DEPARTMENT OF
ECOLOGY
State of Washington

Guidance For Groundwater Monitoring at Landfills and Other Facilities Regulated Under Chapters 173-304, 173-306, 173-350, and 173-351 WAC

December 2012
Publication no. 12-07-072

Publication and Contact Information

This report is available on the Department of Ecology's website at
https://fortress.wa.gov/ecy/publications/SummaryPages/1207072.html

For more information contact:

Waste 2 Resourcs
P.O. Box 47600
Olympia, WA 98504-7600

Phone: 360-407-6900

Washington State Department of Ecology - www.ecy.wa.gov

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Yakima 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

If you need this document in a format for the visually impaired, call the Waste 2 Resources Program at 360-407-6900. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call 877-833-6341.

Guidance For Groundwater Monitoring at Landfills and Other Facilities Regulated Under Chapters 173-304, 173-306, 173-350, and 173-351 WAC

By

Tom Culhane, Cole Carter, Sally Safioles, and Patricia Shanley

Waste 2 Resources Program,
Washington State Department of Ecology
Olympia, Washington

Table of Contents

FIGURES

TABLES

1.0 Introduction

This document provides guidance for monitoring groundwater at landfills and other facilities regulated under Chapters 173-304, 173-306, 173-350 and 173-351 of the Washington Administrative Code (WAC). Operation of groundwater monitoring systems, methods of data analyses and reporting, and other monitoring-related topics are presented. In this document the word "landfill" refers to any disposal facility, surface impoundment, or other facility covered under these four regulations that are required to have a groundwater monitoring program. This guidance does not address solid wastes regulated under Washington State's *Dangerous Waste Regulations,* Chapter 173-303 WAC.

The science of groundwater monitoring has advanced since the Washington State Department of Ecology (Ecology) released the 1990 guidance titled, "*Ground Water Monitoring Guidance for Solid Waste Facilities*". Additionally, professional licensing, laboratory procedures, statistical analyses, and the understanding of contaminant fate and transport have advanced. This document does not attempt to cover all aspects of groundwater monitoring at regulated landfills. Rather, it discusses requirements associated with the four regulations and Ecology's recommendations on specific topics of concern.

Chapter 18.220 Revised Code of Washington (RCW), which regulates the practice of geology and the specialty of hydrogeology, was adopted in 2002. This statute requires that individuals practicing geology or hydrogeology be professionally licensed. The law is administered by Geologist Licensing Board at the Washington State Department of Licensing. Questions regarding meeting professional requirements under Chapter 18.220 RCW should be directed to Washington Department of Licensing. They can be contacted by phone at 360-664-1497, email at geologist@dol.wa.gov, or by mail at Geologist Licensing Board, Department of Licensing, PO Box 9045, Olympia, WA 98507-9045.

2.0 History of Solid Waste Regulation in Washington

Before 1969, no state or federal statutes or rules were in place to directly deal with the handling of Washington's solid waste. In 1969, the state legislature passed the first statute specific to solid waste, Chapter 70.95 RCW, the Solid Waste Management Act.

State regulations for municipal and non-municipal solid waste landfill construction, operation, and closure began in 1972 with the adoption of Chapter 173-301 WAC, *Regulations Relating to Minimum Functional Standards for Solid Waste Handling*. This rule was performance-based, leaving an operator's discretion to meet the requirements. In 1985, Chapter 173-304 WAC, *Minimum Functional Standards for Solid Waste Handling*, was enacted. This rule was more prescriptive, limiting discretionary options for meeting facility requirements. Rule amendments in 1988 included additional closure, post-closure, and financial assurance requirements. Chapter 173-304 WAC also required groundwater monitoring for certain piles and surface impoundments.

In 1990 Chapter 173-306 WAC, *Special Incinerator Ash Management Standards*, established performance standards, emissions standards, and design requirements for municipal solid waste incinerator and energy recovery facilities. It defines special incinerator ash, prohibits disposal of this ash in municipal solid waste (MSW) landfills, and includes stringent handling requirements.

Both Chapters 173-304 and 173-306 WAC state that the Chapter 248-54 interim maximum contaminant levels (MCLs) for groundwater are to be used until Ecology establishes groundwater quality standards. Ecology adopted Chapter 173-200 WAC, *Water Quality Standards for Groundwaters of the State of Washington* in December, 1990.

In 1991, the Environmental Protection Agency (EPA) established federal requirements for the construction, operation, monitoring, closure and post-closure of MSW landfills under the Resource Conservation and Recovery Act (RCRA), subpart D. States were given two years to adopt these rules or make them more stringent in order to receive federal delegation authority. In response to the federal requirements, Ecology adopted Chapter 173-351 WAC, *Criteria for Municipal Solid Waste Landfills* in 1993, and received partial delegation authority from EPA.

Chapter 173-350 WAC, *Solid Waste Handling Standards*, was enacted in 2003 to address non-municipal solid waste landfills. It requires groundwater monitoring at limited purpose landfills and surface impoundments constructed without leak detection layers including those at biosolids facilities. The new regulation provides beneficial use options and applies modern standards to other solid waste facilities. There is no federal equivalent to this regulation.

Ecology updated Chapter 173-351 WAC in November of 2012. The revisions were made to adopt new federal regulations which allow for issuance of Research, Development, and Demonstration (RD&D) permits; address landfill design and post-closure issues; to address "general housekeeping" issues such as clarifying definitions, making formatting changes, and

ensuring that the rule is consistent with Chapter 173-350 WAC; and to make the rule consistent with federal regulations for full delegation. Some important changes that affect groundwater monitoring activities include:

1. Most metals analyses for groundwater sampling must now be for total metals rather than for dissolved metals. This change was made to be consistent with federal regulations and state groundwater standards.

2. The requirement for use of forms for annual and quarterly groundwater reports (WAC 173-351-415) now refers to the checklist available online at: https://fortress.wa.gov/ecy/publications/summarypages/ecy070316.html.

3. All groundwater monitoring data must be submitted consistent with procedures specified by the department. The procedures specified by Ecology are described in Section 8 of this guidance document.

4. A licensed professional must prepare the groundwater monitoring and hydrogeological reports in accordance with the requirements of Chapter 18.220 RCW.

3.0 Groundwater Monitoring Requirements

There are several stages in the life of a landfill. Active landfills currently accept waste. Once a landfill ceases to accept waste, the owner or operator must close the landfill in accordance with the approved closure plan. Once the owner or operator completes and certifies closure activities the landfill is considered a closed. Following closure, a landfill enters into post-closure care. Owner/operators conduct monitoring and maintenance to evaluate and assure a landfill's proper performance while waste materials continue to degrade. Landfill post-closure care can end after the site has stabilized and the permitting agency authorizes the owner or operator to discontinue post-closure care.

In Washington the period during which a landfill operated or closed, the type of waste it contained, and how the landfill was constructed determines which groundwater monitoring regulations apply. All four landfill regulations require that the owner/operator:

- Install a groundwater monitoring network.
- Measure groundwater elevations in each monitoring well prior to purging.
- Determine the rate and direction of groundwater flow.
- Follow the current approved sampling and analysis plan (a.k.a. quality assurance project plan).
- Determine groundwater quality at each well at the approved sampling interval while the landfill is active and through the post-closure care period.
- Compare groundwater quality results to Chapter 173-200 WAC, *Water Quality Standards for Ground Waters of the State of Washington*, criteria.
- Use approved statistical procedures following each sampling event to determine if there has been a significant change in groundwater quality.
- Notify the jurisdictional health department (JHD) and Ecology if there has been a statistically significant increase (SSI) for any monitoring parameter, and resample the groundwater for that parameter. (The time frame notification is 7 days in Chapters 173-304 and 173-306 WAC, and 30 days in Chapter 173-350 WAC. Chapter 173-351 WAC provides 30 days after receipt of data to determine an SSI, then 14 days to send notice.)
- Implement remedial actions in consultation with the JHD and/or Ecology when contamination thresholds have been exceeded.
- Submit annual reports (by March 1 for Chapters 173-304 and 173-306 WAC, and April 1 for Chapters 173-350 and 173-351 WAC).

There are also significant differences in the monitoring requirements in the four regulations. One fundamental difference between Chapter 173-306 WAC and the other three regulations, is that Chapter 173-306 WAC establishes Ecology as the agency with regulatory authority of special incinerator ash landfill activities, while the other three regulations provide the local JHDs with that authority. Ecology serves as a technical consultant to the JHD under those three regulations.

Chapter 173-350 WAC requires groundwater monitoring for limited purpose landfills, and surface impoundments constructed without leak detection layers, as well as compliance with

approved local solid waste regulations that require monitoring at certain solid waste handling facilities. Additionally, Chapter 173-350 WAC surface impoundment standards apply to biosolids facilities with surface impoundments that lack leak detection systems.

3.1 Points of Compliance

The four regulations vary in the manner in which the point of compliance is addressed. The requirements are as follows:

- Chapters 173-304 and 173-306 WAC establish the point of compliance as that part of groundwater that lies beneath the perimeter of a landfill's active area as it would be at closure.
- Chapter 173-350 WAC indicates that the point of compliance be established by the JHD as near to the possible source of release as technically, hydrogeologically, and geographically feasible.
- Chapter 173-351 WAC specifies that the point of compliance be located on land owned by the landfill owner and that it be no more than one hundred fifty meters (four hundred ninety-two feet) from the waste management unit boundary. Beyond this, WAC 173-351-300(6) describes a number of factors that must be considered when determining a point of compliance.

3.2 Required Parameters

The required monitoring parameters are not the same for all the regulations. The parameters required during groundwater monitoring in Chapters 173-304, 173-306 and 173-350 WAC are as follows:

- Chapter 173-304 WAC requires monitoring of static water level, three field-monitored parameters, and eleven analytical constituents.
- Chapter 173-306 WAC requires monitoring of static water level, three field-monitored parameters, and sixteen analytical constituents including gamma radiation. This regulation also includes ash and soil sampling and analyses requirements, as well as ambient air quality sampling for lead.
- Chapter 173-350 WAC requires monitoring of static water level, and a minimum of three field-monitored parameters, ten groundwater, and three leachate indicator analytical constituents.

Chapter 173-351 WAC is more prescriptive and takes a different approach for groundwater monitoring. This regulation makes a distinction between a Detection Monitoring Program and an Assessment Monitoring Program as follows:

Detection Monitoring is similar to the quarterly monitoring requirements of the other solid waste regulations, except it requires that more constituents be monitored. These constituents are identified in Chapter 173-351 WAC Appendixes I and II. Appendix I includes 62 organic and inorganic constituents. Appendix II includes static water levels, three field monitored parameters, ten geochemical analytical constituents, and three leachate indicator analytical constituents.

Assessment Monitoring is triggered whenever there is a statistically significant increase (SSI) above background for any constituent listed in Appendix I or an approved alternative groundwater monitoring list (see WAC 173-350-440(2)). An Assessment Monitoring Program involves much more comprehensive groundwater monitoring, as described Section 9 of this guidance document.

3.3 Procedures for Obtaining Approval to Alter Groundwater Monitoring Requirements

Approval to vary from the standard groundwater monitoring requirements depends upon the regulation. WAC 173-304-700, WAC 173-306-900, and WAC 173-350-710 allow owners/ operators to apply for variances from those respective regulations. Variances may be granted as long as the proposed practices do not endanger public health, safety or the environment, and compliance with the regulation from which variance is sought would not produce hardship without equal or greater benefits to the public.

The jurisdiction for approval of a variance request or a demonstration depends upon the regulation. A variance request under Chapter 173-304 WAC must be approved by the JHD and Ecology. Under Chapter 173-306 WAC, a variance request must be approved by Ecology. Under Chapter 173-350 WAC a variance request must be approved by both agencies, while a demonstration need only be made to the JHD.

Chapter 173-350 WAC contains provisions allowing owner/operators to request a variance to decrease monitoring parameters or make a demonstration to change monitoring frequency (WAC 173-350-500 (4) (g)). An associated form titled, “Application for Modification of Solid Waste Handling Permit Chapter 173-350 WAC” is available at: https://fortress.wa.gov/ecy/publications/publications/ecy070401.pdf.

WAC 173-351-450 describes requirements regarding how standard groundwater monitoring elements may be altered based on site-specific demonstrations through a permit modification. Such demonstrations must show that human health and the environment will be protected. There

are two locations in Chapter 173-351 WAC that discuss the form that an application to modify groundwater monitoring elements must take. WAC 173-351-720 states,

> (6) Permit modifications.
>
> (a) Any owner or operator intending to modify a valid MSWLF permit must file a modification application at least forty-five days before the intended modification. A modification application must be made on forms authorized by the jurisdictional health department and the department, and the forms must include information identified in WAC 173-351-730 (3)(a).

And WAC 173-351-730 states,

> (3) Modification and renewal applications.
>
> (a) Modification applications. An application specified by the jurisdictional health department and the department to modify a valid MSWLF permit issued pursuant to WAC 173-351-700 must include, and address, the following:
> (i) A description of the proposed modification;
> (ii) The reasons for the proposed modification;
> (iii) A description of the impacts from the proposed modification upon the MSWLF unit or the facility as presently permitted;
> (iv) A showing that, as modified, the MSWLF unit will be capable of compliance with the applicable requirements of this regulation; and
> (v) Any other information as required by the jurisdictional health department.

Ecology is specifying through this guidance document that any document that contains the information in items (i) through (v) in WAC 173-351-730(3) will be deemed to meet the “forms” requirement described in WAC 173-351-720.

4.0 Site Characterization and Groundwater Monitoring

Site characterization is conducted to ensure an adequate groundwater monitoring system is installed at a landfill. Groundwater monitoring is conducted to determine landfill impacts on groundwater quality. In order to do this, background samples – either groundwater samples collected prior to facility construction or from upgradient locations – are compared with samples from downgradient wells. Many elements go into the establishment of a groundwater monitoring program, including an adequate characterization of the site hydrogeologic setting and the installation of a viable monitoring well network.

Some landfills have both older, closed landfill units that were permitted under an earlier regulation, and more recent landfill units permitted under a newer regulation. If a landfill has a distinct monitoring network for the old units(s) and a distinct network for the new units(s), then different regulations apply to those units. If a landfill has a single monitoring network that covers both the old and new units, then the landfill is regulated under the newer regulation.

4.1 Similarities and Differences in Requirements in the Four Regulations

Chapters 173-304 and 173-306 WAC provide fairly minimal, but similar, requirements regarding site characterization and development of a groundwater monitoring network. These regulations require that the groundwater monitoring system consist of at least one background or upgradient well and three downgradient wells, installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer and all hydraulically connected aquifers below the active portion of the facility. In addition, the groundwater monitoring system must:

- Represent the quality of background water that has not been affected by leakage from the active area; and
- Represent the quality of groundwater passing the point of compliance. Additional wells may be required by the JHD or Ecology in complicated hydrogeological settings or to define the extent of contamination detected.

Chapters 173-350 and 173-351 WAC are more prescriptive regarding site characterization, development of a groundwater monitoring network, development of a sampling and analysis plan, groundwater monitoring data analysis, and notification and reporting. In Chapter 173-350 WAC, the groundwater monitoring requirements are described in the WAC 173-350-500 section.

The groundwater monitoring requirements in Chapter 173-351 WAC are described in several sections, including:

- WAC 173-351-405 - Performance standards for groundwater monitoring system designs.
- WAC 173-351-410 Groundwater sampling and analysis requirements.
- WAC 173-351-415 Groundwater reporting.
- WAC 173-351-490 The hydrogeologic report contents. This section includes a description of the site characterization requirements.

WAC 173-350-330 indicates that monitoring guidance provided in Chapter 173-350 WAC applies not only to landfills, but also groundwater monitoring required for leachate lagoons that lack leak detection systems.

The term “hydrostratigraphic unit” is defined in both Chapters 173-350 and 173-351 WAC as:

> "Hydrostratigraphic unit" means any water-bearing geologic unit or units hydraulically connected or grouped together on the basis of similar hydraulic conductivity which can be reasonably monitored; several geologic formations or part of a geologic formation may be grouped into a single hydrostratigraphic unit; perched sand lenses may be considered a hydrostratigraphic unit or part of a hydrostratigraphic unit, for example.

Although the language in Chapters 173-350 and 173-351 WAC is not identical, both rules require that a sufficient number of wells be installed at appropriate locations and depths to yield representative groundwater samples from those hydrostratigraphic units which have been identified as the earliest potential contaminant flowpaths. Therefore, the following questions should be considered when designating appropriate hydrostratigraphic units for groundwater monitoring purposes:

- Is the uppermost water-bearing unit hydraulically connected to underlying aquifers?
- Where are all of the potential contaminant pathways?
- Where are the earliest hydraulic pathways to detect a release from the landfill?
- What are the groundwater travel times and direction?

Subsequent expansion of landfills regulated under either Chapter 173-350 or 173-351 WAC requires additional site characterization and may require additional monitoring wells.

4.2 Monitoring Well Network Considerations

Many considerations need to go into the placement of monitoring wells. Wells should be located both upgradient and downgradient of a facility to detect any changes in groundwater quality. Well placement must also take into account well depth and potential perched groundwater conditions for detection of impacts on all hydrostratigraphic units. In some instances it is appropriate to monitor multiple units, since more than one unit may potentially be affected by the

waste deposited at a site. However, the evaluation of groundwater flow direction and comparisons in water quality data should be made in upgradient and downgradient wells screened in the same hydrostratigraphic unit.

4.2.1 Number of Monitoring Wells

Monitoring networks should consist of a sufficient number of wells installed at appropriate locations and depths to yield representative groundwater samples from those hydrostratigraphic units identified during site characterization as the earliest potential contaminant flowpath. An understanding of a site's hydrogeology is necessary to meet these requirements.

The different regulations have different requirements for the minimum number of monitoring wells. Those regulations indicate:

> WAC 173-304-490 and WAC 173-306-500 - The groundwater monitoring system must consist of at least one background or upgradient well and three downgradient wells, installed at appropriate locations and depths to yield groundwater samples from the upper most aquifer and all hydraulically connected aquifers below the active portion of the facility.
>
> WAC 173-350-500 (3)(a)(i) - A sufficient number of monitoring wells shall be installed at appropriate locations and depths to yield representative groundwater samples from those hydrostratigraphic units which have been identified in the site characterization as the earliest potential contaminant flowpaths.
>
> WAC 173-351-405(1) - A sufficient number of wells must be installed at appropriate locations and depths to yield representative groundwater samples from those hydrostratigraphic units which have been identified as the earliest target hydraulic pathways and conduits of flow for groundwater and contaminant movement, and storage.

4.2.2 Upgradient Well Locations

Based on the groundwater flow analyses, upgradient wells must be located beyond any potential impacts from the landfill. Groundwater samples from these wells should represent the quality of the water passing beneath the landfill. As gas transport of volatile organic compounds can impact even upgradient wells, such wells should be placed sufficiently distant from the waste to ensure background conditions. Installation of multiple upgradient wells is recommended, as discussed in the statistics section below.

4.2.3 Downgradient Well Locations

Downgradient wells must monitor or intercept all potential contaminant pathways from a facility. Potential contaminant pathways should be evaluated based on the site characterization

information, and may include zones of higher hydraulic conductivity, both laterally and vertically in the aquifer, and fracture or fault zones present in the aquifer.

Downgradient well locations must monitor the groundwater quality passing the relevant point(s) of compliance (see Section 3.1 above, for differences in point of compliance requirements). Additional wells may be required based upon the extent of the landfill unit, complexity of the hydrogeologic settings, or to define the extent of contamination at a site. It is worth noting that Washington State's Model Toxics Cleanup Act (MTCA) regulations provide different point of compliance requirements than those in the solid waste regulations.

