8.10 Vegetation Monitoring

Vegetation monitoring and control activities conducted on and around the Hanford Site in 2004 are summarized in the following sections. The sections include discussions on surveys and monitoring of Hanford Site plant populations; monitoring contaminants in perennial vegetation growing near facilities and operations on the site; monitoring contaminant concentrations in perennial vegetation growing onsite at locations away from facilities (site-wide) and at perimeter, community, and distant locations around the site (offsite); and control of contaminated or unwanted vegetation on the site. Surveys and monitoring of plant populations are conducted to assess the abundance, vigor or condition, and distribution of populations and species. These data can be integrated with contaminant monitoring results and used to help characterize potential risks or impact to biota. Radiological monitoring of vegetation near onsite facilities and operations is done to determine the effectiveness of effluent monitoring and controls within facilities, to assess the adequacy of containment at waste disposal sites, and to detect and monitor unusual conditions. Site-wide and offsite vegetation samples are analyzed for information on atmospheric deposition of contaminants in uncultivated areas offsite and around operational areas onsite. These data provide a baseline against which unplanned releases can be compared. Vegetation management activities help to prevent, limit, or clean up contaminated plants or undesirable plant species. For further information about these monitoring and control efforts, the programs that support them, and their purposes, see Section 8.0 in this report or DOE/RL-91-50.

8.10.1 Plant Communities and Population Surveys on the Hanford Site

J. L. Downs, M. R. Sackschewsky, K. D. Hand, R. E. Durham, and R. K. Zufelt

The Hanford Site contains biologically diverse shrub-steppe plant communities that have been protected from most disturbances, except for fire and limited livestock grazing, for more than 60 years. This protection has allowed native plant species and communities that have been displaced by agriculture and development in other parts of the Columbia Basin to persist at Hanford. Surveys and mapping efforts have documented the occurrence and extent of rare plant populations and plant community types on the Hanford Site (PNNL-13688; PNL-8942; Soll et al. 1999). Plant populations monitored on the site include taxa listed by Washington State as endangered, threatened, or sensitive (Section 8.12), and those species listed as review group 1 (i.e., taxa in need of additional field work before status can be determined) (Washington Natural Heritage Program 1997). Data are collected for plant populations and plant communities on the Hanford Site to develop baseline information and to monitor any changes resulting from Hanford operations. The data provide information that is used for site planning processes and land-use policy development.

8.10.1.1 Vegetation Cover Types and Habitats

Monitoring of the plant communities and cover types at Hanford focuses on two main objectives: mapping the distribution and extent of major plant cover types on the

uplands and riparian areas on the site and conducting periodic surveys to assess whether community composition and structure are changing. Mapping the distribution and extent of vegetation on the Hanford Site provides important information on potential and existing habitats of sensitive or rare species as well as provides information regarding the presence of ecological receptor species. The spatial data for upland habitats were updated to reflect changes in vegetation following the 24 Command Hanford Site Wildfire in 2000. Spatial information for the riparian vegetation cover types was updated during 2003 and 2004 to provide a continuous map of vegetation along the Benton County shoreline of the Hanford Reach. Information from these survey and monitoring efforts are also used to update maps depicting areas with highly valued biological resources (http://www.pnl.gov/ecomon/Veg/Veg.html). Periodic surveys of the frequency, cover, and number of species found on permanent monitoring plots provide information on trends or changes in species diversity, presence of invasive and key species, and the overall condition of the plant community and available habitat.

8.10.1.2 Rare Plant Monitoring

More than 100 plant populations of 47 taxa listed by the Washington Natural Heritage program as endangered, threatened, sensitive, review, or watch list are found at the Hanford Site (http://www.pnl.gov/ecomon/Veg/Habitat.html; PNNL-13688). The U.S. Fish and Wildlife Service has designated 5 of these 47 taxa, including the two species, Umtanum buckwheat (*Eriogonum codium*) and White Bluffs bladderpod (*Lesquerella tuplashensis*), as species of concern in the Columbia River Basin ecoregion (http://www.dnr.wa.gov/nhp/refdesk/lists/plantrnk.htm). These two species are proposed as candidates for federal listing. In addition to the rare plant populations, several areas on the Hanford Site are designated as special habitat types with regard to potential occurrence of plant species of concern listed by Washington State. These are areas that potentially support populations of rare annual forbs that have been documented in adjacent habitats.

In June 2004, a population of coyote tobacco, *Nicotiana attenuata*, was discovered in a disturbed, open sand dune adjacent to the 618-10 burial ground, approximately 3.2 kilometers (2 miles) southeast of the 400 Area. A total of approximately 30 individual plants was found, and the habitat in the vicinity of the population was designated a rare plant protection area to help conserve the population while cleanup of the 618-10 burial ground proceeds. Similar habitats within 1.6 to 3.2 kilometers (1 to 2 miles) of the 618-10 population site were surveyed, but no other populations were found. A small population of this species was observed on the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit in 1999, but had otherwise not been observed within the area of the Hanford Site for nearly 100 years.

Transects established to examine condition and status of persistent sepal yellowcress (*Rorippa columbiae*) along the Columbia River shoreline near the 100-F Area and on several islands of the Hanford Reach of the Columbia River were not surveyed during 2003 because of high river flows. In September 2004, the Locke Island populations of this species were surveyed to compare numbers of individual stems with numbers counted during previous surveys. In 2004, approximately 1,800 plants were counted in the Locke Island population, which is comparable to numbers of stems found on the island during the last count in 2001, but fewer than reported during the mid-1990s. Data that describe trends in plant numbers and the timing of growth for this species are of interest because large variations in population numbers have been observed. These variations are believed to be related to river-level fluctuations that inundate habitat for the species during a large proportion of the growing season.

8.10.2 Vegetation Monitoring Near Hanford Site Facilities and Operations

R. M. Mitchell

Vegetation samples were collected on, or adjacent to, waste disposal sites and from locations downwind and near or within the boundaries of operating facilities and remedial action sites. Samples were collected to evaluate long-term trends in environmental accumulation and potential migration of radioactive material. Contamination in vegetation can occur as the result of surface deposition of radioactive materials from other radiologically

contaminated sources and/or by absorption of radionuclides by the roots of vegetation growing on or near waste disposal sites.

The number and location of vegetation samples collected near facilities and operations during 2004 are summarized in Table 8.10.1. Only those radionuclide concentrations reported above analytical detection limits are discussed in this section. A comprehensive presentation of the analytical data from these samples can be found in PNNL-15222, APP. 2.

