

**PART III UNIT-SPECIFIC CONDITIONS FOR FINAL STATUS OPERATIONS**

**OPERATING UNIT 11**

**Integrated Disposal Facility**

**Chapter 5.0 Groundwater Monitoring for Land Based Units**

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## 5.0 GROUNDWATER MONITORING FOR LAND BASED UNITS [D-10]

The IDF will be a RCRA-compliant landfill (i.e., a double-lined trench with leachate collection system). This chapter describes the groundwater monitoring plan for the IDF and addresses the requirements of RCRA, as described in 40 CFR 264, Subpart F, by reference of WAC 173-303-645(3). Figure 5-1 shows the location of the IDF and surrounding groundwater wells in the 200 East Area. This chapter is designed to meet final status detection-level groundwater monitoring requirements for the IDF. This groundwater monitoring plan is based on the application of a modified data quality objectives (EPA QA/G-4) process to a conceptual model, and the most recent evaluations of groundwater hydrology and chemistry at the site.

This plan describes the characteristics of the waste to be disposed in the IDF and the site geology and hydrology used to design and operate the monitoring well network and to interpret the groundwater data. The historic groundwater chemistry from wells near the IDF site is provided. Much of the information pertaining to waste characterization is taken from HNF-4921 and that pertaining to hydrogeology from PNNL-11957, PNNL-12257, PNNL-13652, and PNNL-14029.

The plan includes a description of network well locations, well construction, sample constituents, and sampling frequency for detection-level groundwater monitoring. Procedures for determination of compliance point groundwater quality also are included. Finally, this plan provides the basis for rapid development of a compliance-monitoring plan if a validated exceedance of an indicator parameter is found. This plan controls initial baseline monitoring and subsequent detection level monitoring only for the IDF.

Source, special nuclear, and byproduct materials as defined by the *Atomic Energy Act of 1954*, as amended, are regulated at DOE facilities exclusively by DOE acting pursuant to its AEA authority. These materials are not subject to regulation by the State of Washington. All information contained herein and related to, or describing AEA-regulated materials and processes in any manner, may not be used to create conditions or other restrictions set forth in any permit, license, order, or any other enforceable instrument. DOE asserts that pursuant to the AEA, it has sole and exclusive responsibility and authority to regulate source, special nuclear and by-product materials at DOE-owned nuclear facilities. Information contained herein on radionuclides is provided for process description purposes only.

### 5.1 EXEMPTION FROM GROUNDWATER PROTECTION REQUIREMENT [D-10a]

An exemption is not requested.

### 5.2 INTERIM STATUS PERIOD GROUNDWATER MONITORING DATA [D-10b]

The IDF will be a new facility constructed in the 200 East Area. Interim status groundwater monitoring is not applicable.

### 5.3 AQUIFER IDENTIFICATION [D-10c]

The following sections discuss geology and hydrology.

#### 5.3.1 Geology of the IDF Site

The 200 East Area lies on the Cold Creek bar, a geomorphic remnant of the cataclysmic, glacial related floods of the Pleistocene Epoch. As the floodwaters raced across the lowlands of the Pasco Basin and Hanford Site, floodwaters lost energy and began to deposit sand and gravel. The 200 Area Plateau is one of the most prominent deposits. The 200 Area Plateau lies just southwest of one of the major flood channels across the Hanford Site that forms the topographic lowland south of Gable Mountain.

1 Borehole data provide the principal source of geologic, hydrologic, and groundwater information for the  
2 200 East Area and the IDF site. Numerous boreholes (both vadose zone boreholes and groundwater  
3 monitoring wells) have been drilled in the 200 East Area for groundwater monitoring and waste  
4 management studies (Figure 5-1 shows the location of groundwater wells near the IDF site.) However,  
5 data are limited within the IDF site primarily because no previous construction or waste disposal activities  
6 have occurred in this part of the Hanford Facility. Most boreholes in the 200 East Area have been drilled  
7 using the cable tool method and either a hard tool or drive barrel to advance the hole. Some boreholes  
8 have been drilled by rotary and wire-line coring methods. More recently, boreholes in the area have been  
9 drilled, and in five cases cored, by percussion hammer methods. Geologic logs are based on examination  
10 of drill core, chips, and cuttings from these boreholes. Chip samples typically are taken at 1.5-meter  
11 intervals and routinely archived at the Hanford Geotechnical Sample Library.

### 12 **5.3.1.1 Structural Framework**

13 The IDF site will be located south of the Gable Mountain segment of the Umtanum Ridge anticline and  
14 about 3 kilometers north of the axis of the Cold Creek syncline, which controls the structural grain of the  
15 basalt bedrock and the Ringold Formation. The basalt surface and Ringold Formation trend roughly  
16 southeast-northwest parallel to the major geologic structures of the site. As a result, the Ringold  
17 Formation and the underlying Columbia River Basalt Group gently dip to the south off the Umtanum  
18 Ridge anticline into the Cold Creek syncline.

19 Geologic mapping on the Hanford Site and examination of drill core and borehole cuttings in the area  
20 have not identified any faults in the vicinity of the IDF site (DOE/RW-0164). The closest known faults  
21 are along the Umtanum Ridge-Gable Mountain structure north of the disposal site and the May Junction  
22 fault east of the site (Figure 5-2).

### 23 **5.3.1.2 Stratigraphy**

24 The basalt and post-basalt stratigraphy for the IDF site is shown in Figure 5-3. Approximately 137 to 167  
25 meters of suprabasalt sediments overlie the basalt bedrock at the site.

26 **Basalt Bedrock.** Previous studies (RHO-BWI-ST-14; Reidel and Fecht 1994) have shown that the  
27 youngest lava flows of the Columbia River Basalt Group at the 200 East Area are those of the  
28 10.5 million-year old Elephant Mountain Member. This member underlies the entire 200 East Area and  
29 surrounding area and forms the base of the suprabasalts aquifer. No erosional windows in the basalt are  
30 known or suspected to occur in the area of the IDF site.

31 **Ringold Formation.** Few boreholes penetrate the entire Ringold Formation at the IDF site so available  
32 data are limited. The Ringold Formation reaches a maximum thickness of 95 meters on the west side of  
33 the site and thins eastward. The member of Wooded Island (Figure 5-3) is the only member of the  
34 Ringold Formation in the 200 East Area. The deepest Ringold Formation unit encountered is the lower  
35 gravel, unit A. Lying above unit A is the lower mud unit and overlying the lower mud unit is upper  
36 gravel, unit E. The sand and silt units of the members of Taylor Flat and Savage Island of the Ringold  
37 Formation are not present at the IDF site. Unit A and unit E are equivalent to the Pliocene-Miocene  
38 continental conglomerates (Reidel and Fecht 1994). The lower mud unit is equivalent to the  
39 Pliocene-Miocene continental sand, silt, and clay beds (Reidel and Fecht 1994).

40 Only three boreholes have penetrated unit A in the area of the IDF site. Unit A is 19 meters thick on the  
41 west side of the site and thins to the northeast. Unit A is partly to well-cemented conglomerate consisting  
42 of both felsic and basaltic clasts in a sandy matrix and is interpreted as a fluvial gravel facies (Lindsey  
43 1996). There are minor beds of yellow to white interbedded sand and silt. Green-colored, reduced-iron  
44 stain is present on some grains and pebbles. Although the entire unit appears to be cemented, the zone  
45 produced abundant high-quality water in borehole 299-E17-21 (PNNL-11957).

1 Nineteen meters of the lower mud unit were encountered in one borehole at the IDF site (PNNL-11957).  
2 The upper most 1 meter or so consists of a yellow mud to sandy mud. The yellow mud grades downward  
3 into about 10 meters of blue mud. The blue mud, in turn, grades down into 7 meters of brown mud with  
4 organic rich zones and occasional wood fragments. The lower mud unit is absent in the center of the site  
5 (northeast of borehole 299-E24-7 on Figure 5-4).

6 Unit E is described as a sandy gravel to gravelly sand. Unit E is interpreted to consist of as much as  
7 15 meters of conglomerate with scattered large pebbles and cobbles up to 25 centimeters in size in a  
8 sandy matrix. The gravel consists of both felsic and basaltic rocks that are well rounded with a sand  
9 matrix supporting the cobbles and pebbles. Cementation of this unit ranges from slight to moderate. The  
10 upper contact of unit E is not identified easily at the IDF site. In the western part of the study area,  
11 unconsolidated gravels of the Hanford formation directly overly the Ringold Formation unit E gravels,  
12 making exact placement of the contact difficult. The dominance of basalt and the absence of cementation  
13 in the Hanford formation are the key criteria used to distinguishing these here (PNNL-11957). In the  
14 central and northeast part of the area, unit E has been eroded completely. Unconsolidated gravels and  
15 sands typical of the Hanford formation replace unit E.

16 **Unconformity at the Top of the Ringold Formation.** The surface of the Ringold Formation is irregular  
17 in the area of the IDF site. A northwest-southeast trending erosional channel or trough (the Columbia  
18 River/Missoula flood channel) is centered through the northeast portion of the site. The trough is deepest  
19 near borehole 299-E24-21 in the northern part of the site (PNNL-13652). This trough is interpreted as  
20 part of a larger trough under the 200 East Area resulting from scouring by the Missoula floods. Borehole  
21 299-E17-21, located at the southwest corner of the IDF site, is at the west side of the channel where  
22 approximately 46 meters of Ringold Formation have been removed and replaced by Hanford formation  
23 gravels. Boreholes 299-E17-25 and 299-E17-23, located along the southeastern edge of the Site, are near  
24 the deepest portion of the channel where it is interpreted that almost all of the Ringold Formation has  
25 been eroded. At this location the water table in the channel is interpreted to be 52 meters above the basalt,  
26 which forms the floor of the channel. The surface of basalt rises to the north where the water table is  
27 approximately 27 meters above the basalt at the northeast corner of the site near borehole 299-E24-21.