4.2.4 Well Spacing Distance

Appropriate spacing between monitoring wells depends upon the hydrogeology of the site. Spacing determinations should be based upon the professional judgment of a licensed professional considering all relevant factors. Unlined landfills may release contaminants over a large area, while lined landfills may produce point discharges. Closer well spacing may be required to detect point discharge contaminant plumes.

4.2.5 Monitoring Well Design and Construction

Monitoring wells must be designed and constructed to account for specific hydrogeologic conditions encountered during drilling. The primary objectives of the monitoring wells are to provide representative groundwater quality samples and water-level measurements. A secondary purpose may be to conduct aquifer pumping tests. Monitoring wells must be constructed so as not to create a conduit for contaminant migration. Some information to consider when constructing monitoring wells includes:

- All wells must be constructed in accordance with Chapter 173-160 WAC, *Minimum Standards for Construction and Maintenance of Water Wells,* and Chapter 173-162 WAC, *Regulation and Licensing of Well Contractors and Operators*.
- Monitoring or screened intervals must be placed vertically within an aquifer such that representative water quality samples and water-level measurements can be obtained.
- Monitoring wells may be placed such that they monitor the water-table aquifer, the base of the aquifer, a confined or semi-confined aquifer, or a specific zone within an aquifer. However, according to WAC 173-160-450 all wells must be constructed so as to prevent interconnection of separate aquifers. Therefore, more than one well will be required when screening more than one hydrogeologic unit.
- In horizontally layered sediments or where contamination may occur in a single zone, screen lengths should be designed to monitor across specific hydrostratigraphic units. Shorter screens may be necessary to obtain meaningful chemical results, since longer screens may allow for dilution across several saturated zones. A rule of thumb is that screened intervals not exceed 10 feet.

4.3 Other Groundwater Monitoring Considerations

This section discusses other factors that should be considered when establishing groundwater monitoring strategies at landfills within Washington.

4.3.1 Interwell versus Intrawell Strategies

As discussed in the statistics section of this document (Section 6.0), either interwell or intrawell strategies may be used during the analyses of groundwater monitoring data. The choice of one or both of these strategies will depend upon spatial variation in aquifer properties or water quality, groundwater gradient, presence or absence of seasonal fluctuations, and potentially the type of background data available for a site.

4.3.2 Low Flow Sampling

In general, the use of low flow sampling methods will produce more representative groundwater samples than those obtained through the use of bailers or the evacuation of 3 to 5 well volumes of water. Therefore, Ecology recommends the use of low flow groundwater sampling and the use of dedicated pumps.

Low flow sampling relies on the slow withdrawal (< 1.0 liter/minute) of groundwater from monitoring or observation wells. The typical low flow sampling system consists of a pump (e.g. bladder or electric submersible) with a variable speed controller, an air compressor (for bladder pumps), polyethylene or Teflon tubing and instruments that measure pH, dissolved oxygen, conductivity and static water levels. The low flow sampling technique is designed to minimize the impacts of turbidity volatilization, and mixing while pumping, and allows for the continuous monitoring of field parameters (i.e. pH, dissolved oxygen, conductance and temperature) in order to determine when sample collection is appropriate.

4.3.3 Water Sampling by Qualified Field Personnel

All water samples should be collected by well-qualified and well-trained individuals in accordance with the facility's approved Quality Assurance Project Plan (QAPP) and RCW 18.220.

4.3.4 Water-Level Measurements

The depth to water is measured from a surveyed marked reference point on the casing and should be accurate to 0.01 feet. All water-level measurements should be made within a reasonably narrow time frame, such as over a several day period.

4.3.5 Groundwater Flow Rate Calculations and Flow Direction

The different solid waste regulations have varying requirements associated with groundwater flow, as indicated in the table below.

Table 4.1. Frequency of groundwater flow rate and flow direction calculations.

Regulation	Frequency
Chapter 173-304 WAC	At least annually.
Chapter 173-306 WAC	At least annually.
Chapter 173-350 WAC	Annual report will summarize for each sampling event.
Chapter 173-351 WAC	Quarterly.

Horizontal groundwater velocity can be calculated with the following modification of Darcy's Law (Freeze and Cherry, 1979):

$$V = \frac{Ki}{n}$$

Where: V = average linear velocity in cm/sec
K = hydraulic conductivity in cm/sec
i = hydraulic gradient in ft/ft
n = effective porosity (unitless)

Groundwater gradients can be calculated from water-level elevations in the monitoring wells. Hydraulic conductivity values can be determined from aquifer tests, laboratory effective porosity results for borehole samples, or tables in hydrogeology textbooks. Effective porosity results are specific to the boreholes where an aquifer was sampled. Site conditions can vary significantly from those described in a textbook. For these reasons, values determined from aquifer tests are generally the most likely to represent overall site conditions.

Calculated flow rates allow estimations of solute transport times, but actual transport times may be considerably faster or slower. Groundwater flow velocity calculations are for advective flow, but preferred pathways and other transport mechanisms such as dispersion and diffusion also affect the flow rates of contaminants in groundwater.

5.0 Quality Assurance Project Plan (QAPP)

Washington's solid waste regulations require a sampling and analysis plan (SAP) for groundwater monitoring programs. Since the implementation of the solid waste regulations, overall methods for SAPs have become more prescriptive and are now generally referred to as Quality Assurance Project Plans (QAPPs). Therefore, when referring to sampling and analysis plans in this document the term QAPP will be used.

The QAPP must be approved by the permitting agency (the JHD or Ecology, depending on the regulation) and be included with the permit application for a facility. The QAPP becomes part of the facility permit.

Requirements for sampling and analysis at landfills can be found in the following regulations:

WAC 173-304-490(2)(c)
WAC 173-306-500(2)(c)
WAC 173-350-500(4)
WAC 173-351-410

Ecology recommends using *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies, Ecology, June 2004* to ensure that data collection and use is adequate to determine if there is a release from the landfill. A QAPP ensures the project collects the data necessary to meet the requirements of the activity, provides direction on how to perform activities during the project, and describes data assessment to determine how and if the data can be used. The QAPP process is intended to generate continued improvement in data collection and assessment. The development of the QAPP requires an understanding of the concepts related to sampling, field and laboratory measurements and the assessment of data quality.

Each facility's QAPP must describe procedures for generating reliable data to perform statistics and prepare quarterly and annual reports. To be scientifically and legally defensible, data quality must be documented.

A QAPP should:

- Identify the goals and objectives of monitoring at the facility.
- Identify the type and quality of data needed (e.g., detection limits at or very near the groundwater quality criteria).
- Identify the sampling and measurement procedures needed to acquire the data.
- Describe the quality control and assessment procedures needed to ensure the QAPP objectives are met.

5.1 Elements of the QAPP

The QAPP should include a section on the site history, and a map with the monitoring networks for all environmental monitored media, the footprint of the landfill, and the property boundary at a readable scale. A scale of not greater than one inch equals 200 feet is recommended. For groundwater, the procedures and techniques described in the following table should be described.

Table 5.1. Procedures and techniques to be included in a QAPP.

Elements	Details

Data handling	• Data Quality Objectives
	• Measurement quality objectives
	• Data Validation
	  • Review of analytical data
	  • Identification of questionable data
	  • Identification of unusable data
	  • Consultation with JHD if resampling is necessary

Sample collection and handling	• Groundwater elevation with each sampling event to the nearest 0.01 feet at each well. Provide a table with the survey data, locations, depths, and construction details of all the monitoring wells. • Frequency of sampling • Sampling devices (Ecology encourages dedicated devices and low-flow purge/sampling techniques) • Field parameters indicating stabilization prior to sample collection • Sequence of sample collection (taking into consideration volatilization) • Filtering (depending on the regulation) • Disposal of purge water • Equipment list • Examples of field logs
Sample preservation and shipping	• Sample containers and preservatives • Sample preservative and holding times • Sample numbering scheme • Storage and shipment including custody seals and documentation of samples
Analytical procedures	• List of constituents and test methods • Detection limits that allow comparison of results to groundwater criteria (Chapter 173-200 WAC)
Chain-of-custody control	• Sample labels • Field logbook • Sample analysis request sheet • Custody tape on sample bottles or cooler • Lab receipt records • Example of chain-of-custody form
Quality assurance and quality control	• Field

Elements	Details

(field and analytical)	• Documentation of field activities
	• Calibration and maintenance of field equipment
	• Sample identification scheme and record keeping
	• Blanks (e.g. field, trip, temperature, or equipment)
	• Duplicates
	• Collection of the lab quality assurance samples for matrix spike, matrix spike duplicates
	• Analytical
	  • Calibration to standards
	  • Method blanks, laboratory control samples, duplicates and matrix spikes
	  • Reporting of percent recovery of surrogates and internal standards
	  • Data flags

Decontamination of sampling equipment	• Decontamination of water level probe, pumps, meters, etc.
Procedures to ensure employee health and safety conducting groundwater monitoring	• Follow site health and safety plan
Well operation and maintenance procedures	• Frequency of sounding the total well depth • Inspection of monitoring wells for security or vandalism
Statistical procedures/data evaluation	• See Section 6
Reporting	• See Section 8

Many of these elements can also be used for other environmental monitoring such as surface water, leachate, gas probes, hydraulic gradient control system, gas extraction wells, leak detection system, vadose zone and soil.

Samples must be sent to an accredited laboratory in accordance with Chapter 173-50 WAC - *Accreditation of Environmental Laboratories*. The laboratory must be accredited for each analytical method performed.

Analytical testing must be performed using the latest version of *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, US EPA Publication SW-846 or other test methods approved by the permitting agency. Other test methods that will be considered are the latest version of *Guidelines Establishing Test Procedures for the Analysis of Pollutants* contained in 40 CFR Part 136 or the latest version of *Standard Methods for the Examination of Water and Wastewater* (APHA). Test methods for drinking water are not considered equivalent.

All laboratory results for groundwater sampling are to be compared to the Chapter 173-200 WAC groundwater quality criteria. Appendix A of Ecology's Implementation Guidance for the Groundwater Quality Standards (revised 2005) provides most current groundwater criteria and is included as Appendix C of this document. However, other factors may need to be considered when determining applicable criteria, as discussed in Section 7.5.1.

Facility's and their consultants need to work with their laboratories to achieve reporting limits low enough to detect chemical concentrations at the regulatory limits. For example, in order to detect vinyl chloride down to the groundwater criteria of 0.02 ug/L, EPA Method 8260 Selected Ion Monitoring (SIM) for vinyl chloride may be required.

Appendix D of this document provides lists of constituents grouped by chemical type. These lists were developed from Chapter 173-351 WAC Appendix I, II and III. Not all of these analyses are required at all landfills and applicable regulations need to be consulted to determine which analyses apply.

5.2 Filtering

Field filtering removes particulate matter from water samples. Field filtering is needed when samples are analyzed for dissolved ion concentrations, since the presence of suspended particles interferes with ion results. This includes metals such as Ca, Mg, Fe, and Mn, as well as sulfate. Mineral particulates in the sample can skew the results.

For metals analyses, there are instances when field filtering and dissolved metals analyses are appropriate, and other times when they are not. When metals analyses are conducted to facilitate cation-anion balancing or produce ion diagrams (such as a trilinear diagram), field filtering and dissolved metals analyses are needed. However, when metals analyses are conducted to produce results for comparison to the groundwater quality standards (Chapter 173-200 WAC) or cleanup criteria (Chapter 173-340 WAC), samples should not be filtered and those results must be reported as total metals.

The following table indicates the filtering requirements for the inorganic constituents that are listed in the four regulations.

Table 5.2. Regulations related to inorganics filtering requirements.

Regulation	What Regulations Specify
Chapter 173-304 WAC	Requires dissolved iron, manganese, zinc, WAC 173-304-490(2(d)(i)
Chapter 173-306 WAC	Requires dissolved iron, cadmium, lead, mercury, zinc, manganese, WAC 173-306-500(2)(d)
Chapter 173-350 WAC	Does not specify
Chapter 173-351 WAC	For existing landfills requires both total and dissolved metals for eight sampling events to establish relationship, then total metals thereafter, WAC 173-351-430 and 440 (see Section 7.4 for more details.)

5.3 Changes to QAPPs

Plans should be reviewed periodically during the landfill life cycle to determine whether updates are warranted prior to renewal or issuance of permits. Modifications should not be implemented until approved by the permitting agency. Solid waste regulations allow changes to the required sampling frequency or parameter list based on successful demonstrations or variances.

All of the solid waste regulations require quarterly monitoring. To perform less than quarterly monitoring requires the actions described in the following table.

Table 5.3. Actions required for less than quarterly monitoring.

Regulation	Action to Change Frequency
Chapter 173-304 WAC	Variance, WAC 173-304-700
Chapter 173-306 WAC	Variance, WAC 173-306-900
Chapter 173-350 WAC	Demonstration, WAC 173-350-500(4)(g)
Chapter 173-351 WAC	Demonstration, WAC 173-351-450(2)

Each regulation has a different list of parameters. Any change to the standard parameter list requires the actions described in the following table.

Table 5.4. Actions required for changes to the parameter list.

Regulation	Action to Change Parameters
Chapter 173-304 WAC	JHD in consultation with Ecology can add or subtract parameters depending on waste, WAC 173-304-490(d)(ii)
Chapter 173-306 WAC	Ecology can add or subtract parameters based on leachate analysis, the composition of ash, and other information, WAC 173-306-500(d)(ii)
Chapter 173-350 WAC	JHD with written concurrence from Ecology can issue variances to decrease required list, WAC 173-350-710(7). Parameters can be added based on waste and leachate profile, WAC 173-350-500(4)(i)
Chapter 173-351 WAC	Demonstration to the JHD to delete parameters, WAC 173-351-450(3)

6.0 Statistics

The purpose of groundwater sampling is to determine if landfill activities affect groundwater quality and whether corrective action should be initiated. Changes in groundwater quality at landfills are sometimes subtle. The significance of the numbers on a laboratory's analytical report often cannot be determined without comparisons to background values and past sampling results. Statistical procedures provide a mechanism for determining when groundwater changes are significant and when they are within a normal, acceptable range. For a statistical analysis to be meaningful, factors like hydrogeology, sampling procedures, and laboratory quality control must be considered.

For guidance on statistical analysis of landfill groundwater data, Ecology recommends the U. S. EPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance, March 2009* (Unified Guidance). This guidance is available online at: http://www.epa.gov/epawaste/hazard/correctiveaction/resources/guidance/sitechar/gwstats/unified-guid-fs.pdf . This comprehensive document contains important updates and improvements over previous versions, as well as background and usage information for many statistical tests.
Many of the statistical procedures used in evaluating contamination at landfills are specialized and complex. Computer programs are available to perform statistical calculations, but results can be misleading unless the data meets specific criteria and the statistical test is appropriate for the data and the problem. Ecology recommends consultation with a qualified statistician with expertise in groundwater monitoring when designing and implementing a statistical program for landfill monitoring.

6.1 Regulatory Requirements

All four landfill regulations in Washington require owner/operators to use statistical procedures with each sampling event to determine if groundwater constituents show a significant increase over background. There are differences in the wording of the regulations, so the landfill owner/operator should become familiar with the specific regulation(s) for their landfill. The statistical procedures used at a landfill are included in the operating permit, which is approved by the JHD (or Ecology for Chapter 173-306 WAC, special ash landfills).

Landfill sites in Washington are also subject to Chapter 173-200 WAC, *Water Quality Standards for Ground Waters of the State of Washington*. This regulation includes a table of groundwater quality criteria for a number of primary and secondary constituents, radionuclides, and carcinogens. Washington's landfill regulations refer to these water quality criteria as the performance standards for landfills. Exceedances of these values can prompt additional actions.

6.2 Background Values

Background samples of groundwater that have not been impacted by the facility are important for a successful statistical program. Background values developed from local samples allow a comparison of constituent values to natural conditions and enables tracking of natural changes in the site's groundwater. A minimum of four background samples is needed for any statistical test. However, eight to ten background samples are recommended. Generally the background sample size should be as large as feasible.

Background values should periodically be updated because aquifer conditions may change over time. In some cases, a moving window approach is suggested with the most recent 8-10 sampling events used as the background. If there are no clear trends, then the newer data can be pooled with the older background data. Increasing trends in background do not necessarily suggest an off-site source of contamination. For example, background wells can be impacted by landfill gas which follows the path of least resistance and does not necessarily travel downgradient.

Background samples can be collected from either the same well that subsequent compliance samples are collected from (intrawell) or from specific background wells (interwell). In interwell tests, the background values are usually collected from the upgradient wells. The Unified Guidance (Chapter 5) recommends multiple, ideally three or more, background wells for interwell testing. The following criteria are required for interwell tests:

- no significant natural spatial variation in concentration means or variance (stationarity),
- a consistent groundwater gradient,
- no seasonality or fluctuations in sample concentrations,
- sample independence, and
- background data do not include statistical outliers.

If these conditions are not met, then an intrawell test is appropriate. In intrawell testing, early samples collected from a well are compared to subsequent samples from the same well. The early samples are less likely to show impacts from the landfilling operations. Ideally, the background samples are collected before the landfill begins operation. Requirements of intrawell test include:

- sample data do not exhibit temporal non-stationarity in the form of trends, autocorrelation, or other seasonal or cyclic variation, and
- background data do not include statistical outliers.

6.3 Statistically Significance Increases

Under the landfill regulations, a statistically significant increase (SSI) of a monitored constituent triggers an action. A SSI is declared when the change in a constituent concentration is greater

than natural variability, unless it can be proven that the cause of the increase involves contamination from some source other than the landfill operations. To declare an SSI, the null hypothesis that the sample concentration is the same as the background concentration is rejected and the alternative hypothesis that they are different is accepted.

Statistical tests are based on a limited number of samples that were collected from the entire population. Since samples may not be completely representative, there is an inherent amount of statistical error with each test. False positives occur when the null hypothesis is rejected when the actual population would show that it should have been accepted. A false negative is the opposite – the null hypothesis is accepted when it should have been rejected. The false positive rate is usually set at 1 or 5 percent. In statistical tests, decreasing the false positive rate increases the false negative rate. For most constituents, a trend test with a statistically significant positive slope is considered an SSI. Section 4.3.1 of the Unified Guidance provides a checklist of statistical, system design, sampling, hydrogeologic, geochemical, analytical, and data factors to consider.

If a SSI does occur, water quality retesting should occur with samples collected prior to the next routine sampling. If there is an SSI but there is no resampling, then it should be considered as an exceedance and the facility should go into assessment monitoring.

6.4 Site-Wide False Positive Rates

Groundwater-monitoring programs at landfills are concerned with the Site Wide False Positive Rate (SWFPR) for constituents where formal statistics are applied. This is a function of the number of constituents, the number of wells, and the number of annual evaluations. With the inherent error in statistical tests, it follows that the larger the numbers of constituents the greater likelihood of false positives. The EPA recommends a 10 percent annual target for false positives. The regulations specify which chemicals should be analyzed, but not all of those chemicals have to be included in the formal statistical testing. The goal is to monitor for chemicals that are likely to show up at a particular facility. Per the Unified Guidance, formal statistics should be performed on 10 to 15 detection monitoring constituents for most sites.

6.5 Assumptions and Requirements for Statistical Tests

All statistical models require that the data meet certain criteria. Consider the following items when choosing statistical tests to determine if the tests are appropriate.

6.5.1 Statistical Independence

Even though groundwater samples are collected from the same location at regular intervals, they can still be considered statistically independent if there is no statistical association between pairs of sampled measurements. The Unified Guidance says that allowing as much time as possible to pass between sampling events is the best way to achieve some amount of statistical independence. The appropriate length of time between samples will depend on the hydrogeological conditions and groundwater flow velocity. The Unified Guidance states that 1 to 2 months between samples may be appropriate. Seasonal or long term trends or sampling at too short of an interval may also invalidate independence.