8.10.2.1 Vegetation Sampling Near Hanford Site Facilities and Operations

Each sample (approximately 500 grams [16.1 ounces]) consisted of new-growth leaf cuttings taken from the available brushy, deep-rooted species (e.g., sagebrush and/or rabbitbrush) at a sample location. Often, the sample consisted of a composite of several like members of the sampling site plant community to avoid decimation of any individual plant through overharvesting. Vegetation samples were dried prior to analyses and analytical results were reported on a dry weight basis.

Samples were analyzed for the radionuclides expected to occur in the areas sampled (i.e., gamma-emitting radionuclides [cobalt-60 and cesium-137], strontium-90, uranium isotopes, and/or plutonium isotopes). Selected analytical results were compared to concentrations in samples collected by Pacific Northwest National Laboratory at offsite sampling locations in Yakima, Benton, and Franklin Counties. Comparisons were used to determine the differences between contributions from site operations and remedial action sites and contributions from natural sources and worldwide fallout.

Some degree of variability is always associated with the collection and analysis of environmental samples. Therefore, variations in sample concentrations from year to year are expected. In general, radionuclide concentrations in vegetation samples collected from, or adjacent to, waste disposal facilities in 2004 were higher than the concentrations in samples collected farther away and were significantly higher than concentrations measured offsite. The data also show, as expected, that concentrations of certain radionuclides in 2004 were higher within different operational areas when compared to concentrations measured in distant communities. Generally, the predominant radionuclides were activation and fission products in the 100-N Area, fission products in the 200 and 600 Areas, and uranium in the 300 and 400 Areas.

8.10.2.2 Analytical Results for Vegetation Samples Collected Near Hanford Site Facilities and Operations

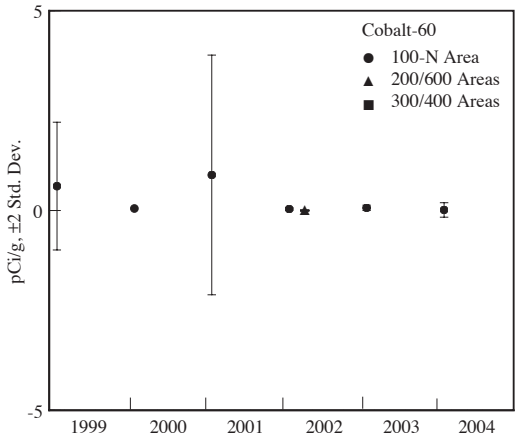
Strontium-90, cesium-137, plutonium-239/240, and uranium were detected consistently from samples taken in 2004. Concentrations of these radionuclides were elevated near and within facility boundaries compared to concentrations measured at distant communities. Figure 8.10.1 shows the average concentrations in vegetation samples collected near onsite facilities and operations during 2004 and the preceding 5 years and results for 2004 for distant communities. The results demonstrate a high degree of variability.

Six vegetation samples were collected at locations in the 100-N Area in 2004. Analytical results from these samples were comparable to those observed in 100-N Area samples collected in 2003 and were within the range of historical

Table 8.10.1. Number and Locations of Vegetation Samples Collected Near Hanford Site Facilities and Operations in 2004

Sample Type	Number of Sampling Locations	Operational Area								
		100-B/C	100-D/DR	100-K	100-F	100-H	100-N	ERDF[a]	200/600	300/400
Vegetation	69	0	0	0	0	0	6	0	49	14

(a) Environmental Restoration Disposal Facility in the 200-West Area.



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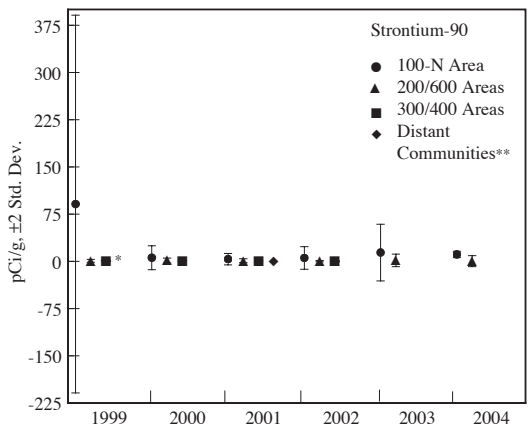
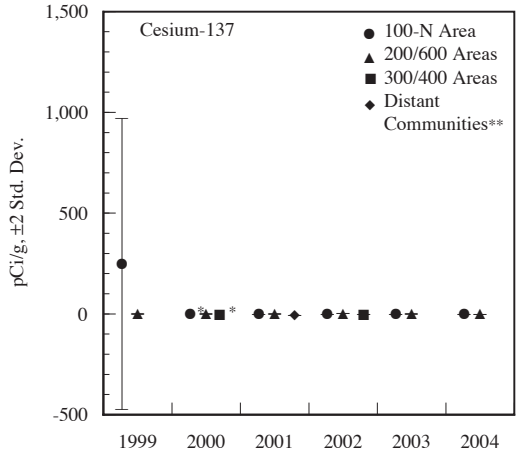


* = single value above detection limits ± analytical uncertainty
** = not detected in samples from distant communities in 2004

G05030031.7



* = single value above detection limits ± analytical uncertainty
** = not detected in samples from distant communities in 2004

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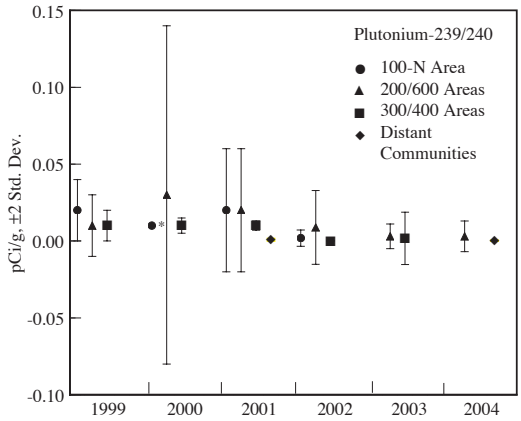

* = single value above detection limits ± analytical uncertainty

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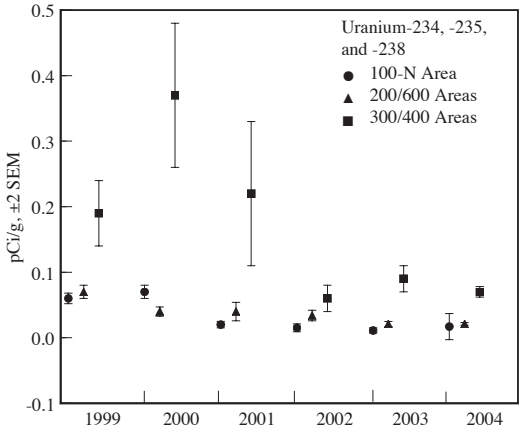

SEM = Standard error of the mean.