28 **Hanford formation.** The Hanford formation is as much as 116 meters thick in and around the IDF site.  
29 The Hanford formation thickens in the erosional channel cut into the Ringold Formation and thins to the  
30 southwest along the margin of the channel.

31 At the IDF site, the Hanford formation consists mainly of sand dominated facies with lesser amounts of  
32 silt dominated and gravel dominated facies. The Hanford formation has been described as poorly sorted  
33 pebble to boulder gravel and fine- to coarse-grained sand, with lesser amounts of interstitial and  
34 interbedded silt and clay. In previous studies of the site (WHC-MR-0391), the Hanford formation was  
35 described as consisting of three units: an upper and lower gravel facies and a sand facies between the two  
36 gravelly units. The upper gravel dominated facies appears to be thin or absent in the immediate area of  
37 the IDF site (PNNL-12257, PNNL-13652, and PNNL-14029).

38 The lowermost part of the Hanford formation encountered in boreholes at the IDF site consists of the  
39 gravel dominated facies. Drill core and cuttings from boreholes 299-E17-21, 299-E17-22, 299-E17-23,  
40 299-E17-25, and 299-E24-21 indicate that the unit is a clast-supported pebble- to cobble-gravel with  
41 minor amounts of sand in the matrix. The cobbles and pebbles almost are exclusively basalt with no  
42 cementation. This unit pinches out west of the IDF site and thickens to the east and northeast  
43 (Figure 5-4). The water table beneath the IDF site is located in the lower gravel unit. The lower gravel  
44 unit is interpreted to be Missoula flood gravels deposited in the erosional channel carved into the  
45 underlying Ringold Formation.

46 The upper portion of the Hanford formation consists of at least 73 meters of fine- to coarse-grained sand  
47 with minor amounts of silt and clay and some gravelly sands.

1 **Holocene Deposits.** Holocene, eolian deposits cover the southern part of the IDF site. Caliche coatings  
2 on the bottom of pebbles and cobbles in drill cores through this unit are typical of Holocene caliche  
3 development in the Columbia Basin. The southern part of the IDF site is capped by a stabilized sand  
4 dune. The eolian unit is composed of fine- to coarse-grained sands with abundant silt, as layers and as  
5 material mixed with the sand.

6 **Clastic Dikes.** A clastic dike was encountered in borehole C3828, adjacent to well 299-E17-25, at the  
7 IDF site. Clastic dikes also have been observed in excavations surrounding the site [e.g., US Ecology, the  
8 former Grout area, the 216-BC cribs, the Central Landfill, and the Environmental Restoration Disposal  
9 Facility (BHI-01103)]. In undisturbed areas, such as the IDF site, clastic dikes typically are not observed  
10 because these are covered by wind blown sediments. The occurrence of a clastic dike in borehole C3828  
11 suggests that these probably are present elsewhere in the subsurface at the disposal site. The IDF  
12 excavation will be geologically mapped to document the occurrence of any clastic dikes that may exist at  
13 the site.

### 14 **5.3.2 Groundwater Hydrology**

15 The unconfined aquifer under the IDF site occurs in the fluvial gravels of the Ringold Formation and  
16 flood deposits of the Hanford formation. The thickness of the aquifer ranges from about 70 meters at the  
17 southwest corner of the site to about 30 meters under the northeast corner of the IDF site. The Elephant  
18 Mountain Member of the Columbia River Basalt Group forms the base of the unconfined aquifer  
19 (Figure 5-4).

20 The unsaturated zone beneath the land surface at the IDF site is approximately 100 meters thick and  
21 consists of the Hanford formation. The water level in boreholes in and around the site indicates that the  
22 water table is in the lower gravel sequence of the Hanford formation and at an elevation of approximately  
23 123 meters above sea level. The water table is nearly flat beneath the IDF site. Table 5-1 gives water  
24 level information from wells near the site. The locations of the wells are shown on Figure 5-1. The latest  
25 water table map shows less than about 0.1 meter of hydraulic head differential across the IDF site  
26 (Figure 5-5).

27 The Ringold Formation lower mud unit occurs within the aquifer at the southwest corner of the IDF site  
28 (299-E17-21) but is absent in the central and northern parts of the site (299-E24-7 and 299-E24-21). The  
29 lower mud unit is known to be a confining or partly confining layer at places under the Hanford Site  
30 (PNNL-12261) and this might be the case under the southwest corner of the IDF site. Groundwater  
31 samples were collected and analyzed from above and below the lower mud unit during drilling of well  
32 299-E17-21. Chemical parameters (pH, electrical conductivity, and Eh) were different in the two samples  
33 suggesting that the lower mud is at least partly confining in the area. No contamination was found above  
34 or below the lower mud. An interpretation of the distribution and thickness of this stratum is shown in  
35 Figure 5-4. The surface of the lower mud unit is interpreted to dip gently to the southwest  
36 (PNNL-13652).

37 Hydrographs for selected wells near the IDF site are shown in Figure 5-6. Although the water table is  
38 extremely flat in the area of the IDF, hydrographs suggest that groundwater flow has had an easterly  
39 component throughout the 1990s and has not significantly changed due to cessation of discharges to the  
40 216 B pond system. Hydrographs for the older wells (299-E23-1, 299-E23-2, and 299-E24-7) show two  
41 maxima in the water level. These coincide with the operation of the PUREX Plant, which operated  
42 between 1956 and 1972 and between 1983 and 1988. All the hydrographs show a decline in the water  
43 table during recent years. The rate of decline is between 0.18 and 0.22 meter per year and will take  
44 between 10 and 30 years to stabilize. The reason for the decline is the cessation of effluent discharge to  
45 the 216-B Pond System, which is centered northeast of 200 East Area. Based on hindcast water table  
46 maps (BNWL-B-360), the water table is expected to decline another 2 to 7 meters before reaching

1 pre-Hanford Site elevations. The cessations of effluent discharge also are responsible for changes in the  
2 direction of groundwater flow across much of the 200 East Area.

3 Groundwater flow beneath the IDF site recently was modeled to be southeasterly (PNNL-13400). This  
4 direction differs from the easterly direction predicted by the analysis of WHC-SD-WM-RPT-241 and  
5 other earlier reports. The southeasterly flow direction primarily is attributable to inclusion of the highly  
6 permeable Hanford formation sediments in the ancestral Columbia River/Missoula flood channel in the  
7 analysis. A southeasterly flow direction is reflected in the geographic distribution of the regional nitrate  
8 plume and in the distribution of other constituents under the south-central 200 East Area (PNNL-14187).  
9 As stated in PNNL-13404, the water table gradient is too low to be used for determining flow direction or  
10 flow rate at the PUREX Plant cribs immediately east of the IDF site.

11 Hydraulic conductivity directly beneath the IDF site was estimated from data collected during four slug  
12 tests at well 299-E17-21 and five slug tests of 299-E24-21. The interval tested at 299-E17-21 was the  
13 upper 7.8 m of the unconfined aquifer from 101.3 to 109.1 m depth. That portion of the aquifer is  
14 Hanford formation gravel from 101.3 to 102.1 m depth and Ringold Formation unit E gravels from 102.1  
15 to 109.1 m depth (PNNL-11957). The interval tested at well 299-E24-21 was entirely in the Hanford  
16 formation gravel sequence between 95.2 and 101.3 m depth. The best-fit value to the data from  
17 299-E17-21 indicated a hydraulic conductivity of about 68.6 meters per day (PNNL-11957) and from  
18 299-E24-21 suggested a hydraulic conductivity of 75 meters per day (PNNL-13652).

## 19 **5.4 CONTAMINANT PLUME DESCRIPTION [D-10d]**

20 Although no groundwater monitoring has been done for the IDF, groundwater monitoring has been done  
21 in support of RCRA permitting activities and in support of other activities in the area. The results of that  
22 monitoring show that a regional nitrate plume exists beneath the IDF site (PNNL-14187). In the  
23 south-central 200 East Area, the plume extends in a northwest - southeast direction along the axis of the  
24 Columbia River/Missoula flood channel eroded into the Ringold Formation sediments. The channel is  
25 filled with more transmissive Hanford formation sediments.

### 26 **5.4.1 Groundwater Contamination**

27 Nitrate, associated with past-practice activities in 200 East Area, is a general groundwater chemistry  
28 parameter and is not a contaminant of concern for the IDF. However, the distribution of existing nitrate  
29 in the groundwater gives an indication of the general groundwater flow direction and the influence that  
30 adjacent sites might have on the IDF.

31 High nitrate concentrations found near liquid waste disposal facilities located outside the IDF site that  
32 received effluent from the PUREX Plant are decreasing steadily with time. The highest nitrate  
33 concentration found in 2002 was 170,000 µg/L in well 299-E17-9 at the 216-A-36B crib and the crib is  
34 thought to be the source of the nitrate. The drinking water standard for nitrate is 45,000 µg/L (nitrate  
35 ion).

