR compliance, facilities operate their waste treatment and analysis processes accordingly, and inspectors conduct sampling to determine LDR compliance.

Waste Analysis Plans (WAPs)

A WAP establishes enforceable hazardous waste sampling and analysis procedures that a RCRA permitted or interim status facility will routinely conduct to ensure owners and operators of treatment, storage, and disposal facilities (TSDF) comply with RCRA standards. Among other things, the WAP provides the basis for monitoring how a facility meets LDRs, including mandatory requirements for sampling by treatment facilities under 40 CFR 268.7(b) and disposal facilities under 40 CFR 268.7(c). The WAP regulations (40 CFR 264/265.13) state that before an owner or operator treats, stores, or disposes of any hazardous wastes, a detailed chemical and physical analysis of a representative sample of the waste must be obtained and, at a minimum, the analysis must contain all the information which must be known to treat, store or dispose of the waste in compliance with applicable requirements, including LDR requirements.

[1] This bulletin includes information and practices based on existing regulations and policy. This document does not constitute new policy and is solely intended to provide guidance to federal and state regulators, and the regulated community, on implementing the RCRA Subtitle C regulations and to provide policy advice and recommendations. As such, this document does not impose any legally binding requirements, and the use of such phrases as "guidance," "recommend," "may," "should," and "can," are not intended to impose or connote any legal obligations. Accordingly, this document does not change or substitute for any law, regulation, or any other legally binding requirement and is not legally enforceable. The policies described in this document may not apply to a particular situation based upon the circumstances, and EPA may deviate from or revise any of the policies described in this document without prior notice to the public. While EPA has made every effort to ensure the accuracy of the discussion in this document, the obligations of the regulated community are determined by statutes, regulations or other legally binding requirements. In the event of a conflict between the discussion in this document and any statute or regulation, this document would not be controlling.

The information in this document largely stems from key concepts used by the EPA in promulgating the LDR treatment standards. These concepts support three areas. The first is for permit writers and facilities addressing effective treatment process designs and operating controls in RCRA permits. The LDR treatment standards are based on the expected performance of well-designed and well-operated processes that treat wastes with high concentrations of LDR constituents. The second area considers WAP conditions that address LDR verification sampling and analysis that ensure proper treatment of all portions of the waste, including appropriate consideration of temporal (time) and spatial variations in the treated waste. The third emphasizes the inspector's role to determine LDR compliance by obtaining independent sampling.

There are distinctions between WAP sampling to ensure proper treatment of all portions of the waste, and inspectors' sampling to determine compliance with LDR treatment standards. In setting the LDR treatment standards, EPA calculated compliance values at high constituent concentrations for the purpose of allowing inspectors to determine compliance with easily obtained grab samples from well-designed and well-operated treatment processes. The LDR treatment standards are set so that well-designed and well-operated treatment processes should always produce compliance sample concentrations of less than the LDR treatment standards.

EPA described the basis, purpose and intended implementation of the LDR regulations in the rule preambles. The LDR rule preambles are clear regarding inspectors' sampling to determine facilities' compliance with LDR requirements. Because EPA intended permit writers and facilities to establish day-to-day compliance demonstrations (specified in their WAPs) on a permit-by-permit basis to provide flexibility, the LDR regulations do not include detailed requirements for permit controls (design and operation) and routine waste analysis necessary to ensure compliance. The issues found in EPA's inspections and WAP reviews suggest that permits and WAPs may have failed to differentiate between inspectors' sampling objectives to determine compliance versus LDR treatment verification sampling objectives to ensure compliance.

The purpose of the LDR program *is to minimize short and long-term threats to human health and the environment by reducing the toxicity or mobility of hazardous constituents before they are land disposed by:*

- ✓ *Prohibiting hazardous wastes from land disposal unless EPA makes a stringent "no migration" determination or the wastes meet established LDR treatment standards;*
- ✓ *Specifying LDR treatment standards by concentration or a treatment method; and*
- ✓ *Attaching LDRs at the point of generation, not the point of disposal.*

The regulations describing EPA's LDR program can be found in Title 40 of the Code of Federal Regulations (CFR) in Part 268. The rulemakings (including preambles) establishing the LDR regulations are found in the Federal Register (FR) and listed in the eCFR.

RCRA National Permitting Priority Review and Regulatory Background

Findings from WAP Reviews and Treatment Facility Inspection Results

As part of the FY2018/2019 National RCRA Permitting Priority, EPA reviewed 57 WAPs from selected treatment facilities to assess how metal-bearing hazardous waste is treated and disposed. The review found numerous WAP deficiencies including insufficient sampling frequency, sampling methods, and waste variability characterization. In addition, EPA examined 14 facility inspection sampling data sets from some of the same WAP-reviewed facilities. Only four facility inspection sampling events (28%) showed all sampled batches in compliance with LDR treatment standards, whereas 10 inspection sampling events (72%) *failed* LDR treatment standards. Batch *failure rates* ranged from 2.6 to 84% at facilities with LDR treatment standard failures. EPA is concerned that some historical practices in WAPs are inadequate to ensure LDR compliance.

This analysis revealed the following LDR areas of concern:

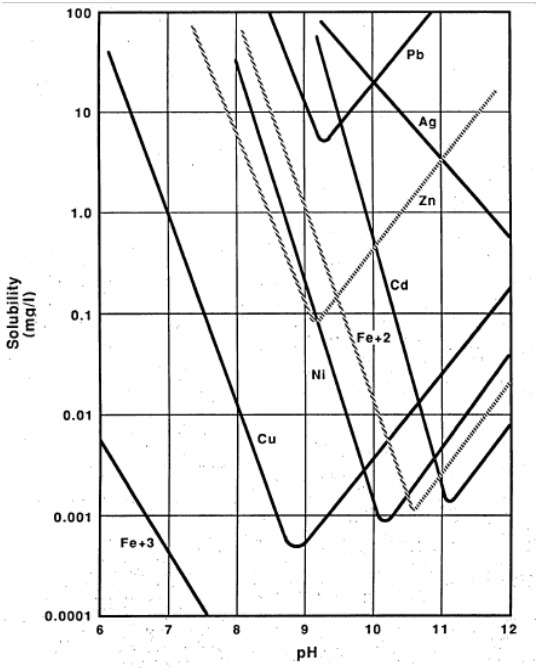
- Inadequate or unjustified WAP LDR verification sampling frequencies.
- Incorrect or unjustified WAP LDR verification sampling methods.
- Inadequate evaluation of incoming waste variability and treated waste variability.
- Lack of permit controls to ensure well-designed and operated processes (e.g., reagents used, mixing method, mixing time, storage after treatment) that would justify the WAP sampling approach.

Frequent and adequate WAP LDR verification sampling, independently confirmed with inspectors' effective compliance sampling, will prevent land disposal of significant amounts (hundreds of thousands of tons) of waste that do not meet LDR treatment standards. EPA's analysis of inspection sampling results and WAPs shows that facilities that perform more frequent LDR verification sampling are more likely to dispose of wastes that meet LDR treatment standards. In other words, more frequent LDR verification sampling increases the chance of identifying failed treatment batches and preventing subsequent disposal of non-compliant wastes and helps facilities ensure treatment processes continue to be well operated.