6.5.2 Stationarity

A stationary statistical distribution is required for many statistical tests. That is, the average (mean) and variance (how much the values typically vary from the mean) must be the same over time and space. Increasing, decreasing, or seasonal trends (seasonality) indicate that the distribution is not stationary. If uncontaminated wells show spatial variation in constituent amounts, an intrawell statistical approach may be preferred over an interwell approach.

6.5.3 Statistical Outliers

Unusual values are considered outliers. Typically outliers are very high values an order of magnitude or more above the mean. Outliers in sample results can be due to a number of factors including measurement errors, laboratory errors, clerical errors, and contaminated samples. Statistical calculations are required to determine if a sample result is a statistical outlier. If outliers are present in a data set, the following actions should be taken:

- If the cause of an outlier cannot be documented, keep the observed value, as it may represent a contamination event or natural variability.
- Delete the observation if an error is found, but the correct value is unknown.
- Correct the value if possible.

Section 6.33 of the Unified Guidance provides an excellent discussion of outliers and the many considerations necessary for dealing with them.

6.5.4 Normal Distribution

The probability distribution of a population refers to a mathematical model that represents the statistical characteristics of the population. Many populations have what is called a normal distribution. Statistical tests designed for data sets with normal distributions are called parametric tests.

Populations of groundwater constituents, however, commonly have different distributions. Volatile organic compounds in groundwater often have a lognormal distribution. Other mathematical distributions are common for some data. If the distribution of the original population can be defined mathematically, it is possible to transform the raw data to a normal distribution and then use a test that requires normality. Chapter 10 in the Unified Guidance discusses tests for normality and how to transform non-normal data.

A non-parametric statistical test should be used if it is not possible to transform the original data. These tests assume symmetry and constant variance of the data.

6.6 Non-Detections

Samples with values below the laboratory quantification limit or detection limit are called "non-detects". The actual value of the sample may be anywhere between zero and the detection limit. Detection limits for a contaminant may change with advances in analytical procedures. Vinyl chloride, for example, has a detection limit of 1 µg/L with Method 8260, but Method 8260-SIM has a detection limit of 0.02 µg/L. It is important to use an analytical method with a detection limit that is low enough to detect chemical concentrations at the regulatory limit.

The Unified Guidance discusses three general methods to handle non-detects in statistical calculations including: simple substitution, Kaplan-Meier, and regression on order statistics (ROS). A value of one half of the detection limit for the constituent is commonly substituted for the non-detect. Substitution should be used only if the sample size is small and non-detects comprise less than 15 percent of the sample data set. Kaplan-Meier and ROS are more sophisticated methods that require calculations, but there should be no more than 50 percent non-detects in order to get an accurate result from either of these methods. Chapter 15 of the Unified Guidance is a discussion of non-detects. Some statistical guidance suggest that non-parametric tests should be used if there are many non-detects in the data.

6.7 Statistical Tests

The three different stages of groundwater monitoring at landfills may have different statistical requirements and may use different statistical tests to determine statistically significant increases or exceedances. This progression is more explicit for Chapter 173-351 WAC landfills, but the concepts and statistical test can be extended to the other landfill regulations.

> Detection monitoring assumes that the groundwater is clean or not impacted by the landfill. Such monitoring continues unless there is a statistically significant increase over background.

Assessment monitoring follows detection monitoring (for 173-351 landfills) if an increase above background is detected. With assessment monitoring, contaminants are assumed to be below the groundwater protection standard (Chapter 173-200 WAC criterion) but above background. Statistical tests are constructed to determine when the groundwater values are above the standard.

Corrective action refers to the stage of a landfill after a groundwater criterion is exceeded. As such, the statistical tests associated with corrective action are designed to determine when constituent values attain a consistent level below the standard.

Depending on which statistical requirements are called for, one or more of the following statistical tests may be appropriate.

6.7.1 Basic Statistical Tests

Computations of basic statistics assist in determining which additional tests are appropriate for the data. Chapter 173-351 WAC requires quarterly calculations of mean, variance, standard deviation, coefficient of variation, standard error, and other statistics testing for homogeneity of variance and normality of the background data. It is useful to calculate these statistics for each compliance and background well.

6.7.2 Two Sample Tests

Two sample tests determine whether there is a statistically significant difference between the means of two populations. These tests can be used to compare a single downgradient well to background data or for determining if background in interwell data sets should be updated. Welch's t-test is the commonly used parametric test, and the Wilcoxian rank sum is its non-parametric equivalent. The Tarone-Ware test is used to test if values are statistically below a standard, as in compliance monitoring.

6.7.3 Prediction Limits

Prediction limits are the preferred statistical method in the Unified Guidance during detection monitoring. The statistical power and properties of prediction limits make them preferable to analysis of variance (ANOVA) or tolerance limits when testing multiple sample groups. Prediction limits estimate the likely range of constituent concentrations based on the observed background concentrations. Contamination is indicated if values are outside of this calculated range. There are both parametric and non-parametric tests for prediction limits. Chapter 18 of the Unified Guidance discusses the variations, uses, and methodologies of prediction limits.

6.7.4 Retesting

Retesting, that incorporates verification samples into the statistical calculations, is encouraged by the Unified Guidance. Retesting can be applied to large monitoring networks and maintain statistical power and meet false positive objectives. Prediction limits are well suited mathematically for retesting, while other methods, such as tolerance limits, are not. If the original sample exceeds the prediction limit, then additional samples are collected at wells where the initial results exceed the limit.

One type of retesting is the 1-of-m strategy. 1-of-2 sampling, for example, includes the original sample and one resample. If the resample also exceeds the prediction limit, then there is an exceedance. If the resample does not exceed the prediction limit, then an exceedance is not declared. Chapter 19 of the Unified Guidance discusses retesting. As discussed earlier, samples need to be statistically independent, so sufficient time must elapse between sampling events. The Unified Guidance recommends that resampling occurs at an intermediate period (or periods) between regularly scheduled sampling events. If there is an SSI, but there is no resampling, then it should be considered as an exceedance. In the case of Chapter 173-351 WAC, this scenario dictates that the facility should go into assessment monitoring.

6.7.5 Trend Tests

The Unified Guidance recommends trend tests as an alternative to prediction limits when the data are not suitable to those techniques. Section 17.3 of the Unified Guidance discusses several trend tests and their assumptions. Linear regression, Mann-Kendall, and Sen's Slope tests are all commonly used trend tests. For most constituents, trend test results indicating (1) a statistically significant decreasing slope, indicate that water quality may be improving, (2) a zero or insignificant slope, indicate that water quality is staying the same, and (3) a statistically significant increasing slope, indicates that water quality may be getting worse.

6.7.6 Confidence Intervals

When a landfill is in assessment or compliance monitoring, groundwater constituent values are compared to a standard (Chapter 173-200 WAC criterion) or background if background is above a criteria. The Unified Guidance recommends confidence intervals as the preferred test during these phases of monitoring. Confidence intervals can be calculated around a mean, an upper percentile, or a trend line. The test determines how likely it is that a value is within a certain range. Chapter 21 of the Unified Guidance discusses the use of confidence intervals.

6.7.7 Double Quantification Rule

The Double Quantification Rule is new to the revised Unified Guidance and is discussed in detail in Section 6.2.2 of that document. It recommends that constituents detected in compliance wells that are not normally detected in background samples are not subject to formal statistics. Instead,

if the constituent is above the laboratory reporting limit for two consecutive sample events, then it should be considered a confirmed exceedance. The double quantification rule applies to most volatile organic compounds in detection monitoring because they are not normally present in background sampling.

7.0 Contaminant Chemistry and Water Quality Considerations

This chapter presents some considerations regarding the nature of the fate and transport of contaminants at landfill sites, as well as information about applicable groundwater criteria.

7.1 Contaminant Processes at Landfills

It is important to consider contaminant processes when interpreting landfill groundwater quality data. Some constituents detected in groundwater may not be present in the landfill waste. They instead may be present in groundwater because of chemical changes brought about by the presence of the waste. For example, elevated iron, manganese and arsenic can result from leaching of those metals from a landfill. Alternatively, the elevated levels may result from changes in groundwater pH and the effect this has upon solubility of these metals. Similarly, vinyl chloride may originate from waste and be detected because it has not biodegraded, or it may be the end product of the biodegradation of other volatile organic compound (VOC) contaminants released from the landfill (see Figure 4.1 below). Therefore, if any of these constituents are detected, more than one possible explanation of the source must be considered.

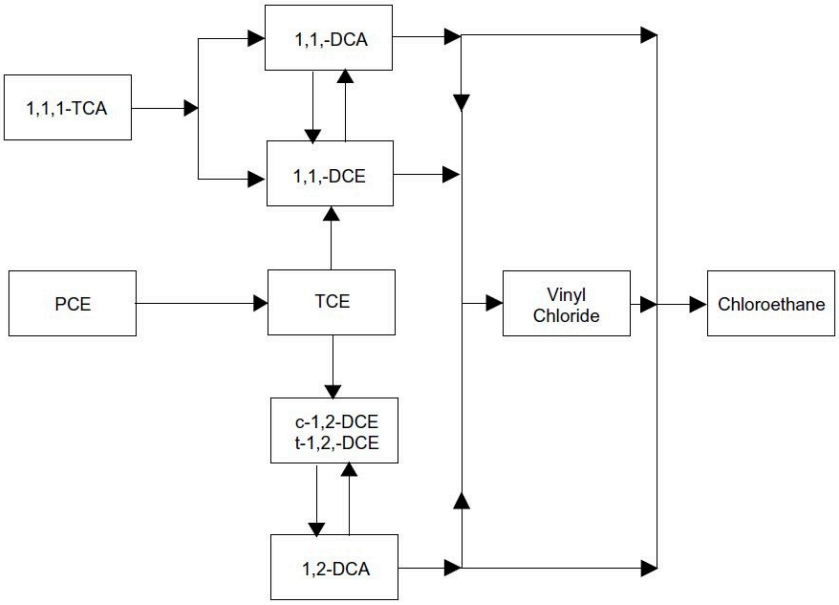


Figure 7.1 Some potential transformation pathways for chlorinated volatile hydrocarbons in soil systems (Simms et al., 1991, Drugun 1988).

7.2 Landfill Gas Migration

Landfill gas has a greater potential for migration than groundwater due to its greater mobility. Possible clues to landfill gas contamination can include detections of VOCs and/or increasing VOC trends in upgradient wells or wells in an aquifer separated by a dry layer beneath a landfill. Landfill gas can also lead to VOC contamination in downgradient wells as well.

It can be difficult to determine whether or not elevated VOCs found within groundwater are due to leachate or partitioning of VOCs from landfill gas. One approach for evaluating this is to analyze landfill gas for VOCs, and determine whether these are the same VOCs that are detected in the groundwater. Another approach is to try correlating total VOC concentrations with concentrations of certain dissolved inorganic constituents. According to Kerfoot et al. (2004), such correlations may exist, since landfill gas can act as an acid or a reducing agent due to its carbon dioxide and methane content, respectively. Through geochemical processes these changes can mobilize inorganic constituents within the vadose zone material. If a correlation exists between VOCs and concentrations of certain inorganic constituents, but no correlation exists with sodium or chloride, for example, in some instances this may indicate that VOCs within landfill gas have partitioned into the groundwater. This may produce different concentrations than what one would expect from leachate impacts.

7.3 Common Laboratory Contaminants

Detections of sample contaminants sometimes can be due to laboratory contamination. The most common laboratory contaminants include methylene chloride, acetone, 2-butanone (methyl ethyl ketone), cyclohexane, and phthalate esters. There are recognized techniques for discerning whether a particular detection is due to laboratory contamination, including methods for comparing concentrations in laboratory blanks with those in groundwater samples. Chapter 5 in EPA's "Risk Assessment Guidance for Superfund (RAGS) Part A" (1989) provides an explanation of these techniques.

7.4 Total versus Dissolved Metals for Chapter 173-351 WAC Landfills

In order for Washington State to have full delegation authority, the U.S. EPA requires that groundwater metals found in Appendix I and III of this rule be analyzed for total metals instead of dissolved metals. Therefore under the revised Chapter 173-351 WAC requirements, samples for Appendix I and III metals analyses will not be filtered in the field and these samples will be analyzed for total metals (see section 5.2 for further discussion of sample filtering). There are

advantages in sampling for total metals because the groundwater standards (Chapter 173-200 WAC) and cleanup criteria (Chapter 173-340 WAC) are expressed in total metals.

Total metals results may be higher than historical dissolved metals results for some sites. Also, elevated total metals can result from sources other than landfill waste. Outdated techniques involving removing three well-casing volumes at high flow rates can stir up metal particulates in well casings and/or neighboring formations, and that, in turn, can potentially lead to elevated total metals results. As such, all sites conducting total metals sampling should move toward low-flow sampling techniques. Since this transition for some landfills may involve changes in both field equipment and QAPPs, the 2012 update of Chapter 173-351 WAC includes a period of transition.

In some instances the change to total metals may make it difficult to recognize trends in metal concentrations. Therefore, 2012 revision of Chapter 173-351 WAC requires sampling for both total and dissolved metals for eight sampling events to evaluate the relationship between dissolved metals and total metal concentrations. A statistical comparison, such as a t-test, can be made between the two populations to determine the viability of continued use of historical dissolved metal samples as background values.

The specific language in WAC 173-351-430 (2)(b) requiring that total metals background data be developed for existing MSWLF units under a detection monitoring program states that,

> (i) An owner or operator must follow the permit modification process in WAC 173-351-720(6) to amend the sampling and analysis program to address (b)(ii) and (iii) of this subsection by May 31, 2013. Amendments must meet the standards of WAC 173-351-410 (1) and (2).
> (ii) Beginning at the first sampling event after jurisdictional health department approval of amendments to the sampling and analysis program in (b)(i) of this subsection, independent samples must be collected from each monitoring well and analyzed for the parameters in (ii)(A) and (B) of this subsection. Samples must be collected and analyzed over eight sampling periods, which may be quarterly or semi-annually to coincide with routine monitoring as approved by the jurisdictional health department.
>
> (A) Total metals from Appendix I Inorganic Constituents 1-15.
>
> (B) Dissolved metals:
>
> Antimony (Dissolved)
> Arsenic (Dissolved)
> Barium (Dissolved)
> Beryllium (Dissolved)
> Cadmium (Dissolved)
> Chromium (Dissolved)
> Cobalt (Dissolved)
> Copper (Dissolved)
> Lead (Dissolved)
> Nickel (Dissolved)
> Selenium (Dissolved)
> Silver (Dissolved)

Thallium (Dissolved)
Vanadium (Dissolved)
Zinc (Dissolved)

(iii) After collecting and analyzing samples for total and dissolved metals for eight sampling periods, collection and analysis of Appendix I Inorganic Constituents 1-15 (total metals) must continue and collection and analysis of dissolved metals under (b)(ii)(B) of this subsection can cease.

Landfills that are conducting assessment monitoring under WAC 173-351-440 in December 2012, when the revised version of Chapter 173-351 WAC goes into effect, also need to evaluate the relationship between dissolved and total metals concentrations. Therefore, the revised version of WAC 173-351-440(2) requires them to perform the same background data development for total metals under the same timelines as outlined in WAC 173-351-430 (2)(b).

Section 3.3 of this guidance document addresses the WAC 173-351-720(6) permit modification process that is referred to in WAC 173-351-430 (2)(b)(i) above.

7.5 Applicable Groundwater Criteria

This section discusses the criteria applicable when evaluating groundwater quality data at landfills within the state.

7.5.1 Other Criteria

Analytical values for constituents required under any of the four regulations must always be compared to the Chapter 173-200 WAC groundwater quality criteria. However, some constituents included in Appendices I, II or III of Chapter 173-351 WAC do not have Chapter 173-200 WAC criteria. When evaluating which criteria to apply, Appendix A in Ecology's *Implementation Guidance for the Groundwater Quality Standards* (revised 2005) provides a good starting point. That guidance cites Chapter 173-200 WAC as the source for regulatory authority in most cases. Drinking water standards from Chapter 246-290 are included in the guidance for constituents that do not have a groundwater standard. For all constituents applicable to landfills, if Chapter 173-200 WAC standards do not exist, the Chapter 246-290 WAC standards apply.

Groundwater standards may change over time as more information becomes available on the toxicological effects of various elements and compounds . Chapter 173-200 WAC requires that the most stringent of these two criteria must be used for each parameter. For example, both Chapter 173-200 WAC and Appendix A in Ecology's Implementation Guidance for the Groundwater Quality Standards (revised 2005) list the criteria for lead as 50 ug/l. However, the current drinking water standard (Chapter 246-290 WAC) for lead is 15 ug/l. Therefore, if

Ecology's Implementation Guidance for the Groundwater Quality Standards were revised today, it would cite the 15 ug/l drinking water standard value as the applicable criterion.

7.5.2 Nitrite and Ammonia Standards

Chapter 173-200 WAC does not include specific criteria for either nitrite or ammonia. The Chapter 173-200 WAC implementation guidance does provide a limit of 1 mg/l for total nitrite (as N) based on the state drinking water standards, so this is the most relevant number for comparison purposes. Similarly, the Chapter 173-200 WAC implementation guidance provides a limit of 10 mg/l for total nitrogen, which includes: nitrate (as N), nitrite (as N), ammonia & organic nitrogen. Therefore, ammonia results can be summed with these other forms of nitrogen and compared to this standard, or, in instances where the ammonia concentration alone exceeds 10 mg/l, it is useful to compare the ammonia concentration to this standard directly.

7.5.3 Polycyclic Aromatic Hydrocarbon (PAH) Concentrations

Laboratory analyses for PAHs are typically performed for many PAH compounds. Chapter 173-200 WAC generically lists a 0.01 ug/l criteria for PAHs, and specifically 0.008 ug/L for benzo(a)pyrene. Supporting documentation about the development of Chapter 173-200 WAC indicates that the reported analytical concentrations of all PAH congeners should be summed without applying any weighting factors, then compared to this 0.01 ug/l PAH criteria. In addition to this analysis, in some instances it may also be instructive to analyze the data using a MTCA approach. That process involves a process of weighting the reported analytical concentrations values based on tables of toxicity equivalency factors (TEFs), which subsequently allows an evaluation of the collective cancer risk of all the PAH congeners relative to benzo(a)pyrene.

8.0 Recommended Reporting

Washington State's landfill regulations require annual reports. Quarterly reports are not required under Chapters 173-304, 173-306 or 173-350 WAC; however, many JHDs require landfills under those rules to submit quarterly reports. Those facilities typically are sampling groundwater quarterly, and the owner/operators must complete statistical analyses for each sampling event and notify the JHD and/or Ecology if there are statistically significant increases. Chapter 173-351 WAC requires both quarterly and annual reports. In the interest of efficiency many facilities choose to combine their last quarterly report for each year with their annual report for that year.

If other environmental monitoring data are collected (e.g. gas, surface water, or leachate), those should be submitted to the JHD regularly and/or incorporated in the quarterly or annual reports. All four regulations require that owner/operators report to the JHD and/or Ecology annually about items such as the quantities of solid waste handled, status of financial assurance accounts, etc. That information should be submitted to the JHD and Ecology separately from the groundwater reports.

8.1 Regulatory Requirements

There are both similarities and differences in the reporting requirements in the four regulations.

8.1.1 Chapters 173-304 and 173-306 WAC Landfills

Chapter 173-304 WAC requires that reports be submitted to both the local JHD and Ecology, while Chapter 173-306 WAC only requires that reports be submitted to Ecology. Among other things, both regulations require that annual reports:

- be submitted by March 1 of each year
- provide the statistical results of quarterly monitoring
- provide groundwater flow rate and direction

Additionally, if quarterly monitoring indicates that there is a statistically significant increase (SSI) above background, the facility must notify the JHD or Ecology within seven days of receipt of the sampling data. This notification is to include the constituent(s) that show an increase.