36 Nitrate in well 299-E24-18, just inside the east boundary of the IDF site, decreased from a high of  
37 86,300 µg/L in 1990 to a low of 17,000 µg/L in 1993, reflecting the cessation of PUREX Plant operations  
38 in 1988. Since 1993, nitrate has increased to 48,300 µg/L in 2003 (Figure 5-7). The reason for the  
39 increase is not understood. One possibility is related to changing groundwater flow direction. During  
40 PUREX Plant operations, flow direction was probably to the northwest because of effluent discharges to  
41 the B Pond System and PUREX Plant cribs, and nitrate contamination might have spread to the northwest  
42 during that period. Subsequently, liquid discharges to the B Pond System and PUREX Plant cribs have  
43 ceased and the flow direction in the area of the IDF site apparently has returned to the southeast direction.  
44 With that change, higher levels of nitrate-contaminated groundwater might be returning to the area from  
45 the northwest.

1 Except for an anomalous value of 82,600 µg/L in 1988, nitrate concentration in well 299-E24-7 was fairly  
2 steady and ranged between 12,800 and 35,400 µg/L between 1985 and 1996 when the well was last  
3 sampled (Figure 5-7). The last two measured values from 1995 and 1996 were 26,000 µg/L. Farther  
4 southwest, nitrate detected in 1998 in well 299-E17-21 in Ringold unit E was 23,600 µg/L.

#### 5 **5.4.2 Vadose Zone Contamination**

6 Very little characterization and monitoring of the soil have been done at the IDF site because no major  
7 construction or waste disposal activities have occurred in this part of the Hanford Site. A pre-operational  
8 environmental monitoring plan (RPP-6877) for the disposal facility was issued in 2000. Implementation  
9 of that plan has begun and characterization activities will occur during the next few years. The  
10 pre-operational environmental monitoring plan has a strong emphasis on vadose zone characterization and  
11 deferred groundwater monitoring to this groundwater monitoring plan. Vadose zone information  
12 resulting from pre-operational monitoring will be included, if applicable, in updates to this groundwater  
13 monitoring plan.

14 The pre-operational monitoring plan identified three areas near the IDF site that might have had an  
15 influence on the vadose zone beneath the site. These are the 218-E-1 Burial Ground and an unplanned  
16 release associated with the burial ground; the coal ash pile in the northwest part of the site; and a transfer  
17 line along the northern part of the west boundary of the IDF site (RPP-6877). Work was outlined in the  
18 pre-operational monitoring plan to determine whether these three areas had introduced contamination to  
19 the site. Appropriate results from pre-operational monitoring will be incorporated into this groundwater  
20 monitoring plan as results become available and as revisions are needed.

21 In addition to these facilities, the 216-A-38-1, 216-A-45, and 216-A-10 cribs and the 299-E24-111  
22 injection well are located east of the IDF site. The 216-A-38-1 crib never was used (DOE/RL-92-04).  
23 The 299-E24-111 injection well never received any waste (DOE/RL-92-04). The 216-A-45 and the  
24 216-A 10 cribs both received large quantities of liquid waste (DOE/RL-92-04). Because these latter two  
25 facilities are more than 200 meters from the IDF site, it is unlikely these facilities have affected the soil  
26 beneath the IDF site. Data from the vadose zone in IDF wells drilled along the east side of the site  
27 support this.

### 28 **5.5 DETECTION MONITORING PROGRAM [D-10e]**

29 Because the IDF has not been constructed, no contaminants have been released to the ground or to the  
30 groundwater.

#### 31 **5.5.1 Indicator Parameters, Waste Constituents, Reaction Products to be Monitored [D-10e(1)]**

##### 32 **Regulated Constituents**

33 The regulated constituents for this groundwater monitoring plan are the constituents identified on the  
34 Part A Permit application included in Chapter 1 of this document.

##### 35 **Monitoring Parameters**

36 The parameters to be routinely monitored are listed in Table 5.2. These parameters include the indicator  
37 parameters and supplemental parameters.

38 The indicator parameters will be used to monitor for hazardous constituents reaching the groundwater as a  
39 result of IDF operations. Only the indicator parameters are subject to the statistical methods described in  
40 Section 5.5.4.7. Total organic carbon and total organic halides are indicator parameters selected to  
41 monitor impacts of RCRA regulated organic constituents on the groundwater quality. Specific  
42 conductance is selected as an indicator parameter to monitor impacts of metals and anions on

1 groundwater quality. pH is a general indicator of groundwater quality. Specific conductance and pH are  
2 measured in the field at the time of sampling. Chromium is included as an indicator parameter because  
3 hexavalent chromium is one of the more mobile of the regulated metals to be disposed of at the IDF and  
4 should be one of the first constituents to enter groundwater if the regulated facility impacts groundwater.

5 Analyses of alkalinity, anions, and metals are to provide supplemental data on general groundwater  
6 chemistry beneath the IDF. This information aids data interpretation and quality control. Supplemental  
7 parameters will not be used in statistical evaluations. Turbidity is analyzed at the well just before  
8 sampling and provides an indication of the groundwater condition at the time of sampling.

9 For the first year of monitoring, all parameters listed in Table 5-2 will be monitored twice each quarter to  
10 determine background concentrations. After the first year, indicator and supplemental parameters will be  
11 monitored semi-annually. In addition, field measurements of temperature and turbidity will be made at  
12 each sampling event.

13 During the first sampling event at each well for the first year of monitoring, samples will be collected for  
14 analysis of the indicator parameters, the supplemental parameters, and the Appendix IX constituents (40  
15 CFR 264) included in Chapter 1 of this permit application. After the first sampling event, samples will be  
16 collected for analysis of indicator parameters and supplemental parameters only.

17 After the first year of sampling, if an indicator parameter suggests there is an impact to groundwater,  
18 additional samples will be collected to verify the initial results. If a statistically significant increase in any  
19 indicator parameter is confirmed, analyses will be made for the regulated parameters in Chapter 1.

#### 20 **5.5.1.1 Dangerous Waste Characterization [D-10e(1)(a)]**

21 This section describes the waste to be disposed in the IDF and gives background information on how the  
22 constituents of concern (regulated constituents) and indicator parameters were selected.

#### 23 **Volume of the Waste Package**

24 The IDF will be a single, expandable disposal facility constructed to RCRA Subtitle C standards, half of  
25 which is for disposal of mixed waste the other half will be for disposal of low-level waste. Initial capacity  
26 for mixed waste disposal is 82,000 cubic meters of waste with an ultimate capacity of up to 450,000 cubic  
27 meters of waste. Disposal capacity beyond the initial 82,000 cubic meters will require a modification to  
28 the Part B Permit. The mixed waste types to be disposed in the IDF include vitrified LAW from the RPP-  
29 WTP and DBVS. Additionally, mixed waste generated by IDF operations will be disposed of in IDF.

30 The vitrified LAW will be mostly silicate glass monoliths. The RPP-WTP packages nominally measure  
31 approximately 1.22 m diameter by 2.3 m high and the DBVS package nominally measure approximately  
32 2.4 m wide by 3.1 m high by 7.3 m long. Vitrified LAW will be remote handled.

33 If other forms of immobilized LAW are considered in the future, this monitoring plan will be amended.

34 Mixed waste generated through waste operations at IDF will be packaged based on the size of the waste,  
35 with the most common container being galvanized or aluminized 208 liter containers.

#### 36 **Composition of the Waste Packages**

37 HNF-4921 provides detailed estimates for the inventory of hazardous chemicals in the vitrified LAW feed  
38 and in the vitrified LAW package. The composition of the vitrified LAW package was estimated in  
39 HNF-4921 based on

40 (1) the Tank Waste Retrieval System Characterization Program tank-by-tank Best Basis Inventories,

- 1 (2) the latest U.S. Department of Energy, Office of River Protection (DOE/ORP) guidance,
- 2 (3) the requirements for waste retrieval and vitrification,
- 3 (4) available information from waste treatment plant contractors, and (5) proposed operating scenarios for
- 4 retrieval of waste from DSTs and SSTs.

#### 5 **5.5.1.2 Behavior of Constituents [D-10e(1)(b)]**

6 Almost all of the regulated constituents for the IDF show some degree of retardation in the vadose zone  
7 and in the saturated zone. Table 5.3 indicates the range of expected behaviors in the subsurface at the  
8 IDF for selected regulated constituents. The constituents in Table 5.3 were selected by comparing the  
9 expected constituents in the vitrified LAW package (from HNF-4921) and the historical inventories of the  
10 Hanford Site low-level burial grounds (from WHC-MR-0008 and WHC-SD-EN-AP-015) to 40 CFR 264,  
11 Appendix IX (see Chapter 1). The mobilities and solubilities in Table 5.3 give an estimated range for the  
12 properties of the constituents of concern.

#### 13 **5.5.1.3 Detectability [D-10e(1)(c)]**

14 The detection limits in groundwater for each RCRA regulated constituent and the indicator parameters are  
15 given in Table 5-4.

#### 16 **5.5.2 Groundwater Monitoring Program [D-10e(2)]**

17 The following sections provide a description of wells, equipment decontamination, representative  
18 samples, and monitoring wells that are not upgradient.

#### 19 **5.5.2.1 Description of Wells [D-10e(2)(a)]**

20 The groundwater monitoring well network for the IDF ultimately will have eight wells: three  
21 hydraulically upgradient of the facility and five hydraulically downgradient. The downgradient wells will  
22 be placed to sample groundwater passing the point of compliance. The point of compliance at the IDF  
23 site is a plane connecting the groundwater monitoring wells along the southern and eastern sides of the  
24 site in accordance with WAC 173-303-645 (6), which states "The point of compliance is a vertical surface  
25 located at the hydraulically downgradient limit of the waste management area that extends down into the  
26 uppermost aquifer underlying the regulated unit". The monitoring network will consist of existing and  
27 new, downgradient wells to complete the monitoring network. All wells will be WAC 173-160  
28 compliant.

