8.2 Ecosystem Monitoring and Ecological Compliance

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The Hanford Site is a relatively undisturbed area of shrub-steppe (a drought-resistant, grassland ecosystem) that contains a rich diversity of plant and animal species adapted to the region's semiarid environment. The Ecological Monitoring and Compliance Project provides data and information to fulfill U.S. Department of Energy (DOE) Richland Operations Office's needs to achieve compliance with natural resource-related legal and regulatory requirements for the biological resources found on Hanford. Under this project, surveys and monitoring of resources and key biota are conducted to assess the abundance, vigor or condition, and distribution of populations and species on the Hanford Site. Data collection and analysis are integrated with environmental monitoring of biotic and abiotic media under the Surface and Environmental Surveillance Project to characterize any potential risk or impacts to the biota. Ecological monitoring and ecological compliance support multiple objectives for completion of Hanford's waste management and environmental restoration mission by:

- Assuring Hanford Site operational compliance with laws and regulations including the *Endangered Species Act of 1973*, the *Bald and Golden Eagle Protection Act*, and the *Migratory Bird Treaty Act*.
- Providing data for environmental impact and ecological risk assessments.
- Providing maps and information useful for biological resource impact mitigation during facility expansion.
- Supporting Hanford Site land-use planning and stewardship.

These activities are intended to assure protection of the natural resources within the DOE-operated portions of the Hanford Site including the DOE-managed portion of the Hanford Reach National Monument and provide information useful to the Hanford natural resource stakeholders and the public on the status of some of Hanford's most highly valued biological resources.

8.2.1 Chinook Salmon

Chinook salmon (*Oncorhynchus tshawytscha*) are an important resource in the Pacific Northwest; they are caught commercially and for recreation. Salmon are also of cultural importance to Native American tribes. Today, the most important natural spawning area in the mainstem Columbia River for the fall chinook salmon is found in the free-flowing Hanford Reach. In the early years of the Hanford Site, only a few spawning nests (redds) were found in the Hanford Reach. Between 1943 and 1973, a number of dams were constructed on the Columbia River and the formation of reservoirs behind these dams eliminated most mainstem spawning areas. These changes resulted in increased numbers of salmon spawning in the Hanford Reach. Fisheries management strategies aimed at maintaining spawning populations in the mainstem Columbia River also have contributed to the increased number of redds found in the Hanford Reach.

The number of fall chinook salmon redds estimated in the Hanford Reach by aerial surveys increased during the 1960s, 1970s, and 1980s until reaching a high in 1989 of nearly 9,000 (Figure 8.2.1). In the early 1990s, redd estimates declined to approximately one-third of the 1989 peak. The number of redds peaked again in 1996 and 1997 and then declined before rising again in 2001.

During 2002, ~8,040 redds were observed, an increase of nearly 1,800 from 2001 and similar to the numbers seen during the late 1980s. The main use areas for spawning were similar to previous years with the majority of redds occurring near Locke Island, the Columbia River islands between river miles 365-368 (Islands 8 [near the 100-D Area] through 10 [near the 100-F slough]), and Vernita Bar. Aerial surveys do not yield absolute redd counts because environmental conditions vary, depending on

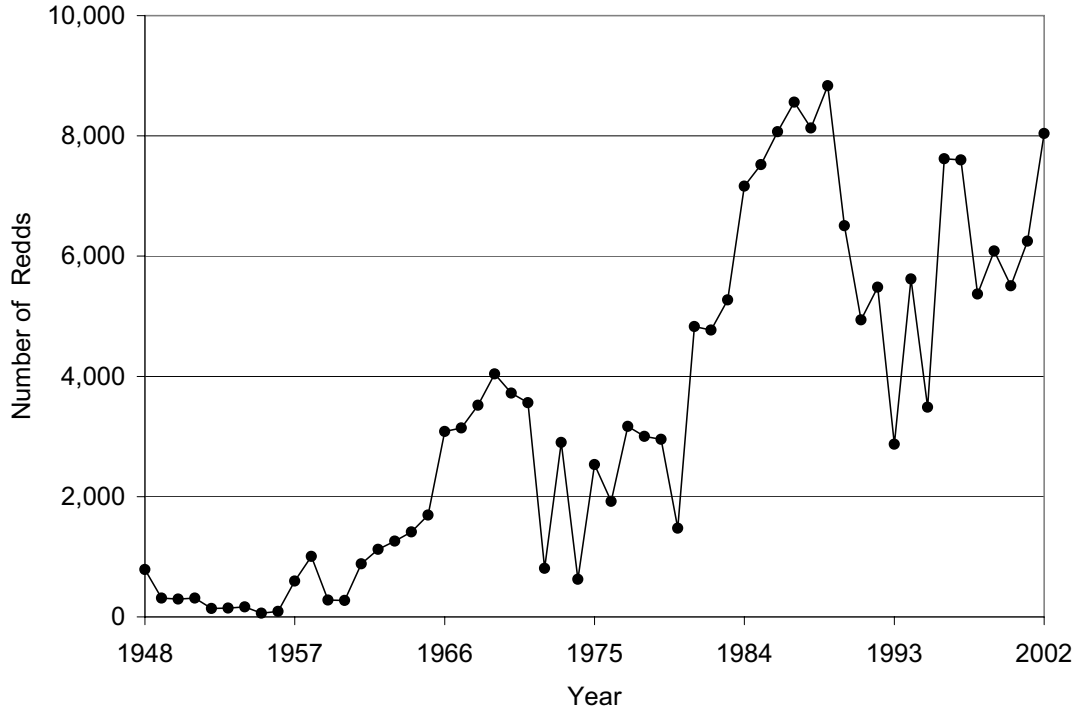

Figure 8.2.1. Number of Fall Chinook Salmon Spawning Redds in the Hanford Reach of the Columbia River, 1948 through 2002

water depth and other factors, such as water turbidity and sun angle. In addition, the number of redds in high-density locations cannot be counted with absolute accuracy while flying. However, redd survey data are highly correlated with adult salmon escapement estimates obtained by state and federal agencies within the Columbia River Basin (Dauble and Watson 1997). The Hanford Reach remains the largest spawning area for fall chinook salmon in the mainstem Columbia River.