8.1.2 Chapter 173-350 WAC Landfills

WAC 173-350-500 requires an annual report that summarizes and interprets the data, submitted to both the JHD and Ecology by April 1 of each year. Among other things, this regulation requires that annual reports include:

- all groundwater monitoring results
- statistical results and trends
- any exceedances of Chapter 173-200 WAC standards
- an evaluation of the collected groundwater geochemical data
- static water-level readings and potentiometric maps for each sampling event, as well as notations regarding any trends or changes
- leachate data, if collected

If during quarterly monitoring it is determined that a SSI has occurred, the facility is to notify the JHD and Ecology within 30 days of receipt of the sampling data.

8.1.3 Chapter 173-351 WAC Landfills

Chapter 173-351 WAC is different from the other regulations in that it includes requirements for both annual and quarterly groundwater reports. This regulation requires submittal of annual reports to both the JHD and Ecology by April 1 of each year. The annual reports must include:

- summaries of statistical results and/or trends, including findings of statistical increases for the year
- summaries of groundwater flow rate and direction, noting any trends or changes
- potentiometric surface maps developed for each quarter or approved semi-annual period
- summaries of any changes or trends in cation-anion balances, trilinear diagrams, and general water chemistry for each well.

Chapter 173-351 WAC also requires quarterly reports submitted to both the JHD and Ecology within sixty days of receipt of the quarterly analytical data. These reports must include:

- all groundwater monitoring data for that sampling period
- a summary of statistical results, trends and statistical calculations
- notification of any statistical increases and/or concentrations above Chapter 173-200 WAC criteria
- cation-anion balances and Trilinear diagrams
- static water-level readings, and potentiometric maps with the flow rate and direction
- leachate results and analyses, if sampled

If during quarterly monitoring it is determined that a SSI has occurred, WAC 173-351-440 Assessment Monitoring requirements go into effect, as described in Section 9.0 of this guidance document. WAC 173-351-415 states that annual and quarterly groundwater reports must include

completed forms developed by Ecology. The requirement for use of forms refers to the checklist available online at: https://fortress.wa.gov/ecy/publications/summarypages/ecy070316.html.

8.2 Report and Data Submittal Format

Reports may be submitted to the JHD and Ecology in either hard copy or digital format. For Chapter 173-304, 173-306 or 173-350 WAC landfills, Ecology (and the JHD, in some instances) recommends that electronic versions of all data collected up to that point (not just the most recent) be submitted. WAC 173-351-415(3) requires that:

> All groundwater monitoring data must be submitted consistent with procedures specified by the department. Unless otherwise specified by the department, all groundwater monitoring data must be submitted in an electronic form capable of being transferred into readily available statistical software and the department's data management system.

Ecology's current data management system is the Environmental Information Management (EIM) database. Ecology is specifying through this guidance document that all owner/operators must submit all groundwater monitoring data directly to EIM within sixty days after receipt of the quarterly analytical data for Chapter 173-351 WAC landfills. The method for submitting data into EIM and submittal guidelines are available at http://www.ecy.wa.gov/eim/submitdata.htm. EIM requires that all survey data be input relative to the NAVD88 datum. Many analytical laboratories can output results in an EIM-ready format. The EIM database must be setup for specific projects. If problems develop when setting up or importing data into EIM, Ecology can be contacted for assistance.

Owner/operators of Chapters 173-304, 173-306 or 173-350 WAC landfills are not required to submit their groundwater monitoring data to EIM, but Ecology encourages them do so, or at least submit their lab data in an EIM-ready electronic format. This can be achieved by requesting an EIM-ready format from the lab, or manually filling out an EIM compatible spreadsheet. EIM spreadsheets can be downloaded from the EIM data submittal link (http://www.ecy.wa.gov/eim/submitdata.htm).

Landfill sites under a MTCA order require submission of MTCA data directly to EIM, **i**n addition to the data submission requirements specific to the landfill regulations applicable to that site (Chapter 173-304, 173-306,173-350 or 173-351 WAC).

In addition to data tables, owner/operators are encouraged to submit laboratory and field data sheets with their reports, since those items can be useful when data issues arise. Scanned images of any of these can be provided on a CD.

8.3 Recommended Report Elements

The basic quarterly reporting requirement for Chapters 173-304, 173-306, and 173-350 WAC landfills involves notification of an SSI within a specified period of time. For these three types of landfills there is no requirement to submit a quarterly report, although some JHDs (or Ecology, in the case of Chapter 173-306 WAC landfills) may require this. All Chapter 173-351 WAC landfills must submit quarterly reports and the regulation specifies a number of required reporting elements. Annual reporting is required for all four landfill types.

The tables below provide Ecology's recommendations for elements to be included in quarter, semiannual, and annual reports.

Table 8.1. Recommended quarterly or semi-annual report elements.

Information	304	306	350	351
SSI notification deadline after receipt of analytical data.	7 days	7 days	30 days	14 days
Report due date.	May be specified by JHD	May be specified by Ecology	May be specified by JHD	60 days after receipt of lab data
Site map showing landfill footprint, property boundary, all monitoring well locations, and other relevant information.	X	X	X	X
Groundwater data (see Section 8.2)	X	X	X	X
Description of statistical analyses performed (intrawell, interwell, Sen's Slope, etc.) and results, per the statistical methods described in Section 6.0 above.	X	X	X	X
Tables indicating: o All groundwater quality constituents exceeding Chapter 173-200 WAC standards o All groundwater quality constituents exceeding statistical limits or tests (including trend tests) o Any volatile organic or semi-volatile organic detections in groundwater o All gas or surface water exceedances	X	X	X	X
Discussion of all statistical or Chapter 173-200 WAC criterion exceedances, as well as potential causes.	X	X	X	X
Tabulated ash and soil data, including laboratory and field data.		X		
Tabulated leachate data including laboratory and field data.			X[1]	X[1]
Static water-level data for each monitoring well, potentiometric surface elevation maps depicting flow direction, and results of groundwater flow rate analyses.				X
Cation-anion balances, including an explanation of greater than 5% or 10% difference, if needed.			X	X
Trilinear diagrams.			X	X
Signature and stamp of licensed professional that meets the requirement of Chapter 18.220 RCW.	X	X	X	X

[1] If those data are collected.

Table 8.2. Recommended annual report elements.

Information	304	306	350	351
Report due date.	March 1	March 1	April 1	April 1
Site map showing landfill footprint, property boundary, all monitoring well locations, and other relevant information.	X	X	X	X
For each sampling event: static water-level data for each monitoring well, potentiometric surface elevation maps depicting flow direction, results of groundwater flow rate analyses, and a discussion of any trends or changes.	X	X	X	X
Tables indicating: o All groundwater quality constituents exceeding Chapter 173-200 WAC standards o All groundwater quality constituents exceeding statistical limits or tests (including trend tests) o Descriptive statistics o Any volatile organic or semi-volatile organic detections in groundwater o All gas or surface water exceedances	X	X	X	X
A statement indicating the laboratory used for water quality analyses, and also whether that lab is accredited by Washington State for each type of analysis performed.	X	X	X	X
Time series plots for parameters exceeding Chapter 173-200 WAC standards and/or statistical limits or tests. Plots should include all wells in same aquifer for each parameter, with background well(s) noted. Wells with only non-detects should be noted but not graphed. Plots should: o Distinguish between detected and non-detected values using different symbols o Indicate applicable groundwater quality standards o Indicate statistical limits, if applicable o Have adjusted scaling to reduce crowding and make graph readable When applicable, it is also recommended that graphs with both short-term and long-term timescales be included, and that significant activities, such as closure dates, be indicated.	X	X	X	X
A discussion of all analyses performed and results. Statistics section should follow the methods described in Section 6 above, and the statistics discussion should describe all methods and assumptions, including how non-detect values were evaluated, results of parametric	X	X	X	X

Information	304	306	350	351
testing, how prediction intervals were developed, etc. The main goal of all discussions should be to evaluate: • if any contaminant concentrations exceed groundwater quality criteria, • if any SSIs have occurred, • what may have produced exceedance or changes (if any), and, • if applicable, (4) whether corrective actions have been effective.				
Ash and soil data summary tables.		X		
Cation-anion data evaluations using the differences between cation and anion sums, trilinear plots, or other methods to present data.	X[1]	X[1]	X	X
Signature and stamp of licensed professional that meets the requirements of Chapter 18.220 RCW.	X	X	X	X

8.4 Other Reporting Considerations

The following evaluation tools are required in Chapters 173-350 and 173-351 WAC. These tools are also useful for facilities permitted under Chapters 173-304 and 173-306 WAC, however, for those landfills sampling beyond the minimum required constituents would be necessary.

8.4.1 Anion-Cation Balances

Chapters 173-350 and 173-351 WAC both require cation-anion balancing. The correctness of anion-cation balance analyses can be checked using a method described in Section 1030 E of Standard Methods for the Examination of Water and Wastewater (Clesceri, et al., 1998). The formula described there can be used to calculate the anion-cation balance (in meq) as follows:

$$\%\ difference = 100 \times \frac{\sum(cations - anions)}{\sum(cations + anions)}$$

WAC 173-351-430(5)(a) specifies that if the following threshold limits are exceeded, the owner/operator must provide a summary explanation and examine whether the difference is due to a laboratory error, poor well conditions, or other ions not accounted for in natural or impacted groundwater conditions:

- A ten percent difference threshold is used if the total cation-anion sums are less than 5.0 meq/liter.

[1] If those data are collected.

- A five percent difference threshold is used if the total cation-anion sums are greater than or equal to 5.0 meq/liter

8.4.2 Graphical Representation of Groundwater Quality

Graphical representations of groundwater geochemistry are useful for comparing water quality data sets between different monitoring wells. Graphical methods provide means to visually evaluate performance and water quality trends for single wells or groups of wells for individual or periodically-scheduled recording events. Two principal examples of graphical representation are trilinear diagrams and Stiff diagrams. Both methods plot and chart major anions and cations as means of illustrating groundwater geochemistry. Numerous commercial software programs are available and free software is available at the U. S. Geological Survey website (http://water.usgs.gov/nrp/gwsoftware/GW_Chart/GW_Chart.html).

9.0 Assessment Monitoring Under Chapter 173-351 WAC

An assessment monitoring program may be required at Chapter 173-351 WAC landfills if detection monitoring indicates increasing concentrations of monitored constituents. Assessment monitoring includes sampling for additional constituents as described in WAC 173-351-440.

Assessment monitoring is required if the analyses indicate there has been a statistically significant increase (SSI) over background for one or more of the constituents listed in Appendix I of Chapter 173-351 WAC. Analyses of samples for constituents listed in Appendix I and Appendix II of the regulation are part of detection monitoring at the landfill.

9.1 Statistically Significant Increases

Statistical analyses of groundwater data are required with each sampling event under the regulation. Recent constituent values are compared with background values using statistical procedures specified in the operating permit and/or QAPP. A SSI means that the value of a constituent is greater than what would be expected from past data variability. The statistical procedure will determine if the increase is statistically significant. Refer to the second paragraph in section 4.3 of the EPA's Unified Guidance.

An owner/operator can avoid going into assessment monitoring even if results show a SSI, if it can be demonstrated that a source other than the landfill caused the contamination or that the SSI resulted from an error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. EPA's Unified Guidance should be consulted if resampling is part of the demonstration.

9.2 Time Limits for Starting Assessment Monitoring

A groundwater report must be submitted to the JHD and Ecology within 60 days after receipt of analytical data from detection monitoring. The statistical analyses are a component of the report, so they must be completed within the 60-day period. From the time that a SSI is noted, an owner/operator has:

- 14 days to send a notice of a SSI to the JHD and put a notice in the operating record.
- 90 days to demonstrate that a source other than the landfill caused the contamination, or to establish an assessment monitoring program.

9.3 Assessment Monitoring Requirements

Assessment monitoring includes sampling for the full set of constituents listed in Appendix III of Chapter 173-351 WAC. For the assessment monitoring program, the following is required:

- Sample each downgradient well for the full set of Appendix III constituents within 90 days of noting a statistical increase.
- If any Appendix III constituents are detected, sample all wells four times within a 180-day period. At least one month must pass between each sampling event. Analyze for just the Appendix III constituents that were detected during the initial Appendix III sampling to establish background levels. Notify the JHD which constituents have been detected and place the notice in the operating record.
- Within 90 days of the last Appendix III background sampling event, and quarterly thereafter, resample all wells for all Appendix I and II constituents and any previously detected Appendix III constituents.
- As long as a facility remains in Assessment Monitoring, resample for the full set of Appendix III constituents annually in all downgradient wells or an approved subset of the wells.

9.4 Possible Outcomes of Assessment Monitoring

Under assessment monitoring constituent values and statistical results determine the next steps:

- If concentrations for all Appendix III constituents are at or below background values for two consecutive events, an owner/operator can return to detection monitoring if they receive approval from the JHD.
- If Appendix III constituents are above background but below groundwater-protection standards (chapter 173-200 WAC), owners/operators must continue to include the detected Appendix III constituents in the quarterly sampling.
- If one or more Appendix III constituents are detected at statistically significant levels above the protection standard, the site goes into corrective action. The owner/operator must notify the JHD, Ecology, and all appropriate local government officials within 14 days and do the following:
    - Install additional monitoring wells and characterize the chemical composition, fate and transport, and rate and extent of contamination in all groundwater flow paths. At least one new well must be installed at the facility boundary in the direction of contaminant migration. This well must be sampled four times within a 180-day period to establish a background for Appendix III contaminants as discussed above.
    - Notify land owners or people who reside on the land that overlies the contaminant plume if any contaminants have migrated off-site.

- Initiate an assessment, selection, and implementation of remedial actions as required by the Model Toxics Control Act (Chapter 173-340 WAC).
- Continue assessment monitoring as usual.

9.5 Assessment Monitoring Program Modifications

Owners/operators can propose deleting or changing groundwater monitoring constituents or an appropriate subset of wells to be sampled. Suitable hydrogeology and chemical characteristics must be demonstrated, in accordance with WAC 173-351-450, in order for a modification to be considered. There is no provision in the regulation to change the frequency of the sampling under assessment monitoring. It remains quarterly.

10.0 Remedial Action

The solid waste regulations are designed to protect human health and the environment. If groundwater quality criteria (Chapter 173-200 WAC) are exceeded as a result of landfill activities, a facility may be required to undertake cleanup actions. These cleanup actions are called corrective or remedial actions. Older solid waste regulations use the term corrective action, but this section will use the term remedial action to be consistent with Washington's Model Toxics Control Act (MTCA), Chapter 173-340 WAC. If a site is in remedial action, the owner/operator should become familiar with these cleanup regulations and work with a knowledgeable consultant throughout the cleanup process.

10.1 Model Toxics Control Act (MTCA)

The MTCA regulation, Chapter 173-340 WAC, provides a process to accomplish effective cleanups of sites with releases of hazardous substances. MTCA applies to all facilities where there has been a release or threatened release of a hazardous substance that may pose a threat to human health or the environment. MTCA law (Chapter 70.105 RCW), MTCA regulations (Chapter 173-340 WAC), Uniform Covenants Act (Chapter 64.70 RCW), and MTCA focus sheets are all combined in Ecology publication No. 94-06. This publication is available on the Department of Ecology's web site at: http://www.ecy.wa.gov/biblio/9406.html. Anyone involved in remediation activities should become familiar with this publication. A good general description of MTCA is available in Ecology Focus Sheet No. 94-12, entitled, "Model Toxics Cleanup Act Cleanup Regulation: Process for Cleanup of Hazardous Waste Sites", provided in Appendix E of this guidance document.

10.2 Solid Waste Regulations and Remedial Action

All solid waste regulations have a cleanup provision triggered by one or more exceedances of groundwater quality criteria (Chapter 173-200 WAC). A solid waste permit with the JHD does not exempt a facility from meeting the Chapter 173-200 WAC groundwater criteria. Ecology can use Chapter 173-200 WAC as a basis to direct owners and operators of landfills to meet groundwater quality objectives.

Some specific cleanup provisions relative to the four solid waste regulations include:

> Chapter 173-304 WAC –This regulation grants JHDs authority over remedial actions (WAC 173-304-490(2)(j) and (3)). However, this rule was written before the effective dates of MTCA and the groundwater quality rule, both of which establish Ecology's authority for cleanup actions and groundwater protection. Ecology is usually the lead

agency on remedial actions, however, section WAC 173-340-110 allows Ecology to determine if another law is more appropriate and consider the success of the remedial action before assuming direct authority.

Chapter 173-306 WAC - Ecology may require modifications to a facility or to a plan of operation. Ecology can also use MTCA or the groundwater quality rule to initiate remedial action.

Chapters 173-350 and 173-351 WAC - Both of these rules place Ecology in the lead role for remedial action, which it carries out using MTCA. The JHD may participate in all negotiations, meetings, and correspondence. The roles for Ecology and the JHD are found at WAC 173-350-900 and WAC 173-351-460 and -465.

When Ecology takes the lead for a remedial action, a solid waste permit is still required to address those facility functions not related to cleanup activities. The solid waste permit should reference the section of the regulation pertaining to remedial action or refer to an order administered by Ecology. The site continues to operate under a solid waste permit when cleanup activities are complete.

11.0 Ending Post-Closure Care

None of the four regulations list the requirements for ending post-closure care in a specific section. However, within these regulations many of the post-closure care requirements can be found in the following:

WAC 173-304-407 - General closure and post-closure requirements
WAC 173-306-410 - General closure and post-closure requirements
WAC 173-350-400 (7) - Limited purpose landfills - Post-closure requirements
WAC 173-351-500 (2) - Post-closure care requirements

11.1 Regulatory Requirements

Under Chapters 173-304 and 173-350 WAC, to discontinue post-closure activities the owner/operator must certify that post-closure activities are no longer necessary. For Chapter 173-306 WAC landfills, the owner/operator must submit an affidavit stating why post-closure activities are no longer necessary. For all three of these three regulations, these declarations must be signed by the owner/operator and a registered professional engineer. When post-closure care activities are complete under Chapter 173-351 WAC, the owner/operator must submit a certification or declaration of construction signed by an independent licensed professional engineer that post-closure has been completed in accordance with the post-closure plan.

Chapters 173-304, 173-306 and 173-350 WAC include the following definitions about the duration of post-closure care and the standards for ending it. Beyond this, some JHDs may have their own county codes dictating standards for post-closure care.

WAC 173-304-100 (59) - “Post-closure” means the requirements placed upon disposal sites after closure to ensure their environmental safety for at least a twenty-year period or until the site becomes stabilized (i.e., little or no settlement, gas production, or leachate generation).

WAC 173-306-100 (43) - “Post-closure" means the requirements placed upon disposal facilities after closure to ensure their environmental safety for a thirty-year period or until the site becomes stabilized (i.e., cap integrity maintained, little or no settlement or leachate generation).

WAC 173-350 (100) - "Post-closure" means the requirements placed upon disposal facilities after closure to ensure their environmental safety for at least a twenty-year period or until the site becomes stabilized (i.e., little or no settlement, gas production, or leachate generation).

Chapters 173-304, 173-306, 173-350 and 173-351 WAC have similar requirements for ending post-closure care. These regulations allow JHDs to authorize the owner/operator to discontinue post-closure maintenance and monitoring activities if they agree that the landfill is stabilized. Chapter 173-306 WAC also uses stabilization as the standard. This regulation indicates Ecology may gradually reduce or discontinue post-closure maintenance and monitoring requirements if it determines that stabilization has been achieved.

