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# The role of ecological assessments in the evaluation of contaminated sites*

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**Abstract**

Ecological assessments are required components of most hazardous waste site investigations. Such assessments, in conjunction with contamination and human health risk assessments, help to evaluate the environmental hazards posed by contaminated sites and to determine remediation requirements. Ongoing Dames & Moore projects in New Jersey, Oregon, and Illinois serve as the basis for the discussion of selected technical approaches to ecological assessment and integration of assessments into the overall site investigations. Ecological assessment components to be discussed include practical field observations indicative of ecological impacts, useful indicator species, and semiquantitative methodologies to translate ecological observations into remediation requirements.

## 1. Introduction

The U.S. Environmental Protection Agency defines an ecological assessment as a "qualitative or quantitative assessment of the actual or potential effects of a hazardous waste site on plants and animals other than people and domesticated species" [1]. The methodologies used for ecological assessment mandated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) — unlike human health risk assessment — are only vaguely defined. As a result, assessment methods applied by both consultants and regulatory agencies range from qualitative approaches, such as listings of potential biotic receptors at a contaminated site, to fully quantitative

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approaches that include detailed exposure estimations, quantitative toxicity comparisons, and supplementary biota sampling to evaluate uptake estimates.

Early efforts to assess risks at hazardous waste sites generally used the qualitative approach, wherein the principal "finding" was the simple listing of species that could be potential receptors. Both EPA and the regulated community recognized the limited value of this method in contributing to remediation decisions. Around 1990, EPA gradually shifted emphasis from the qualitative approach to the conduct of onsite investigations by biological professionals. The use of established as well as experimental quantitative and semiquantitative methods for assessing chemical impacts was encouraged. The trend toward the use of more integrated and comprehensive assessment approaches was reflected by EPA's relatively new *ECO-Update* bulletin and the formation of Biological Technical Advisory Groups (BTAGs) at EPA's regional levels. The BTAGs are composed of biological, environmental engineering, toxicological, and resource management specialists from local, state, and regional regulatory and resource management agencies.

Three recent Dames & Moore ecological assessments demonstrate the variable approaches to conducting ecological assessments and the role of these approaches in facilitating decision making. These three assessments

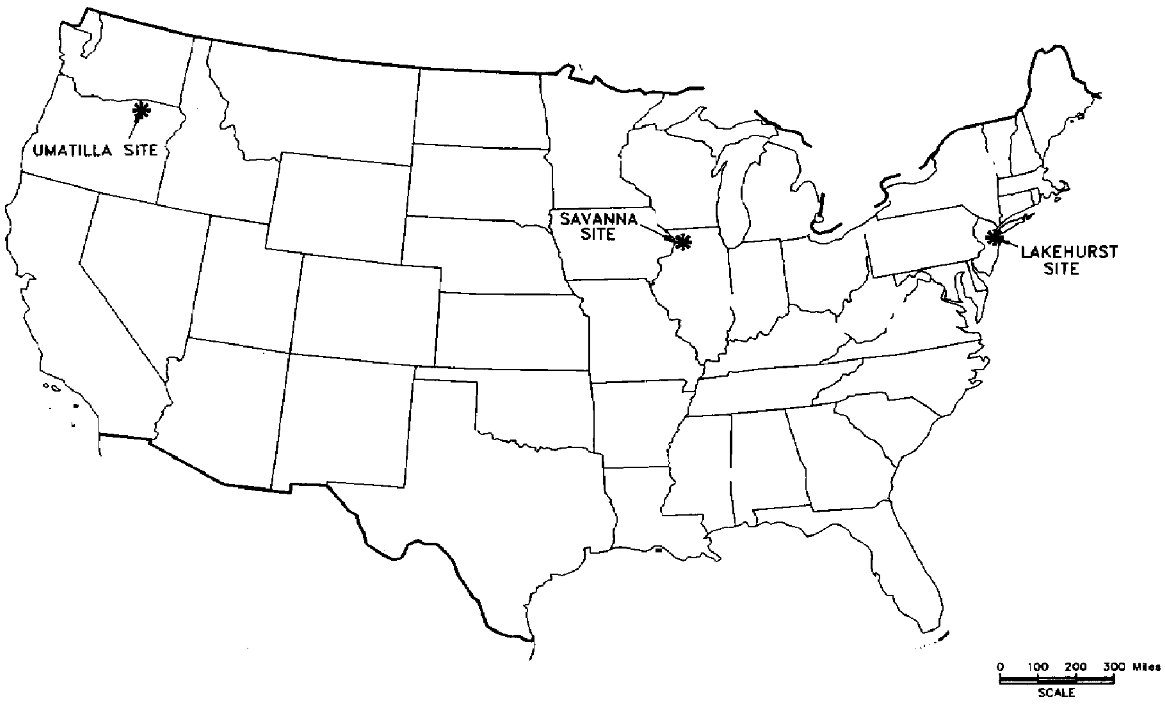


Fig. 1. Ecological assessment site locations.

were conducted in three EPA regions and in three very different biotopes — the Atlantic Coastal Plain Pine Barrens area, the semiarid shrub- and grassland-dominated high plains along the Columbia River, and the upper Mississippi River bottomland hardwood forest and adjacent relict tall-grass prairie. Figure 1 shows the locations of these sites. The first ecological assessment — near Lakehurst, New Jersey — represents a highly qualitative approach. The second — located in northeastern Oregon — represents a preliminary quantitative approach. The third — in northwestern Illinois — represents a more fully quantitative approach.