8.2.2 Canada Goose Nesting on the Hanford Reach

Canada goose (*Branta canadensis moffitti*) nesting surveys began during the 1950s to document the reproductive performance of the goose population and determine whether nesting performance would demonstrate a response to nuclear reactor operations. Continuous documentation of nesting performance has provided a way to evaluate the potential effects of legacy contamination from reactor operations, upstream industrial uses of Columbia River water, changes introduced by hydroelectric dam operations, and increased recreational use of the region. During 2002, the nesting survey data and relevant contaminant information for this population were summarized.

Examination during 2002 of Canada goose nesting over the last 50 years reveals that the protection afforded the islands because of public exclusion from the Hanford Site has allowed geese to thrive. This trend is supported by the overall increases in numbers of nests and hatching rates. During 2001, strontium-90 and heavy metal concentrations were analyzed in egg shells collected from Canada goose nests where at least one egg hatched. Analytical results (Figure 8.2.2) show strontium-90 levels have continued to decrease since the late 1980s. Heavy metal concentrations were comparable to concentrations found at uncontaminated waterfowl and shorebird sites, except for nickel (Morera et al. 1997; Currie and Valkama 1998; Thomas 1999; Rodriguez et al. 2002). Nickel concentrations appeared elevated with respect to other bird species at contaminated sites (maximum concentrations of 12.4 µg/g in Hanford geese compared to 2.3 µg/g in curlew near a metal smelter; Currie and Valkama 1998). Nickel has no

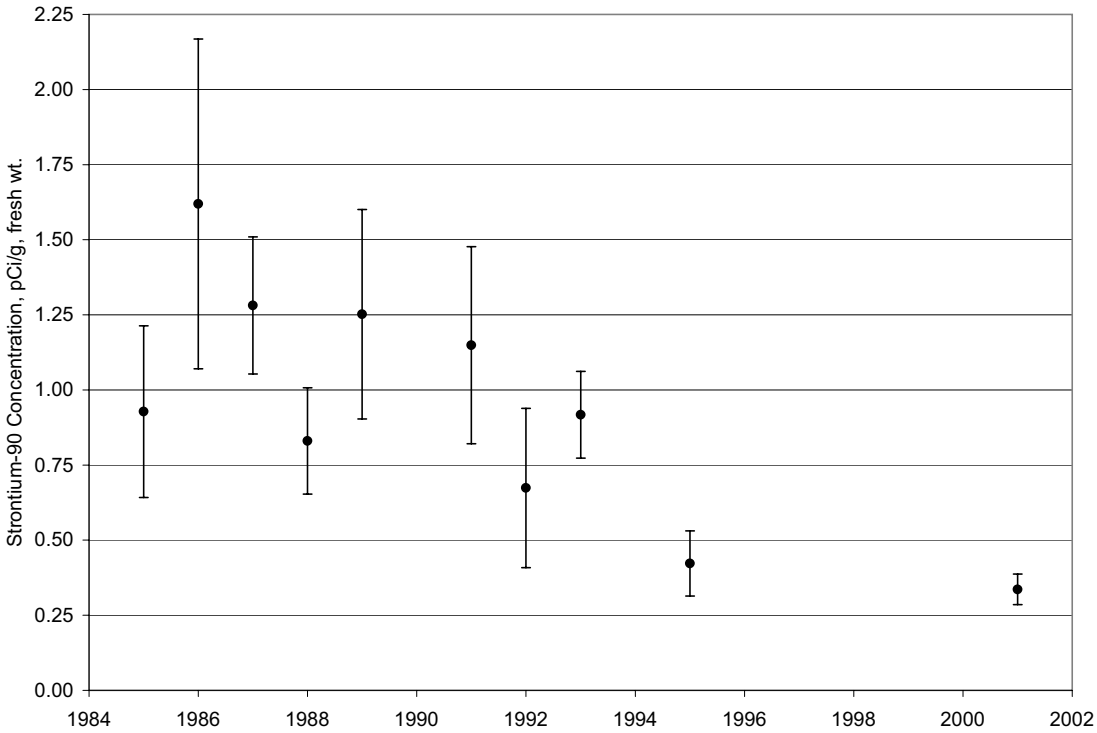

Figure 8.2.2. Average Strontium-90 Concentrations (pCi/g, fresh wt.) in Canada Goose Eggshells Collected from the Hanford Reach of the Columbia River Between 1985 and 2002. Bars represent ±2 standard errors of the mean.

known toxicological effects at these concentration levels (Outridge and Scheuhammer 1993). Birds appear to eliminate heavy metal by excretion and deposition in feathers and eggs (Burger 1994).