G05030031.10

Figure 8.10.1. Average Concentrations of Selected Radionuclides in Vegetation Samples Collected Near Hanford Site Facilities and Operations Compared to Those Collected in Distant Communities (PNNL-13910), 1999 through 2004. Radionuclide concentrations below analytical detection limits are not shown. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

values. The levels of strontium-90 in 100-N Area samples were higher than levels found samples from the 200, 300, and 400 Areas. The radionuclide levels measured in 100-N Area vegetation in 2004 were greater than those measured at distant communities in 2004. The 2004 maximum and average concentrations for vegetation samples collected at the 100-N Area are compared to historic distant community averages in Table 8.10.2. Average radionuclide concentrations detected in all of the near-facility vegetation samples collected in the 100-N Area from 1999 through 2004 are presented in Table 8.10.3. A complete list of radionuclide concentrations and sampling location maps are provided in PNNL-15222, APP. 2

Samples from 49 locations were collected in the 200 and 600 Areas during 2004. Concentrations of selected radionuclides reported for 1999 through 2004 are summarized in Table 8.10.4. Analytical results from samples taken from the 200 and 600 Areas were generally lower than those observed in previous years. Radionuclide levels for strontium-90, cesium-137, and plutonium-239/240 were greater than those measured off the Hanford Site. The 2004 maximum and average concentrations for selected radionuclides are compared to distant communities in Table 8.10.5. A complete list of radionuclide concentrations and sampling location maps are provided in PNNL-15222, APP. 2.

Fourteen samples were collected from the 300/400 Areas in 2004. Table 8.10.6 provides a summary of the 300 and 400 Areas results from samples collected from 1999 through 2004. Uranium levels were higher than levels measured in the 100 and 200 Areas. The higher uranium levels were expected because uranium was released to the environment during past fuel fabrication operations in the 300 Area.

The 2004 maximum, average, and distant community average concentrations for 300 and 400 Areas samples

Table 8.10.2. Concentrations of Selected Radionuclides (pCi/g[a] dry wt.) in Vegetation Samples Collected on the Hanford Site in the 100-N Area, 2004

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{238}U	$^{239/240}$Pu
Maximum[b]	0.015 ± 0.18	68 ± 8.2	0.05 ± 0.09	0.016 ± 0.008	0.0067 ± 0.006	ND
Average[c]	0.015 ± 0.18[b,d]	11 ± 5.1	0.05 ± 0.09[b,d]	0.0093 ± 0.0078	0.0048 ± 0.0027	ND
Distant communities[c,e]	NR	ND	ND	NR	ND	0.00022 ± 0.00098

(a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
(b) ± total analytical uncertainty.
(c) ±2 times the standard deviation.
(d) Single value above detection limit.
(e) See Section 8.10.3.
ND = Not detected.
NR = Not reported.

Table 8.10.3. Average Radionuclide Concentrations[a] (pCi/g[b] dry wt.) Detected in Vegetation Samples Collected on the Hanford Site in the 100-N Area, 1999 through 2004

Year	^{60}Co	^{90}Sr	^{137}Cs	$^{239/240}$Pu
1999	0.61 ± 1.4	91 ± 300	250 ± 670	0.01 ± 0.02
2000	0.05 ± 0.09	5.7 ± 16	0.2[c] ± 0.2	0.0004 ± 0.04
2001	0.89 ± 2.3	3.5 ± 8.4	0.38 ± 0.44	0.024 ± 0.03
2002	0.004 ± 0.037	5.4 ± 18.0	0.002 ± 0.008	0.002 ± 0.005
2003	0.066 ± 0.068	14 ± 45	0.15 ± 0.15	ND
2004	0.015 ± 0.18	11 ± 5.1	0.05 ± 0.09	ND

(a) ±2 times the standard error of the mean.
(b) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
(c) Single value above detection limit.
ND = Not detected.

Table 8.10.4. Average Radionuclide Concentrations[a] (pCi/g[b] dry wt.) Detected in Vegetation Samples Collected Near Hanford Site Facilities and Operations in the 200 and 600 Areas, 1999 through 2004

Year	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{238}U	$^{239/240}$Pu
1999	ND	0.79 ± 2.3	0.13 ± 0.18	0.033 ± 0.004	0.023 ± 0.003	0.009 ± 0.017
2000	ND	1.30 ± 3.3	0.16 ± 0.21	0.020 ± 0.02	0.014 ± 0.002	0.033 ± 0.06
2001	ND	1.00 ± 2.3	0.17 ± 0.24	0.019 ± 0.002	0.018 ± 0.018	0.021 ± 0.03
2002	0.0003 ± 0.0018	0.32 ± 1.10	0.089 ± 0.42	0.016 ± 0.016	0.014 ± 0.015	0.009 ± 0.024
2003	ND	1.5 ± 10	0.27 ± 2.0	0.01 ± 0.01	0.008 ± 0.009	0.003 ± 0.008
2004	ND	0.22 ± 8.8	0.04 ± 0.14	0.0097 ± 0.01	0.0082 ± 0.0093	0.003 ± 0.01

(a) ±2 times the standard deviation.
(b) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
ND = Not detected.

Table 8.10.5. Concentrations of Selected Radionuclides (pCi/g[a] dry wt.) in Vegetation Samples Collected Near Hanford Site Facilities and Operations in the 200 and 600 Areas, 2004

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{238}U	$^{239/240}$Pu
Maximum[b]	ND	17 ± 3.4	0.33 ± 0.1	0.028 ± 0.013	0.022 ± 0.011	0.029 ± 0.014
Average[c]	ND	0.22 ± 8.8	0.04 ± 0.14	0.0097 ± 0.01	0.0082 ± 0.0093	0.003 ± 0.01
Distant communities[c,d]	NR	ND	ND	NR	ND	0.00022 ± 0.00098

(a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
(b) ± total analytical uncertainty.
(c) ±2 times the standard deviation.
(d) See Section 8.10.3.
ND = Not detected.
NR = Not reported.