## 2. Qualitative approach: New Jersey Pine Barrens Site

### *2.1 Background and ecological setting*

The facility selected to represent the qualitative approach to ecological assessment is an 8,000-acre military installation — Naval Air Warfare Center-Lakehurst — located in the Pine Barrens region of north-central New Jersey, as shown on Fig. 2. The Pine Barrens area has special protection status as a State-designated critical habitat containing unique flora and fauna. Many State-listed and several Federally listed rare plant and animal species exist only in this area. The site is also in the Atlantic migratory flyway. Such conditions place higher than normal importance on the assessment of ecological risks from chemical releases.

The installation is entirely within the Atlantic Coastal Plain physiographic province. The area has a moist maritime climate, receiving about 45 inches of annual precipitation, mostly as rain. The soil is extremely permeable sand underlain by shallow clay lenses. Most chemicals released at the surface are likely to be transported rapidly downward and along clay layers in the direction of the hydrologic gradient. Discharges to many adjacent and nearby wetland ecosystems are possible.

Operation of the installation has resulted in inadvertent discharge to the environment of an array of chemicals — principally jet fuel — used in the servicing and repair of aircraft. Most discharges have occurred from the major fueling and maintenance facilities. Smaller fueling facilities are located in the densely forested western areas.

Dames & Moore evaluated chemical releases from the various waste sites during multiple phases of sampling and testing. Table 1 lists the principal chemicals detected.

An ecological assessment was initiated in early 1992. Prior to that time, no biological or toxicological data had been collected or assembled. Because both time and funding were sharply limited, the primary focus was to define the operable units and contaminated sites most likely to cause adverse ecological impacts.