29 Three upgradient wells will be used for the IDF monitoring network. Two of these wells (299-E18-1 and  
30 299-E24-21) are existing wells. Upgradient well 299-E24-21 was installed in March 2001 for  
31 characterization of the IDF site. The well, located at the northeast corner of the site (Figure 5-8), was  
32 constructed to RCRA standards as per WAC 173-160. Well 299-E18-1 was installed in 1988 as part of  
33 the 2101-M RCRA monitoring network. The well currently has 2 to 3 meters of water above the bottom  
34 of the screened interval.

35 The third upgradient well will be a new well located at the northwest corner of the IDF (Figure 5-8). The  
36 well will be constructed to RCRA standard as per WAC 173-160 and screened at the water table.

37 Three of the downgradient wells are existing wells (299-E17-22, 299-E17-23, and 299-E17-25) that were  
38 installed as WAC 173-160 compliant wells in 2002. Their location is shown in Figure 5-8. The  
39 remaining two downgradient wells will be installed in a sequence coordinated with the IDF operations.

40 Three phases of trench construction are assumed for the purposes of this monitoring plan. Excavation for  
41 the first phase is scheduled for September 2004 and a new phase is planned for every ten subsequent

1 years. Changes in the planned operations of the IDF will be reflected in changes to this groundwater  
2 monitoring plan as needed.

3 The first new downgradient well will be installed along the eastern side of the facility (Figure 5-8) at least  
4 one year before the IDF receives waste. The second new downgradient well will be installed along the  
5 southern boundary of the Site at least one year before the third phase of waste disposal becomes  
6 operational. Both wells will be installed such that at least one year of background data can be obtained  
7 prior to the associated operational phase becoming active. Figure 5-8 shows the sequence for both  
8 groundwater well construction and waste disposal. The locations of all existing and new wells in the IDF  
9 monitoring network are noted on the figure.

10 The placement of the wells for the IDF monitoring network was based on professional judgment. The  
11 efficiency of the resulting groundwater monitoring network was evaluated using a simple two  
12 dimensional, horizontal transport model called the monitoring efficiency model (MEMO) (Wilson et al.  
13 1992). The model estimates the efficiency of a monitoring network at the point of compliance. The  
14 model simulates a contaminant plume originating from a series of grid points within the disposal facility  
15 using the Domenico-Robbins method (Domenico and Robbins 1985). The model calculates both  
16 advective flow and dispersive flow in two dimensions and determines whether the resulting plume will be  
17 detected by a monitoring well before the plume travels some selected distance beyond the disposal facility  
18 boundary. The selected distance is termed the buffer zone. (A longitudinal dispersivity of 95 meters and  
19 horizontal dispersivity of 9.5 meters were used to evaluate the monitoring network in Figure 5-8.)  
20 Outputs from the model are the monitoring efficiency and a map of the disposal facility showing areas  
21 where leaks would not be detected under the given site-specific parameters provided as input to the  
22 model. Monitoring efficiency is defined as the ratio of the area within a disposal facility from which a  
23 release likely would be detected to the total area of the disposal facility, expressed as a percentage.

24 The monitoring efficiency calculated by the MEMO model for the proposed monitoring network is 100%  
25 for phase I, 98% for phase II, and 99% for phase III (Figure 5-8).

26 All wells for the IDF site will be constructed to meet WAC 173-160 requirements. The wells will be  
27 protected at the surface with a concrete pad, protective posts, a protective outer casing, and locking cap.  
28 The casing and screen will be stainless steel, an appropriate filter pack for the screen slot size will be  
29 used, and an annular seal of bentonite and cement will be emplaced. All wells will be screened at the  
30 water table with 10.6 meter long screens, which will accommodate the greatest possible future decrease in  
31 water level. The wells will be developed and dedicated sampling pumps will be installed.

32 New wells will be surveyed with a down hole gyroscope at the time of construction to determine any  
33 deviation from vertical so that corrections can be made to subsequent water level measurements.  
34 Gyroscope surveys will also be conducted on existing wells in the network prior to IDF operations.

### 35 **5.5.2.2 Equipment Decontamination [D-10e(2)(b)]**

36 Drilling equipment will be decontaminated using high temperature and pressure [82°C (180°F) and  
37 greater than 70.3 kg/cm<sup>2</sup> (1,000 psi)] washing with an approved cleaning solution. The equipment will be  
38 rinsed with clean water. The procedure is specified in controlled manuals.

39 Equipment for collecting soil samples during drilling for later chemical analysis and for measuring the  
40 water table will be decontaminated according to established methods. The methods call for washing  
41 equipment with phosphate-free detergent, rinsing three times with reverse osmosis/de-ionized water,  
42 rinsing once with 1M or 10% nitric acid (glass or stainless steel equipment only), rinsing three more times  
43 with reverse osmosis/de-ionized water, and a final rinse with chromatograph grade hexane. Equipment  
44 will be dried for 50 minutes at 100°C (212°F). After drying, equipment will be wrapped in unused  
45 aluminum foil and sealed with tape.

1 No decontamination of groundwater sampling equipment will be necessary because each well will have a  
2 dedicated pump.

3 **5.5.2.3 Representative Samples [D-10e(2)(c)]**

4 No groundwater chemistry data specific to the IDF site are available. Sample representativeness will be  
5 addressed after collection of the first year of background data.

6 **5.5.2.4 Locations of Background Groundwater Monitoring Wells that are not Upgradient**  
7 **[D-10e(2)(d)]**

8 All background groundwater monitoring wells at the IDF are located upgradient.

9 **5.5.3 Background Values**

10 Groundwater background (baseline) has not been established for the IDF site. Background data will be  
11 determined before construction of the site using the wells described previously (Section 5.5.2.1) for the  
12 use of upgradient vs. downgradient comparisons (Section 5.5.4.7).

13 **5.5.3.1 Plan for Establishing Groundwater Quality Data [D-10e(3)(b)]**

14 Well location, sampling frequency, sampling quantity, and background values are discussed in the  
15 following sections.

16 **5.5.3.1.1 Well Locations [D-10e(3)(b)(i)]**

17 Groundwater monitoring wells in the IDF monitoring network were described in Section 5.5.2.1 and their  
18 locations are shown on Figure 5-8.

19 **5.5.3.1.2 Sampling Frequency [D-10e(3)(B)(ii)]**

20 Eight background samples will be collected during the first year of monitoring from phase I wells. Two  
21 samples will be collected quarterly for one year. For the new well needed for phase III operations, two  
22 samples will be collected quarterly for one year before phase III is operational. For all wells, two  
23 independent samples will be collected each quarter, one per month for 2 consecutive months followed by  
24 a month of non-sampling. This sequence will be repeated each quarter during the first year of monitoring.  
25 Section 5.5.3.1.3 provides frequency logic.

26 **5.5.3.1.3 Sampling Quantity [D-10-e(3)(b)(iii)]**

27 The performance of the statistical method proposed for the IDF is evaluated by the following two goals:

- 28 • To have adequate statistical power to detect real contamination when contamination occurs
- 29 • To keep the network-wide Type I error (across all constituents and wells being tested) at an  
30 acceptably low level (approximately 5%). [Note that the Type I error in the detection monitoring  
31 stage equates to the false positive rate, that is, the probability that the test will indicate contamination  
32 has occurred although no contamination has truly occurred.]

33 The statistical power and the network-side false-positive rate of a test depend on several factors, including  
34 the background sample size, the type of proposed test, and the number of comparisons. All other factors  
35 being equal, the larger the sample size is (i.e., the number of background samples), the greater the  
36 statistical power is. Therefore, as recommended in EPA/530-R-93-003, at least eight independent  
37 samples will be collected from each well for background purposes. This is a sufficient number of samples

1 to establish a reliable background (EPA/530-R-93-003) and meets the regulations in WAC-173-303-  
2 645(9)(d).

### 3 **5.5.3.1.4 Background Values**

4 The default method of analysis of variance (ANOVA) will be used to detect any impact on groundwater  
5 quality at the IDF where the mean of the measurements from compliance (downgradient) wells is  
6 compared to the mean of the distribution of background data from the upgradient wells. The details of the  
7 method are described in Section 5.5.4.7.1.

## 8 **5.5.4 Sampling, Analysis and Statistical Procedures [D-10e(4)]**

9 Sample collection, sample preservation and transfer/shipment, analytical procedures, chain of custody and  
10 additional requirements for compliance point monitoring are discussed in the following sections.

### 11 **5.5.4.1 Sample Collection [D-10e4(a)]**

12 Groundwater sampling procedures, sample collection documentation, sample preservation and  
13 transfer/shipment, and chain-of-custody requirements are described in subcontractor operating  
14 procedures/manuals and in a quality assurance project plan for the Hanford Groundwater Performance  
15 Assessment Project. Quality requirements for sampling activities, including requirements for procedures,  
16 containers, transport, storage, chain of custody, and records requirements, are specified in a statement of  
17 work (SOW) to subcontractors. To ensure that samples of known quality are obtained, the subcontractor  
18 will be required to use contractor-controlled procedures based on standard methods for groundwater  
19 sampling whenever possible. The procedures will be reviewed for technical quality and consistency. In  
20 addition, periodic assessments of sample collection activities will be performed to further ensure that  
21 procedures are followed to maintain sample quality and integrity. The following is a brief description of  
22 the sampling requirements.