Table 8.10.6. Average Radionuclide Concentrations[a] (pCi/g[b] dry wt.) Detected in Vegetation Samples Collected Near Hanford Site Facilities and Operations in the 300 and 400 Areas, 1999 through 2004

Year	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{238}U	$^{239/240}$Pu
1999	ND	0.45 ± 0.25	ND	0.094 ± 0.20	0.890 ± 0.19	0.005 ± 0.008
2000	ND	0.21 ± 0.15	ND	0.018 ± 0.72	0.017 ± 0.73	0.004 ± 0.008
2001	ND	0.26 ± 0.39	ND	0.098 ± 0.33	0.110 ± 0.33	0.003 ± 0.004
2002	ND	0.21 ± 0.47	0.011 ± 0.079	0.032 ± 0.055	0.029 ± 0.33	-0.0004 ± 0.0007[c]
2003	ND	ND	ND	0.043 ± 0.11	0.036 ± 0.19	0.0017 ± 0.017[d]
2004	ND	ND	ND	0.33 ± 0.09	0.025 ± 0.073	ND

(a) ±2 times the standard deviation.
(b) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
(d) Negative value indicates a result at or below background levels of radioactivity.
(e) Single value above detection limit; ± total analytical uncertainty.
ND = Not detected.

are listed in Table 8.10.7. Complete listings of radionuclide concentrations and sampling location maps are provided in PNNL-15222, APP. 2.

8.10.2.3 Investigations of Radioactive Contamination in Vegetation Near Hanford Site Facilities and Operations

S. M. McKinney and R. M. Mitchell

Investigative sampling was conducted in and near operational areas to monitor the presence or movement of radioactive materials around areas of known or suspected contamination or to verify radiological conditions at specific project sites. All investigative samples were field surveyed for alpha and beta/gamma radiation and some samples were analyzed at a laboratory to identify specific radionuclides. Most samples were disposed of without being analyzed. Generally, the predominant radionuclides in investigative samples from the 100 and 200 Areas were strontium-90, cesium-137, and plutonium-239/240. Uranium-234, uranium-235, and uranium-238 were usually found in 300 Area samples.

During 2004, radiological contamination was found in 60 investigative vegetation samples. Fifty-seven samples were tumbleweeds (Russian thistle) or tumbleweed fragments, two samples were rabbitbrush, and one sample was big sagebrush. Only one tumbleweed sample was analyzed for specific radionuclides. Samples not sent to the laboratory for analysis were disposed of onsite in burial grounds. A discussion of vegetation control efforts at Hanford during 2004 is provided in Section 8.10.4.

The number and general locations of vegetation contamination incidents investigated during 2004 are summarized in Table 8.10.8. The numbers of contamination incidents investigated in 2004 and during the previous 10 years are provided in Table 8.10.9.

8.10.3 Vegetation Monitoring at Site-Wide and Offsite Locations

B. G. Fritz

Monitoring of rabbitbrush and sagebrush leaves and stems provides information on atmospheric deposition of radioactive materials in uncultivated areas and at site-wide locations that could potentially be affected by contaminants from Hanford Site operations. Vegetation samples have been collected on and around the Hanford Site for more than 50 years. Data from these samples are maintained in a database to document onsite and offsite levels of manmade radionuclides in vegetation at specific locations. This database holds baseline data against which data from unplanned contaminant releases from the Hanford Site can be compared. Collection of vegetation samples at site-wide and offsite locations was last conducted in 2001 (Section 4.6 in PNNL-13910).

8.10.3.1 Vegetation Sampling at Site-Wide and Offsite Locations

Vegetation samples were collected at 14 locations on and around the Hanford Site in 2004 (Figure 8.10.2).

Table 8.10.7. Concentrations of Selected Radionuclides (pCi/g[a] dry wt.) in Vegetation Samples Collected Near Hanford Site Facilities and Operations in the 300 and 400 Areas, 2004

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{238}U	$^{239/240}$Pu
Maximum[b]	ND	ND	ND	0.18 ± 0.05	0.15 ± 0.05	ND
Average[c]	ND	ND	ND	0.033 ± 0.09	0.025 ± 0.073	ND
Distant communities[c,d]	NR	ND	ND	NR	ND	0.00022 ± 0.00098

(a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
(b) ± total analytical uncertainty.
(c) ±2 times the standard deviation.
(d) See Section 8.10.3.
ND = Not detected.
NR = Not reported.

Table 8.10.8. Number of Vegetation Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 2004

Location	Number of Incidents
200-East Area tank farms	4
200-West Area tank farms	2
200-East Area burial grounds	14
200-West Area burial grounds	2
200-East Area cribs, ponds, and ditches	8
200-West Area cribs, ponds, and ditches	12
200-East Area fence lines	0
200-West Area fence lines	0
200-East Area roads and railroads	1
200-West Area road and railroads	0
200-East Area unplanned release sites	1
200-West Area unplanned release sites	2
200-East Area underground pipelines	8
200-West Area underground pipelines	1
Cross-site transfer line	3
200-East Area miscellaneous	0
200-West Area miscellaneous	1
200-North Area	0
100 Areas	0
300 Area	0
400 Area	0
600 Area	1
1100 Area	0
Total	**60**

Table 8.10.9. Annual Number of Vegetation Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 1994 through 2004

Year	Number of Incidents	Year	Number of Incidents
1994	39	2000	66
1995	39	2001	31
1996	21	2002	16
1997	46	2003	32
1998	51	2004	60
1999	85		

Samples were organized into four distinct groups: (1) site-wide (onsite), (2) perimeter, (3) Columbia River shoreline, (4) and distant upwind (Table 8.10.10). Site-wide sampling locations were generally selected in areas around industrial development on the site. The perimeter locations were Ringold, Byers Landing, Sagemoor, and Riverview. These four locations lie generally downwind, i.e., east and southeast, of the site. They are expected to be in areas of highest deposition of contaminants from site atmospheric emissions.

Vegetation samples consisted of the current year's growth of leaves, stems, and new branches collected from sagebrush and rabbitbrush. Samples were dried before analyses, and analytical results were reported on a dry weight basis. Shoreline samples were usually taken from a predominant species at the sampling location. A contaminant was detected if the analytical result was greater than the minimum detectable activity and was larger than the total analytical error.

8.10.3.2 Analytical Results for Vegetation Samples Collected at Site-Wide and Offsite Locations

Vegetation sampling results in 2004 generally confirmed observations from past sampling efforts. Cesium-137, strontium-90, uranium-238, and plutonium-238 concentrations were all below nominal detection limits at distant and shoreline locations, as were cesium-137, strontium-90, and plutonium concentrations at perimeter locations (Table 8.10.11). Uranium-238 was detected in one of four perimeter samples. The maximum uranium-238 concentration measured in vegetation during 2004 was collected at Byers Landing (a perimeter sampling location) (0.018 ± 0.0011 pCi/g [0.67 ± 0.41 mBq/g]). This result was higher than the maximum site-wide uranium-238 concentration measured in 2001. The average uranium-238 concentration at perimeter locations was similar to the average of samples collected in 1993, 1994, 1998, and 2001.

Concentrations of cesium-137 and strontium-90 in site-wide samples were all less than the analytical detection limits. Plutonium-238 and uranium-238 were each measured at detectable levels in one sample, and results were similar to those from past years (Table 8.10.11).