A permit writer should assure a facility's strategy for WAP LDR verification sampling evaluates all factors that could cause the waste to fail LDR treatment standards. Failures could stem from treatment chemistry or from poor design and operation. Since LDR treatment standards are set as a *not-to-exceed* requirement such that "all portions of the waste must meet the applicable standards," as stated in the LDR Phase IV Rule[2] preamble (63 FR 28567), waste should be treated not only to achieve the LDR treatment standards from a particular sample, but also to be so well-mixed that all portions will pass. WAP LDR verification sampling should confirm the spatial homogeneity and temporal variability of treated wastes, as well as showing that concentrations do not exceed the LDR treatment standards or lower WAP verification target concentrations. This document addresses these concerns by providing information that may help improve compliance with LDR requirements by improving permits and WAPs.

Treatment Technologies used by Reviewed Facilities.

Stabilization technologies are the most used technologies for treatment of metals in hazardous wastes. These processes are commercially available and are employed at hazardous waste treatment facilities throughout the country. The treatments are intended to reduce the toxicity or mobility of a waste by changing its chemical state and reducing the solubility or chemical reactivity. These technologies are applicable to wastes containing leachable metals and having a high filterable solids content, low total organic carbon content, and low oil and grease content. The basic mechanism of metal stabilization is the immobilization of metals after the addition of stabilizing agents or chemicals. The formation of chemical bonds that adhere the metals to the solid matrix reduces metal leachability and thereby limits the amount of metal constituents that can migrate when water or mild acid solutions come into contact with the waste. Stabilization is most effective when the waste metal exists in its least soluble state. The combining of wastestreams containing different metals prior to treatment may result in a waste that is more difficult to treat as the least soluble state for each metal may exist at different conditions, and could result in impermissible dilution per 40 CFR 268.3. (See figure at right: Solubilities of metal hydroxides as a function of pH, from 52 FR 29999).



A treatment facility's stabilization equipment generally consists of a weighing device, a mixing unit, and a curing vessel or pad. The two principal stabilization processes used are cement-based and lime/pozzolan-based processes. In both, the stabilization process can be modified using additives (e.g., silicates) that control curing rates, reduce permeability, and enhance the properties of the solid material.

While the information from EPA's review of inspection results and treatment facility WAPs mostly addressed metal-bearing hazardous waste stabilization methods, the critical concepts discussed here are broadly applicable to many other LDR treatment processes that address other constituents of concern. Permit writers and treatment facilities should consider the elements of well-designed and operated treatment processes, and the critical concepts for LDR sampling presented below, for other treatment processes such as chemical oxidation, cyanide destruction, etc.

[2] *Land Disposal Restrictions Phase IV: Final Rule Promulgating Treatment Standards for Metal Wastes and Mineral Processing Wastes; Mineral Processing Secondary Materials and Bevill Exclusion Issues; Treatment Standards for Hazardous Soils, and Exclusion of Recycled Wood Preserving Wastewaters*, May 26, 1998, 63 FR 28556.

LDR Treatment Standards and WAPs

Under the LDR program, there are specific waste analysis requirements applicable to hazardous waste generators and owners/operators of treatment, storage, and disposal facilities (TSDFs).[3] The LDR regulations in 40 CFR 268.7 state (in part) that facilities that treat and/or land dispose must test the wastes or treatment residues according to the frequency specified in their WAP to assure they are meeting the LDR treatment standards.

40 CFR 264/265.13(b)(6) require WAPs to specify the methods that will be used to meet the waste analysis requirements for the LDR program at 40 CFR 268.7. These methods include the required elements at 40 CFR 264/265.13(b)(1-5) that the WAPs specify the parameters and rationale for analysis, the test methods, sampling methods, and frequency for each hazardous waste.

The 1990 LDR Third Third Rule[4] preamble emphasizes that the frequency of verification testing to ensure LDR compliance must be detailed in the WAP (40 CFR 268.7) at permitted facilities to the satisfaction of the permit writer on a case-by-case basis (55 FR 22669). Consultation between the facility and the permitting agency helps develop the LDR verification sampling strategy selected in a WAP. Accordingly, both hazardous waste treatment and hazardous waste disposal facilities must conduct periodic detailed physical and chemical waste analysis on a justified and specified frequency to ensure both treated wastes and land disposed wastes meet LDR treatment standards (40 CFR 268.7(b) and (c)).

How EPA Set LDR Treatment Standards

EPA established the LDR treatment standards for most wastes based on an analysis of grab samples as described in the 1989 LDR Second Third Rule[5] preamble because "[I]t is normally easier and more expeditious . . . to enforce on the basis of grab samples . . . [and] in addition, grab samples normally reflect maximum process variability, and thus would reasonably characterize the ranges of treatment system performance" (54 FR 26605). When developing LDR treatment standards, EPA reviewed both pre- and post-treatment concentrations, and process descriptions of facilities that treated wastes. If a facility's process was well-designed and operated, and total or leachable constituent concentrations were reduced by the treatment, EPA considered that process a potential *Best Demonstrated Available Technology* (BDAT).

EPA then statistically compared the treatment results from potential BDAT processes. Unless some processes could be shown to significantly outperform other potential BDAT processes, EPA generally combined the data from all potential BDAT processes for each metal, adjusted the data for laboratory variability, and statistically derived an upper-bound concentration in treated waste for each metal that any facility properly implementing a BDAT process would likely never exceed.

Setting the LDR treatment standards at the upper-bound concentration of combined BDAT data sets accounts for process variability. They are derived from mean concentrations and variability factors, and set at an estimate of the 99th percentile of daily observations. The 99th-percentile concentrations are greater than the mean values, and account for almost all process variability. Because EPA statistically evaluated data representing the performance of BDAT in a manner that accounts for both process and analytical variability, the resulting LDR treatment standards are considered *not-to-exceed* standards.

Setting the LDR treatment standards at essentially the worst performance (99th percentile) of the BDAT justifies the standard as a *not-to-exceed* standard in all portions of the waste. To determine compliance of such *not-to-exceed* standards, it is evident that an inspector's single failing sample would determine non-compliance. Conversely, from the perspective of day-to-day operations, treatment facilities' WAPs would ensure compliance using more robust LDR verification sampling to support conclusions that all portions of the waste meet the LDR treatment standards.

Even though EPA set the LDR treatment standards as concentrations for inspectors to *determine* compliance, the RCRA Permit and WAP need to be written to *ensure* compliance. This can be achieved with proper treatment design and operation, robust routine sampling, and appropriate verification of target concentrations that may be lower than the LDR treatment standard concentrations.

[3] For more information and resources on the LDR program, go to the EPA's Land Disposal Restrictions for Hazardous Waste website at: https://www.epa.gov/hw/land-disposal-restrictions-hazardous-waste.
[4] *Land Disposal Restrictions for Third Third Scheduled Wastes - Final Rule*, June 1, 1990, 55 FR 22520.
[5] *Land Disposal Restrictions for Second Third Scheduled Wastes - Final Rule*, June 23, 1989, 54 FR 26594.

EPA established methods for determining BDAT[6] and setting LDR treatment standards stating "a treatment facility would have to be designed to meet the *mean achievable treatment performance level* [emphasis added] rather than the treatment standard to ensure that the performance level remains within the limits of the treatment standards" (p. 1-11). The BDAT background document reiterates that "[a]s a practical matter, facilities will have to incorporate variability factors into process design to ensure performance that is *more stringent than the standard* [emphasis added] in order to ensure continuous compliance with the standard" (p. 3-11).

As described above, EPA's review of WAPs and inspection sampling results found substantial rates of noncompliance with LDR treatment standards in the inspection datasets. These noncompliance rates indicate that many facilities are not properly designed and operated to meet the LDR treatment standards, and facilities' WAP procedures are not rigorous enough to ensure compliance with LDR treatment standards on a routine or batch-to-batch basis. This further demonstrates the need for facility owners or operators to understand that the design basis of a treatment facility should be aimed toward the mean BDAT concentrations and not the actual LDR treatment standard concentrations, to ensure post-treatment waste concentrations do not exceed LDR treatment standards at any time with any sample, or in any portion of the waste.