23 Samples generally will be collected after three casing volumes of groundwater are withdrawn or after the  
24 field parameters pH, temperature, and specific conductance have stabilized. Field parameters are  
25 measured in a flow-through chamber. Turbidity should be equal to or below 5 NTU (nephelometric  
26 turbidity units) before sample collection if possible. Sample preservatives will be added to the collection  
27 bottles in the laboratory before their use in the field. Samples to be analyzed for metals will be filtered in  
28 the field to ensure results represent dissolved metals and do not include particulates (40 CFR 136.3).  
29 Duplicates, trip blanks, and field equipment blanks will be collected as part of the general quality control  
30 program.

31 Water level measurements will be made each time a well is sampled. Procedures developed in  
32 accordance with the techniques described in American Society for Testing and Materials (1988), Garber  
33 and Koopman (1968), OSWER 9950.1, and U. S. Geological Survey (1977) will be followed to measure  
34 water levels. Water levels will be measured primarily with laminated steel electrical sounding tapes,  
35 although graduated steel tapes are used occasionally.

### 36 **5.5.4.2 Sample Preservation and Shipment [D-10e(4)(b)]**

37 Sample preservation will be done in accordance with existing procedures. A chemical preservative label  
38 will be affixed to the sample container listing the specific preservative. The brand name, lot number,  
39 concentration, and date opened of the preservatives will be recorded. A calibrated dispenser or pipette  
40 will be used to dispense preservatives. Appropriate measures will be taken to eliminate any potential for  
41 cross contamination.

42 Sample packaging and transfer/shipping will be done in accordance with subcontract procedures.  
43 Samples will be labeled and sealed with evidence tape, wrapped with bubble wrap, and placed in a

1 Department of Transportation approved container with coolant (if required). Hazardous samples will  
2 have packaging parameters determined by associated hazards. A chain of custody will accompany all  
3 samples.

#### 4 **5.5.4.3 Analytical Procedures [D-10e(4)(c)]**

5 The methods for analysis of chemical constituents in groundwater will conform to *Test Methods for*  
6 *Evaluating Solid Wastes: Physical/Chemical Methods, 3<sup>rd</sup> Ed.* (SW-846); *Methods for Chemical Analysis*  
7 *of Water and Wastes* (EPA-600/4-79-020) or other EPA methods; and the *Annual Book of ASTM*  
8 *Standards* (American Society for Testing and Materials, 1986). The methods used to obtain routine data  
9 results are presented in Table 5-4.

#### 10 **5.5.4.3.1 Data Storage and Retrieval**

11 All contract analytical laboratory results will be submitted by the laboratory to be loaded into the Hanford  
12 Environmental Information System (HEIS) database. Most data are received from the laboratory in  
13 electronic form, and will be loaded electronically. Parameters measured in the field will be entered into  
14 HEIS either manually or through electronic transfer. Hard copy data reports are received for records  
15 storage. Data from the HEIS database will be retrieved for data validation, data reduction, and trend  
16 analysis. Copies of supporting analytical data will be sent yearly to Pacific Northwest National  
17 Laboratory (PNNL) for storage.

#### 18 **5.5.4.3.2 Data Verification and Validation**

19 Verification of analytical data provided by the subcontracted laboratory will be performed in accordance  
20 with established procedure. This procedure includes checks for: (1) completeness of hardcopy  
21 deliverable, (2) condition of samples on receipt by the laboratory, (3) problems that arose during the  
22 analysis of the samples, and (4) correct reporting of results. The procedure also describes the actions to  
23 be taken if data are incomplete or deficient.

24 Verification and validation of groundwater chemistry data will be performed according to established  
25 procedures. Data will be reviewed quarterly to assure the data are complete and representative. The  
26 review will include evaluation of quality control data (e.g., field blanks, duplicates, and laboratory blanks)  
27 and a technical review by a project scientist familiar with the hydrogeology of the site. The technical  
28 review might include comparison of recent data to historical trends and comparison of related  
29 constituents. Suspect data will be investigated through the data review process in accordance with  
30 established procedures and will be flagged in the database.

#### 31 **5.5.4.3.3 Reporting**

32 Groundwater chemistry and water level data will be reviewed after each sampling event and will be  
33 available in the HEIS database. The results of the statistical evaluation and associated information will be  
34 submitted to Ecology quarterly in Hanford Site groundwater monitoring reports.

35 If statistically significant evidence of contamination is determined (after waste has been introduced to the  
36 facility and after the confirmation re-sampling evaluation process) for one or more of the indicator  
37 parameters at any monitoring well at the compliance point, and if the owner or operator decides not to  
38 make a false-positive claim, the following will be performed.

- 39 • Notify Ecology in writing within 7 days of the finding indicating which chemical parameters or  
40 dangerous waste constituents have shown statistically significant evidence of contamination.
- 41 • Determine whether dangerous constituents are present and, if so, in what concentration.

- 1 • The owner or operator might re-sample within 1 month and repeat the analysis for those compounds  
2 detected in the above (i.e., second bullet). The resample data will be compared with the trigger value.
- 3 • Submit an application for a permit modification, if necessary, to establish a compliance-monitoring  
4 program to Ecology in 90 days or within the time agreed to in writing by Ecology.
- 5 The dangerous constituents detected, either in the initial analysis or in the second confirmation analysis,  
6 will form the basis for compliance monitoring.
- 7 In case of a false-positive claim [as allowed by WAC 173-303-645 (9)(g)(vi)], the following will apply.
- 8 • Notify Ecology in writing within 7 days of the finding (i.e., exceedance) and indicate that a  
9 false-positive claim will be made.
- 10 • Submit a report to Ecology within 90 days or within the time agreed to in writing by Ecology. This  
11 report should demonstrate that a source other than the regulated unit caused the contamination or that  
12 the contamination resulted from an error in sampling, analysis, evaluation, or natural variation in  
13 groundwater chemistry.
- 14 • Submit an application for a permit modification, if necessary, to make any appropriate changes to the  
15 detection-monitoring program within 90 days or within the time agreed to in writing by Ecology.
- 16 • Continue to monitor in accordance with the detection-monitoring program.
- 17 • Submit an application for a permit modification, if the detection monitoring program is determined to  
18 no longer satisfy the requirements [of WAC 173-303-645(9)], to make any appropriate changes to the  
19 program within 90 days or within the time agreed to in writing by Ecology.

#### 20 **5.5.4.4 Chain of Custody [D-10e(4)(d)]**

21 The procedures used for chain-of-custody control of samples are documented in existing manuals. The  
22 procedure requires that each transfer of custody shall be documented by the signatures of the custodian  
23 relinquishing the samples and the custodian receiving the samples, as well as the time and date of transfer.  
24 The laboratory custodian will sign and date the chain-of-custody form upon receipt of the samples at the  
25 laboratory.

#### 26 **5.5.4.5 Additional Requirements for Compliance Point Monitoring [D-10e(4)(e)]**

27 This section describes sampling frequency and determination of groundwater quality for the samples from  
28 the groundwater monitoring network. Compliance data will be compared to baseline data collected from  
29 the upgradient wells and a determination of impacts to groundwater will be made using the proposed  
30 ANOVA method (explained in Section 5.5.4.7.1).

##### 31 **5.5.4.5.1 Sampling Frequency [D-10e(4)(e) (i)]**

32 Under final status regulations, the default sampling procedure states that a sequence of at least four  
33 samples from each well (background and compliance wells) must be collected at least semiannually  
34 during detection monitoring at an interval that ensures, to the greatest extent technically feasible, that an  
35 independent sample is obtained [40 CFR 264.97(g)(1) and (2), WAC 173-303-645 (8)(g)(i) and (ii), and  
36 (9)(d)].

37 The default sampling procedures are adopted for the IDF as follows: four independent samples from each  
38 groundwater monitoring well will be sampled for the indicator parameters (Table 5-2) semiannually  
39 during the active life of the regulated unit (including the closure period), one per month for 4 consecutive  
40 months followed by two months of non-sampling. The mean of the measurements from the downgradient

1 wells will be compared semiannually to the mean of the distribution of the background data using  
2 ANOVA.

### 3 **5.5.4.5.2 Compliance Point Groundwater Quality Values [D-10e(4)(e)(ii)]**

4 The groundwater quality data collected from the groundwater monitoring wells will be compared to the  
5 mean of the background data from upgradient wells for each constituent by ANOVA. If the mean is  
6 calculated from transformed baseline data (logarithmic transformation or nonparametric approach), then  
7 the monitoring data will be transformed accordingly; otherwise, the original monitoring data will be used  
8 in the comparisons.

9 During detection monitoring, data verification will be applied in case of an initial exceedance. For  
10 ANOVA test, if the test of hypothesis of equal means for all wells fails, *post hoc* comparisons are needed  
11 to determine which compliance well(s) is (are) contaminated. This will be done by comparing  
12 concentration differences (called contrasts in the ANOVA and multiple comparison framework) between  
13 each compliance well with the background wells (EPA/530-SW-89-026). If the contaminated compliance  
14 well(s) is (are) determined by *post hoc* comparisons, verification sampling will be implemented for the  
15 constituent(s) in question. Verification sampling is needed to determine if the exceedance is an artifact  
16 caused by an error in sampling, analysis, or statistical evaluation or an actual variation in groundwater  
17 chemistry. A collection of at least four measurements from the re-sampled compliance well(s) is required  
18 to perform ANOVA test on comparison with the mean of the background data (EPA/530-R-93-003).  
19 Adequate time should elapse to ensure statistical independence between the original measurements and  
20 the re-sample measurements, which is assured by the sampling frequency proposed in Section 5.5.4.5.1.