Post-closure care in Chapter 173-351 WAC continues until the site is functionally stable. According to WAC 173-351-500 an owner/operator must estimate the time needed to become functionally stable and plan to perform post-closure care based on this estimate. WAC 173-351-500(2) indicates that functional stability is achieved when a site does not present a threat to human health or the environment at the point of exposure for humans or environmental receptors. These threats are assessed by considering leachate, landfill gas, cover systems and groundwater. The required filing of environmental covenants to reduce exposure is also considered. WAC 173-351-500 provides standards to meet for each of the considerations.

It is important to recognize that for all four of these regulations, post-closure care may be extended beyond the 20- or 30-year period if a site has not stabilized.

11.2 Terminating Post-Closure Care at Chapter 173-304 WAC Landfills

In February 2011 Ecology issued *Preparing for Termination of Post-Closure Activities at Landfills Closed Under Chapter 173-304 WAC* (Publication no. 11-07-006, available on-line at: http://www.ecy.wa.gov/pubs/1107006.pdf). This publication describes administrative recommendations, regulatory agency roles, and a definition for the end of post-closure care. The discussion of landfill stabilization includes four stabilization indicator factors: settlement, gas production, leachate generation, and groundwater monitoring.

If data gaps exist for any of the stabilization factors, periods of confirmational monitoring may be required. At sites where groundwater or surface water monitoring data are inadequate, the frequency of sampling, number of analyzed parameters, or number of sampling points may have to be increased. When evaluating how much additional sampling is appropriate, key factors are:

- Have there been exceedances of groundwater protection standards or evaluation criteria.
- Are there statistically significant differences between the up-gradient and down-gradient groundwater data.

Ecology recommends that an operator proposing to end post-closure activities at a Chapter 173-304 WAC facility provide the solid waste permitting agency with a report summarizing all relevant environmental information about the stability of the landfill. This will help the permitting agency assess the operator's proposal and support the permitting agency's decision.

Information to include in a post-closure care summary report is described in Publication no. 11-07-006. Items specific to groundwater monitoring include:

- Information on the site hydrogeology with descriptions of the geology, hydrogeologic cross sections, drilling history, aquifers, seeps, and tidal influence (if present).
- Summary tables and discussion of groundwater elevations and velocity calculations, temporal and seasonal changes, and water level contour maps representative of the four quarters of the year.
- A summary of groundwater and surface water sampling with discussion of:
    - Any changes to the monitoring plan (including whether and how changes were approved).
    - Exceedances of groundwater quality standards (Chapter 173-200 WAC) or evaluation criteria.
    - Statistical evaluation of constituent trends.

  EPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance* provides appropriate statistical methods for evaluating data.
- A comprehensive discussion with conclusions about site stabilization, including an evaluation of settlement and cover integrity, gas production, leachate production, and groundwater monitoring.

It is important to recognize that Chapter 173-304 WAC's criteria for showing that a landfill facility has stabilized are qualitative. Decision-makers will have to exercise judgment in making their findings on individual facilities. However, Publication no. 11-07-006 does indicate that data presented in support of terminating post-closure activities should be assessed while considering a number of general principles, which for groundwater monitoring include:

- The monitoring well network should be able to identify direction and velocity of groundwater flow across the facility.
- Groundwater quality sampling results should meet groundwater protection standards of Chapter 173-200 WAC at the facility's permitted point of compliance.
- Monitored analyte concentration trends should have slopes of zero or less (unless the cause for increasing slopes is not related to the landfill).
- Groundwater quality sampling results should indicate no statistically significant increases between upgradient and downgradient wells where the concentration of an analyte exceeds the groundwater protection standards in the upgradient wells.

While Publication Number 11-07-006 provides these general principles, it does not discuss time period(s) over which these factors should be evaluated. Due to the great variety of landfill sites, specific rules for time periods are not practical. Instead, professional judgment needs to be exercised while taking into consideration such site-specific factors as groundwater flow rates, contaminants present, effectiveness of monitoring network, etc.

Exceedances of Chapter 173-200 WAC secondary groundwater protection standards for constituents such as iron or manganese may serve as indications of broader chemical changes resulting from waste deposited at a landfill site. However, such contaminants may not pose much

of a health risk themselves. As such, exceedances of secondary contaminants in general should not carry the same weight as primary or carcinogenic contaminant exceedances.

11.3 Terminating Post-Closure Care at Chapters 173-306 and 173-350 WAC Landfills

Publication no. 11-07-006 is currently the only Ecology document with guidance on ending post-closure care activities at Washington landfills. This document specifically addresses Chapter 173-304 WAC landfills, but Chapters 173-306 and 173-350 WAC contain similar stabilization-based standards for ending post-closure care. This suggests that similar approaches can be applied to landfills covered by those regulations.

11.4 Terminating Post-Closure Care at Chapter 173-351 WAC Landfills

Chapter 173-351 WAC, as revised November 2012, takes a similar stabilization-based approach as the other regulations. However, this regulation also relates stabilization to protection of human and environmental health and sets standards for assessing gas, settlement, leachate and groundwater. Chapter 173-351 WAC also requires an environmental covenant to help ensure ongoing protection of human and environmental health. The stabilization standards for leachate and groundwater contained in WAC 173-351-500(2)(b)(iii) are as follows:

> The jurisdictional health department and owner or operator will consider at least the following factors when determining when a landfill unit is functionally stable or whether [54] OTS-4676.3 to decrease or increase the post-closure care period:
>
> (A) Leachate. Leachate production and quality must be such that maintenance and operation of the leachate collection system can be ceased beyond the post-closure care period without posing a threat to human health or the environment.
>
> (B) Landfill gas. Landfill gas production and composition must be such that maintenance and operation of the gas collection system can be ceased beyond the post-closure care period while meeting the criteria in WAC 173-351-200 (4)(a)(i) through (iii) and not pose a threat to human health or the environment from methane or nonmethane compounds.
>
> (C) Settlement and cover integrity. The cover system must attain geotechnical stability for slope and settlement. Vegetation and other erosion controls must prevent exposing waste or otherwise threaten integrity of the cover system. The cover system must stabilize such that no additional care is required beyond the post-closure care period to ensure its integrity from settlement or erosion.

(D) Groundwater quality. Groundwater quality must remain in compliance with the protection standards established in WAC 173-351-440(7) at the relevant point of compliance.

12.0 References

Clesceri, L.S., Greenberg, A.E., and Eaton, A.D. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. APHA American Public Health Association,

Dragun, J. 1988. The Soil Chemistry of Hazardous Materials. Hazardous Materials Control Research Institute, Silver Spring, MD.

Freeze, A.R., and Cherry, J.A. 1979. Groundwater. Prentice Hall, 604 p.

Fuchs, M. 1990. Ground Water Monitoring Guidance for Solid Waste Facilities. Washington State Department of Ecology, Solid and Hazardous Waste Program, Open-File Technical Report 90-04. http://www.ecy.wa.gov/pubs/90004.pdf

Kerfoot, H. B., Baker, J.A., and Burt, D.M. 2004. Geochemical Changes in Ground Water due to Landfill Gas Effects. Ground Water Monitoring & Remediation, vol. 24, no. 1, pages 60-65

Lombard, S. and Kirchmer, C. 2004. Guidelines for Preparing Quality Assurance Project Plan for Environmental Studies, Washington State Department of Ecology Publication No. 04-03-030. http://www.ecy.wa.gov/pubs/0403030.pdf

Sims, J.L., Suflita, J.M., and Russell, H.H. 1991. Reductive Dehalogenation of Organic Contaminants in Soils and Ground Water. EPA/540/4-90/054, USEPA, Ada, OK. http://www.epa.gov/tio/tsp/download/reddehal.pdf

USEPA. 1989. Risk Assessment Guidance for Superfund (RAGS) Part A, EPA/540/1-89/002 December 1989. http://www.epa.gov/oswer/riskassessment/ragsa/pdf/rags_ch5.pdf

USEPA. 1993. Solid Waste Disposal Facility Criteria, Technical Manual, EPA530/R-93/017. http://www.epa.gov/osw/nonhaz/municipal/landfill/techman/intro.pdf

USEPA. 2002. Guidance for Quality Assurance Project Plans, EPA QA/G-5, December 2002. http://www.epa.gov/quality/qs-docs/g5-final.pdf

USEPA. 2008. Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review, EPA-540/R-08/01, June 2008.

USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities-Unified Guidance. United States Environmental Protection Agency, EPA 530/R-09/007. http://www.epa.gov/osw/hazard/correctiveaction/resources/guidance/sitechar/gwstats/index.htm

USEPA. 2010. Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review, OSWER 9240.1-51, EPA 540/R-10/011, January 2010.

Washington State. 1973. Chapter 173-301 Washington Administrative Code - Minimum Functional Standards for Solid Waste Handling.

Washington State. 1988. Chapter 173-304 Washington Administrative Code - Minimum Functional Standards for Solid Waste Handling.

Washington State. 1990. Chapter 173-306 Washington Administrative Code - Special Incinerator Ash Management Standards.

Washington State. 1990. Chapter 173-200 Washington Administrative Code - Water Quality Standards for Groundwaters of the State of Washington.

Washington State. 2012. Chapter 173-351 Washington Administrative Code - Criteria for Municipal Solid Waste Landfills.

Washington State. 2000. Chapter 18.220 Revised Code of Washington - Geologists.

Washington State. revised 2005.Implementation Guidance for the Groundwater Quality Standards. http://www.ecy.wa.gov/pubs/9602.pdf.

Washington State. 2005. Chapter 173-350 Washington Administrative Code - Solid Waste Handling Standards.

Washington State. 2006. Chapter 173-162 Washington Administrative Code - Regulation and Licensing of Well Contractors and Operators.

Washington State. 2009. Chapter 173-160 Washington Administrative Code - Minimum Standards for Construction and Maintenance of Water Wells.

Washington State. 2011. Preparing for Termination of Post-Closure Activities at Landfills Closed Under Chapter 173-304 WAC. Washington State Department of Ecology, Waste 2 Resources Program, Publication no. 11-07-006. http://www.ecy.wa.gov/pubs/1107006.pdf

Washington State. 2011. Chapter 70.95 Revised Code of Washington - Solid Waste Management — Reduction and Recycling.

Note: Chapters of the Revised Administrative Code of Washington can be found at http://apps.leg.wa.gov/rcw/, and Chapters of Washington Administrative Code can be found at http://apps.leg.wa.gov/wac/.

Appendices

Appendix A. Definitions

Appendix B. Acronyms

Appendix C. Appendix A from Ecology Chapter 173-200 Implementation Guidance

Appendix D. Chapter 173-351 WAC Appendices I, II, and III parameters

Appendix E. MTCA Cleanup Regulation: Ecology Focus Sheet No. 94-129

Appendix A

Definitions

Aquifer – in the context of this document this term refers to any hydrostratigraphic unit (please see definition below). This definition is in contrast to to the more common definition of an aquifer, which is a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

Background - the quality of the environment (air, soil or water) which is unaffected by waste disposal operations.

Congener - a chemical compound similar in composition and effect to another compound.

Contaminant - any chemical, physical, biological, or radiological substance that does not occur naturally in the environment or that occurs at concentrations greater than natural background levels.

Contamination – the concentration of a substance in groundwater that exceeds the Chapter 173-200 WAC groundwater criteria, or

a statistically significant increase in the concentration of a substance in the groundwater where the existing concentration of that substance exceeds the Chapter 173-200 WAC groundwater criteria, or

a statistically significant increase above background in the concentration of a substance which;

is not specified in Chapter 173-200 WAC, and

is present in the solid waste, and

has been determined to present a substantial risk to human health or the environment in the concentrations found at the point of compliance.

Criteria - numerical values or narrative standards that represent the maximum allowable contaminant concentrations in the groundwater.

Downgradient - the location in the aquifer flow field that groundwater flows horizontally away from the facility of interest. The gradient and flow direction in the aquifer are determined from groundwater elevation data from monitoring wells.

Ecology - Department of Ecology.

Groundwater - that part of the subsurface water that is in the zone of saturation.

Groundwater Quality Standards - the criterion set for maximum allowable contamination of groundwater as set forth in chapter 173-200 WAC, *Water Quality Standards for Ground Waters of the State of Washington*.

Hydrostratigraphic unit - any water-bearing geologic unit or units hydraulically connected or grouped together on the basis of similar hydraulic conductivity which can be reasonably monitored; several geologic formations or part of a geologic formation may be grouped into a single hydrostratigraphic unit; perched sand lenses may be considered a hydrostratigraphic unit or part of a hydrostratigraphic unit, for example.

Jurisdictional health department (JHD) - means city, county, city-county, or district public health department.

Landfill - a disposal facility or part of a facility at which solid waste is permanently placed in or on land including facilities that use solid waste as a component of fill.

Leachate - a liquid that has passed through or emerged from solid waste and contains soluble, suspended, or miscible materials removed from such waste.

Monitoring interval - the stratigraphic interval from which groundwater level measurements or groundwater quality samples will be obtained

Municipal solid waste (**MSW)** - a subset of solid waste which includes unsegregated garbage, refuse and similar solid waste material discarded from residential, commercial, institutional and industrial sources and community activities, including residue after recyclables have been separated.

Permeability - the ease with which a porous material allows liquid or gaseous fluids to flow through it. For water, this is usually expressed in units of centimeters per second and termed hydraulic conductivity.

Point of compliance - refers to specific definitions depending upon the WAC including:

> Per WAC 173-304 - that part of groundwater that lies beneath the perimeter of a solid waste facilities' active area as that active area would exist at closure of the facility.
>
> Per WAC 173-306 - that part of groundwater which lies beneath the perimeter of a disposal facility's active area as that active area would exist at the closure of the facility.
>
> Per WAC 173-350 - a point established in the groundwater by the jurisdictional health department as near a possible source of release as technically, hydrogeologically and geographically feasible.

Per WAC 173-351 – This rule does not provide a simple definition, and instead WAC 173-351-300(6) describes a number of factors that must be considered when agreeing upon a point of compliance.

Post-closure - refers to specific definitions depending upon the WAC including:

Per WAC 173-304 - the requirements placed upon disposal sites after closure to ensure their environmental safety for at least a twenty-year period or until the site becomes stabilized (i.e., little or no settlement, gas production, or leachate generation).

Per WAC 173-306 - the requirements placed upon disposal facilities after closure to ensure their environmental safety for a thirty-year period or until the site becomes stabilized (i.e., cap integrity maintained, little or no settlement or leachate generation).

Per WAC 173-350 - the requirements placed upon disposal facilities after closure to ensure their environmental safety for at least a twenty-year period or until the site becomes stabilized (i.e., little or no settlement, gas production, or leachate generation).

Per WAC 173-351 - those actions taken by an owner or operator of a facility or MSWLF unit after closure.

Quality Assurance Project Plan (QAPP) – a written plan describing objectives and procedures for assuring reliability of the data while collecting and handling samples, analyzing data, etc.

Post-closure plan - a written plan developed by an owner or operator of a facility detailing how a facility is to meet the post-closure requirements for the facility.

Representative sample - a sample that can be expected to exhibit the average properties of the sample source.

Sampling and analysis plan (SAP) - a written plan describing sampling and handling techniques, frequency of sampling, and analyses requirements.

Screened interval - the open or screened section of the well through which groundwater recharges the well.

Semivolatile organic analysis – analysis for volatile organic compounds using gas chromatography/ mass spectrometry (GC/MS) methods, which in the case of landfills typically relies upon EPA Method 8270.

Statistically significant increase (SSI) – a change in the concentration of a constituent that is large enough to account for natural variability as well as the detected change.

Upgradient - the location in the aquifer flow field that groundwater flows horizontally towards the facility of interest. The gradient and flow direction in the aquifer are determined from groundwater elevation data from monitoring wells.

Uppermost aquifer - a "geologic formation or group of formations underlying the facility which is capable of yielding monitorable quantities of water to an approved monitoring device. Site specific hydrogeologic conditions, defined in a comprehensive hydrogeologic evaluation, will dictate what is to be considered a monitorable quantity of water" (Ecology, 1988).

Vadose zone - that portion of a geologic formation in which soil pores contain some water, the pressure of that water is less than atmospheric pressure, and the formation occurs above the zone of saturation.

Volatile organic analysis - analysis for volatile organic compounds (VOCs) using gas chromatography/ mass spectrometry (GC/MS) methods, which in the case of landfills typically relies upon EPA Method 8260.

WAC - Washington Administrative Code.

Zone of saturation - that part of a geologic formation in which soil pores are filled with water and the pressure of that water is equal to or greater than atmospheric pressure.

Appendix B

Acronyms

Analysis Of Variance (**ANOVA**)
Cleanup Level and Risk Calculations (**CLARC**) database
Comprehensive Environmental Response, Compensation, and Liability Act (**CERCLA**)
Environmental Information Management (**EIM**) database
Environmental Protection Agency (**EPA**)
Jurisdictional Health Department (**JHD**)
Maximum Cleanup Level (**MCL**)
Model Toxics Cleanup Act (**MTCA**)
Municipal Solid Waste (**MSW**)
Polycyclic Aromatic Hydrocarbon (**PAH**)
Quality Assurance Project Plan (**QAPP**)
Regression on Order Statistics (**ROS**)
Resource Conservation and Recovery Act (**RCRA**)
Revised Code of Washington (**RCW**)
Risk Assessment Guidance for Superfund (**RAGS**)
Sampling and Analysis Plan (**SAP**)
Selected Ion Monitoring (**SIM**)
Site Wide False Positive Rate (**SWFPR**)
Statistically Significant Increase (**SSI**)
Technical Information Memorandum (**TIM**)
Toxicity Equivalency Factors (**TEFs**)
Volatile Organic Compounds (**VOC**)
Washington Administrative Code (**WAC**)
Washington State Department of Ecology (**Ecology**)

Appendix C

Appendix A from Ecology Chapter 173-200

Implementation Guidance

Note: While the tables below provide a good starting point for most current groundwater criteria, other factors may need to be considered when determining applicable criteria, as discussed in Section 7.5.1.

9.0 Appendix A: Ground Water Contaminant Levels

This table lists the most stringent regulatory levels for ground water contaminants derived from Ch 173-200 WAC (10/31/90) and Ch 246-290 WAC (07/03/04). The listed Regulatory Source should be referenced when establishing appropriate ground water limits in permit.