In 2004, plutonium-239/240 was detected in three vegetation samples collected at one site-wide location, one Columbia River shoreline location, and one distant location (Table 8.10.11). A vegetation sample collected east of the 200-West gate sampling location had the highest measured plutonium-239/240 concentration (Figure 8.10.3). This is consistent with historical data, which show this sampling location to have higher concentrations of all radionuclides.

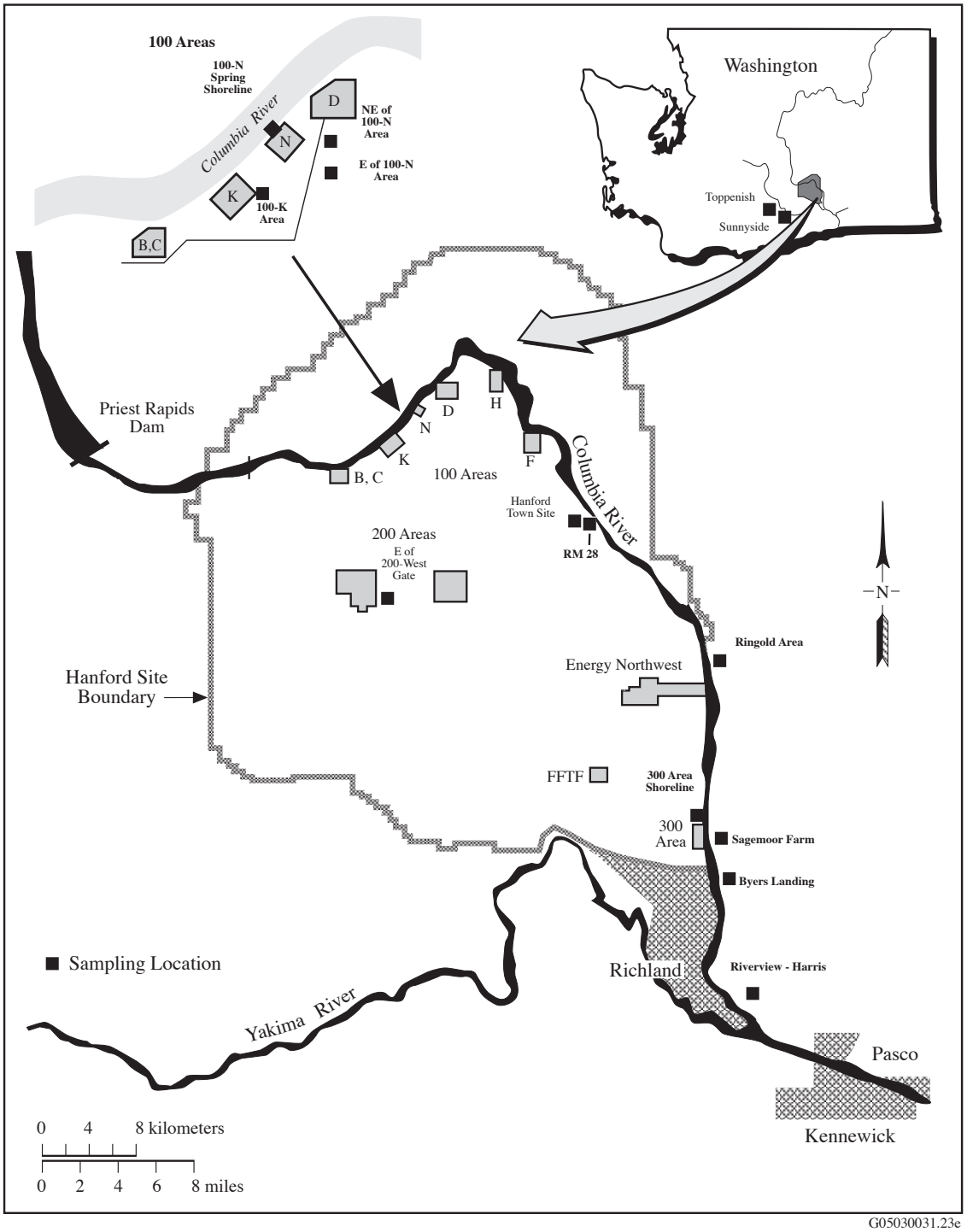

Figure 8.10.2. Hanford Site-Wide and Offsite Vegetation Sampling Locations, 2004

Table 8.10.10. Hanford Site-Wide and Offsite Vegetation Samples Collected and Analyzed, 2004

Location	No. of Samples	Frequency	Analytes[a]
Site-wide[b]	5	Annual to once every 5 years	Gamma, ^{90}Sr, U_{iso},[c] Pu[d]
Perimeter[b]	4	Annual to once every 5 years	Gamma, ^{90}Sr, U_{iso}, Pu
Columbia River shoreline	3	Annual to once every 5 years	Gamma, ^{90}Sr, U_{iso}, Pu
Distant	2	Annual to once every 5 years	Gamma, ^{90}Sr, U_{iso}, Pu

(a) Not all analytes are analyzed for at each location.
(b) Site-wide denotes sample locations designated as "onsite." Some perimeter samples are collected inside the Hanford Site boundary.
(c) Isotopic uranium (^{234}U, ^{235}U, ^{238}U).
(d) Plutonium-238 and plutonium-239/240.

8.10.4 Vegetation Control Activities

Vegetation control at Hanford consists of cleaning up contaminated plants that can be a threat to workers or the public (i.e., either safety, health, or radiation protection), controlling or preventing the growth or re-growth of plants in contaminated or potentially contaminated areas on the site, and monitoring and removing unwanted (noxious) plant species.

8.10.4.1 Control of Contaminated or Potentially Contaminated Vegetation in 2004

A. R. Johnson, J. G. Caudill, R. C. Roos, J. M. Rodriguez, R. A. Schieffer, and R. K. Woodford

There were no incidents of offsite contamination by plants during 2004, and all cases of new contamination reported onsite were cleaned up or scheduled for cleanup.

During 2004, 60 incidents of contaminated vegetation occurred on the Hanford Site. This is a decrease of 29% compared to the peak year of 1999 (84), but nearly double the number seen in 2003 (32). Severe wind-related soil erosion at several inactive waste disposal sites (e.g., the 216-U-10 and 216-S-17 inactive ponds in the 200-West Area and the 216-B-3 inactive pond in the 200-East Area) where surrounding wind breaks were denuded by a fire resulted in seven cases of contaminated new-growth tumbleweeds. All contaminated vegetation was removed from these waste sites and revegetation of these sites began in autumn 2004.