21 The existing nitrate plume beneath the IDF site is described in Section 5.4.1. Nitrate is not included in  
22 Chapter 1 and, therefore, is not a constituent of concern for the IDF. Existing groundwater conditions  
23 will be monitored by the indicator parameters and supplemental constituents as described in Section 5.5.1.  
24 Specific conductance will respond to nitrate so that any changes in the nitrate concentration will be  
25 reflected by changes in the indicator parameter specific conductance.

26 Anion analysis is one of the supplemental constituents to be monitored at the IDF site. Anion analysis  
27 will determine the nitrate concentration. Therefore, through comparison of regression lines of specific  
28 conductance and nitrate (Zar, 1999) and/or contaminant source analysis (Gibbons, 1994), it can be  
29 determined whether any change in specific conductance is due to a change in nitrate. If a change in  
30 specific conductance is due to a change in nitrate, then that specific conductance change is not attributed  
31 to the IDF. If, however, a statistically significant change in specific conductance is not attributable to  
32 nitrate, verification sampling will occur as described above.

### 33 **5.5.4.6 Annual Determination [D-10e(4)(f)]**

34 Groundwater flow rate and flow direction at the IDF site will be determined annually for the uppermost  
35 aquifer. Flow rate will be determined by calculation using the groundwater gradient, and the Darcy flow  
36 equation,  $v_h = K_h i_h / n_e$ , where  $v_h$  is the horizontal groundwater velocity,  $K_h$  is the horizontal hydraulic  
37 conductivity,  $i_h$  is the horizontal hydraulic gradient, and  $n_e$  is the effective porosity. Effective porosities  
38 used at Hanford Site RCRA regulated units are on the order of 0.1 to 0.3 (PNNL-14187); effective  
39 porosity might be determined specifically for the IDF from hydrologic tests.

40 Hydraulic gradients will be determined from measurements of water levels.

### 41 **5.5.4.7 Statistical Determination [D-10e(4)(g)]**

42 This section describes the method of statistical evaluation and the statistical procedures to indicate  
43 whether dangerous waste or dangerous waste constituents from the IDF might have entered the

1 groundwater in the uppermost aquifer. These evaluations will be made as soon as practicable after  
2 validation of the full data set from each sampling event.

3 The monitoring program periodically will re-evaluate the statistical tests being used. The methods  
4 described will be reviewed during and after background data are collected to ensure the methods are the  
5 most appropriate, considering site conditions.

6 The goal of a RCRA final status detection-monitoring program [WAC 173-303-645(9)] is to monitor for  
7 indicator parameters that provide a reliable indication of the presence of dangerous constituents in  
8 groundwater in the uppermost aquifer beneath the site. This is accomplished by testing for statistically  
9 significant changes in concentrations of indicators in downgradient wells relative to baseline values. The  
10 default statistical method ANOVA is proposed for the detection monitoring program of the IDF. The  
11 proposed statistical method is consistent with EPA/530-SW-89-026, EPA/530-R-93-003, and  
12 WAC-173-303-645.

13 The number of tested constituents will be limited to the indicators to maintain a sufficiently low false-  
14 positive rate (EPA/530-R-93-003, page 62; Gibbons 1994, page 16). Verification sampling is an integral  
15 part of the statistical design to lower the overall false-positive rate and determine whether the difference  
16 between background and compliance-point data is an artifact caused by an error in sampling, analysis, or  
17 statistical evaluation (Section 5.5.4.5.2).

#### 18 **5.5.4.7.1 Statistical Procedure [D-10e(4)(g)(i)]**

19 In accordance with WAC 173-303-645(8)(h), acceptable statistical methodology includes analysis of  
20 variance (ANOVA), tolerance intervals, prediction intervals, control charts, test of proportions, or other  
21 statistical methods approved by Ecology. The type of monitoring, the nature of the data, the proportions  
22 of non-detects, and spatial and temporal variations are some of the important factors to be considered in  
23 the selection of appropriate statistical methods. The EPA default method ANOVA will be implemented  
24 for the IDF site to compare the differences of means of the measurements from upgradient and  
25 downgradient wells. The detailed discussions of the ANOVA test can be found in EPA/530-SW-89-026  
26 and statistical textbooks (Gilbert, 1987; Casella and Berger, 1990; Davis, 2002), and can be executed  
27 using commercial statistical software such as SAS or SYSTAT. Under WAC 173-303-645(8)(i)(ii), the  
28 proposed statistical method must comply with the performance standard, that is, for a multiple  
29 comparisons procedure the Type I error level must be no less than 0.05, and maintained at the level of no  
30 less than 0.01 for individual well comparisons. By definition, Type I error is the false rejection rate of the  
31 null hypothesis ( $H_0$ ) of the statistical test. In detection or compliance monitoring, the statistical test is  
32 defined as  $H_0$ : no release, i.e., the means of the distributions from upgradient and downgradient wells are  
33 the same, and the alternative ( $H_a$ ) evidence of release, e.g., "clean until proven contaminated" (EPA/530-  
34 R-93-003). Therefore, the proposed statistical method must comply with the requirement of maintaining  
35 Type I error which equates false positive rate in the stage of detection monitoring at approximate 5%  
36 level. As described in EPA/530-SW-89-026, ANOVA procedures have the advantages of combining  
37 multiple downgradient into a single statistical test, thus enabling the network-wide false positive rate for  
38 any single constituent (not multiple constituents) to be kept at 5%, and also maintain reasonable power for  
39 detecting contamination.

40 The details of the ANOVA procedures are described as follows (EPA/530-SW-89-026):

- 41 • First, check the proportion of non-detects of the measurements from the upgradient and downgradient  
42 wells. When the proportion of non-detects is less than 15%, the non-detects will be reported as one-  
43 half the minimum detection limit or practical quantitation limit, and proceed with parametric  
44 ANOVA analysis. When the proportion of non-detects is greater than 15%, non-parametric ANOVA  
45 analysis will be used for comparing the means of downgradient and upgradient wells.

1 • Evaluate the distributions of the measurements from the upgradient and downgradient wells. The  
2 assumptions with parametric ANOVA test are the residuals are normally distributed with equal  
3 variance. The normality of the distribution the residuals can be checked using coefficient of  
4 variation, plotting the data on probability plot, and/or Shapiro-Wilk's test (EPA/530-SW-89-026;  
5 Gibbons, 1994). The assumption of normality usually can be met by log-transforming the data or by  
6 other Box-Cox transformations. When the assumptions of normality and lognormality cannot be  
7 justified, the non-parametric ANOVA method will be used for the IDF. Bartlett's test can be used in  
8 checking equality, or homogeneity, of variances.

9 • The parametric ANOVA procedures include:

10 • Assume a monitoring network with k wells, and total number of observations N. First, compute  
11 well total, well mean, and well residuals (observations subtracted by well mean) for each well,  
12 and grand total and mean of all observations (all wells). The well residuals are used to check the  
13 assumption of normality.

14 • Compute the sum of squares of difference between well means and the grand mean,  $SS_{wells}$  which  
15 is a measure of the variability between wells with (k-1) degrees of freedom.

16 • Compute the total sum of squares of differences between all observations and the grand mean,  
17  $SS_{total}$ , which is a measure of the variability in all observations with (N-1) degrees of freedom.

18 • Compute the sum of squares of differences of observations within wells from the well means,  
19  $SS_{error}$ , which is a measure of the variability within wells with (N-k) degrees of freedom  
20 calculated by the following subtraction:

$$SS_{error} = SS_{total} - SS_{wells}$$

22 • Test the hypothesis of equal means for all k wells by computing F value with the means squares  
23 of differences:

$$F = MS_{wells} / MS_{error}$$

25 where the means of squares are the sums of squares divided by the associated degrees of freedom,  
26 that is,  $MS_{wells} = SS_{wells} / (k-1)$ , and  $MS_{error} = SS_{error} / (N-k)$ . Compare the F value to the tabulated  
27 F statistics with (k-1) and (N-k) degree of freedom at the 5% significance level (EPA/530-SW-  
28 89-026, Appendix B, Table 2). If the calculated F value exceeds the tabulated F statistics, the  
29 null hypothesis of equal well means is rejected. Proceed with test of contrasts in the next step.  
30 Otherwise, the hypothesis of equal means is accepted that there is no significant difference  
31 between the concentrations at k wells (upgradient and downgradient wells), that is, no evidence of  
32 contamination.

33 • If the hypothesis of equal well means is rejected, contrasts (concentration differences between a  
34 compliance well and background wells) will be tested for each compliance well to determine  
35 which compliance well(s) is (are) contaminated. Bonferroni t-statistics will be computed to  
36 determine if the significant F value is due to difference between background and compliance  
37 wells. Assume that of the k wells,  $k_b$  are background (upgradient) wells, and  $k_c$  are compliance  
38 (downgradient) wells (i.e.,  $k_b + k_c = k$ ). Each of the  $k_c$  compliance wells is compared to the mean  
39 of the background wells as the following steps:

40 • Compute the mean  $m_b$  from the  $k_b$  background wells with a total of  $n_b$  samples.

41 • Compute the difference  $D_i$  between the mean from the  $i^{th}$  compliance well and the mean from  
42 the background wells.