* = Listed as Carcinogens in WAC 173-200, Table 1

Table 9.1 Ground Water Contaminant Levels

CONTAMINANT	REG. LEVEL	CAS NUMBER	REGULATORY SOURCE
Contaminants without established criteria shall have enforcement limits not exceeding the Practical Quantification Level [WAC 173-200-050(4)], except as allowed under WAC 173-200-050(4)(b).			
*Acrylamide	0.02 ug/L	79-06-1	Ch 173-200 WAC, Table 1
*Acrylonitrile	0.07 ug/L	107-13-1	Ch 173-200 WAC, Table 1
Alachlor	2 ug/L	15972-60-8	Ch 246-290 WAC
Aldicarb	3 ug/L	116-06-3	Ch 246-290 WAC
Aldicarb sulfone	2 ug/L	1646-88-4	Ch 246-290 WAC
Aldicarb sulfoxide	4 ug/L	1646-87-3	Ch 246-290 WAC
*Aldrin	0.005 ug/L	309-00-2	Ch 173-200 WAC, Table 1
*Aniline	14 ug/L	62-53-3	Ch 173-200 WAC, Table 1
Antimony	6 ug/L	7440-36-0	Ch 246-290 WAC
*Aramite	3 ug/L	140-57-8	Ch 173-200 WAC, Table 1
*Arsenic	0.05 ug/L	7440-38-2	Ch 173-200 WAC, Table 1
Asbestos	7 MFL	1332-21-4	Ch 246-290 WAC
Atrazine	3 ug/L	1912-24-9	Ch 246-290 WAC
*Azobenzene	0.7 ug/L	103-33-3	Ch 173-200 WAC, Table 1
Barium (total)	1.0 mg/L	7440-39-3	Ch 173-200 WAC, Table 1
*Benzene	1.0 ug/L	71-43-2	Ch 173-200 WAC, Table 1
*Benzidine	0.0004 ug/L	92-87-5	Ch 173-200 WAC, Table 1
*Benzo(a)pyrene	0.008 ug/L	50-32-8	Ch 173-200 WAC, Table 1
*Benzotrichloride	0.007 ug/L	98-07-7	Ch 173-200 WAC, Table 1
*Benzyl chloride	0.5 ug/L	100-44-7	Ch 173-200 WAC, Table 1
Beryllium	4 ug/L	7440-41-7	Ch 246-290 WAC
*Bis(chloroethyl)ether	0.07 ug/L	111-44-4	Ch 173-200 WAC, Table 1
*Bis(chloromethyl)ether	0.0004 ug/L	542-88-1	Ch 173-200 WAC, Table 1
*Bis(2-ethylhexyl)phthalate	6 ug/L	117-81-7	Ch 173-200 WAC, Table 1
*Bromodichloromethane	0.3 ug/L	75-27-4	Ch 173-200 WAC, Table 1
*Bromoform (tribromomethane)	5 ug/L	75-25-2	Ch 173-200 WAC, Table 1
Cadmium (total)	5 ug/L	7440-43-9	Ch 246-290 WAC
*Carbazole	5 ug/L	86-74-8	Ch 173-200 WAC, Table 1
Carbofuran	40 ug/L	1563-66-2	Ch 246-290 WAC
*Carbon Tetrachloride	0.3 ug/L	56-23-5	Ch 173-200 WAC, Table 1
Chloramines	4 mg/L(as Cl_2)		Ch 246-290 WAC
*Chlordane	0.06 ug/L	57-74-9	Ch 173-200 WAC, Table 1
Chloride	250 mg/L	16887-00-6	Ch 173-200 WAC, Table 1
Chlorine	4 mg/L(as Cl_2)	7782-50-5	Ch 246-290 WAC
Chlorine Dioxide	0.8 mg/L(as ClO_2)	10049-04-4	Ch 246-290 WAC
Chlorite	1 mg/L	14998-27-7	Ch 246-290 WAC

CONTAMINANT	REG. LEVEL	CAS NUMBER	REGULATORY SOURCE
*4-Chloro-2-methyl analine hydrochloride	0.2 ug/L	3165-93-3	Ch 173-200 WAC, Table 1
*4-Chloro-2-methyl aniline	0.1 ug/L	95-69-2	Ch 173-200 WAC, Table 1
Chlorobenzene	100 ug/L	108-90-7	Ch 246-290 WAC
*Chlorodibromomethane	0.5 ug/L	124-48-1	Ch 173-200 WAC, Table 1
*Chloroform (trichloromethane)	7 ug/L	67-66-3	Ch 173-200 WAC, Table 1
*o-Chloronitrobenzene	3 ug/L	88-73-3	Ch 173-200 WAC, Table 1
*p-Chloronitrobenzene	5 ug/L	100-00-5	Ch 173-200 WAC, Table 1
*Chlorthalonil	30 ug/L	1897-45-6	Ch 173-200 WAC, Table 1
Chromium (total)	50 ug/L	7440-47-3	Ch 173-200 WAC, Table 1
Color	15 color units		Ch 173-200 WAC, Table 1
Copper (total)	1 mg/L	7440-50-8	Ch 173-200 WAC, Table 1
Corrosivity	non-corrosive		Ch 173-200 WAC, Table 1
Cyanide (as free cyanide)	0.2 mg/L	57-12-5	Ch 246-290 WAC
Dalapon	200 ug/L	75-99-0	Ch 246-290 WAC
*4,4-DDD (Dichlorodiphenyl dichloroethane)	0.3 ug/L	72-54-8	Ch 173-200 WAC, Table 1
*4,4-DDE	0.3 ug/L	72-55-9	Ch 173-200 WAC, Table 1
*4,4-DDT (Dichlorodiphenyl trichloroethane)	0.3 ug/L	50-29-3	Ch 173-200 WAC, Table 1
*Diallate	1 ug/L	2303-16-4	Ch 173-200 WAC, Table 1
Dibromochloropropane (DBCP)	0.2 ug/L	96-12-8	Ch 246-290 WAC
*1,2-Dibromoethane	0.001 ug/L	106-93-4	Ch 173-200 WAC, Table 1
*1,4 Dichlorobenzene	4 ug/L	106-46-7	Ch 173-200 WAC, Table 1
o-Dichlorobenzene	600 ug/L	95-50-1	Ch 246-290 WAC
*3,3-Dichlorobenzidine	0.2 ug/L	91-94-1	Ch 173-200 WAC, Table 1
*1,1-Dichloroethane	1 ug/L	75-34-3	Ch 173-200 WAC, Table 1
*1,2 Dichloroethane (Ethylene chloride)	0.5 ug/L	107-06-2	Ch 173-200 WAC, Table 1
1,1-Dichloroethylene	7 ug/L	75-35-4	Ch 246-290 WAC
cis 1,2-Dichloroethylene	70 ug/L	156-59-2	Ch 246-290 WAC
trans 1,2-Dichloroethylene	100 ug/L	156-60-5	Ch 246-290 WAC
2,4-D (2,4-Dichlorophenoxyacetic acid)	70 ug/L	94-75-7	Ch 246-290 WAC
*1,2 Dichloropropane	0.6 ug/L	78-87-5	Ch 173-200 WAC, Table 1
*1,3-Dichloropropene	0.2 ug/L	542-75-6	Ch 173-200 WAC, Table 1
*Dichlorvos	0.3 ug/L	62-73-7	Ch 173-200 WAC, Table 1
*Dieldrin	0.005 ug/L	60-57-1	Ch 173-200 WAC, Table 1
*3,3-Dimethoxybenzidine	6 ug/L	119-90-4	Ch 173-200 WAC, Table 1
*3,3-Dimethylbenzidine	0.007 ug/L	119-93-7	Ch 173-200 WAC, Table 1
*1,2-Dimethylhydrazine	60 ug/L	540-73-8	Ch 173-200 WAC, Table 1
*2,4-Dinitrotoluene	0.1 ug/L	121-14-2	Ch 173-200 WAC, Table 1
*2,6-Dinitrotoluene	0.1 ug/L	606-20-2	Ch 173-200 WAC, Table 1
Dinoseb	7 ug/L	88-85-7	Ch 246-290 WAC
*1,4-Dioxane	7 ug/L	123-91-1	Ch 173-200 WAC, Table 1
*1,2-Diphenylhydrazine	0.09 ug/L	122-66-7	Ch 173-200 WAC, Table 1
Diquat	20 ug/L	85-00-7	Ch 246-290 WAC
*Direct Black 38	0.009 ug/L	1937-37-7	Ch 173-200 WAC, Table 1
*Direct Blue 6	0.009 ug/L	2602-46-2	Ch 173-200 WAC, Table 1
*Direct Brown 95	0.009 ug/L	16071-86-6	Ch 173-200 WAC, Table 1
Endothall	100 ug/L	145-73-3	Ch 246-290 WAC
Endrin	0.2 ug/L	72-20-8	Ch 173-200 WAC, Table 1
*Epichlorohydrin	8 ug/L	106-89-8	Ch 173-200 WAC, Table 1
*Ethyl acrylate	2 ug/L	140-88-5	Ch 173-200 WAC, Table 1
Ethylbenzene	700 ug/L	100-41-4	Ch 246-290 WAC

CONTAMINANT	REG. LEVEL	CAS NUMBER	REGULATORY SOURCE
*Ethylene dibromide (EDB)	0.001 ug/L	106-93-4	Ch 173-200 WAC, Table 1
*Ethylene thiourea	2 ug/L	96-45-7	Ch 173-200 WAC, Table 1
Fecal coliform and *E.coli.*	0		Ch 246-290 WAC
Fluoride	2 mg/L	16984-48-8	Ch 246-290 WAC
Foaming Agents	500 ug/L		Ch 173-200 WAC, Table 1
*Folpet	20 ug/L	133-07-3	Ch 173-200 WAC, Table 1
*Furazolidone	0.02 ug/L	67-45-8	Ch 173-200 WAC, Table 1
*Furium	0.002 ug/L	531-82-8	Ch 173-200 WAC, Table 1
*Furmecyclox	3 ug/L	60568-05-0	Ch 173-200 WAC, Table 1
Glyphosate	700 ug/L	1071-83-6	Ch 246-290 WAC
Gross Alpha Particle Activity	15 pCi/L		Ch 173-200 WAC, Table 1
Gross Beta Activity	50 pCi/L		Ch 173-200 WAC, Table 1
Haloacetic acids (five) (HAA5)	60 ug/L		Ch 246-290 WAC
*Heptachlor	0.02 ug/L	76-44-8	Ch 173-200 WAC, Table 1
*Heptachlor Epoxide	0.009 ug/L	1024-57-3	Ch 173-200 WAC, Table 1
*Hexachlorobenzene	0.05 ug/L	118-74-1	Ch 173-200 WAC, Table 1
*Hexachlorocyclohexane (alpha)	0.001 ug/L	319-84-6	Ch 173-200 WAC, Table 1
*Hexachlorocyclohexane (technical)	0.05 ug/L	608-73-1	Ch 173-200 WAC, Table 1
Hexachlorocyclopentadiene	50 ug/L	77-47-4	Ch 246-290 WAC
*Hexachlorodibenzo-p-dioxin, mix	0.00001 ug/L	19408-74-3	Ch 173-200 WAC, Table 1
*Hydrazine	0.03 ug/L	302-01-2	Ch 173-200 WAC, Table 1
*Hydrazine sulfate	0.03 ug/L	10034-93-2	Ch 173-200 WAC, Table 1
Iron (total)	0.30 mg/L	7439-89-6	Ch 173-200 WAC, Table 1
Lead (total)	50 ug/L	7439-92-1	Ch 173-200 WAC, Table 1
*Lindane	0.06 ug/L	58-89-9	Ch 173-200 WAC, Table 1
Manganese (total)	50 ug/L	7439-96-5	Ch 173-200 WAC, Table 1
Mercury (total)	2 ug/L	7439-97-6	Ch 173-200 WAC, Table 1
*2-Methoxy-5-nitroaniline	2 ug/L	99-59-2	Ch 173-200 WAC, Table 1
Methoxychlor	0.1 mg/L	72-43-5	Ch 173-200 WAC, Table 1
*2-Methylaniline	0.2 ug/L	95-53-4	Ch 173-200 WAC, Table 1
*2-Methylaniline hydrochloride	0.5 ug/L	636-21-5	Ch 173-200 WAC, Table 1
*4,4-Methylene bis (n,n-dimethyl) aniline	2 ug/L	101-61-1	Ch 173-200 WAC, Table 1
*Methylene chloride (dichloromethane)	5 ug/L	75-09-2	Ch 173-200 WAC, Table 1
*Mirex	0.05 ug/L	2385-85-5	Ch 173-200 WAC, Table 1
*N-Nitroso-di-n-butylamine	0.02 ug/L	924-16-3	Ch 173-200 WAC, Table 1
*N-Nitroso-di-n-propylamine	0.01 ug/L	621-64-7	Ch 173-200 WAC, Table 1
*N-Nitroso-N-methylethylamine	0.004 ug/L	10595-95-6	Ch 173-200 WAC, Table 1
*N-Nitrosodiethanolamine	0.03 ug/L	1116-54-7	Ch 173-200 WAC, Table 1
*N-Nitrosodiethylamine	0.0005 ug/L	55-18-5	Ch 173-200 WAC, Table 1
*N-Nitrosodimethylamine	0.002 ug/L	62-75-9	Ch 173-200 WAC, Table 1
*N-Nitrosodiphenylamine	17 ug/L	86-30-6	Ch 173-200 WAC, Table 1
*N-Nitrosopyrrolidine	0.04 ug/L	930-55-2	Ch 173-200 WAC, Table 1
Nickel	0.1 mg/L	7440-02-0	Ch 246-290 WAC
Nitrate (as N)	10 mg/L	14797-55-8	Ch 173-200 WAC, Table 1
Nitrite (as N)	1 mg/L	14797-65-0	Ch 246-290 WAC
*Nitrofurazone	0.06 ug/L	59-87-0	Ch 173-200 WAC, Table 1
Nitrogen, total [includes: ammonia, nitrate (as N), nitrite (as N) & organic nitrogen]	10 mg/L		Ch 246-290 WAC
Odor	3 threshold odor units		Ch 173-200 WAC, Table 1
Oxamyl (Vydate)	200 ug/L	23135-22-0	Ch 246-290 WAC

CONTAMINANT	REG. LEVEL	CAS NUMBER	REGULATORY SOURCE
*PAH (Polyaromatic hydrocarbons)	0.01 ug/L	130498-29-2	Ch 173-200 WAC, Table 1
*PBB's (Polybrominated Biphenyls)	0.01 ug/L		Ch 173-200 WAC, Table 1
*PCBs (Polychlorinated Biphenyls)	0.01 ug/L	1336-36-3	Ch 173-200 WAC, Table 1
pH	6.5-8.5		Ch 173-200 WAC, Table 1
*o-Phenylenediamine	0.005 ug/L	95-54-5	Ch 173-200 WAC, Table 1
Picloram	500 ug/L	1918-02-1	Ch 246-290 WAC
*Propylene oxide	0.01 ug/L	75-56-9	Ch 173-200 WAC, Table 1
Radium 226	3 pCi/L	13982-63-3	Ch 173-200 WAC, Table 1
Radium 226 & Radium 228	5 pCi/L	13982-63-3 & 15262-20-1	Ch 173-200 WAC, Table 1 Ch 173-200 WAC, Table 1
Selenium (total)	10 ug/L	7782-49-2	Ch 173-200 WAC, Table 1
Silver (total)	50 ug/L	7440-22-4	Ch 173-200 WAC, Table 1
2,4,5-TP Silvex	10 ug/L	93-72-1	Ch 173-200 WAC, Table 1
Simazine	4 ug/L	122-34-9	Ch 246-290 WAC
Sodium	RL=20 mg/L	7440-23-5	Ch 246-290 WAC
Specific conductivity	700 umhos/cm		Ch 246-290 WAC
Strontium-90	8 pCi/L	10098-97-2	Ch 173-200 WAC, Table 1
Styrene	100 ug/L	100-42-5	Ch 246-290 WAC
Sulfate	250 mg/L	14808-79-8	Ch 173-200 WAC, Table 1
*2,3,7,8-Tetrachlorodibenzo-p-dioxin	0.0000006 ug/L	1746-01-6	Ch 173-200 WAC, Table 1
*Tetrachloroethylene (perchloroethylene)	0.8 ug/L	127-18-4	Ch 173-200 WAC, Table 1
*p,α,α,α-Tetrachlorotoluene	0.004 ug/L	5216-25-1	Ch 173-200 WAC, Table 1
Thallium	2 ug/L	7440-28-0	Ch 246-290 WAC
Toluene	1 mg/L	108-88-3	Ch 246-290 WAC
*2,4-Toluenediamine	0.002 ug/L	95-80-7	Ch 173-200 WAC, Table 1
*o-Toluidine	0.2 ug/L	95-53-4	Ch 173-200 WAC, Table 1
Total Coliform Bacteria	0		Ch 246-290 WAC
Total Dissolved Solids	500 mg/L		Ch 173-200 WAC, Table 1
*Toxaphene	0.08 ug/L	8001-35-2	Ch 173-200 WAC, Table 1
1,2,4-Trichlorobenzene	70 ug/L	120-82-1	Ch 246-290 WAC
1,1,1-Trichloroethane	200 ug/L	71-55-6	Ch 173-200 WAC, Table 1
*Trichloroethylene	3 ug/L	79-01-6	Ch 173-200 WAC, Table 1
*2,4,6-Trichlorophenol	4 ug/L	88-06-2	Ch 173-200 WAC, Table 1
Trihalomethanes (total)	80 ug/L		Ch 246-290 WAC
*Trimethyl phosphate	2 ug/L	512-56-1	Ch 173-200 WAC, Table 1
Tritium	20,000 pCi/L	10028-17-8	Ch 173-200 WAC, Table 1
Uranium	30 ug/L	7440-61-1	Ch 246-290 WAC
*Vinyl chloride	0.02 ug/L	75-01-4	Ch 173-200 WAC, Table 1
Xylene (total)	10 mg/L	1330-20-7	Ch 246-290 WAC
Zinc (total)	5 mg/L	7440-66-6	Ch 173-200 WAC, Table 1

RL = EPA "recommended level" for those on a sodium restricted diet.
mg/L = milligrams per liter
pCi/L = pico Curie per liter
ug/L = micrograms per liter
MFL = million fibers per liter (longer than 10 microns)
CAS = Chemical Abstract Service Number

Appendix D

Chapter 173-351 WAC

Appendices I, II, and III parameters

Appendix I Volatile Organic			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
Acetone	67–64–1	2-Propanone	NE
Acrylonitrile	107–13–1	2-Propenenitrile	0.07 ug/L
Benzene	71–43–2	Benzene	1.0 ug/L
Bromochloromethane; Chlorobromomethane.	74–97–5	Methane, bromochloro-	NE
Bromodichloromethane; Dibromochloromethane	75-27-4	Methane, bromodichloro-	0.3 ug/L
Bromoform; Tribromomethane	75-25-2	Methane, tribromo-	5.0 ug/L
Carbon disulfide	75-15-0	Carbon disulfide	NE
Carbon tetrachloride	56-23-5	Methane, tetrachloro-	0.3 ug/L
Chlorobenzene	108-90-7	Benzene, chloro-	100.0 ug/L
Chloroethane; Ethyl chloride	75-00-3	Ethane, chloro-	NE
Chloroform; Trichloromethane	67-66-3	Methane, trichloro-	7.0 ug/L
Dibromochloromethane; Chlorodibromomethane	124-48-1	Methane, dibromochloro-	0.5 ug/L
1,2-Dibromo-3-chloropropane; DBCP	96-12-8	Propane, 1,2-dibrome-3-chloro-	0.2 ug/L
1,2-Dibromoethane; Ethylene dribromide; EDB	106-93-4	Ethane, 1,2-dibromo-	0.001 ug/L
o-Dichlorobenzene; 1,2-Dichlorobenzene	95-50-1	Benzene, 1,2-dichloro-	600.0 ug/L
p-Dichlorobenzene; 1,4-Dichlorobenzene	106-46-7	Benzene, 1,4-dichloro-	4.0 ug/L
trans-1,4-Dichloro-2-butene	110-57-6	2-Butene, 1,4-dichloro-, (E)-	NE
1,1-Dichloroethane; Ethyldidene chloride	75-34-3	Ethane, 1,1-dichloro-	1.0 ug/L
1,2-Dichloroethane; Ethylene dichloride	107-06-2	Ethane, 1,1-dichloro-	0.5 ug/L
1,1-Dichloroethylene; 1,1-Dichloroethene; Vinylidene chloride	75-35-4	Ethene, 1,1-dichloro-	7.0 ug/L
cis-1,2-Dichloroethylene; cis-1,2-Dichloroethene	156-59-2	Ethene, 1,2-dichloro-, (Z)-	70.0 ug/L
trans-1,2-Dichloroethylene trans-1,2-Dichloroethene	156-60-5	Ethene, 1,2-dichloro-, (E)-	100.0 ug/L
1,2-Dichloropropane; Propylene dichloride	78-87-5	Propane, 1,2-dichloro-	0.6 ug/L
cis-1,3-Dichloropropene	10061-01-5	1-Propene, 1,3-dichloro-, (Z)-	NE
trans-1,3-Dichloropropene	10061-02-6	1-Propene, 1,3-dichloro-, (E)-	NE
Ethylbenzene	100-41-4	Benzene, ethyl-	700.0 ug/L
2-Hexanone; Methyl butyl ketone	591-78-6	2-Hexanone	NE
Methyl bromide; Bromomethane	74-83-9	Methane, bromo-	NE
Methyl chloride; Chloromethane	74-87-3	Methane, chloro-	NE
Methyl ethyl ketone; MEK; 2-Butanone	78-93-3	2-Butanone	NE
Methyl iodide; Iodomethane	74-88-4	Methane, iodo-	NE
4-Methyl-2-pentanone; Methyl isobutyl ketone	108-10-1	2-Pentanone, 4-methyl-	NE
Methylene bromide; Dibromomethane	74-95-3	Methane, dibromo-	NE
Methylene chloride;Dichloromethane	75-09-2	Methane, dichloro-	5.0 ug/L
Styrene	100-42-5	Benzene, ethenyl-	100.0 ug/L