The following table of *LDR Phase IV Nonwastewater BDAT Mean Treatment Concentrations and LDR Universal Treatment Standards (mg/L TCLP[7])* provides the arithmetic BDAT mean treatment concentrations and references for 14 metals.

LDR Phase IV Nonwastewater BDAT Mean Treatment Concentrations and LDR Universal Treatment Standards (mg/L TCLP)

Constituent	Arithmetic Mean of BDAT Treatment	LDR Treatment Standard (99th percentile of log normal distribution)	Number of Observations	Technology	Document Number in LDR Phase IV Rule Docket (regulations.gov) or other Reference
Antimony	0.21	1.15	50	Stabilization	EPA-HQ-RCRA-1998-0003-0115
Arsenic	2.0	5.0	1	Vitrification	EPA 530-SW-90-059A
Barium	2.6	21.0	12	Stabilization	Finkel 1997
Beryllium	0.19	1.22	7	Stabilization	EPA-HQ-RCRA-1998-0003-0108
Cadmium	0.025	0.11	38	HTMR	EPA-HQ-RCRA-1998-0003-0107
Chromium	0.10	0.60	38	HTMR	EPA-HQ-RCRA-1998-0003-0107
Lead	0.12	0.75	27	Stabilization	Finkel 1997
Mercury	0.0043	0.025	371	Acid Leaching	EPA-HQ-RCRA-1998-0003-0151 and EPA 530-SW-88-031F
Nickel	2.9	11.0	117	HTMR	EPA-HQ-RCRA-1998-0003-0107
Selenium	0.80	5.7	4	Stabilization	EPA 530-SW-90-059A
Silver	0.032	0.14	111	HTMR	EPA-HQ-RCRA-1998-0003-0107
Thallium	0.092	0.20	15	Stabilization	Finkel 1997
Vanadium	0.57	1.6	1	Stabilization	Finkel 1997
Zinc	0.35	4.3	6	Stabilization	Finkel 1997

Finkel 1997, Memorandum: *Final Revised Calculation of Treatment Standards Using Data Obtained from Rollins Environmental's Highway 36 Commercial Waste Treatment Facility and GNB's Frisco, Texas Waste Treatment Facility,* from Howard Finkel, ICF Consulting Group, Fairfax, VA to Anita Cummings, U.S. EPA, Washington, D.C., March 10, 1997

[6] *Final, Best Demonstrated Available Technology (BDAT) Background Document for Quality Assurance/Quality Control Procedures and Methodology*, U.S. EPA OSW, Washington, DC, October 23, 1991.

[7] Toxicity Characteristic Leaching Procedure (TCLP) is a solid waste test method to simulate leaching through a municipal solid waste landfill that is used in regulatory standards (SW-846 Method 1311).

Critical Concepts of LDR Sampling

Here we discuss effective sampling strategies for ensuring and determining compliance with LDR treatment standards. Selection of a WAP LDR verification sampling strategy should consider the pros and cons regarding sampling frequency, methods, number, and type of samples to ensure that the LDR treatment standards are met for all treated waste prior to land disposal with a high degree of statistical confidence. In preparing a treatment LDR verification sampling strategy, a facilty's WAP must provide a sampling and testing rationale to achieve the required regulatory objectives (40 CFR 264/265.13(b)).

Sampling Strategy Objectives: *Proving the Positive* versus *Proving the Negative*

Waste Analysis at Facilities that Generate, Treat, Store, and Dispose of Hazardous Waste – Final (the 2015 WAP Guidance)[8] describes two sampling approaches to LDR compliance, each with a different objective. One sampling approach is for inspectors seeking to determine LDR compliance, and the other approach is for permit writers and facilities intending to ensure LDR compliance utilizing permit and WAP conditions. It is important not to confuse these two objectives (i.e., incorrectly applying the inspectors' axiom that one sample can show noncompliance as justification for the WAP to specify only one LDR verification sample, even when factors such as variability or volume necessitate more comprehensive sampling).

The 2015 WAP Guidance indicates that the inspector's sampling and analysis objective is sometimes called "*proving the positive*." The 1990 Hazardous Waste Management System Notice of Data Availability (NODA)[9] describes this approach as attempting *to determine* if "the waste concentration . . . exceeds a regulatory level" (55 FR 4442). Simply stated, an inspector's grab sample with a concentration greater than the LDR standard *positively* proves the batch has failed. This only requires a single measurement above the regulatory level to draw the conclusion that the waste, at least in part, exceeds the *not-to-exceed* regulatory standard. Sampling strategies for this purpose would not require sampling for all aspects of the waste to prove the waste has failed the regulatory threshold.

LDR regulations require that a prohibited waste may only be land disposed if the waste meets the LDR treatment standards (40 CFR 268.40(a)). EPA clearly states in the LDR Phase IV Rule preamble that if testing results show that "hot spots" remain, this is evidence that the treatment was not effective and there is noncompliance with the LDR treatment standards (63 FR 28567). In other words, all portions of the treated waste must meet applicable concentration-based LDR treatment standards, and averaging or compositing of samples is not allowed for an inspector to determine compliance (63 FR 28567).

In contrast, the LDR sampling and analysis objectives of a treatment facility's WAP may focus on "*proving the negative*." *Proving the negative* is described as attempting to "prove that a waste does not contain a given analyte at a specific concentration. . ." (55 FR 4441). Sampling strategies for *proving the negative* "should be thorough enough to insure that one does not conclude waste [meets the regulatory standard] when, in fact, it [does not]. For example, one needs to take enough samples so that one does not miss areas of high concentration in an otherwise clean material" (55 FR 4441).

From a *proving the negative* perspective, the WAP LDR treatment verification sampling strategy assumes the treated waste may *not* meet applicable concentration-based LDR treatment standards. With this approach, only when reliable demonstrations of process effectiveness and LDR verification sampling show all portions of the waste are successfully treated, may the facility conclude the waste is likely to meet LDR treatment standards. EPA's 2015 WAP Guidance also points out that the permit writer and treatment facility may need to "ensure that waste concentrations are low enough so that it would be highly unlikely that any individual sample of the waste would exceed a 'do not exceed' regulatory

[8] *Waste Analysis at Facilities that Generate, Treat, Store, and Dispose of Hazardous Waste – Final*, U.S. EPA Office of Solid Waste and Emergency Response, Washington, D.C., EPA 530-R-12-001, April 2015, text box *Different Sampling and Analysis Objectives for Enforcement Agencies and Waste Handlers "Proving the Positive" versus "Proving the Negative",* p. 2-30.
[9] *Hazardous Waste Management System; Testing and Monitoring Activities, Notice of Reopening of Comment; Notice of Data Availability*, February 8, 1990, 55 FR 4440.

standard" (p. 2-30). Taken together, the recommendations for more robust sampling in order to *prove the negative* from both the 2015 WAP Guidance and the 1990 NODA are consistent with the 1991 BDAT that state "facilities will have to . . . ensure performance that is more stringent than the standard in order to ensure continuous compliance with the standard" (p. 3-11).