8.2.3 Characterization of Asiatic Clams

An assessment of contaminant concentrations in bivalves during 2001 demonstrated that this species could be used as a monitoring species in the Columbia River to identify patterns of contaminant uptake (PNNL-13692). Because bivalves are relatively sedentary filter-feeders, they represent organisms with high potential for exposure to contaminants of concern along the near-shore environment when or if contaminants reach the river. Therefore, in 2002, ecological monitoring and contaminant surveillance of bivalves was initiated. Asiatic clams (*Corbicula fluminea*) were collected during November 2002 to evaluate (1) demographics and distributions of the clam populations inhabiting Hanford shorelines, (2) bivalve tissue residue levels of three radionuclides and 16 metals, and (3) histology of target organs. Results of tissue residue levels and histological inspections are expected to be available in 2003.

Densities (number per area) and sizes (lengths) of clams were measured along the Hanford Reach shoreline near existing reactor installations, the Hanford town site, the 300 Area, and at reference areas upstream from Hanford. The distribution of Asiatic clam shell lengths was used to separate the population into age groups; in this analysis, each identified mode is assumed to represent an age group (MacDonald and Pitcher 1979). From the analysis, there appear to be four distinct year classes: 0, 1, 2, and 3 years represented by peaks in the distribution (Figure 8.2.3). This information can be used to define duration of exposure.

Clam densities were measured with respect to substrate size and percent of the time the shoreline was inundated (i.e., covered with water). The percent inundation is related to daily and seasonal fluctuations of river flow in response to natural cycles, and operations of hydroelectric dams upstream and downstream of the Hanford Reach.

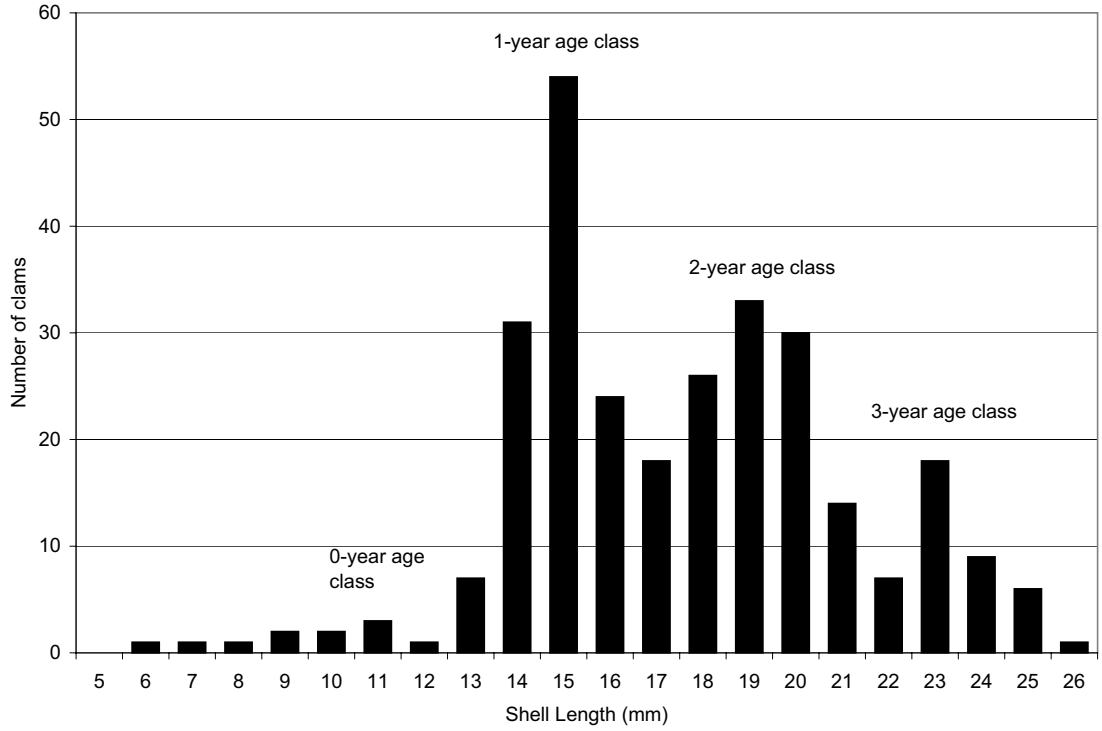

Figure 8.2.3. Length Frequencies for Asiatic Clam Shells Located in Gravel Substrates (gravel size: 6-153 mm) Along Shoreline Areas in the Hanford Reach of the Columbia River that are Inundated 95% of the Time (i.e., river flows greater than or equal to 1,250 cubic meters [44,000 cubic feet] per second) (n = 9 plots and 289 individuals), Fall 2002

Figure 8.2.4 depicts clam densities (number of individuals per 1 square meter [10.8 square feet]) in four substrate classes found along the Columbia River. Clam densities were generally lowest where substrates were sand/silt or large boulders. Higher densities were found in gravels and cobbles, with the densities in gravel being highly variable.

Evaluating the clam densities (Figure 8.2.5) revealed that densities were highest in areas that were covered with water more than 80% of the time and that viable populations of clams did not persist in shoreline areas that are frequently exposed. High clam densities also appear to be correlated with the presence of periphyton and the absence of riparian vegetation. Knowledge of the distribution and abundance of clams in the near-shore environment will be used in further monitoring and surveys of contaminant uptake by biota.