1,1,1,2-Tetrachloroethane	630-20-6	Ethane, 1,1,1,2-tetrachloro-	NE
1,1,2,2-Tetrachloroethane	79-34-5	Ethane, 1,1,2,2-tetrachloro-	NE
Tetrachloroethylene;Tetrachloroethene;Perchloroethylene	127-18-4	Ethene, tetrachloro-	0.8 ug/L
Toluene	108-88-3	Benzene, methyl-	1000.0 ug/L
1,1,1-Trichloroethane; Methylchloroform	71-55-6	Ethane, 1,1,1-trichloro-	200.0 ug/L
1,1,2-Trichloroethane	79-00-5	Ethane, 1,1,2-trichloro-	NE
Trichloroethylene; Trichloroethene	79-01-6	Ethene, trichloro-	3.0 ug/L
Trichlorofluoromethane; CFC-11	75-69-4	Methane, trichlorofluoro-	NE
1,2,3-Trichloropropane	96-18-4	Propane, 1,2,3-trichloro-	NE
Vinyl acetate	108-05-4	Acetic acid, ethenyl ester	NE
Vinyl chloride; Chloroethene	75-01-4	Ethene, chloro-	0.02 ug/L
Xylene (total)	Note 11	Benzene, dimethyl-	10000.0 ug/L
Note 11: Xylene (total): This entry includes o-xylene (CAS RN 96-47-6), m-xylene (CAS RN 108-38-3), p-xylene (CAS RN 106-42-3), and unspecified xylenes (dimethylbenzenes) (CAS RN 1330-20-7). PQLs for method 8021 are 0.2 for o-xylene and 0.1 for m-or p-xylene.			
Additional Appendix III Volatile Organic			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
Acetonitrile; Methyl cyanide	75–05–8	Acetonitrile	NE
Acrolein	107–02–8	2-Propenal	NE
Allyl chloride	107–05–1	1-Propene, 3-chloro	NE
Chloroprene	126-99-8	Chloroprene 126-99-8 1,3-Butadiene, 2-chloro-	NE
Dichlorodifluoromethane; CFC 12;	75-71-8	Methane, dichlorodifluoro-	NE
1,3-Dichloropropane; Trimethylene dichloride	142-28-9	Propane, 1,3-dichloro-	NE
2,2-Dichloropropane; Isopropylidene chloride	594-20-7	Propane, 2,2-dichloro-	NE
1,1-Dichloropropene	563-58-6	1-Propene, 1,1-dichloro-	NE
Ethyl methacrylate	97-63-2	2-Propenoic acid, 2-methyl-,ethyl ester	NE
Isobutyl alcohol	78-83-1	1-Propanol, 2-methyl-	NE
Methacrylonitrile	126-98-7	2-Propenenitrile, 2-methyl-	NE
Methyl methacrylate	80-62-6	2-Propenoic acid, 2-methyl-,methyl ester	NE
Naphthalene	91-20-3	Naphthalene	NE
Propionitrile; Ethyl cyanide	107-12-0	Propanenitrile	NE
1,2,4-Trichlorobenzene	120-82-1	Benzene, 1,2,4-trichloro-	70.0 ug/L
Ground Water Criteria=Chapter 173-200 WAC			
NE=not established			

Appendix III Semi-Volatile Organics			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
Acenaphthene	83–32–9	Acenaphthylene, 1,2-dihydro-	see note
Acenaphthylene	208–96–8	Acenaphthylene	see note
Acetophenone	98–86–2	Ethanone, 1-phenyl-	NE
2-Acetylaminofluorene; 2-AAF	53–96–3	Acetamide, N-9H-fluoren-2-yl-	NE
4-Aminobiphenyl	92–67–1	[1,1'-Biphenyl]-4-amine	NE
Anthracene	120–12–7	Anthracene	see note
Benzo[a]anthracene; Benzanthracene	56–55–3	Benz[a]anthracene	see note
Benzo[b]fluoranthene	205–99–2	Benz[e]acephenanthrylene	see note
Benzo[k]fluoranthene	207–08–9	Benzo[k]fluoranthene	see note
Benzo[ghi]perylene	191–24–2	Benzo[ghi]perylene	see note
Benzo[a]pyrene	50–32–8	Benzo[a]pyrene	0.008 ug/L
Benzyl alcohol	100–51–6	Benzenemethanol	NE
Bis(2-chloroethoxy)methane	111–91–1	Ethane, 1,1'-[methylenebis(oxy)]bis[2-chloro-	NE
Bis(2-chloroethyl) ether; Dichloroethyl ether	111-44-4	Ethane, 1,1'-oxybis[2-chloro	0.07 ug/L
Bis-(2-chloro-1-methylethyl) ether; 2,2-Dichlorodiisopropyl ether; DCIP	108–60–1	Propane, 2,2'-oxybis[1-chloro	NE
Bis(2-ethylhexyl) phthalate	117–81–7	1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester	6.0 ug/L
4-Bromophenyl phenyl ether	101-55-3	Benzene, 1-bromo-4-phenoxy-	NE
Butyl benzyl phthalate; Benzyl butyl phthalate	85-68-7	1,2-Benzenedicarboxylic acid, butyl phenylmethyl ester	NE
p-Chloroaniline	106-47-8	Benzenamine, 4-chloro-	NE
Chlorobenzilate	510-15-6	Benzeneacetic acid, 4-chloro-α- (4-chlorophenyl)-α-hydroxy-, ethyl ester	NE
p-Chloro-m-cresol; 4-Chloro-3-methylphenol	59-50-7	Phenol, 4-chloro-3-methyl-	NE
2-Chloronaphthalene	91-58-7	Naphthalene, 2-chloro-	NE
2-Chlorophenol	95-57-8	Phenol, 2-chloro-	NE
4-Chlorophenyl phenyl ether	7005-72-3	Benzene, 1-chloro-4-phenoxy-	NE
Chrysene	218-01-9	Chrysene	see note
m-Cresol; 3-methylphenol	108-39-4	Phenol, 3-methyl-	NE
o-Cresol; 2-methylphenol	95-48-7	Phenol, 2-methyl-	NE
p-Cresol; 4-methylphenol	106-44-5	Phenol, 4-methyl-	NE
Dibenz[a,h]anthracene	53-70-3	Dibenz[a,h]anthracene	see note
Dibenzofuran	132-64-9	Dibenzofuran	NE
Di-n-butyl phthalate	84-74-2	1,2-Benzenedicarboxylic acid, dibutyl ester	NE
3,3 ' -Dichlorobenzidine	91-94-1	[1,1 ' -Biphenyl]-4,4 1 -diamine, 3,3 1 -dichloro	0.2 ug/L
2,4-Dichlorophenol	120-83-2	Phenol, 2,4-dichloro-	NE
2,6-Dichlorophenol	87-65-0	Phenol, 2,6-dichloro-	NE
Diethyl phthalate	84-66-2	1,2-Benzenedicarboxylic acid, diethyl ester	NE
p-(Dimethylamino)azobenzene	60-11-7	Benzenamine, N,N-dimethyl-4-(phenylazo)-	NE

7,12-Dimethylbenz[a]anthracene	57-97-6	Benz[a]anthracene, 7,12-dimethyl-	see note
3,3 ' -Dimethylbenzidine	119-93-7	[1,1 ' -Biphenyl]-4,4 1 -diamine, 3,3 1 -dimethyl-	0.007 ug/L
2,4-Dimethylphenol; m-Xylenol	105-67-9	Phenol, 2,4-dimethyl-	NE
Dimethyl phthalate	131-11-3	1,2-Benzenedicarboxylic acid, dimethyl ester	NE
m-Dinitrobenzene	99-65-0	Benzene, 1,3-dinitro-	NE
4,6-Dinitro-o-cresol 4,6-Dinitro-2-methylphenol	534-52-1	Phenol, 2-methyl-4,6-dinitro	NE
2,4-Dinitrophenol	51-28-5	Phenol, 2,4-dinitro-	NE
2,4-Dinitrotoluene	121-14-2	Benzene, 1-methyl-2,4-dinitro-	0.1 ug/L
2,6-Dinitrotoluene	606-20-2	Benzene, 2-methyl-1,3-dinitro-	0.1 ug/L
Di-n-octyl phthalate	117-84-0	1,2-Benzenedicarboxylic acid, dioctyl ester	NE
Diphenylamine	122-39-4	Benzenamine, N-phenyl-	NE
Ethyl methanesulfonate	62-50-0	Methanesulfonic acid, ethyl ester	NE
Famphur	52-85-7	Phosphorothioic acid, 0-[4-[(dimethylamino)sulfonyl]phenyl] 0,0-dimethyl ester	NE
Fluoranthene	206-44-0	Fluoranthene	see note
Fluorene	86-73-7	9H-Fluorene	see note
Hexachlorobenzene	118-74-1	Benzene, hexachloro-	0.05 ug/L
Hexachlorobutadiene	87-68-3	1,3-Butadiene, 1,1,2,3,4,4-hexachloro-	NE
Hexachlorocyclopentadiene	77-47-4	1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-	50.0 ug/L
Hexachloroethane	67-72-1	Ethane, hexachloro-	NE
Hexachloropropene	1888-71-7	1-Propene, 1,1,2,3,3,3-hexachloro	NE
Indeno(1,2,3-cd)pyrene	193-39-5	Indeno(1,2,3-cd)pyrene	see note
Isodrin	465-73-6	1,4,5,8-Dimethanonaphthalene,1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a hexahydro-(1α,4α,4aβ,5β,8β,8aβ)-	NE
Isophorone	78-59-1	2-Cyclohexen-1-one, 3,5,5-trimethyl-	NE
Isosafrole	120-58-1	1,3-Benzodioxole, 5-(1-propenyl)-	NE
3-Methylcholanthrene	56-49-5	Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-	see note
Methyl methanesulfonate	66-27-3	Methanesulfonic acid, methyl ester	NE
2-Methylnaphthalene	91-57-6	Naphthalene, 2-methyl-	NE
Methyl parathion; Parathion methyl	298-00-0	Phosphorothioic acid, 0,0-dimethyl	NE
1,4-Naphthoquinone	130-15-4	1,4-Naphthalenedione	NE
1-Naphthylamine	134-32-7	1-Naphthalenamine	NE
2-Naphthylamine	91-59-8	2-Naphthalenamine	NE
o-Nitroaniline; 2-Nitroaniline	88-74-4	Benzenamine, 2-nitro-	NE
m-Nitroaniline; 3-Nitroanile	99-09-2	Benzenamine, 3-nitro-	NE
p-Nitroaniline; 4-Nitroaniline	100-01-6	Benzenamine, 4-nitro-	NE
Nitrobenzene	98-95-3	Benzene, nitro-	NE
o-Nitrophenol; 2-Nitrophenol	88-75-5	Phenol, 2-nitro-	NE
p-Nitrophenol; 4-Nitrophenol	100-02-7	Phenol, 4-nitro-	NE
N-Nitrosodi-n-butylamine	924-16-3	1-Butanamine, N-butyl-N-nitroso-	0.02 ug/L
N-Nitrosodiethylamine	55-18-5	Ethanamine, N-ethyl-N-nitroso-	0.0005 ug/L

N-Nitrosodimethylamine	62-75-9	Methanamine, N-methyl-N-nitroso-	0.002 ug/L
N-Nitrosodiphenylamine	86-30-6	Benzenamine, N-nitroso-N-phenyl-	17.0 ug/L
N-Nitrosodipropylamine; N-Nitroso-N-dipropylamine; Di-n-propylnitrosamine	621-64-7	1-Propanamine, N-nitroso-N-propyl-	0.01 ug/L
N-Nitrosomethylethalamine	10595-95-6	Ethanamine, N-methyl-N-nitroso-	0.004 ug/L
N-Nitrosopiperidine	100-75-4	Piperidine, 1-nitroso-	NE
N-Nitrosopyrrolidine	930-55-2	Pyrrolidine, 1-nitroso-	0.04 ug/L
5-Nitro-o-toluidine	99-55-8	Benzenamine, 2-methyl-5-nitro-	NE
Parathion	56-38-2	Phosphorothioic acid, 0,0-diethyl 0-(4-nitrophenyl) ester	NE
Pentachlorobenzene	608-93-5	Benzene, pentachloro-	NE
Pentachloronitrobenzene	82-68-8	Benzene, pentachloronitro-	NE
Pentachlorophenol	87-86-5	Phenol, pentachloro-	NE
Phenacetin	62-44-2	Acetamide, N-(4-ethoxyphenl)	NE
Phenanthrene	85-01-8	Phenanthrene	see note
Phenol	108-95-2	Phenol	NE
p-Phenylenediamine	106-50-3	1,4-Benzenediamine	NE
Pronamide	23950-58-5	Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2-propynyl)-	NE
Pyrene	129-00-0	Pyrene	see note
Safrole	94-59-7	1,3-Benzodioxole, 5-(2-propenyl)-	NE
1,2,4,5-Tetrachlorobenzene	95-94-3	Benzene, 1,2,4,5-tetrachloro-	NE
2,3,4,6-Tetrachlorophenol	58-90-2	Phenol, 2,3,4,6-tetrachloro-	NE
o-Toluidine	95-53-4	Benzenamine, 2-methyl-	0.2 ug/L
2,4,5-Trichlorophenol	95-95-4	Phenol, 2,4,5-trichloro-	NE
2,4,6-Trichlorophenol	88-06-2	Phenol, 2,4,6-trichloro-	4.0 ug/L
0,0,0-Triethyl phosphorothioate	126-68-1	Phosphorothioic acid, 0,0,0-triethyl-ester	NE
sym-Trinitrobenzene	99-35-4	Benzene, 1,3,5-trinitro-	NE
Ground Water Criteria=Chapter 173-200 WAC			
NE=not established			
NOTE: the groundwater criteria of 0.01 ug/l for PAHs is the sum of the concentrations for the individual PAH compounds			

Appendix III Organochlorine Pesticides			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
Aldrin	309–00–2	1,4:5,8-Dimethanonaphthalene,1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-(1α,4α,4αβ,5α,8α,8αβ)-	0.005 ug/L
alpha-BHC	319–84–6	Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1α,2α,3β,4α,5β,6β)-	0.001 ug/L
beta-BHC	319–85–7	Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1α,2β,3α,4β,5α,6α)-	NE
delta-BHC	319–86–8	Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1α,2α,3α,4β,5α,6β)-	NE
gamma-BHC; Lindane	58–89–9	Cyclohexane, 1,2,3,4,5,6-hexachloro-(1α,2α,3β,4α,5α,6β)-	0.06 ug/L
Chlordane	See Note 8	4,7-Methano-1H-indene, 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7, 7a-hexahydro-	0.06 ug/L
4,4 ' -DDD	72-54-8	Benzene 1,1 ' -(2,2-dichloroethylidene)bis[4-chloro-	0.3 ug/L
4,4 ' -DDE	72-55-9	Benzene, 1,1 ' -(dichloroethyenylidene)bis[4-chloro-	0.3 ug/L
4,4 ' -DDT	50-29-3	Benzene, 1,1 ' -(2,2,2-trichloroethylidene)bis[4-chloro-	0.3 ug/L
Diallate	2303-16-4	Carbamothioic acid, bis(1-methylethyl)-,S-(2,3-dichloro-2-propenyl) ester	1.0 ug/L
Dieldrin	60-57-1	2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexa,chloro-1a,2,2a,3,6,6a,7,7a- octahydro-, (1aα,2β,2aα,3β,6β,6aα,7β,7aα)-	0.005 ug/L
Endosulfan I	959-98-8	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexa-chloro-1,5,5a,6,9,9a-hexahydro-, 3-oxide	NE
Endosulfan II	33213-65-9	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexa- chloro-1,5,5a,6,9,9a-hexahydro-, 3-oxide, (3α,5aα, 6β,9β,9aα)-	NE
Endosulfan sulfate	1031-07-8	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10, 10-hexa- chloro-1,5,5a,6,9,9a-hexahydro-, 3-3-dioxide	NE

Endrin	72-20-8	2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-, (1aα, 2β,2aβ,3α,6α,6aβ,7β,7aα)-	0.2 ug/L
Endrin aldehyde	7421-93-4	1,2,4-Methenocyclopenta[cd]pentalene-5-carboxaldehyde, 2,2a,3,3,4,7-hexachlorodecahydro-, (1α,2β,2aβ,4β,4aβ,5β,6aβ,6bβ,7R*)-	NE
Heptachlor	76-44-8	4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-	0.02 ug/L
Heptachlor epoxide	1024-57-3	2,5-Methano-2H-indeno[1,2-b]oxirene, 2,3,4,5,6,7,7-heptachloro-1a,1b,5,5a,6,6ahexahydro-,(1aα, 1bβ, 2α, 5α,5aβ, 6β, 6aα)	0.009 ug/L
Kepone	143-50-0	1,3,4-Metheno-2H-cyclobuta[cd]pentalen-2-one, 1,1a,3,3a,4,5,5,5a,5b,6-decachlorooctahydro-	NE
Methoxychlor[a]	72-43-5	Benzene,1,1 ' -(2,2,2,trichloroethylidene)bis[4-methoxy-	0.00004 ug/L
Toxaphene	See Note 10	Toxaphene	0.08 ug/L
Note 8: Chlordane: This entry includes alpha-chlordane (CAS RN 5103-71-9), beta-chlordane (CAS RN 5103-74-2), gamma-chlordane (CAS RN 5566-34-7), and constituents of chlordane (CAS RN 57-74-9 and CAS RN 12789-03-6).			
Note 10: Toxaphene: This entry includes congener chemicals contained in technical toxaphene (CAS RN 8001-35-2), i.e., chlorinated camphene.			
[a] As Chapter 173-200 WAC indicates that either Chapter 173-200 WAC criterion or Chapter 246-290 WAC standards should be applied, whichever is more stringent, the current lower drinking water standard for Methoxychlor, 0.00004 ug/l, should be applied.			
Appendix III Chlorinated Herbicides			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
2,4-D; 2,4-Dichlorophenoxyacetic acid	94-75-7	Acetic acid, (2,4-dichlorophenoxy)-	70.0 ug/L
Dinoseb; DNBP; 2-sec-Butyl-4,6-dinitrophenol	88-85-7	Phenol, 2-(1-methylpropyl)-4,6-dinitro-	7.0 ug/L
Silvex; 2,4,5-TP	93-72-1	Propanoic acid, 2-(2,4,5-trichlorophe-noxy)-	10.0 ug/L
2,4,5-T; 2,4,5-Trichlorophenoxyacetic acid	93-76-5	Acetic acid, (2,4,5-trichlorophenoxy)-	NE