Sites with recurring radioactive contamination events caused by deep-rooted vegetation or burrowing insects were covered with Biobarrier®, an engineered fabric impregnated with herbicide to stop root penetration and also provide a physical barrier to burrowing insects. A total of approximately 1,000 square meters (10,800 square feet) of Biobarrier® was installed at seven sites in 2004 to prevent further invasion by biota. Hanford Site demonstrations have shown this barrier to be effective in preventing the spread of contamination. This installation brings the total number of sites at Hanford covered with Biobarrier® since 1999 to 32, amounting to 11,230 square meters (120,834 square feet).

Approximately 0.8 kilometer (0.5 mile) of roadway near the U Tank Farm was closed because of an accumulation of tumbleweeds, some of which were radiologically contaminated. The road, in the 200-West Area, was cleaned of windblown tumbleweeds and reopened.

Approximately 63,000 cubic meters (82,250 cubic yards) of compacted, windblown non-contaminated tumbleweeds that had accumulated along fences and around facilities were disposed of by burning in 2004, approximately the same volume burned in 2003. Tumbleweeds blown into a zoned contamination area were disposed of

Table 8.10.11. Concentrations of Selected Radionuclides (pCi/g dry wt.)[a] in Hanford Site-Wide and Offsite Vegetation Samples, 2004 Compared to Previous Years

		2004				1993, 1994, 1998, and 2001			
Location	Radionuclide	No. of Samples	No. Detected[b]	Mean[c]	Maximum[d]	No. of Samples	No. Detected[b]	Mean[c]	Maximum[d]
Site-wide	$^{239/240}Pu$	5	1	0.0020 ± 0.015	0.0077 ± 0.0013	17	10	0.0014 ± 0.0045	0.0069 ± 0.0014
(Onsite)	^{238}Pu	5	1	0.0000060 ± 0.00042	0.00014 ± 0.00011	17	1	0.00045 ± 0.00038	0.0073 ± 0.0012
	^{137}Cs	5	0	0.0055 ± 0.036	0.015 ± 0.013	17	4	0.0095 ± 0.036	0.055 ± 0.029
	^{90}Sr	5	0	0.0068 ± 0.10	0.042 ± 0.068	17	12	0.16 ± 1.1	2.2 ± 0.39
	^{238}U[e]	5	1	0.0016 ± 0.022	0.0079 ± 0.0085	17	3	0.0018 ± 0.0077	0.0065 ± 0.0029
Perimeter	$^{239/240}Pu$	4	0	0.0050 ± 0.00034	0.00015 ± 0.00024	16	10	0.00038 ± 0.00075	0.0012 ± 0.00048
	^{238}Pu	4	0	0.000043 ± 0.00011	0.000069 ± 0.000092	16	1	0.000072 ± 0.00038	0.00064 ± 0.0010
	^{137}Cs	4	0	0.011 ± 0.040	0.024 ± 0.017	16	0	0.0088 ± 0.015	0.027 ± 0.018
	^{90}Sr	4	0	-0.0080 ± 0.038	0.0031 ± 0.067	16	12	0.031 ± 0.038	0.069 ± 0.016
	^{238}U[e]	4	1	0.0068 ± 0.032	0.018 ± 0.011	16	10	0.0090 ± 0.015	0.029 ± 0.0080
Shoreline[f]	$^{239/240}Pu$	3	1	0.0017 ± 0.00013	0.00020 ± 0.00018	10	4	0.0011 ± 0.0041	0.0059 ± 0.0014
	^{238}Pu	3	0	0.000091 ± 0.00036	0.00017 ± 0.00018	10	0	-0.000010 ± 0.00046	0.00026 ± 0.00027
	^{137}Cs	3	0	0.00058 ± 0.50	0.014 ± 0.017	10	4	0.039 ± 0.16	0.25 ± 0.033
	^{90}Sr	3	0	0.024 ± 0.080	0.045 ± 0.079	10	7	0.16 ± 0.40	0.54 ± 0.10
	^{238}U[e]	3	1	0.0044 ± 0.022	0.010 ± 0.0068	10	1	0.064 ± 0.40	0.64 ± 0.073
Distant	$^{239/240}Pu$	2	1	0.00022 ± 0.00098	0.00040 ± 0.00031	7	3	0.00027 ± 0.00096	0.0013 ± 0.00046
	^{238}Pu	2	0	-0.000011 ± 0.00034	0.000049 ± 0.00012	7	0	0.0000075 ± 0.000041	0.000045 ± 0.000079
	^{137}Cs	2	0	-0.0030 ± 0.0024	-0.0026 ± 0.013	7	1	0.012 ± 0.029	0.032 ± 0.025
	^{90}Sr	2	0	0.012 ± 0.0076	0.013 ± 0.04	7	5	0.033 ± 0.056	0.087 ± 0.10
	^{238}U[e]	2	0	0.0019 ± 0.017	0.0049 ± 0.0087	7	2	0.0018 ± 0.010	0.0079 ± 0.0084

(a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.
(b) Detection is defined as a value reported above the minimum detectable activity or above the total analytical uncertainty.
(c) Reported mean values ±2 standard deviations.
(d) Reported maximum values ± total analytical uncertainty.
(e) Samples from 1993 and 1994 analyzed by a chemical analysis; samples since 1994 analyzed by alpha spectrometry.
(f) Hanford Reach of the Columbia River.