8.2.4 Vegetation Surveys and Monitoring

The Hanford Site contains biologically diverse shrub-steppe plant communities that have been protected from disturbance, except for fire, over the past 55 years. This protection has allowed plant species and communities that have been displaced by agriculture and development in other parts of the Columbia Basin to thrive at Hanford. Surveys and mapping efforts have documented the occurrence and extent of rare plant populations and plant community types on the Hanford Site (Nature Conservancy 1999). Populations of rare plants include taxa listed by Washington State as endangered, threatened, or sensitive (Appendix G) and the locations of species that are 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 to develop baseline

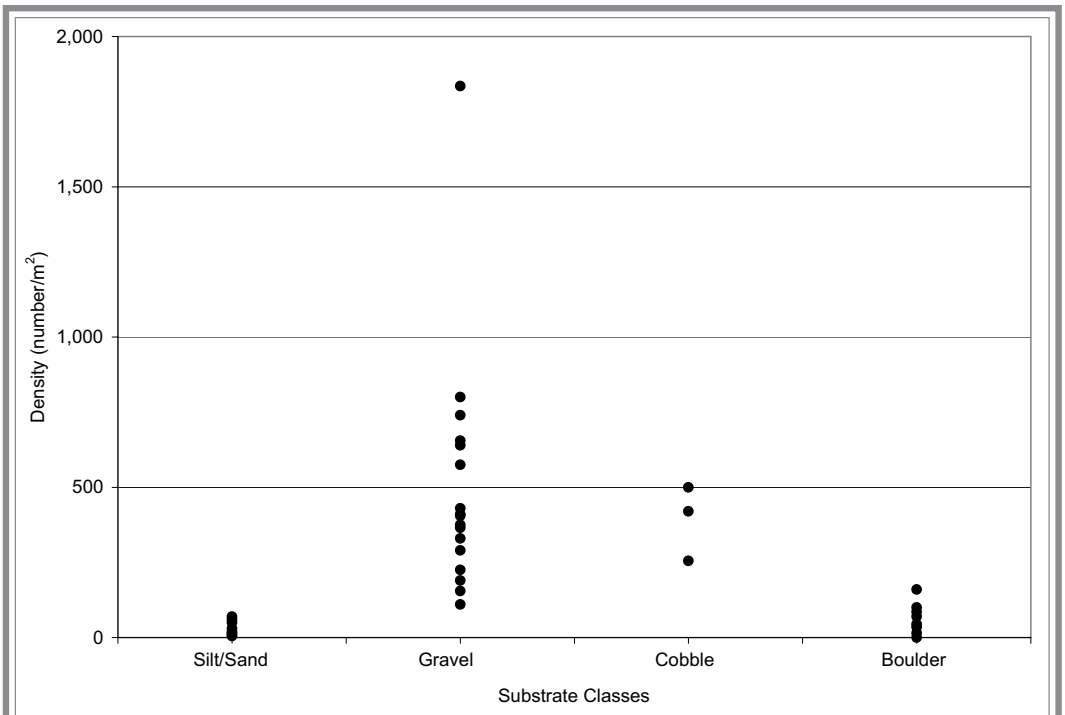

Figure 8.2.4. Asiatic Clam Densities in Four Substrate Categories Along Shoreline Areas that are Inundated 95% of the Time (i.e., river flows greater than or equal to (1,250 cubic meters [44,000 cubic feet] per second) in the Hanford Reach, Columbia River - Fall 2002

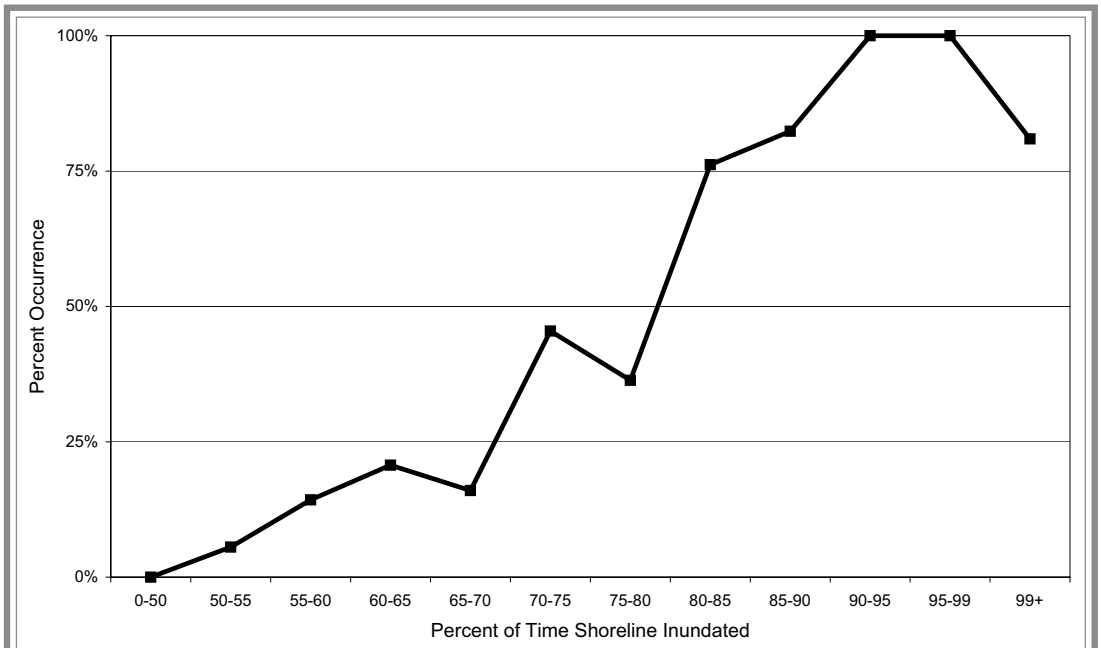

Figure 8.2.5. Asiatic Clam Occurrence on the Hanford Reach of the Columbia River with Respect to Amount of Time Shoreline was Covered with Water, 2002

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.