Sampling Frequency

While an inspector determines LDR treatment compliance by taking samples during routine inspections, a treatment facility's WAP must address sampling frequency (40 CFR 264/265.13(b)(4), 268.7(b), and 268.7(c)(2)). In determining frequency of LDR treatment verification sampling, a treatment facilty's WAP should take into account the variability of incoming waste and the variability of treated waste. EPA's preamble to the 1986 LDR Final Rule (the 1986 Rule)[10] recommends that "Although the frequency of testing will depend to some extent upon the variability of the waste stream, the Agency recommends that a comprehensive analysis of each waste stream be performed at least annually by the generator or treater" (51 FR 40598). The 1986 Rule gives an example scenario where testing frequency of less than every batch could be justified if "a particular generator's waste does not vary and is consistently treated by the same treatment facility using the same treatment process . . ." (51 FR 40597). The 1986 Rule further states "[l]ess frequent testing may be appropriate when there are fewer and less variable waste streams at combined facilities . . ." (51 FR 40598).

The 2015 WAP guidance and official EPA policy[11] repeat the recommendation that treatment facilities perform comprehensive waste analysis on a justified basis. When considering the frequency of LDR sampling at the disposal facility, EPA's 1987 RCRA policy memorandum suggests evaluating additional factors including: "variability of the waste; the prior history of the waste generator's performance and reliability; the impact of improperly treated waste on the waste management process; and the frequency and extent of testing performed by the generator or treater" (RO 12943, p. 2).

The 2015 WAP Guidance illustrates the relationship between waste variability and the need for high-quality and frequent waste analysis. Since LDR treatment standards or verification target concentrations are specific numerical values, permit writers and facilities should apply the increased level of accuracy and precision (high-quality analysis approach) in the two right-hand quadrants in Figure 1-5 to ensure LDR compliance.

[10] *Hazardous Waste Management System; Land Disposal Restrictions – Final Rule*, November 7, 1986, 51 FR 40572.
[11] Memorandum: Waste Analysis Requirements in Incoming Waste Shipments – LDR, from Marcia Williams, U.S. EPA Office of Solid Waste, Washington, D.C., to Suellen Pirages, Institute of Chemical Waste Management, Washington, D.C., June 12, 1987, RCRA Online (RO) number 12943.

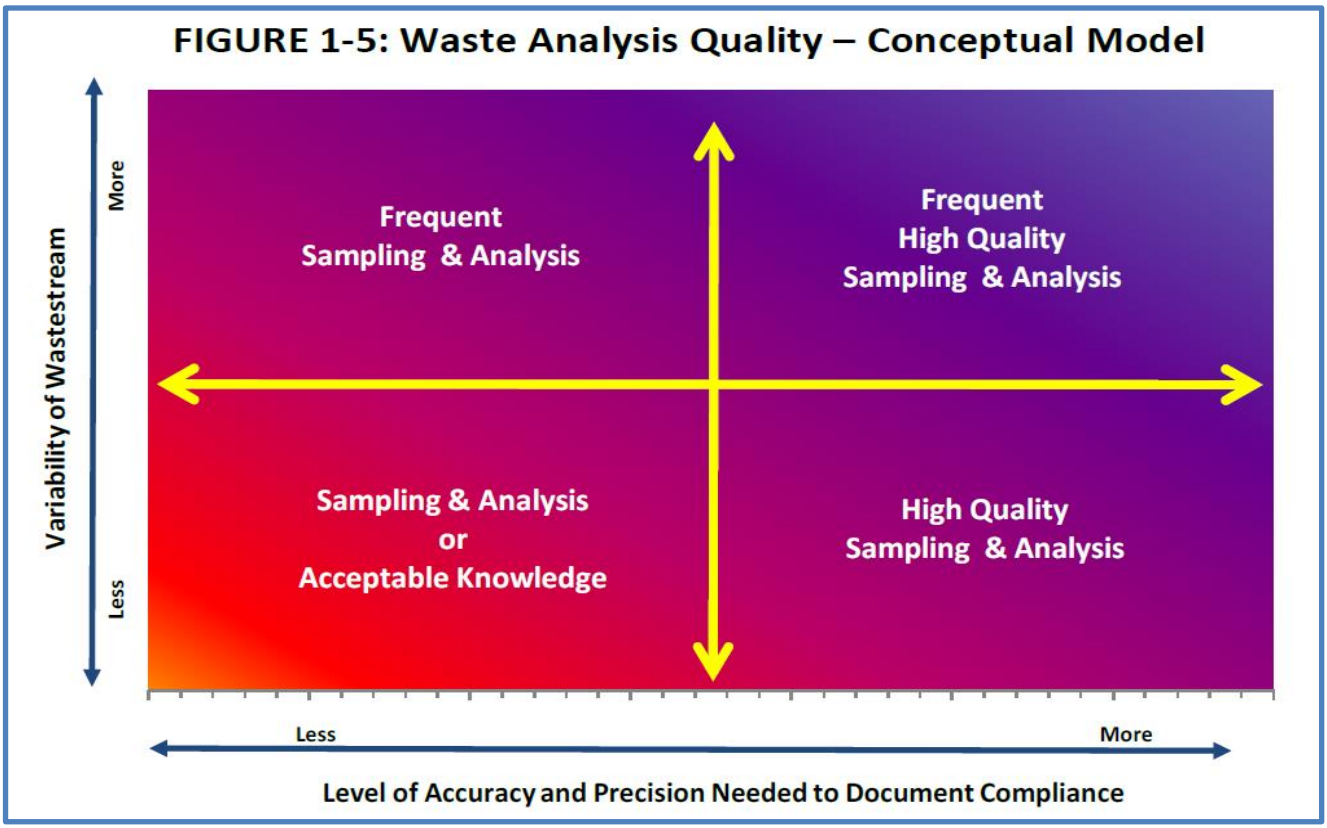


Figure 1-5 from page 1-16 of the 2015 WAP Guidance

In EPA's review of facilties' WAPs, EPA found that many facilities combine multiple incoming wastestreams from different generators or hazardous waste brokers, such that each treatment batch may vary significantly in composition and source. In these instances, increased LDR verification sampling frequency is appropriate to ensure successful treatment. It is important that a treatment facility's WAP addresses the factors discussed above to clearly justify any sampling approach less frequent than each batch, and the number of LDR verification samples taken per batch based on waste volume and other relevant factors.

Grab Sampling versus Composite Sampling

In the 1989 LDR Second Third Rule preamble and again in the 2015 WAP guidance, EPA describes the two principal reasons for using grab sampling to establish nonwastewater LDR treatment standards for prohibited wastes[12] and to determine compliance with LDR treatment standards (54 FR 26605). A grab sample is one aliquot of waste collected at one location and at one point in time. Alternatively, a representative composite sample generally consists of proportionally mixing multiple grab samples taken from more than one point over an area or time period.

For the LDR WAPs reviewed, was sampling frequency specified?

- *40% specified sampling every batch of treated waste.*
- *49% specified using another sampling frequency (periodic, first few batches and then annually, tiered).*
- *11% did not specify sampling frequency (Note: these WAPs do not comply with 40 CFR Parts 264/265.13(b)(4), (6), and 268.7(b) or 268.7(c)(2) as frequency must be specified).*

First, the LDR treatment standard represents a level of treatment that is achievable by a well-designed and well-operated treatment system. If any inspector's grab sample result exceeds a treatment standard, then clearly some fraction of the waste is non-compliant and as such that unit (e..g, tank, drum, roll-off box) is not eligible to be land disposed. Conversely, innappropriate

[12] LDR treatment standards and compliance for D004-D011 wastewaters are also based on grab sampling (40 CFR 268.40(b)).

composite sampling may mask portions of the batch that do not pass LDR treatment standards. All current LDR treatment standards for nonwastewaters are based on grab sampling data, and therefore grab sampling is the most appropriate sampling method for determining LDR compliance. The grab sampling approach was sustained by the D.C. Circuit Court of Appeals in Chemical Waste Management v. EPA, 976 F. 2d at 34, and EPA did not alter the approach in the LDR Phase IV Rule.