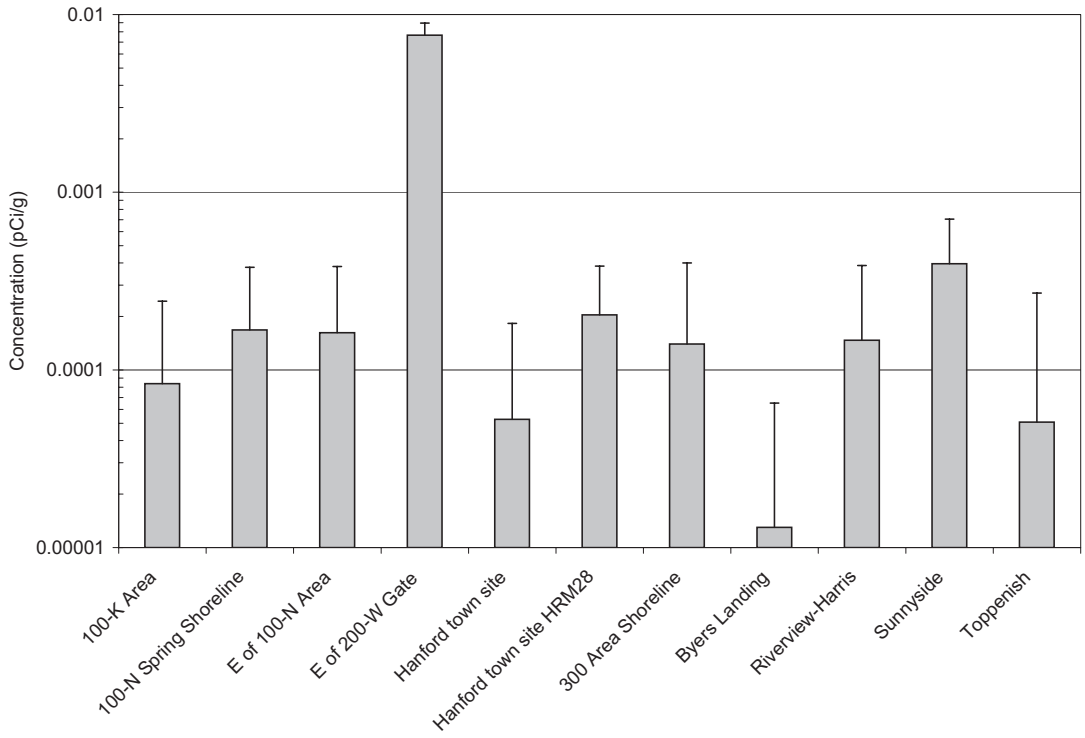

Figure 8.10.3. Plutonium-239/240 Concentrations in Hanford Site-Wide and Offsite Vegetation Samples Collected in 2004 (+ analytical error)

as though they were contaminated to avoid the expense and delay of testing for contaminants. In 2004, such tumbleweeds, previously disposed to a designated burial ground dedicated to receiving low-level contaminated waste, could no longer be disposed in this manner because of a Memorandum of Understanding among DOE and regulatory agencies. Arrangements were made for a licensed bulk process facility to receive the tumbleweeds in 2004. Approximately 2,800 cubic meters (3,700 cubic yards) of compacted tumbleweeds from contaminated areas were disposed in the bulk process facility operated by Pacific EcoSolutions located on Battelle Boulevard about 4 kilometers (2.5 miles) northwest of Richland, Washington.

8.10.4.2 Revegetation Activities in 2004 to Control Blowing Weeds and Dust

Four hundred hectares (1,000 acres) west of the 200-West Area that burned during the 24 Command Hanford Site Wildfire in 2000 were revegetated with such species as Indian rice grass (*Oryzopsis hymenoides*), bottleneck squirreltail (*Sitanion hystrix*), needle and thread grass (*Stipa comata*), Sandberg's bluegrass (*Poa sandbergii*), and big sagebrush (*Artemisia tridentata*) in 2001 and 2002. This revegetation effort resulted in well established grass and shrub communities. The revegetation was done to limit soil erosion and the growth of undesirable plants in the burned area. Windblown dust and tumbleweeds from this fire-damaged area could affect operations, facilities, and workers in the 200-West Area, located just downwind of the burn, and could spread the seeds of undesirable weeds to (and cause subsequent weed control issues at) other sensitive onsite locations. In 2004, 160 hectares (400 acres) of the burned area were overseeded with bunchgrass seed towards this effort.

8.10.4.3 Noxious Weed Control

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Noxious weeds are controlled on the site to prevent their spread and eliminate populations. A noxious weed is a legal

and administrative category designated by federal or state regulatory agencies (e.g., U.S. Department of Agriculture or Washington State Department of Agriculture). Noxious weeds are non-native, aggressively invasive, and hard to control. Entire native plant communities can be destroyed, altering ecosystems, unless control measures are taken. Control measures can be mechanical, chemical, cultural, or biological.

Populations of rare, threatened, or endangered species are identified and marked with visual and physical identifiers. These populations are identified to the control teams so that they know to avoid them.

Ten plant species, categorized as noxious weeds by the U.S. and Washington State Departments of Agriculture are on a high priority list for control at the Hanford Site. These species are discussed in the following paragraphs, with a summary of the 2004 control activities. Major populations of noxious weeds on the Hanford Site are illustrated in Figure 8.10.4.

In 2004, remote populations of noxious weeds were identified with fluorescent flags on 1.83-meter (6-foot) poles so that they could be located and treated by terrestrial herbicide application crews. Areas treated for noxious weed infestations in 2004 included 142 hectares (350 acres) treated by terrestrial application crews and 1,155 hectares (2,850 acres) treated by helicopter.

Yellow Starthistle (*Centaurea solstitialis*). Yellow starthistle represents the most rapidly expanding weed infestation in the western United States. Hanford is at a critical point in the infestation cycle. More than 2,023 hectares (5,000 acres) have been infested and a seed bank has been established in the soil. Many additional hectares (acres) have scattered starthistle infestation. Applications of aerial herbicides in 1998 and 1999 have been effective, resulting in minimal germination prior to 2003. This minimal germination was controlled primarily through mechanical removal (i.e., pulling by hand). During 2003 and 2004, however, significant germination was observed indicating that residual action from prior chemical applications was no longer effective. These plants were again controlled in 2004 by aerial herbicide applications and by terrestrial applications to old agricultural fields with a boom sprayer capable of spraying large areas. Biological control organisms, primarily the hairy weevil (*Eustenopus villosus*) and the bud weevil (*Bangasternus orientalis*), were commonly found in starthistle during 2004. It was observed that plants flowering early through mid-summer were heavily infested with weevils. However, plants flowering late in the season showed reduced infestation of the flowering heads indicating that natural predators (i.e., biological control agents) are not totally effective in eliminating seed production.

Rush Skeletonweed (*Chondrilla juncea*). Rush skeletonweed is widely scattered over large areas on the Hanford Site. Although areas of dense infestation have largely been eliminated, a considerable population remains as scattered individuals. Populations of skeletonweed have increased on some areas burned in the 24 Command Hanford Site Wildfire of June 2000.

During 2004, control of rush skeletonweed concentrated on an area north of the Volpentest Hazardous Materials Management and Emergency Response Training and Education Center (HAMMER) and the Hanford Patrol Training Academy. Effectiveness of the spraying will be evaluated in spring 2005.

As in most years, some populations were highly affected by biological control agents that had been introduced over the past 10 years, and flowering was eliminated. Other populations were less affected. Because of inconsistency of biological control agents, herbicides will remain an important aspect of control for rush skeletonweed.

Medusahead (*Taeniatherum asperum*). Mechanical removal (i.e., pulling by hand) was once again used to control the small population of medusahead on the Central Plateau of the Hanford Site. Plants were pulled before seeds matured. Monitoring and eradication efforts continued in 2004 as the plants matured to the point at which they could be distinguished from neighboring grass species.