More than 100 rare plant populations of 31 different taxa are found at the Hanford Site (Figure 8.2.6). The U.S. Fish and Wildlife Service has designated 5 of these 31 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.html). 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 habitat.

Surveys during 2002 continued to document Piper's daisy (*Erigeron piperianus*) as a species of concern occurring in the 200 Areas. Surveys to the south of the 200 Areas documented previously known occurrences of grey cryptantha (*Cryptantha leucophaea)*, but did not locate any additional populations. Populations of another species of concern in the Columbia River Basin ecoregion, persistent sepal yellowcress (*Rorippa columbiae*), declined as a result of the high river flow levels from 1995 through 2000. Persistent sepal yellowcress is a rhizomatous perennial found in moist soil along the Columbia River within the Hanford Site. This species is often inundated by river flows, but little is known concerning long-term survival under continuous inundation. While river flows were near normal during 2002, data collected by Washington State Natural Heritage Program documented decreases in yellowcress populations from previous survey years.

Vegetation on long-term monitoring plots within the footprint of the 24 Command Wildland Fire that occurred in 2000 was surveyed during 2001 and 2002 to evaluate vegetation status and habitat recovery. Figure 8.2.7 indicates that total vegetation cover has not recovered to pre-fire levels and that large amounts of bare soil still persist in communities where big sagebrush (*Artemisia tridentata*) was the dominant shrub. Decreases in total vegetative cover range from 12% to 79% for the nine vegetation cover types sampled.

Increased bare soil and lack of persistent native vegetation may offer increased opportunities for the establishment of invasive weeds. However, the overall frequency of occurrence of the common exotic annual grass, cheatgrass (*Bromus tectorum*), did not increase appreciably after the fire. In most communities, the frequency of cheatgrass decreased the year following the fire, but increased to near pre-fire levels during 2002 (Table 8.2.1). In three of the nine vegetation cover types sampled, cheatgrass frequencies increased significantly after the fire compared to pre-fire levels: cheatgrass frequency increased by 15% in the plots dominated by threetip sagebrush (*Artemisia tripartita*), by 40% in bluebunch wheatgrass-Sandberg's bluegrass monitoring plots, and by 40% in big sagebrush/bluebunch plots. However, the average cover of cheatgrass across all plots did not increase significantly and total cheatgrass cover did not increase significantly in vegetation where the frequency of this species increased. This indicates that there may be a greater number of individual cheatgrass plants scattered through the plot, but cheatgrass has not become a dominant species in the vegetation.

8.2.5 Ecological Compliance

Policies of the DOE Richland Operations Office require that all projects having the potential to adversely affect biological resources have an ecological compliance review performed prior to initiation of the project. This review determines if the project will comply with the *Endangered Species Act of 1973* and the *Migratory Bird Treaty Act*. It also re-examines whether other significant resources such as Washington State listed species of concern, wetlands, and native shrub-steppe habitats are adequately considered during the project planning process. Where effects are identified, mitigation action is prescribed. Mitigation actions can include avoidance, minimization, rectification, or compensation.

Since many projects occur during periods of the year when the plants are not growing and plants are difficult to identify or evaluate, each of the operational areas (200-East and 200-West Areas, all of the 100 Areas, and the 300 Area) are surveyed each spring. All habitat areas within these areas are surveyed and each building is inspected for the nests of migratory birds. These baseline surveys provide information about the habitat types, and