The second reason is that it is normally easier and more expeditious for inspectors to enforce on the basis of grab sampling. Determining compliance with grab samples allows the inspector to collect samples following the explicitly required grab sampling method for determining compliance (40 CFR 268.40(b) and 268.48(a)), rather than having to implement a more complicated and resource intensive composite sampling scheme involving multiple sample locations or over time.

What sampling methods were used in the WAPs EPA reviewed?

- *58% single grab sampling*
- *30% composite sampling*
- *9% multiple-grab sampling*
- *3% incomplete information (Note: these WAPs do not comply with 40 CFR 264/265.13(b)(3) as sampling methods must be specified).*

WAP LDR Verification Sampling Strategies

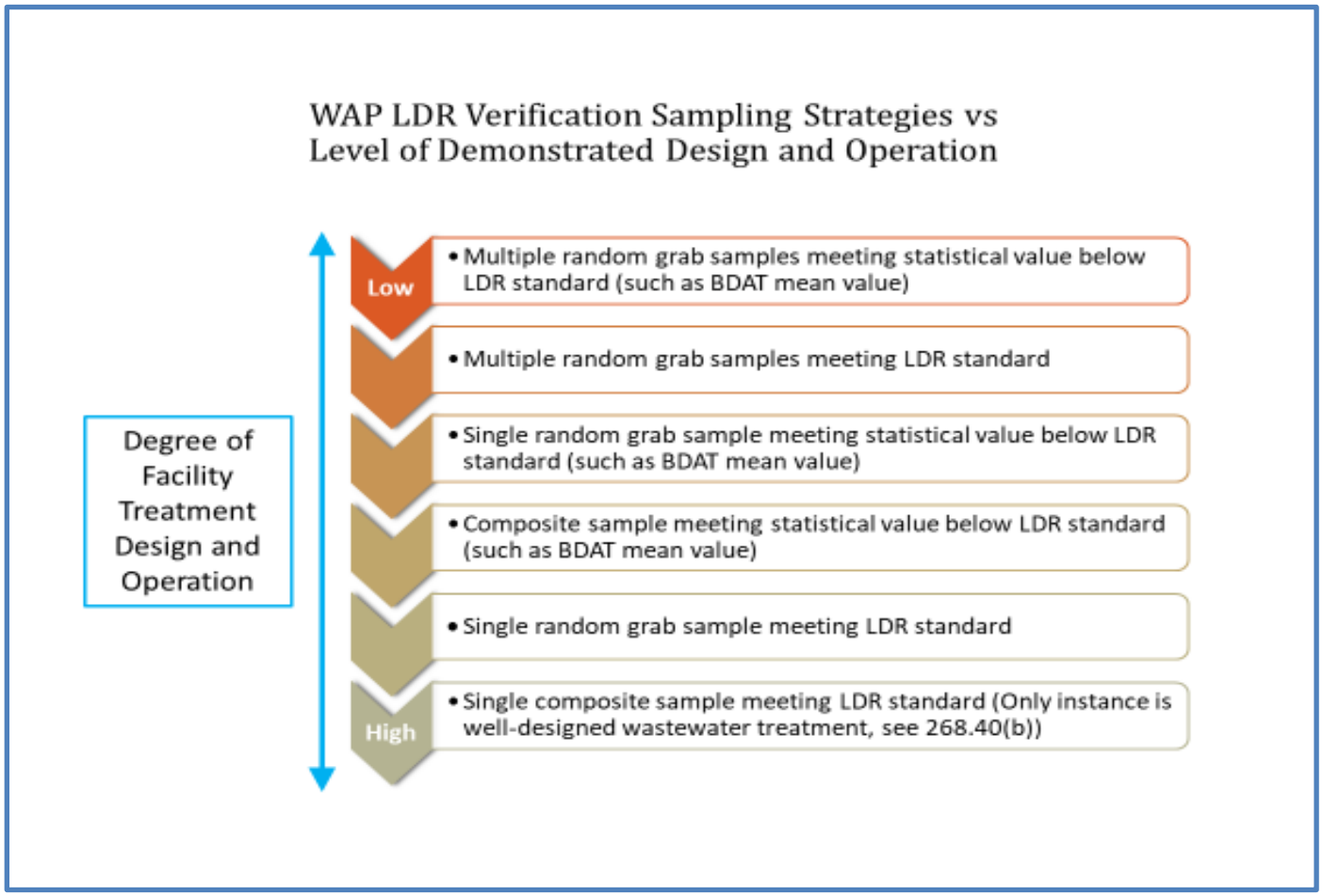
Although every treatment facility must meet regulatory requirements, each facility is different and may work with their environmental agency's permit writer to customize their WAP LDR verification sampling stategy to meet its circumstances. The facility and the permit writer should consider WAP strategies that address LDR sampling and analysis to ensure all portions of the wastes are treated sufficiently. The WAP should include a combination of a justified LDR treatment verification sampling strategy in conjunction with verified demonstrations of effective treatment design and operation.

The treatment facility, in conjunction with the permit writer, should consider a range of possible WAP LDR verification sampling strategies depending on demonstrated LDR treatment design and operations. Sampling demonstrations to show a high degree of design and operations would include: verified mixing processes, verified homogeneity, and robust treatment efficacy, among others. Permit conditions to ensure a high degree of design and operation would include: segregating generator wastestreams, pre-treatment analysis, small treatment batch sizes, prescribed treatment processes, and minimum mixing times, among others. A WAP may require *random sampling* techniques for sample collection if statistical methods are to be used to demonstrate LDR treatment efficacy. See text box *Were random sampling techniques required in the WAPs EPA reviewed?* for the proportion of reviewed WAPs that provided for random sampling.

Were random sampling techniques required in the WAPs EPA reviewed?

- *Random sampling occurs when every possible sample of the waste has an equal chance of being selected. Random sampling approaches include simple, stratified, or systematic random sampling. Random sampling is often required if the data are evaluated with statistical methods.*
- *Judgment sampling (or Authoritative sampling) relies on historical, site, and process information to sample locations of the waste. The accuracy of judgment sampling is dependent on the information used.*
- *Only 21% of the WAPs reviewed provided for randomized sample collection.*

The permit writer and the facility should assess the general WAP LDR verification sampling strategies in accordance with the level of demonstrated design and operation.



Elements to Consider in RCRA LDR Permits, WAPs and Inspections

The regulations require the RCRA permit to incorporate operating conditions for "effective performance, adequate funding, adequate staffing and operator training, and adequate laboratory and process controls, including appropriate quality assurance procedures" (40 CFR 270.30(e)). The regulations state "[e]ach RCRA permit shall include permit conditions necessary to achieve compliance with . . . [part] 268. . . [and] may incorporate applicable requirements of part . . . 268 . . . directly into the permit or establish other permit conditions based on . . . [this] part" (40 CFR 270.32(b)(1)). The regulations also allow the addition of terms and conditions determined "necessary to protect human health and the environment" (40 CFR 270.32(b)(2)).

Moreover, the 1990 LDR Third Third Rule preamble specifically states "For both permitted and interim status facilities, the Agency retains its authority (particularly where a revised WAP has not been Agency-approved) to determine that, based on an inspection or other information, the testing frequencies and/or protocols are inadequate at a particular facility. In such cases, EPA (or an authorized State) may take a number of actions, including, but not limited to, terminating or modifying a facility's permit or pursuing an enforcement action" (55 FR 22670).