Babysbreath (*Gypsophila paniculata*). Efforts to control babysbreath during 2004 concentrated on the main infestation at the former Hanford town site. Although babysbreath is resistant to control by herbicides, herbicides exist that effectively kill the aboveground portions of the plant. Controlling the top of the plant prevents flowering and additional seed production. Killing the top of the

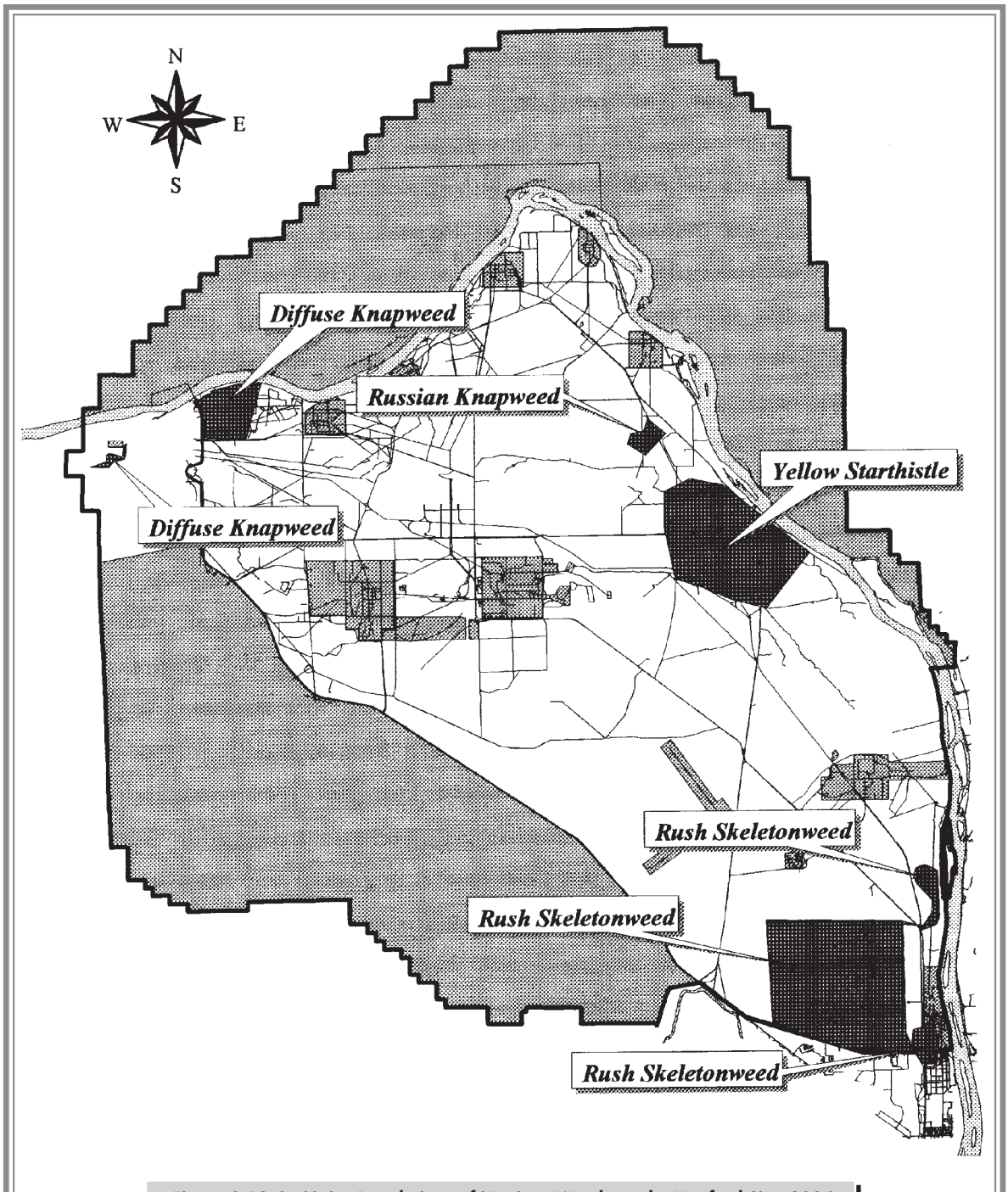

Figure 8.10.4. Major Populations of Noxious Weeds on the Hanford Site, 2004

plant also depletes energy reserves in the roots until the plant dies. The number of these plants on the Hanford Site is relatively small.

Dalmatian Toadflax (*Linaria genistifolia* ssp. *dalmatica*). During 2004, control of dalmatian toadflax focused on a small population at the 100-B/C Area. The species at Hanford has yielded to past control efforts. Seedlings of this long-lived perennial plant will be eliminated by mechanical removal or chemical treatments as they are identified. Currently, the only extant population of dalmatian toadflax is in the Energy Northwest area; it is being watched for signs of migration to other parts of the Hanford Site.

Spotted Knapweed (*Centaurea maculosa*). Most populations of spotted knapweed throughout the Hanford Site have been reduced through mechanical removal and chemical applications to scattered individuals or seedlings germinating from long-lived seeds. Continued monitoring and control efforts are aimed at eliminating spotted knapweed near the Energy Northwest facilities on the Hanford Site.

Diffuse Knapweed (*Centaurea diffusa*). Aerial applications of herbicide to control diffuse knapweed have been effective in the past. Spot treatment with chemicals and mechanical removal of scattered individuals continued during 2004. The population of diffuse knapweed near the high-water mark of the Columbia River has not been controlled by herbicides because of the biological sensitivity of the area. Biological controls (i.e., parasitic insects) have been established in areas near the Columbia River and are monitored to observe effectiveness in controlling the weed. They are somewhat effective.

Russian Knapweed (*Acroptilon repens*). Biological control (e.g., parasitic nematode) of Russian knapweed at Hanford has been tried without success. This weed's largest population is found along the Columbia River, but small populations are found throughout the site. Chemicals, other biological control agents, and mechanical removal techniques that may prove effective with this difficult-to-control species are being developed by federal and state agricultural agencies.

Saltcedar (*Tamarix* spp.). Several individual plants of saltcedar are found on the Hanford Site. Most are remaining from ornamental plantings near homes in the early part of the previous century. A few plants are the result of natural seed dispersal. Most individuals on the site south and west of the Columbia River have been eliminated. Survivors will be treated with herbicide and will be monitored until they are eliminated.

Purple Loosestrife (*Lythrum salicaria*). Purple loosestrife has established only in sparse populations on the Hanford Site along the south and west shorelines of the Columbia River. Portions of the riverbank and shoreline slews are monitored for purple loosestrife and identified individuals are controlled with chemicals approved for wetland areas, with biological control agents, and by mechanical removal.