- Compute the standard error of the difference from the  $i^{\text{th}}$  compliance well with  $n_i$  observations as:

$$SE_i = [MS_{\text{error}} (1/n_b + 1/n_i)]^{1/2}$$

where  $MS_{\text{error}}$  is computed previously as the measure of variability within wells.

- Obtain the t-statistics from Bonferroni's t-table (EPA/530-SW-89-026, Appendix B, Table 3) with a significance level of  $(\alpha=0.05/k_c)$  but no less than 0.01 (for individual comparison) and  $(N-k)$  degrees of freedom. The critical value for the  $i^{\text{th}}$  compliance well is defined as:  $C_i = SE_i \times t$ .

- If the difference  $D_i$  exceeds the critical value  $C_i$ , conclude that the mean of the  $i^{\text{th}}$  compliance well is significantly higher than the mean of the background wells. Otherwise conclude that the well is not contaminated.

- The one-way non-parametric ANOVA tests the null hypothesis that the data from each well come from the same continuous distribution and hence have the same median. The procedures, called the Kruskal-Wallis test, include the following steps:

- Assume the monitoring network as defined previously with a total of  $N$  observations from  $k$  wells ( $k_b$  background wells and  $k_c$  compliance wells). Rank all  $N$  observations from least (1) to greatest ( $N$ ). Let the background wells be group 1, and denote the compliance wells as group 2 to  $(k_c+1)$ . (one group per compliance well).

- Compute the sum ( $R_i$ ) and the average ( $m_i$ ) of the ranks of the  $n_i$  observations in the  $i^{\text{th}}$  group.

- Compute the Kruskal-Wallis statistics ( $H$ ) as

$$H = \left[ \frac{12}{N(N+1)} \sum_{i=1}^{k_c+1} \frac{R_i^2}{n_i} \right] - 3(N+1)$$

- Compare the calculated  $H$  value to the tabulated chi-squared value with  $k_c$  degrees of freedom (EPA/530-SW-89-026, Appendix B, Table 1). The null hypothesis of equal medians is rejected when the calculated  $H$  value exceeds the tabulated critical value.

- When the null hypothesis of equal medians is rejected, compute the critical difference  $C_i$  for each compliance well to the background data (group 1 with  $n_b$  observations):

$$C_i = Z_{(0.05/k_c)} \left[ \frac{N(N+1)}{12} \times \left( \frac{1}{n_b} + \frac{1}{n_i} \right) \right]^{1/2}$$

where  $Z_{(0.05/k_c)}$  is the upper  $(0.05/k_c)$  percentile from the standard normal distribution (EPA/530-SW-89-026, Appendix B, Table 4). If there are more than five compliance wells ( $k_c > 5$ ), use  $Z_{0.01}$ , the upper one-percentile from the standard normal distribution ( $Z_{0.01}=2.32$ ) for individual comparison (WAC-173-303-645(8)(i)(ii)).

- Compute the difference ( $D_i = m_i - m_1$ ) of average rank  $m_i$  ( $i=2$  to  $k_c+1$ ) for each compliance well to the background ( $m_1$ ). Compare the difference  $D_i$  to the critical value  $C_i$  for each compliance well. If  $D_i$  exceeds  $C_i$ , conclude that the median of the  $i^{\text{th}}$  compliance well is significantly higher than the background median.

- 1 • As monitoring continues, the background data will be updated periodically (e.g., every year or two) to  
2 incorporate the new data from upgradient wells. This updating process will continue for the life of  
3 the monitoring program. Prior to updating older background data with more recent results, a two-  
4 sample t-test will be run to compare the older concentration levels with the concentrations of the  
5 proposed update samples. If the t-test does not show a significant difference at the 5 percent  
6 significant level, proceed to re-estimate the baseline parameters by including the more recent data. If  
7 the t-test does show a significant difference, the newer data will not be included as background unless  
8 some specific factors can be identified explaining why background levels at the IDF site have  
9 naturally changed (EPA/530-R93-003).

10 Formal testing for outliers will be done when an observation of the background data seems inconsistently  
11 high (by orders of magnitude) compared to the rest of the data set in order to avoid the artificial increase  
12 of the mean of the background data and a corresponding increase of the false negative rate. Statistical  
13 methods such as the Grubbs' method (Grubbs, 1969), the box-and-whisker plot (Ostle and Malone, 1988),  
14 EPA guidance (EPA/530-SW-89-026, page 11-14) and/or American Society for Testing and Materials  
15 guidance (ASTM, 1996) will be used for testing outliers. The outliers must be checked to determine if the  
16 measurements are in error and need to be corrected or excluded from calculating the background mean. If  
17 no specific error is found, the measurements must be retained in the data.

18 A statistically significant exceedance over background (baseline) levels only indicates that the new  
19 measurement in a particular monitoring well for a particular constituent is inconsistent with chance  
20 expectations based on the available sample of background (baseline) measurements. Any statistical result  
21 must be supported by other information to determine if a waste disposal facility has impacted  
22 groundwater (ASTM 1996).

#### 23 **5.5.4.7.2 Results [D-10e(4)(g)(ii)]**

24 Sampling and analysis results are reviewed at least semiannually (i.e., after each sampling event) and are  
25 available in HEIS. The DOE will submit results of statistical evaluations to Ecology.

#### 26 **5.5.5 Compliance Monitoring Program [D-10f]**

27 A compliance monitoring program that satisfies requirements set forth in WAC 173-303-645(10) will be  
28 established for the IDF if detection-level monitoring reveals statistically significant evidence of dangerous  
29 waste contamination from sources within the regulated unit. If compliance monitoring is required, DOE  
30 will submit a revised monitoring plan to Ecology specifying dangerous constituents to be monitored,  
31 sampling and analysis protocols, statistical evaluation methods, etc. In the compliance monitoring  
32 program, the dangerous constituents or parameters will be compared to concentration limits specified in  
33 the facility permit as discussed in WAC 173-303-645(5) during the compliance period.

34 The RCRA regulations [WAC 173-303-645(9)(g)] state that if a statistical exceedance occurs in a  
35 downgradient well, the entire network immediately must be resampled and analyzed for the constituents  
36 in Appendix IX of 40 CFR 264. This sampling would be conducted in parallel with a required permit  
37 modification. Appendix IX is an extensive list including a wide variety of volatile and semivolatile  
38 organic compounds and trace metals. It is prudent to narrow the analyte list to the specific exceedance  
39 event; e.g., if the exceeding contaminant is total organic halides, the project would analyze for the  
40 halogenated hydrocarbons most likely to be present in the area. Results of the resampling will form the  
41 basis for returning to detection monitoring or designing a compliance monitoring program

#### 42 **5.5.6 Corrective Action Program [D-10g]**

43 If, at a point of compliance (a well), dangerous constituents of concern are measured in the groundwater  
44 at concentrations that exceed the applicable groundwater concentration limit, Ecology must be notified in  
45 7 days, and an application to modify the permit to include a corrective action plan must be sent to

- 1 Ecology within 90 days or within the time agreed to by Ecology. A description of the groundwater
- 2 monitoring plan, including all additional corrective actions that are appropriate for a corrective action
- 3 program will be prepared and submitted to Ecology when the need for corrective action first is identified.

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1

Table 5-1. Water Levels in Groundwater Wells in the Vicinity of the IDF Site.

Well	Measure date	DTW m <sup>a</sup>	WT elev m <sup>b</sup>	Ref elev m <sup>c</sup>
299-E13-10	03/14/02	101.7	122.5	226.31
299-E17-12	03/14/02	100.0	121.1	221.09
299-E17-13	04/12/01	97.7	122.6	220.34
299-E17-17	04/12/99	97.8	122.8	220.54
299-E17-18	10/03/02	98.5	122.3	220.76
299-E17-20	04/09/97	97.1	123.2	220.33
299-E17-21	04/23/98	100.4	122.7	224.26
299-E17-22	05/20/02	98.1	122.5	220.59
299-E17-23	05/20/02	101.6	122.2	223.84
299-E17-25	05/21/02	98.3	126.7	225.03
299-E18-1	03/14/02	98.2	122.4	220.65
299-E18-3	06/27/96	97.8	123.4	221.20
299-E18-4	06/27/96	97.7	123.4	221.05
299-E19-1	03/22/88	100.4	124.9	225.26
299-E23-1	03/14/02	96.0	122.4	218.39
299-E23-2	12/20/94	97.2	123.5	220.77
299-E24-4	08/10/98	90.6	122.9	213.47
299-E24-7	06/11/97	96.2	123.2	219.34
299-E24-16	10/04/02	97.7	122.3	220.02
299-E24-17	04/07/97	97.36	122.9	220.16
299-E24-18	10/02/02	98.0	122.3	220.35
299-E24-21	03/22/01	95.4	122.6	217.85

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<sup>a</sup> DTW = depth to water

<sup>b</sup> WT elev = elevation of water table (meters above mean sea level)

<sup>c</sup> Ref elev = reference elevation (meters above mean sea level, North American Vertical Datum 88 reference), generally top of well casing.

Table 5-2. Monitored Constituents for the IDF.

<b>Indicator parameters</b>	<b>Supplemental constituents</b>
Chromium (filtered)	Alkalinity
Specific conductance (field)	Anions
Total organic carbon	ICP metals
Total organic halides	Turbidity (field)
pH (field)	

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Table 5-3. Expected Behavior of Selected Regulated Constituents/Materials for the IDF.