Elements of Well-Designed and Operated Facilities

In the RCRA permit narrative or in the WAP, permit writers and facilities should include specific enforceable permit conditions that address elements of a well-designed and operated treatment system (as provided for in 40 CFR 270.30(e), 270.32(b)(1) and (2)). These can include minimum mixing times, thorough mixing methods or equipment, treatability studies on each waste, process control samples collected pre-treatment and/or in-treatment that correlate with successful treatment, as well as appropriate pre-treatment analysis to help identify incoming waste variability that may require "recipe" adjustment, and to identify any waste constituents that may interfere with the treatment process.

Design and operation conditions should be added to the permit (or to the WAP which is part of the permit). Some elements of well-designed and well-operated treatment processes include practices observed at the time LDR treatment standards were promulgated based on engineering evaluations of potential BDAT technologies. Example elements of well-designed and well-operated treatment processes that should be considered by permit writers and facilities are described here:

- To determine testing frequencies, consider the design and operation of the treatment process. For example, the 2002 RCRA Waste Sampling Guidance[13] notes that large treatment batch volumes may require more frequent pre-treatment waste characterization testing and more frequent post-treatment verification sampling to ensure compliance with LDR treatment standards. In the 1986 LDR Final Rule preamble, EPA also emphasizes additional verification testing "must be conducted if there is any reason to believe that the composition of the waste has changed or if the treatment process has changed." (51 FR 40597).

- To ensure proper treatment, the wastes should be characterized to ensure the waste treatment "recipes" are appropriate. The amount and type of stabilizing agent and additives should be carefully selected based on the chemical and physical characteristics of the waste to be stabilized, often supported with treatability studies.

- To ensure proper treatment, address specifying reagents and amounts (e.g., Portland cement) (1991 Treatment Technology Background Document[14]).

- Ensure proper treatment by addressing the potential presence of treatment inhibitors and constituents that cause interferences in wastes (i.e., limits on constituents affecting performance of treatment, such as oil or organics) (1991 Treatment Technology Background Document).

- To ensure proper treatment, address the need for a cure time when designing facility operations and verification sampling plans (1991 Treatment Technology Background Document). Stabilization processes may require a minimum reaction time to complete the treatment (curing).

- To ensure a homogenous waste for treatment, use size reduction methods (e.g., hammer mill and shredding) and waste pre-mixing. Industry best practices[15] recommend homogenizing variable wastes to optimize treatment (Conner, J.R., 1990).

- To ensure adequate blending of waste and treatment reagents, specify effective methods of mixing and minimum (and sometimes also maximum) mixing times (Conner, J.R., 1990 and 1991 Treatment Technology Background Document).

- Address how failed treatment batches will be handled, retreated, and resampled; and how the wastestream will be treated to prevent such failures in the future.

[13] *RCRA Waste Sampling Draft Technical Guidance, Planning, Implementation, and Assessment*, U.S. EPA OSWER, Washington, D.C., EPA 530-D-02-002, August 2002, pp. 28.
[14] *Treatment Technology Background Document*, U.S. EPA, Office of Solid Waste, Washington, D.C., PB91-160 556, January 1991.
[15] Conner, J.R., *Chemical Fixation and Solidification of Hazardous Waste,* Van Nostrand Reinhold, New York, NY, 1990.

- To reduce uncertainty (variability) in the treatment process and to avoid impermissible dilution (40 CFR 268.3), consider segregating wastes for treatment (2002 RCRA Waste Sampling Guidance 2002, *pp. 52).*

- To avoid impermissible dilution, address reagent/waste mix ratios. This can be included in the permit application, the WAP, and the subsequent permit. In the LDR Third Third Rule preamble, EPA provides an example scenario where a high mix ratio (of reagent to waste) could indicate concentration reductions are from dilution and not treatment (55 FR 22666/22667).

- To avoid impermissible dilution, permit conditions should prohibit treatment with reagents that do not cause an irreversible chemical or pozzolanic (i.e., supplementary cementitious-forming) reaction when mixed, or do not permanently bind the metals in a non-leachable matrix (63 FR 28566). Permit conditions should also prohibit treatment with reagents that promote physiochemical dilution of the sample during the TCLP or artificially alter the environmental character of the TCLP test by increasing pH, or by lowering redox potential or dissolved oxygen (63 FR 28567). An example of this treatment scenario was specifically codified as impermissible dilution in 40 CFR 268.3(d) for iron filings in lead-containing hazardous wastes.

- In the LDR Third Third Rule preamble, EPA recommends avoiding impermissible dilution by ensuring aggregation of wastes (allowed for treatment on an economic scale) is only applied to wastes and waste constituents legitimately amenable to the same type of treatment (55 FR 22666/22667).

- EPA recommends in the LDR Third Third Proposed Rule[16] preamble that to avoid impermissible dilution with wastes with multiple LDR constituents that require different treatment, ensure that all necessary treatment is completed before further aggregation (54 FR 48495).

Effective Stabilization Technology Practices

- ***Stabilization temperature and humidity*** *– higher temperatures and low humidity increase the rate of curing.*
- ***Form of metal compound*** *– the metal should ideally be in its least soluble form to reduce leaching/migration.*
- *Permit writers and inspectors should confirm the facility is employing the technology and equipment described in the permit application, as there have been instances where cheaper and chemically insufficient reagents and techniques were substituted without notice.*
- *Permit writers and inspectors should also confirm that sufficient moisture is available during hazardous waste stabilization as most stabilization reactions occur only under aqueous conditions. Dry mixing of waste and reagents does not change the chemical form of the waste constituents as no reaction has taken place.*

[16] *Land Disposal Restrictions for Third Scheduled Wastes – Proposed Rule*, November 22, 1989, 54 FR 48372.

Elements for WAP LDR Verification Sampling

> ***LDR Sampling Requirements***
> *The LDR program regulations found at 40 CFR Part 268 require that hazardous waste generators, treatment facilities, and land disposal facilities determine if the waste must be treated before it can be land disposed. This is done by determining if the hazardous waste meets the applicable LDR treatment standards at 40 CFR 268.40, 268.45, 268.48, or 268.49. EPA expresses LDR treatment standards either as required treatment technologies that must be applied to the waste or as contaminant concentration levels that must be met. (Alternative LDR treatment standards have been promulgated for contaminated soil, debris, and lab packs.) While a generator can determine the need for waste treatment in either of two ways (testing the waste or using knowledge of the waste), treatment facilities and land disposal facilities must test the waste (see 40 CFR 268.7).*

A treatment facility's WAP must provide the specific sampling and analysis requirements for the facility's routine monitoring to ensure compliance (40 CFR 264/265.13 and 268.7). "This plan must be adequate to assure compliance with Part 268" (54 FR 26606 and 55 FR 22539) and not allow hazardous waste management practices that are in violation of LDR requirements (such as impermissible dilution, incorrect treatment technology, etc.). Example elements of WAP LDR verification sampling that should be considered by permit writers and facilities are described here:

- A WAP must specify for each waste the parameters that will be analyzed, the rationale for the selection of these parameters, the sampling methods, test methods, frequency (40 CFR 264/265.13(b)(1-4)) and quality assurance/quality control procedures (40 CFR 270.30(e)) that will be followed. This must include provisions for ensuring compliance with all applicable LDR treatment standards for the specific hazardous wastes and any identified Underlying Hazardous Constituents (UHCs) (40 CFR 264/265.13(b)(6)).

- To address post-treatment waste variability, the WAP should provide for the collection of data establishing each treated waste's variability both within batch (important for large batch sizes) and from batch to batch in order to justify the extent of routine verification sampling and analysis.