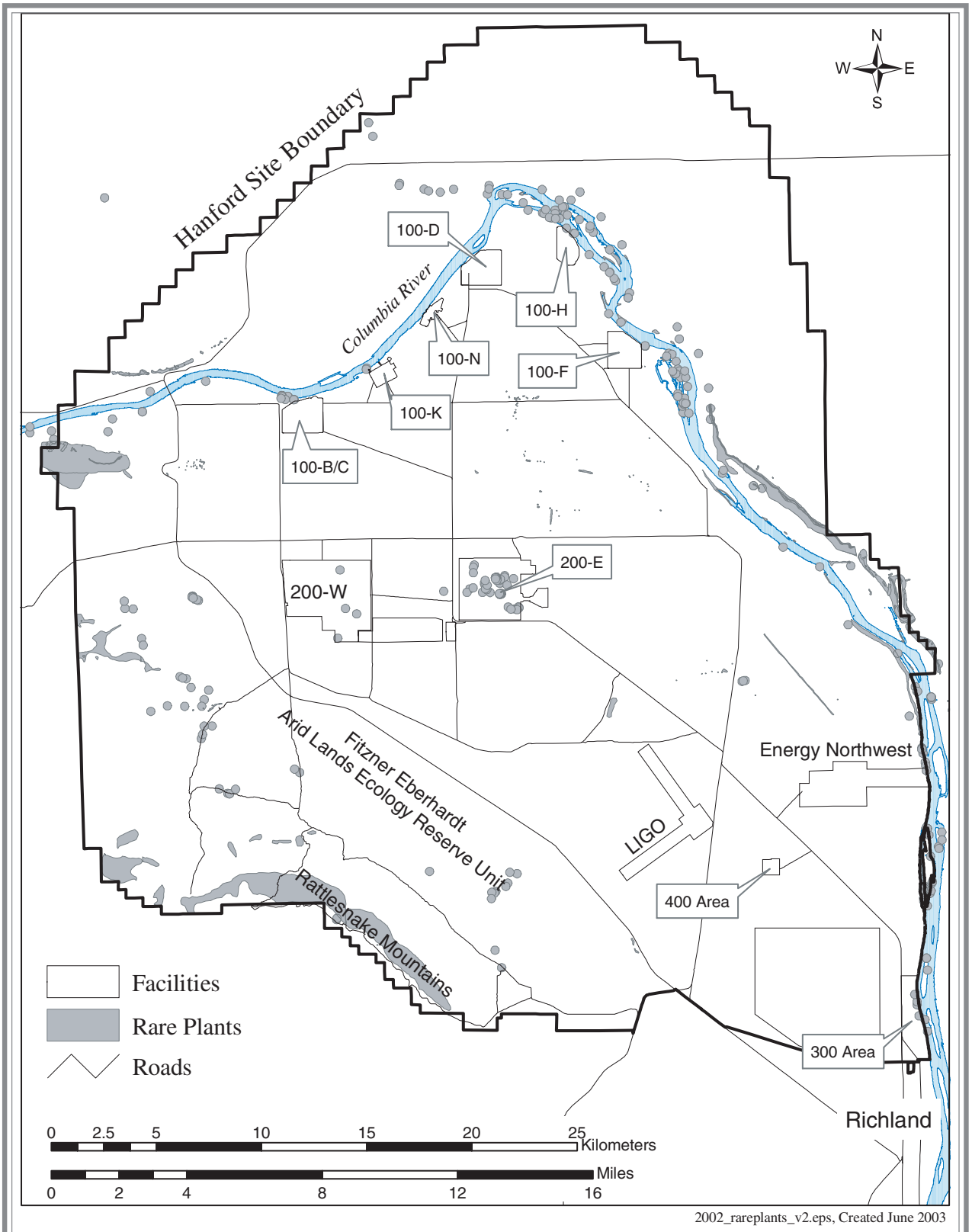

Figure 8.2.6. Rare Plant Locations on the Hanford Site, 2002

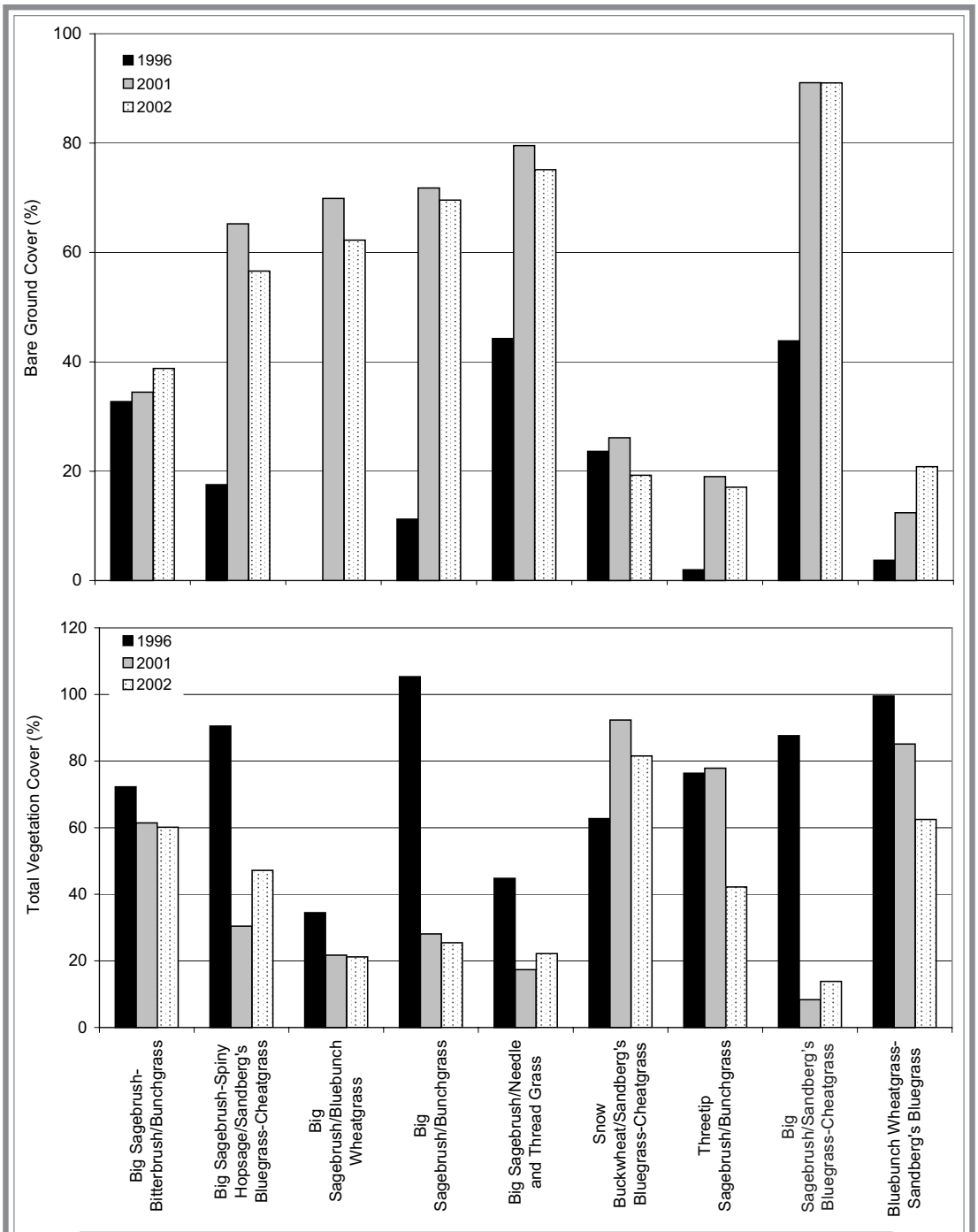

Figure 8.2.7. Percent Cover of Bare Soil and Vegetation on Monitoring Plots on the Hanford Site After the 2000 24 Command Wildland Fire (total percent cover represents the sum of cover for all elements in the community, and for communities with multiple layers, percent cover may exceed 100%)

Table 8.2.1. Frequency of Occurrence and Average Canopy Cover of Cheatgrass (*Bromus tectorum*) on Hanford Site Monitoring Plots Before (1996) and After the 2000 24 Command Wildland Fire

Survey Year	Frequency of Occurrence (%)	Frequency Standard Error	Canopy Cover (%)	Cover Standard Error
1996	63.0	6.8	21.4	3.0
2001	54.7	7.2	7.5	1.7
2002	63.7	6.3	9.3	2.1

species inventories and abundance, which can be used throughout the rest of the year to assess potential impacts. Examples of the baseline survey maps are available at http://www.pnl.gov/ecomon/compliance/comp.html.

A total of 146 ecological compliance reviews were performed during 2002 in support of general Hanford Site activities. An additional 39 reviews were performed in support of environmental restoration activities. The total number of reviews prepared during 2002 (185) was slightly higher than the number of reviews performed during the previous 2 years (Table 8.2.2).

8.2.6 Ecological Compliance for Bald Eagles

The bald eagle is listed as a federally threatened species (50 CFR 17.11) and also a Washington State threatened species (Washington State Department of Wildlife 1994). Protection for bald eagles on the Hanford Site is guided by the management plan contained in DOE/RL-94-150 and coordinated with representatives of the U.S. Fish and Wildlife Service. In accordance with the management plan, when the eagles are present, limited-access road closures within 800 meters (875 yards), or within 400 meters (437 yards) when out of sight of major perching, roost, and nesting