Appendix III Organophoshorus Compounds			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
0,0-Diethyl 0-2-pyrazinyl phosphorothioate; Thionazin	297-97-2	Phosphorothioic acid, 0,0-diethyl 0-pyrazinyl ester	NE
Dimethoate	60-51-5	Phosphorodithioic acid, 0,0-dimethyl S-[2-(methylamino)-2-oxoethyl] ester	NE
Disulfoton	298-04-4	Phosphorodithioic acid, 0,0-diethyl S-[2-(ethylthio)ethyl] ester	NE
Phorate	298-02-2	Phosphorodithioic acid, 0,0-diethyl S-[(ethylthio)methyl] ester	NE
Appendix III PCBs			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
Polychlorinated biphenyls;PCBs; Aroclors	See Note 9	1,1'-Biphenyl, chloro derivatives	0.01 ug/L
Note 9: Polychlorinated biphenyls (CAS RN 1336-36-3); this category contains congener chemicals, including constituents of Aroclor 1016 (CAS RN 12674-11-2), Aroclor 1221 (CAS RN 11104-28-2), Aroclor 1232 (CAS RN 11141-16-5), Aroclor 1242 (CAS RN 53469-21-9), Aroclor 1248 (CAS RN 12672-29-6), Aroclor 1254 (CAS RN 11097-69-1), and Aroclor 1260 (CAS RN 11096-82-5).			
Ground Water Criteria=Chapter 173-200 WAC			
NE=not established			

Appendix I Metals			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
Antimony	(Total)	Antimony	6.0 ug/L
Arsenic	(Total)	Arsenic	0.05 ug/L
Barium	(Total)	Barium	1.0 mg/L
Beryllium	(Total)	Beryllium	4.0 ug/L
Cadmium	(Total)	Cadmium	5.0 ug/L
Chromium	(Total)	Chromium	50.0 ug/L
Cobalt	(Total)	Cobalt	NE
Copper	(Total)	Copper	1.0 mg/L
Lead[b]	(Total)	Lead	15.0 ug/L
Nickel	(Total)	Nickel	0.1 mg/L
Selenium	(Total)	Selenium	10.0 ug/L
Silver	(Total)	Silver	50.0 ug/L
Thallium	(Total)	Thallium	2.0 ug/L
Vanadium	(Total)	Vanadium	NE
Zinc	(Total)	Zinc	5.0 mg/L
[b] As Chapter 173-200 WAC indicates that either Chapter 173-200 WAC criterion or Chapter 246-290 WAC standards should be applied, whichever is more stringent, the current lower drinking water standard for lead, 15 ug/l, should be applied.			
Appendix III Additional Metals			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
Mercury	(Total)	Mercury	2.0 ug/L
Tin	(Total)	Tin	NE
Ground Water Criteria=Chapter 173-200 WAC			
NE=not established			

Other Appendix I Ground Water Quality Parameters			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
Nitrate		Nitrate	10.0 mg/L
Appendix II Ground Water Quality Parameters			
Field Parameters			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
pH			6.5-8.5
Specific Conductance			700 umhos/cm
Temperature			NA
Static Water Level			
Geochemical Indicator Parameters[c]			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
Calcium (Ca)		Calcium	NE
Sodium (Na)	7440-23-5	Sodium	RL=20.0 mg/L
Bicarbonate (HCO3)		Bicarbonate	NE
Chloride (Cl)	16887-00-6	Chloride	250 mg/L
Magnesium (Mg)		Magnesium	NE
Potassium (K)		Potassium	NE
Sulfate (SO3)	14808-79-8	Sulfate	250 mg/L
Alkalinity (as CaCO3)		Alkalinity	NE
Iron (Fe)	7439-89-6	Iron	0.3 mg/L
Manganese (Mn)	7439-96-5	Manganese	0.05 mg/L
[c] Geochemical indicator parameter results compared with Chapter 173-200 WAC criteria or Chapter 246-290 WAC standards should be tested for total constituent concentrations, while results used for cation-anion balancing or ion diagramming should be tested for dissolved constituent concentrations.			
Leachate Indicators			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
Ammonia (NH3-N)		Ammonia	10 mg/L
Total Organic Carbon (TOC)		Total Organic Carbon	NE
Total Dissolved Solids (TDS)		Total Dissolved Solids	500 mg/L
Appendix III Miscellaneous			
Constituent	CAS RN	Chemical Abstract Service Index Name	Ground Water Criteria
Cyanide	57-12-5	Cyanide	0.2 mg/L
Sulfide	18496-25-8	Sulfide	NE
Requirements not in Chapter 173-351 WAC, but included in other landfill regulations:			
Constituent	*CAS RN*	*Chemical Abstract Service Index Name*	*Ground Water Criteria*
Chemical Oxygen Demand (Chapter 173-304 WAC)		*Chemical Oxygen Demand*	*NE*
Total Coliform (Chapter 173-304 WAC)		*Total Coliform*	*0*
Nitrite (Chapter 173-304 WAC)		*Nitrite*	*1 mg/L*
Gamma Radiation (Chapter 173-306 WAC)		*Gamma Radiation*	
Ground Water Criteria=Chapter 173-200 WAC			
NE=not established			
NA=not applicable			

Appendix E

MTCA Cleanup Regulation:

Ecology Focus Sheet No. 94-129

Focus

Model Toxics Control Act Cleanup Regulation: Process for Cleanup of Hazardous Waste Sites

In March of 1989, an innovative, citizen-mandated toxic waste cleanup law went into effect in Washington, changing the way hazardous waste sites in this state are cleaned up. Passed by voters as Initiative 97, this law is known as the Model Toxics Control Act, chapter 70.105D RCW. This fact sheet provides a brief overview of the process for the cleanup of contaminated sites under the rules Ecology adopted to implement that Act (chapter 173-340 WAC).

How the Law Works

The cleanup of hazardous waste sites is complex and expensive. In an effort to avoid the confusion and delays associated with the federal Superfund program, the Model Toxics Control Act is designed to be as streamlined as possible. It sets strict cleanup standards to ensure that the quality of cleanup and protection of human health and the environment are not compromised. At the same time, the rules that guide cleanup under the Act have built-in flexibility to allow cleanups to be addressed on a site-specific basis.

The Model Toxics Control Act funds hazardous waste cleanup through a tax on the wholesale value of hazardous substances. The tax is imposed on the first in-state possessor of hazardous substances at the rate of 0.7 percent, or $7 per $1,000. Since its passage in 1988, the Act has guided the cleanup of thousands of hazardous waste sites that dot the Washington landscape. The Washington State Department of Ecology's Toxic Cleanup Program ensures that these sites are investigated and cleaned up.

What Constitutes a Hazardous Waste Site?

Any owner or operator who has information that a hazardous substance has been released to the environment at the owner or operator's facility and may be a threat to human health or the environment must report this information to the Department of Ecology (Ecology). If an "initial investigation" by Ecology confirms further action (such as testing or cleanup) may be necessary, the facility is entered onto either Ecology's "Integrated Site Information System" database or "Leaking Underground Storage Tank" database. These are computerized databases used to track progress on all confirmed or suspected contaminated sites in Washington State. All confirmed sites that have not been already voluntarily cleaned up are ranked and placed on the state "Hazardous Sites List." Owners, operators, and other persons known to be potentially liable for the cleanup of the site will receive an "Early Notice Letter" from Ecology notifying them that their site is suspected of needing cleanup, and that it is Ecology's policy to work cooperatively with them to accomplish prompt and effective cleanup.

November 2007 (revised) Focus No. 94-129 *printed on recycled paper*

Who is Responsible for Cleanup?

Any past or present relationship with a contaminated site may result in liability. Under the Model Toxics Control Act a potentially liable person can be:

- A current or past facility owner or operator.
- Anyone who arranged for disposal or treatment of hazardous substances at the site.
- Anyone who transported hazardous substances for disposal or treatment at a contaminated site, unless the facility could legally receive the hazardous materials at the time of transport.
- Anyone who sells a hazardous substance with written instructions for its use, and abiding by the instructions results in contamination.

In situations where there is more than one potentially liable person, each person is jointly and severally liable for cleanup at the site. That means each person can be held liable for the entire cost of cleanup. In cases where there is more than one potentially liable person at a site, Ecology encourages these persons to get together to negotiate how the cost of cleanup will be shared among all potentially liable persons.

Ecology must notify anyone it knows may be a "potentially liable person" and allow an opportunity for comment before making any further determination on that person's liability. The comment period may be waived at the potentially liable person's request or if Ecology has to conduct emergency cleanup at the site.

Achieving Cleanups through Cooperation

Although Ecology has the legal authority to order a liable party to clean up, the department prefers to achieve cleanups cooperatively. Ecology believes that a non-adversarial relationship with potentially liable persons improves the prospect for prompt and efficient cleanup. The rules implementing the Model Toxics Control Act, which were developed by Ecology in consultation with the Science Advisory Board (created by the Act), and representatives from citizen, environmental and business groups, and government agencies, are designed to:

- Encourage independent cleanups initiated by potentially liable persons, thus providing for quicker cleanups with less legal complexity.
- Encourage an open process for the public, local government and liable parties to discuss cleanup options and community concerns.
- Facilitate cooperative cleanup agreements rather than Ecology-initiated orders. *Ecology can, and does, however use enforcement tools in emergencies or with recalcitrant potentially liable persons.*

What is the Potentially Liable Person's Role in Cleanup?

The Model Toxics Control Act requires potentially liable persons to assume responsibility for cleaning up contaminated sites. For this reason, Ecology does not usually conduct the actual cleanup when a potentially liable person can be identified. Rather, Ecology oversees the cleanup of sites to ensure that investigations, public involvement and actual cleanup and monitoring are done appropriately. Ecology's costs of this oversight are required to be paid by the liable party.

When contamination is confirmed at the site, the owner or operator may decide to proceed with cleanup without Ecology assistance or approval. Such "independent cleanups" are

allowed under the Model Toxics Control Act under most circumstances, but must be reported to Ecology, and are done at the owner's or operator's own risk. Ecology may require additional cleanup work at these sites to bring them into compliance with the state cleanup standards. Most cleanups in Washington are done independently.

Other than local governments, potentially liable persons conducting independent cleanups do not have access to financial assistance from Ecology. Those who plan to seek contributions from other persons to help pay for cleanup costs need to be sure their cleanup is "the substantial equivalent of a department-conducted or department-supervised remedial action." Ecology has provided guidance on how to meet this requirement in WAC 173-340-545. Persons interested in pursuing a private contribution action on an independent cleanup should carefully review this guidance prior to conducting site work.

Working with Ecology to Achieve Cleanup

Ecology and potentially liable persons often work cooperatively to reach cleanup solutions. Options for working with Ecology include formal agreements such as consent decrees and agreed orders, and seeking technical assistance through the Voluntary Cleanup Program. These mechanisms allow Ecology to take an active role in cleanup, providing help to potentially liable persons and minimizing costs by ensuring the job meets state standards the first time. This also minimizes the possibility that additional cleanup will be required in the future – providing significant assurances to investors and lenders.

Here is a summary of the most common mechanisms used by Ecology:

- **Voluntary Cleanup Program**: Many property owners choose to cleanup their sites independent of Ecology oversight. This allows many smaller or less complex sites to be cleaned up quickly without having to go through a formal process. A disadvantage to property owners is that Ecology does not approve the cleanup. This can present a problem to property owners who need state approval of the cleanup to satisfy a buyer or lender.

  One option to the property owner wanting to conduct an independent cleanup yet still receive some feedback from Ecology is to request a technical consultation through Ecology's Voluntary Cleanup Program. Under this voluntary program, the property owner submits a cleanup report with a fee to cover Ecology's review costs. Based on the review, Ecology either issues a letter stating that the site needs "No Further Action" or identifies what additional work is needed. Since Ecology is not directly involved in the site cleanup work, the level of certainty in Ecology's response is less than in a consent decree or agreed order. However, many persons have found a "No Further Action" letter to be sufficient for their needs, making the Voluntary Cleanup Program a popular option.

- **Consent Decrees:** A consent decree is a formal legal agreement filed in court. The work requirements in the decree and the terms under which it must be done are negotiated and agreed to by the potentially liable person, Ecology and the state Attorney General's office. Before consent decrees can become final, they must undergo a public review and comment period that typically includes a public hearing. Consent decrees protect the potentially liable person from being sued for "contribution" by other persons that incur cleanup expenses at the site while facilitating any contribution claims against the other persons when they are responsible for part of the cleanup costs. Sites cleaned up under a consent decree are also exempt from having to obtain certain state and local permits that could delay the cleanup.

- ***De Minimus* Consent Decree:** Landowners whose contribution to site contamination is "insignificant in amount and toxicity" may be eligible for a de minimus consent decree. In these decrees, landowner typically settle their liability by paying for some of the cleanup instead of actually conducting the cleanup work. Ecology usually accepts a de minimus settlement proposal only if the landowner is affiliated with a larger site cleanup that Ecology is currently working on.
- **Prospective Purchaser Consent Decree:** A consent decree may also be available for a "prospective purchaser" of contaminated property. In this situation, a person who is not already liable for cleanup and wishes to purchase a cleanup site for redevelopment or reuse may apply to negotiate a prospective purchaser consent decree. The applicant must show, among other things, that they will contribute substantial new resources towards the cleanup. Cleanups that also have a substantial public benefit will receive a higher priority for prospective purchaser agreements. If the application is accepted, the requirements for cleanup are negotiated and specified in a consent decree so that the purchaser can better estimate the cost of cleanup before buying the land.
- **Agreed Orders:** Unlike a consent decree, an agreed order is not filed in court and is not a settlement. Rather, it is a legally binding administrative order issued by Ecology and agreed to by the potentially liable person. Agreed orders are available for remedial investigations, feasibility studies, and final cleanups. An agreed order describes the site activities that must occur for Ecology to agree not to take enforcement action for that phase of work. As with consent decrees, agreed orders are subject to public review and offer the advantage of facilitating contribution claims against other persons and exempting cleanup work from obtaining certain state and local permits.

Ecology-Initiated Cleanup Orders

Administrative orders requiring cleanup activities without an agreement with a potentially liable person are known as **enforcement orders**. These orders are usually issued to a potentially liable person when Ecology believes a cleanup solution cannot be achieved expeditiously through negotiation or if an emergency exists. If the responsible party fails to comply with an enforcement order, Ecology can clean up the site and later recover costs from the responsible person(s) at up to three times the amount spent. The state Attorney General's Office may also seek a fine of up to $25,000 a day for violating an order. Enforcement orders are subject to public notification.

Financial Assistance

Each year, Ecology provides millions of dollars in grants to local governments to help pay for the cost of site cleanup. In general, such grants are available only for sites where the cleanup work is being done under an order or decree. Ecology can also provide grants to local governments to help defray the cost of replacing a public water supply well contaminated by a hazardous waste site. Grants are also available for local citizen groups and neighborhoods affected by contaminated sites to facilitate public review of the cleanup. See Chapter 173-322 WAC for additional information on grants to local governments and Chapter 173-321 WAC for additional information on public participation grants.

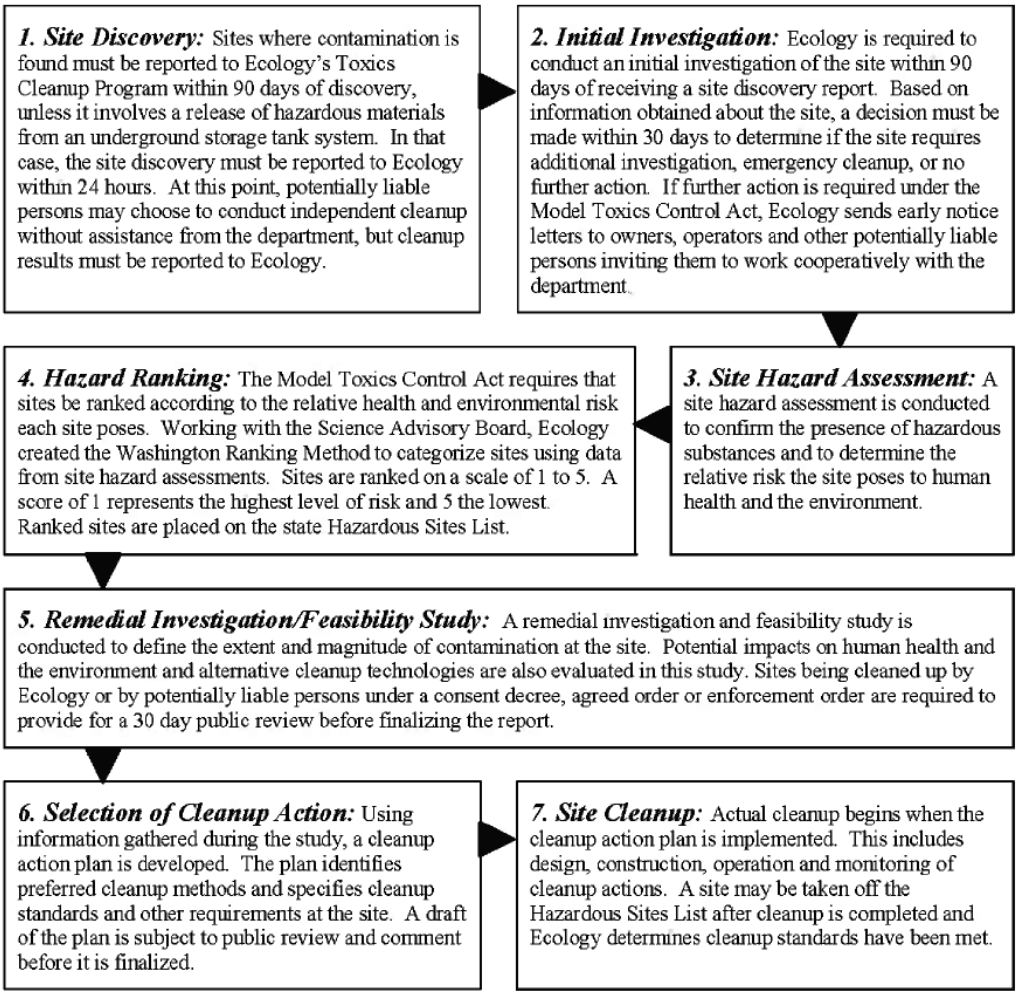
Public Involvement

Public notices are required on all agreed orders, consent decrees, and enforcement orders. Public notification is also required for all Ecology-conducted remedial actions.

Ecology's Site Register is a widely used means of providing information about cleanup efforts to the public and is one way of assisting community involvement. The Site Register is published every two weeks to inform citizens of public meetings and comment periods, discussions or negotiations of legal agreements, and other cleanup activities. The Site Register can be accessed on the Internet at: www.ecy.wa.gov/programs/tcp/pub_inv/pub_inv2.html.

How Sites are Cleaned Up

The rules describing the cleanup process at a hazardous waste site are in chapter 173-340 WAC. The following is a general description of the steps taken during the cleanup of an average hazardous waste site. Consult the rules for the specific requirements for each step in the cleanup process.



For More Information / Special Accommodation Needs

If you would like more information about the state Model Toxics Control Act, please call us toll-free at **1-800-826-7716**, or contact your regional Washington State Department of Ecology office listed below. Information about site cleanup, including a listing of ranked hazardous waste sites, is also accessible through our Internet address: http://www.ecy.wa.gov/programs/tcp/cleanup.html

- **Northwest Regional Office** **425/649-7000**
  (Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom Counties)
- **Southwest Regional Office** **360/407-6300**
  (Southwestern Washington, Olympic Peninsula, Pierce, Thurston and Mason Counties)
- **Central Regional Office** **509/575-2490**
  (Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima Counties)
- **Eastern Regional Office** **509/329-3400**
  (Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman Counties)

If you need this publication in an alternative format, please contact the Toxics Cleanup Program at (360) 407-7170. Persons with a hearing loss can call 711 for the Washington Relay Service. Persons with a speech disability can call 877-833-6341.

Disclaimer Notice: This fact sheet is intended to help the user understand the Model Toxics Control Act Cleanup Regulation, chapter 173-340 WAC. It does not establish or modify regulatory requirements.