- To ensure routine compliance (*proving the negative* – that all portions of the waste do not exceed LDR treatment standards), the WAP should specify a sufficient number of post-treatment verification samples from different areas of the treatment batch to capture areas of high concentrations in consideration of spatial and temporal variabilities of the wastestreams.

- Consider including additional testing of incoming wastes prior to treatment to identify wastes that are outliers and may respond differently to treatment. These parameters could be as simple as pH or redox potential depending on the treatment chemistry. Such robust up-front process control could prevent non-compliance and costly additional treatment, be correlated with successful treatment, and potentially justify less frequent verification sampling.

- For wastes requiring multiple sequential treatment steps, the WAP should employ in-treatment sampling to verify achievement of LDR treatment standards and avoid impermissible dilution. For example, the WAP should include in-treatment sampling of metal-bearing wastes that first require reduction for hexavalent chromium, destruction of cyanide, or oxidation of organics prior to metals stabilization to confirm effective treatments. An example of just such an instance is provided in the preamble of the 1989 LDR Third Third Proposed Rule where EPA recommends avoiding impermissible dilution while treating wastes with multiple LDR constituents that require different treatment by ensuring all necessary treatment is completed before further aggregation (54 FR 48495).

- EPA recommends treating the waste to achieve more stringent verification target concentrations, such as BDAT mean concentrations (as described in the BDAT background documents), to account for spatial variability that may occur even in well-operated treatment processes, and thus provide a higher level of assurance that no portions of the treated batch exceed the compliance standard.

- Treatment facility WAPs should place emphasis on LDR testing requirements for decharacterized wastes as these testing requirements are the last line of defense in verifying LDR treatment before decharacterized wastes are potentially sent to a Subtitle D (nonhazardous) waste disposal facility. LDR regulations do not require Subtitle D disposal facilities to analyze decharacterized wastes in the same manner as Subtitle C disposal facilities.

- The WAP should address the recording and tracking of all verification testing data that demonstrates a failure to meet LDR treatment standards or verification target concentrations (including wastes that were subsequently retreated successfully). This testing data must be maintained as part of the facility's operating record (40 CFR 264.73(b)(3)). The WAP should specify how this information will be used to segregate problem wastestreams for enhanced treatment at the start of the process or otherwise avoid future treatment failure or impermissible dilution. (See text box *Annual Stabilization Report* for an example based on a real-world permit condition addressing this issue with a well-designed annual report).

Annual Stabilization Report
Permittee shall submit an annual report to the Agency that specifies wastes accepted for stabilization treatment from the previous year. The report data shall be sorted chronologically and contain at a minimum the following information:

- *Date of operation.*
- *Waste Generator and EPA waste code(s).*
- *Waste quantities processed/reprocessed per generator with daily and annual totals*
- *Physical state of waste (e.g., liquid or solid).*
- *Total quantity of waste treated annually per generator sorted alphabetically by generator.*
- *Total quantity of waste treated annually from all generators.*
- *Specific name and quantity of primary and secondary reagents (i.e., stabilizing agent such as lime and cement kiln dust, and reagents such as oxidizing and reducing agents) and other additives used to treat each waste.*
- *Lab analyses performed.*
- *Location of where the treated waste was disposed and the date it was disposed.*
- *A discussion on wastes that could not be treated on-site to the applicable LDR treatment standards; generator and generation process descriptions for these wastes; an explanation of why stabilization was not effective; and final disposition of these wastes (e.g., type of treatment, storage, or disposal facility which accepted the waste).*
- *How the information regarding treatment failure will be used to improve treatment and testing processes going forward.*

Elements for Inspectors' LDR Sampling

To determine compliance with LDR treatment standards, inspectors should collect post-treatment grab samples of treated waste. Inspectors determine compliance with LDR treatment standards based on grab sampling for D004-D011 wastewaters and for all nonwastewaters (40 CFR 268.40(b)). In addition, inspectors determine compliance with LDR treatment standards for UHCs by analyzing grab samples, unless otherwise noted in 40 CFR 268.48.

- Inspection sampling for determining LDR compliance *(proving the positive* – that the waste exceeds the treatment standard) for nonwastewaters and D004-D0011 wastewaters[17] should always be performed with grab sampling (54 FR 26605) and not composite sampling (62 FR 26047). Any sample that indicates the waste or any portion of a waste did not meet LDR treatment standards means the waste cannot be land disposed.

[17] Ibid. p. 9

- The Second Third LDR Rule preamble states "A [WAP] cannot immunize land disposal of prohibited wastes. . ." (54 FR 26606). Since the LDR requirements are self-implementing by statute, the facility's RCRA permit cannot be used as a shield to avoid complying with the LDR requirements (40 CFR 270.4(a)(1)(ii)). This means that an inspector's sampling determines compliance even when the LDR verification sampling provided for in the WAP indicates otherwise.

- The Second Third LDR Rule preamble states "A facility remains strictly liable for meeting the treatment standards, so that if it disposes of a waste that does not meet a treatment standard, it is in violation of the land disposal restrictions regulations" (54 FR 26606).

Examples of Improving LDR Elements of Permit Conditions and WAPs

The table *Examples of Improving LDR Elements of Permit Conditions and WAPs* gives examples of permit condition improvements based on the elements of well-designed operations and WAP verification sampling discussed above. The table includes cases of inadequate or ineffective WAP or permit elements, a discussion of why the element is ineffective, and suggestions of improved language. Ineffective elements can often be addressed by improving either the permit, the WAP, or a combination of both. Some of these situations that can be addressed in both the permit and the WAP appear in the table below.

Examples of How to Improve LDR Elements of Permit Conditions and WAPs

Ineffective Element	*Why Element is Ineffective*	*Examples of Improved Elements*
Elements of Well-Designed and Operated Facilities (Permit Conditions)		
Wastes are mixed for combined treatment and sampled after treatment is complete.	**Address Variability:** The limitation on wastes appropriate for combined treatment does not anticipate wastes which may be highly variable, out of specification, or have conditions which may complicate treatment (interfering constituents, etc.). Overall treatment success and treated residual variability may be affected. **Prevent Impermissible Dilution:** Mixing wastes requiring multiple treatment steps with wastes requiring a single treatment may be impermissible dilution if some waste constituents are not amenable to one of the treatment methods.	• Screen wastes during pre-acceptance sampling and/or acceptance sampling (pre-treatment) for LDR constituent concentrations or off-profile conditions and segregate such wastes for treatment to avoid increasing variability of mixed batches. • Confirm wastes are amenable to the same type of treatment method before aggregation to avoid impermissible dilution. • Only aggregate wastes requiring multiple treatment methods with wastes requiring the same treatment train. • Complete in-treatment sampling to confirm that LDR treatment standards for each treatment step are met before further aggregation.
The treated waste is assumed to be homogenous for the purposes of this WAP.	**Address Variability:** Any blanket assumption of waste homogeneity should be justified. Incorrect assumptions about waste variability can lead to sampling strategies that are overly simplistic and inadequate to ensure compliance.	• Segregate wastes to limit variability. • Process wastes for particle size reduction and pre-mixing. • Require minimum mixing time and specific mixing process justified by a mixing effectiveness demonstration.