sites have been mandated since 1994. While road closures for perch and roost sites are effective from November 15 to March 15, nest tending activities by the bald eagles have extended the closure until August. During the closures, only emergency activity is permitted in buffer zones; low-impact activities (well monitoring) are considered on a case-by-case basis and are generally permitted out of the line of sight, but not closer than 400 meters (437 yards) from the nest site.

Since monitoring started in 1961, no bald eagles have successfully nested on the Hanford Site. Nesting attempts have been documented since 1997. Some factors that may result in nest abandonment include (1) adverse weather, (2) food availability, (3) human activity near the nest, and (4) avian predator interactions. To evaluate the effect of human activities on nest abandonment and determine whether the present restrictions are adequate, data were collected on nesting behavior and on the eagles' flush responses.

Table 8.2.2. Ecological Reviews Performed on the Hanford Site, 1997 through 2002

Calendar Year	100 Areas	200 Areas	300 Area	Other[a]	Total
1997	8	79	44	33	164
1998	42	91	28	47	208
1999	36	72	36	52	196
2000	36	52	27	47	161
2001	26	64	27	52	169
2002	36	68	26	55	185
Totals	184	426	188	286	1,083

(a) Includes the 400, 600, 700, Richland North, and former 1100 Areas.

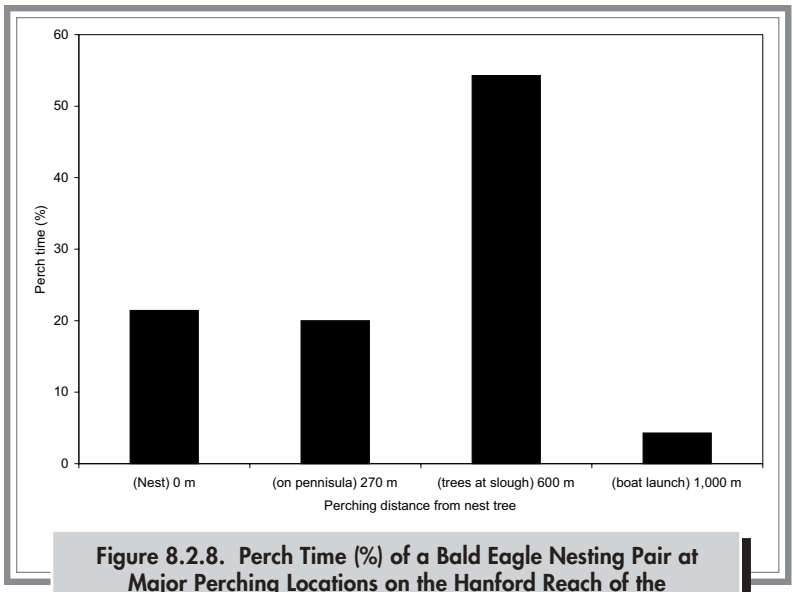

Figure 8.2.8. Perch Time (%) of a Bald Eagle Nesting Pair at Major Perching Locations on the Hanford Reach of the Columbia River Relative to Their Nest Location, 2002

During 2002, a single nesting eagle pair spent ~70% of their time (32.5 observation hours) perching. Much of that time was spent perching at the tree clumps within 600 meters (656 yards) of the nest. These trees also overlooked areas where food items (fish and waterfowl) were plentiful. Observations indicated that the nesting eagles primarily used an area within 600 meters (656 yards) of the nest (Figure 8.2.8).