Constituent/material	Expected charged state	Expected mobility <sup>1</sup> (K <sub>d</sub> )	Comments
<b>Organics</b>			
Acetonitrile	N/A	High (0.16)	Miscible with water (Howard Volume IV, 1993)
Carbon tetrachloride	N/A	High (0.60); 0.29 (DOE/RL-93-99)	Moderately soluble in water (805 mg/L) (Howard, Volume II, 1990)
Creosote <sup>2</sup>	N/A	High (0.03 to 0.06) <sup>3</sup>	Relatively low solubility in water. Naphthalene solubility in water (31.7 mg/L [Howard, Volume 1, 1989]). Anthracene solubility in water (0.03 to 0.5 mg/L [Mackay et al, Volume II, 1992])
Dioxane	N/A	High (0.01)	Miscible with water (Howard, Volume II, 1990)
Ethylene glycol	N/A	Unknown <sup>4</sup>	Miscible with water (Howard, Volume II, 1990)
Naphthalene		Moderate (4 to 10); 1.4 (DOE/RL-93-99)	Sparingly soluble in water (31.7 mg/L [Howard, Volume I, 1989]).
Polychlorinated biphenyls	N/A	Low (20 to 100); 440 to 2,300 (DOE/RL-93-99)	Low solubility in water. 0.01 to 1 mg/L as Alocors (Mackay et al. 1992); 0.27 to 1.45 mg/L (WHC-SD-EN-TI-201)
Tetrachloroethylene	N/A	High (2.1); 0.22 (DOE/RL-93-99)	Moderately soluble in water (1,503 mg/L) (Howard, Volume II, 1990)
Toluene	N/A	High (0.37 to 1.8); 0.18 (DOE/RL-93-99)	Moderately soluble in water (535 mg/L) (Howard, Volume II, 1990)
Trichloroethylene	N/A	High (1.0); 0.1 to 1.0 (WHC-SC-EN-TI-201); 0.11 (DOE/RL-93-99)	Moderately soluble in water (1,100 mg/L) (Howard, Volume II, 1990)
Vinyl chloride	N/A	High (0.004); 0.056 (DOE/RL-93-99)	Moderately soluble in water (2,763 mg/L) (Howard, Volume I, 1989)
<b>Inorganics</b>			
Antimony	Cation (Sb <sup>+2</sup> )	Moderate (0 to 40, best estimate: 20 [DOE/RL-93-99])	Moderately soluble (best estimate): 1,000 mg/L (DOE/RL-93-99)
Arsenic	Anion (AsO <sub>4</sub> <sup>-5</sup> )	High, 0 (DOE/RL-93-99)	Moderately soluble (best estimate): 1,000 mg/L (DOE/RL-93-99)
Barium	Cation (Ba <sup>+2</sup> )	Moderate, 20 to 200, best estimate: 50 (DOE/RL-93-99)	Low solubility (best estimate): 1 mg/L (DOE/RL-93-99)
Beryllium	Cation (Be <sup>+2</sup> )	Moderate, 15 to 200, best estimate: 20 (DOE/RL-93-99)	Solubility unknown. Best estimate: 1 mg/L
Cadmium	Cation (Cd <sup>+2</sup> )	Moderate, 15 to 30, best estimate: 23 (DOE/RL-93-99)	Sparingly soluble. Best estimate: 25 mg/L (DOE/RL-93-99)
Chromium	Anion (CrO <sub>4</sub> <sup>-2</sup> )	High (0.0 to 1.02 [PNNL-13895]; 0.001 (WHC-SC-EN-TI-201)	Low solubility: 0.5 to 10 mg/L (WHC-SC-EN-TI-201)
Lead	Cation (Pb <sup>+2</sup> )	Low (1,330 to 469,000 [PNNL-13895])	Low solubility: 287 µg/L in Hanford Site groundwater (PNL-9791)
Mercury	Cation (Hg <sup>+2</sup> )	Moderate, best estimate: 30 (DOE/RL-93-99)	Solubility unknown. Best estimate: 1 mg/L (DOE/RL-93-99)

Table 5-3. Expected Behavior of Selected Regulated Constituents/Materials for the IDF.

Constituent/material	Expected charged state	Expected mobility <sup>1</sup> ( $K_d$ )	Comments
Nickel	Cation ( $Ni^{+2}$ ) $Ni(OH)_2$ $NiCO_3$	Low (48 to 337 [PNNL-13895])	Low solubility: 1.9 mg/L in Hanford Site groundwater (PNL-9791)
Selenium	Anion ( $SeO_4^{-6}$ )	High (3 to 10 [PNNL-13895]) (3 to 8 PNNL-11966)	Moderately soluble. Best estimate: 1,000 mg/L (DOE/RL-93-99)
Silver	Cation ( $Ag^+$ )	Moderate, 20 to 30, best estimate: 25 (DOE/RL-93-99)	Sparingly soluble (best estimate): 25 mg/L (DOE/RL-93-99).

1 N/A = Not applicable

2 <sup>1</sup> Unless cited in the column,  $K_d$  (partition coefficient) values were calculated from  $K_{oc}$  (normalized sorption  
 3 coefficient) values obtained from either the Handbook of Environmental Fate and Exposure Data for Organic  
 4 Chemicals series (Volumes I-IV) (P.H. Howard, ed) or the Illustrated Handbook of Physical-Chemical Properties  
 5 and Environmental Fate for Organic Chemicals series [Mackay et al. 1992a, 1992b]. For all organics (except carbon  
 6 tetrachloride), the calculation assumes an organic carbon content for Hanford Site soil of 1.0%. The value of  
 7 organic carbon assumed is conservative recognizing that the organic carbon content of most Hanford Site soil falls  
 8 considerably below this value. However, applying this level of conservatism also recognizes that mineral-driven  
 9 sorption likely plays a role in organic constituent mobility for Hanford Site soils with organic carbon content at or  
 10 below 0.1% (PNNL-13560). A calculation of a  $K_d$  value using acetonitrile as an example is as follows. The  
 11 literature estimated value of  $K_{oc}$  for acetonitrile is 16 (Howard 1993).

12

13  $K_d = f_{oc} \times K_{oc}$  where  $f_{oc}$  = the mass fraction of organic carbon in the soil.

14

15  $K_d$  (acetonitrile) = 0.01 X 16 = 0.16.

16

17 <sup>2</sup> Creosote is a coal tar distillate containing high quantities of naphthalene and anthracene (Lewis, R.J., Sr. 1993).

18

19 <sup>3</sup> Because creosote is predominately a mixture of naphthalene and anthracene (footnote 2), assumed  $K_{oc}$  values for  
 20 naphthalene (Howard 1989) and anthracene (Mackay et al., Volume II) in calculating a  $K_d$  range for creosote.

21

22 <sup>4</sup> This constituent has a low octanol/water partition coefficient indicating that its adsorption to soil would be low  
 23 (Howard, Volume II, 1990)

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Table 5-4. Analytical Methods and Method Detection Limits for Regulated Constituents and Indicator Parameters.

Class of Compounds	Analytical Methods	Method Detection Limit <sup>2</sup> (ug/L)
Metals		
	SW 846, Method 6010 (ICP metals)	0.18 - 51 <sup>1</sup>
	SW 864, Method 7060 (Arsenic)	1
	SW 846, Method 7131 (Cadmium)	0.1
	SW 846, Method 7191 (Chromium)	1
	SW 846, Method 7421 (Lead)	1
	SW 846, Method 7470 (Mercury)	0.2
	SW 846, Method 7740 (Selenium)	2
	SW 846, Method 7841 (Thallium)	1
Semi-Volatile Organics		
	SW 846, Method 8041	Not available
	SW 846, Method 8270	10 - 1000 <sup>1</sup>
Pesticides/Polychlorinated Biphenyls		
	SW 846, Method 8081 (Pesticides)	Not available
	SW 846, Method 8082 (PCBs)	0.005 - 0.025 <sup>1</sup>
Herbicides		
	SW 846, Method 8151	0.02 - 1.3 <sup>1</sup>
Volatile Organic Compounds		
	SW 846, Method 8260 (VOAs)	0.01 - 57 <sup>1</sup>
	SW 846, Method 8021 (Halogenated VOAs)	0.003 - 3 <sup>1</sup>
Dioxins		
	SW 846, Method 8280	0.01 - 0.05 <sup>1</sup>
General Chemistry		
	SW 846, Method 9012 (Cyanide)	Not available
	SW 846, Method 9010 (Cyanide)	20
	SW 846, Method 9030 (Sulfide)	200 - 400 <sup>1</sup>
Alkalinity		
	EPA-600/4-79-020, Method 310.1	Not available
Anions		
	EPA-600/R-93-100, Method 300.0	2 - 2 <sup>-1</sup>
pH		
	Company specific	Not applicable
Specific conductance	SW 846, Method 9050	Not available

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1. Detection limit varies according to specific compound. The range of contract required detection limits for all compounds detected by the specific analytical method is given.
2. Method detection limits are from SW846 and EPA Methods, not the detection limits required by contract with the analytical laboratories.

1 **5.6 REFERENCES**

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4 *Resource Conservation and Recovery Act of 1976*, as amended, Public Law 94-580, 90 Stat. 2795, 42  
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6 **Code of Federal Regulations**

7 40 CFR 136.3 (5.5.4.1) Code of Federal Regulations, Title 40, Part 136. Whole Effluent Toxicity:  
8 Guidelines Establishing Test Procedures for Chemical Analysis of Pollutants.

9 40 CFR 264, Code of Federal Regulations, Title 40, Part 264, Subpart F. Standards for Owners of  
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11 **Washington Administrative Code**

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