Examples of How to Improve LDR Elements of Permit Conditions and WAPs

Ineffective Element	*Why Element is Ineffective*	*Examples of Improved Elements*
Failing batches will be retreated until passing.	**Prevent Impermissible Dilution:** Retreatment and high mix ratios of treatment reagents to waste could be a strong indication of impermissible dilution.	• To confirm adequate treatment without impermissible dilution, record and report waste identification, analytical results before and after treatment, links to previous treatment attempts, reagents used, and mix ratios of reagent to waste. • Screen wastes during pre-acceptance and/or acceptance sampling (pre-treatment) for off-specification conditions, the presence of treatment inhibitors, and properties that may interfere with treatment.
Post-treatment wastes that exceed the standard will be confirmed with resampling. If the confirmation sample meets the standard, the treated waste meets the LDR treatment standard.	**Proper Process Control:** Stabilization may require minimum cure times for completion of treatment reactions. Sampling before adequate curing is completed may or may not result in failing LDR treatment standards.	• Specify minimum cure times for each recipe in the permit or WAP. Since a sample has already failed, a passing resample does not indicate all portions of the waste are effectively treated.
Collect one grab sample per treatment batch. [no further justification provided]	***Proving the Negative:*** This strategy is not adequate for heterogeneous wastes, large treatment batches, and batches comprising multiple wastestreams with no evaluation of variability before and after treatment.	• Segregate wastes to limit variability. • Require minimum mixing time and specific mixing process justified by a mixing effectiveness demonstration.
Elements for LDR Sampling (WAPs)		
The waste will be analyzed to meet LDR treatment standards.	**Specify Parameters:** Parameters and their rationale must be specified for each waste (40 CFR 264/265.13(b)(1)). Referring generally to "LDR treatment standards" is not specific.	• Analyze post-treatment waste to ensure all parts of the waste are less than the LDR treatment standard, 0.75 mg/L TCLP lead (or verification target concentration).
The treated waste will be sampled to show vinyl chloride is less than 0.2 mg/L TCLP.	**Specify the Rationale:** Parameters and their rationale must be specified for each waste (40 CFR 264/265.13(b)(1)). The ineffective element is confusing since vinyl chloride has different potential standards to meet depending on the scenario. If the facility is characterizing an incoming waste for hazardous waste identification by toxicity characteristic, the parameter is 0.2 mg/L TCLP vinyl chloride. If they are attempting to verify LDR treatment, the parameter is 6.0 mg/kg total vinyl chloride. Avoid potential confusion by specifying the rationale.	• Analyze this waste to ensure all parts of the waste are less than the LDR treatment standard, 6.0 mg/kg total vinyl chloride (or verification target concentration). • Analyze this waste to determine it is not hazardous by toxicity characteristic by confirming the waste is less than 0.2 mg/L TCLP vinyl chloride.
The waste will be analyzed using SW-846 methods.	**Specify Test Methods:** Test methods which will be used for the selected parameters must be specified (40 CFR 264/265.13(b)(2)). SW-846 includes over 230 test methods and many parameters are analyzed by multiple methods. Referring generally to "SW-846" is not specific.	Analyze this waste for TCLP lead using SW-846 Methods 1311 and 6010.

Examples of How to Improve LDR Elements of Permit Conditions and WAPs

Ineffective Element	*Why Element is Ineffective*	*Examples of Improved Elements*
Wastes will be sampled in accordance with SW-846.	**Specify Sampling Methods:** Sampling methods which will be used for the selected parameters and wastes must be specified (40 CFR 264/265.13(b)(3)). Referring generally to "SW-846" is not specific. Descriptions of sampling methods should include sample location, type, and preservation, sampling personnel, equipment, and chain of custody procedures.	• Trained personnel will sample at least *X*% of containers of the same wastestream from the same generator from each shipment. • One full-depth composite will be sampled from each selected container employing a COLIWASA for liquids and a bucket auger for solids. • Include a table listing appropriate sample containers and preservation requirements by matrix and parameter. • Include procedures detailing aspects of sampling methods.
Treated residuals will be sampled *periodically*.	**Specify Sampling Frequency:** The frequency with which the initial analysis of the waste will be reviewed or repeated must be specified (40 CFR 264/265.13(b)(4)). LDR regulations (40 CFR 268.7) also require facilities "test . . . according to the frequency specified in the . . . WAP." *Periodically* is not a specific frequency.	• Obtain *X* post-treatment samples from each treated batch to verify compliance with LDR treatment standards (or verification target concentration). • On a weekly basis, obtain *X* grab samples of the dewatered solids (filter cake).
The treated waste is assumed to be homogenous for the purposes of this WAP.	**Address Variability:** Any blanket assumption of waste homogeneity should be justified. Incorrect assumptions about waste variability can lead to sampling schemes that are overly simplistic and inadequate to ensure compliance.	• Screen each incoming waste (pre-treatment) for parameters that help identify wastes that are outliers and may respond differently to treatment. • Verify homogeneous waste treatment with multiple grab samples for LDR treatment standards (or WAP verification target concentrations). • To determine batch sampling frequency for each wastestream, assess post-treatment variability on a batch-to-batch basis.
Collect one grab sample per treated batch (with no further justification provided).	**Proving the Negative:** This strategy is not adequate for heterogeneous wastes, large treatment batches, and batches comprising multiple wastes with no evaluation of variability before and after treatment.	• Collect *X* grab sample(s) post-treatment for each *Y* cubic-yards of treated waste.

Examples of How to Improve LDR Elements of Permit Conditions and WAPs

Ineffective Element	*Why Element is Ineffective*	*Examples of Improved Elements*
Post-treatment wastes that fail the standard will be confirmed with resampling. If the confirmation sample meets the standard, the treated waste meets the LDR requirements.	**Address Variability:** This strategy ignores post-treatment waste variability where there may be portions of waste that meet the standard and portions that exceed. This is inappropriate given that all portions of the waste must meet the standard. Since one sample has already failed, a passing resample does not indicate all portions of the waste are effectively treated. The waste should be retreated.	• Retreat wastes that exhibit any samples that fail to meet LDR treatment standards (or WAP verification target concentrations). • If waste that fails is believed to require more cure time, multiple sequential resamples will be collected to confirm that any passing resamples are not due to sample variability. • Waste that have repeatedly failed LDR treatment standards in the past will be treated and sampled to ensure the waste does not exceed a lower treatment concentration than the BDAT. For example, treat to the BDAT mean concentration, 0.12 mg/L TCLP lead instead of 0.75 mg/L. • To confirm adequate treatment without impermissible dilution, record and report waste identification, analytical results before and after treatment, links to previous treatment attempts, reagents used, and mix ratios of reagent to waste. • Consider requiring in the WAP that the facility periodically submit a report to the Agency that describes wastes accepted and stabilized. See text box describing an *Actual Permit Language Example* - *Annual Stabilization Report*.

Additional Helpful References

- *Guide to the Disposal of Chemically Stabilized and Solidified Waste. USEPA. 1980*.
- *Handbook for Stabilization/Solidification of Hazardous Wastes. USEPA. June 1986*.
- *Chapter Nine of "Sampling Plan" found in Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. EPA publication SW-846. September 1986*.
- *Interference Mechanisms in Waste Stabilization/Solidification Processes. USEPA, Office of Research and Development. 1988*.
- *Stabilization/Solidification of CERCLA and RCRA Wastes. Physical Tests, Chemical Testing Procedures, Technology Screening, and Field Activities. USEPA. 1989.*
- *Stabilization/solidification Processes for Mixed Waste. USEPA. 1996*
- *Land Disposal Restrictions: Summary of Requirements. USEPA, Offices of Solid Waste and Emergency Response & Enforcement and Compliance Assurance. EPA530-R-01-007. Revised August 2001*
- *Guidance on Systematic Planning Using the Data Quality Objectives Process. USEPA, Office of Environmental Information, EPA/240/B-06/001. EPA QA/G-4. February 2006*.