The establishment of the 800-meter (875-yard) protection zone was originally developed from a number of published studies of flush-response patterns of eagles to various manmade disturbances. However, there has been no flush-response study for the bald eagles on the Hanford Site. Data on the flush response of bald eagles to the presence of vehicles or boats at various distances was collected from 1999 to 2001 and analyzed during 2002.

Factors having the greatest effect on eagle flush response included distance from disturbance, disturbance type (boat or vehicle), and age class. In general, juveniles were more susceptible to flushing than adults (Figure 8.2.9). Figure 8.2.10 illustrates the likelihood of flushing in response to distance from a boat or vehicle based on a multivariate logistic model. The model response indicates that vehicles are more likely to flush eagles than boats, and that 800 meters (875 yards) is probably an adequate distance to protect the bald eagles at Hanford from human-related disturbances.

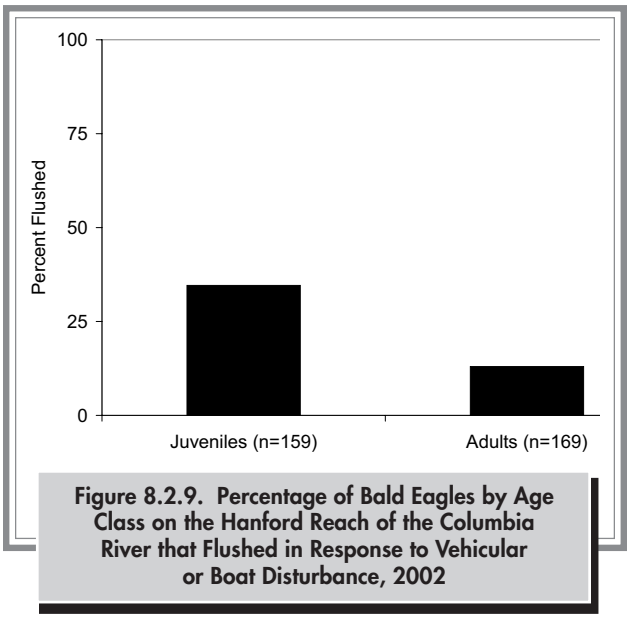

Figure 8.2.9. Percentage of Bald Eagles by Age Class on the Hanford Reach of the Columbia River that Flushed in Response to Vehicular or Boat Disturbance, 2002

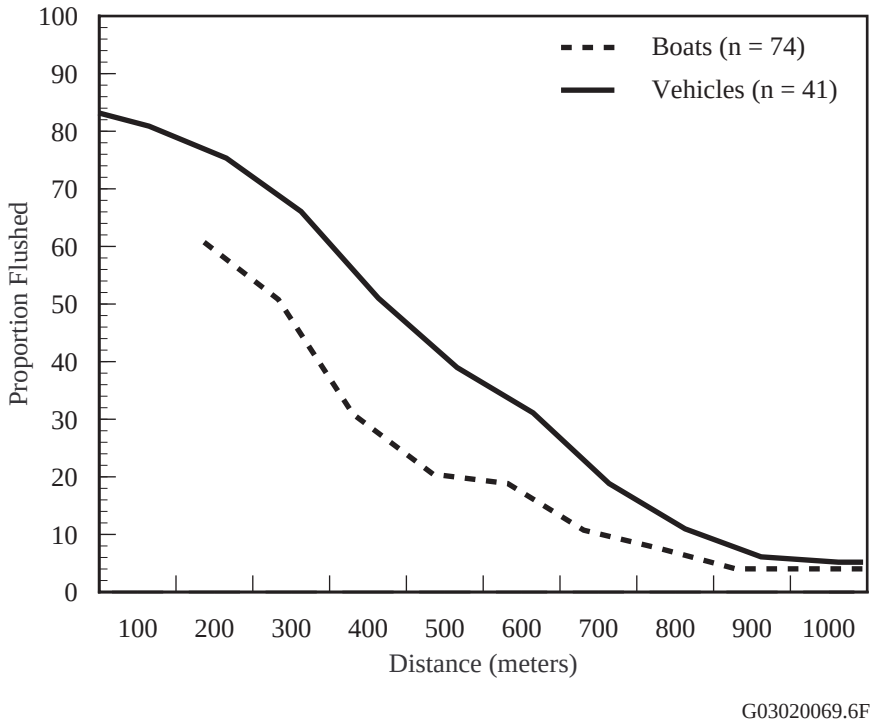

Figure 8.2.10. Flushing Distance of Bald Eagles in Response to Boat and Vehicle Disturbance on the Hanford Reach of the Columbia River. The proportion flushed was derived from a multivariate logistic model incorporating distance and mode of disturbance as predictor variables.