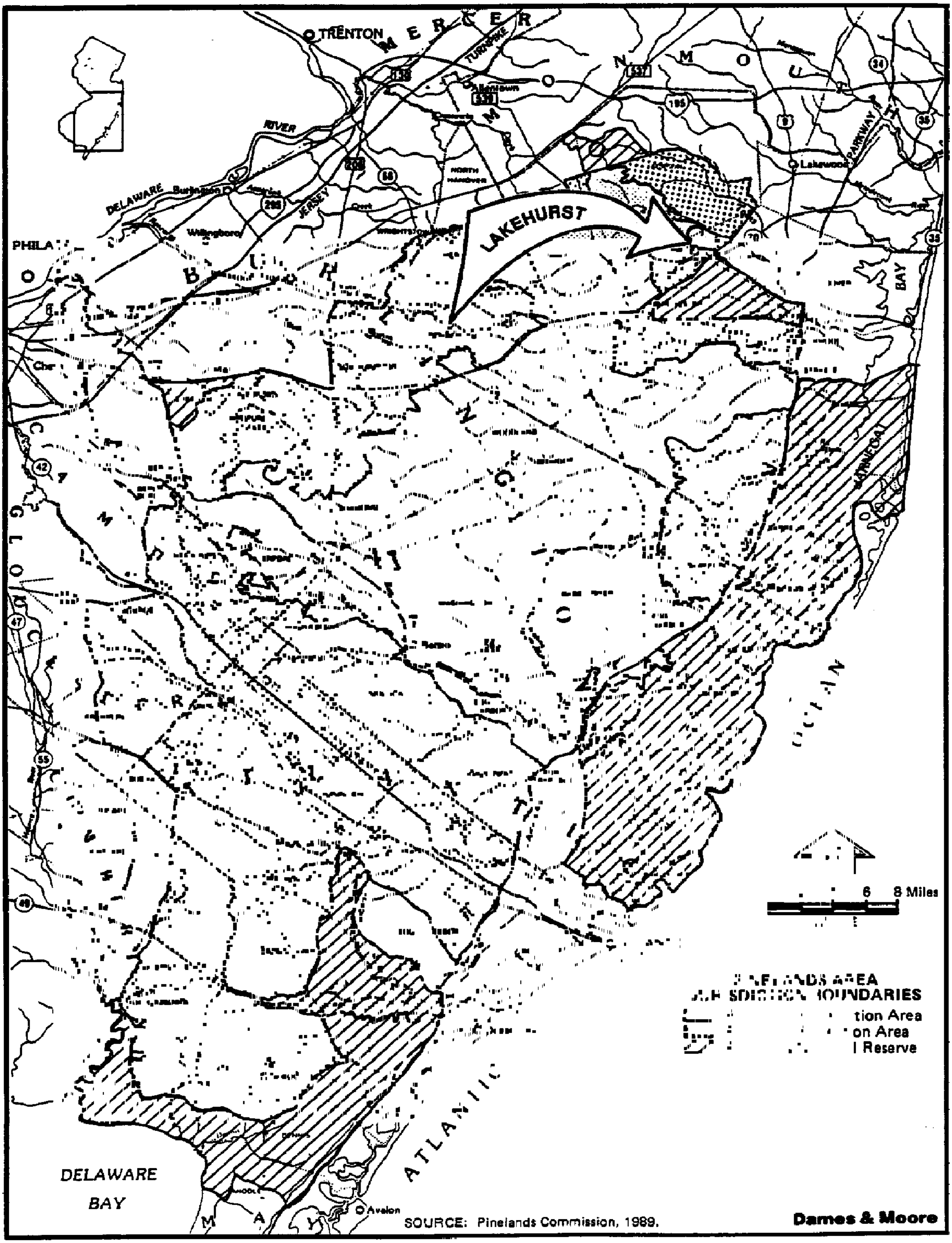


Fig. 2. Lakehurst site location.

TABLE 1

Principal contaminants of concern for the baseline ecological evaluation

| Terrestrial/avian biota | Surface water biota | Sediment biota |
|---|---|---|
| Aluminum | Aluminum | Antimony |
| Antimony | Antimony | Arsenic |
| Barium | Arsenic | Beryllium |
| Beryllium | Barium | Cadmium |
| Cadmium | Beryllium | Chromium |
| DDT | Calcium | Cobalt |
| Dieldrin | Chromium | Copper |
| Iron | Copper | Lead |
| Lead | Iron | Mercury |
| Mercury | Lead | Nickel |
| Toluene | Magnesium | Potassium |
| Xylenes | Manganese | Silver |
| TPH | Mercury | Sodium |
| | Nickel | Thallium |
| | Potassium | Vanadium |
| | Sodium | Zinc |
| | Thallium | 2-Butanone |
| | Vanadium | 2-Methylnaphthalene |
| | Zinc | 4-Methylphenol |
| | 1,2-Dichloroethene | Anthracene |
| | Aldrin | Benzo[a]anthracene |
| | DDD | Benzo[b]fluoranthene |
| | Delta-BHC | Benzo[g,h,i]perylene |
| | Dieldrin | Carbazole |
| | Endrin | Chrysene |
| | Heptachlor | DDD |
| | Lindane | Dibenz[a,h]anthracene |
| | Tetrachloroethene | Fluoranthene |
| | Trichloroethene | Indeno[1,2,3-c,d]pyrene |
| | | Pheranthrene |
| | | Pyrene |
| | | Toluene |
| | | TPH |

## *2.2 Technical approach*

Because of time and funding constraints, a technical approach was needed to rank the contaminated sites by relative hazard to potential ecological receptors. The approach would have to consider the kinds and locations of potential receptors, the relative toxicity of the most prevalent and hazardous chemicals, and the likelihood of the existence of complete exposure pathways. Specifically, a three-element approach was implemented, which included a qualitative ranking of each site.

#### *2.2.1 Element I — Characterization of potential receptors and proximity of receptors to contaminated sites, and visual observation of receptor impacts*

Literature searches; past regional, local, and installation ecological studies; and a brief onsite investigation by an avian biologist and a botanist were initiated to identify receptors, assess proximity factors, and document any unusual disruptions to plant and animal communities.

More than 20 State-listed rare, threatened, and endangered biota were found or documented at the installation. Many of these occupied or favored the use of numerous wetland and aquatic systems. Many of the wetlands were found to be acidic, "black-water" bog systems. Therefore, the wetlands and aquatic systems were considered to be the primary receptors for this investigation.

While general surface flow patterns and the proximity of receptors to contaminated sites could be adequately assessed, field observations of environmental stress could not be fully addressed because of time constraints that restricted fieldwork to the dormant season.

#### *2.2.2 Element II — Toxicity assessment of the chemicals of concern*

Chemicals of concern at each site were defined as those found in the highest concentrations, and with the greatest persistence and relative toxicity to site biota. Two relative measures of the potential for toxicity to wildlife were used:

- Exceedances of published "applicable or relevant and appropriate requirements" (ARARs) by concentrations measured in the surface water medium.
- Exceedances of published $LC_{50}$ concentrations by concentrations estimated to be present in terrestrial and aquatic biota.

#### *2.2.3 Element III — Pathway analysis*

The times required for delivery of toxic levels to identify important receptors (wetlands and aquatic systems) were crudely estimated by considering fundamental hydrogeologic information such as groundwater flow rates and principal chemical attenuation mechanisms such as adsorption. Contaminant arrival times at the wetlands were estimated to range from less than 1 year to greater than 20 years.

### *2.3 Findings*

A qualitative ranking system was created to integrate these findings. The ranking system was somewhat judgmental and subject to the pitfalls that accompany any such simplistic approach; however, it was useful for understanding the relative importance of each site with regard to its potential to cause ecologic risks.

While such findings are highly preliminary, they suggested a course of action. The sites with the highest rankings should be considered for further evaluation regarding potential remedial requirements.

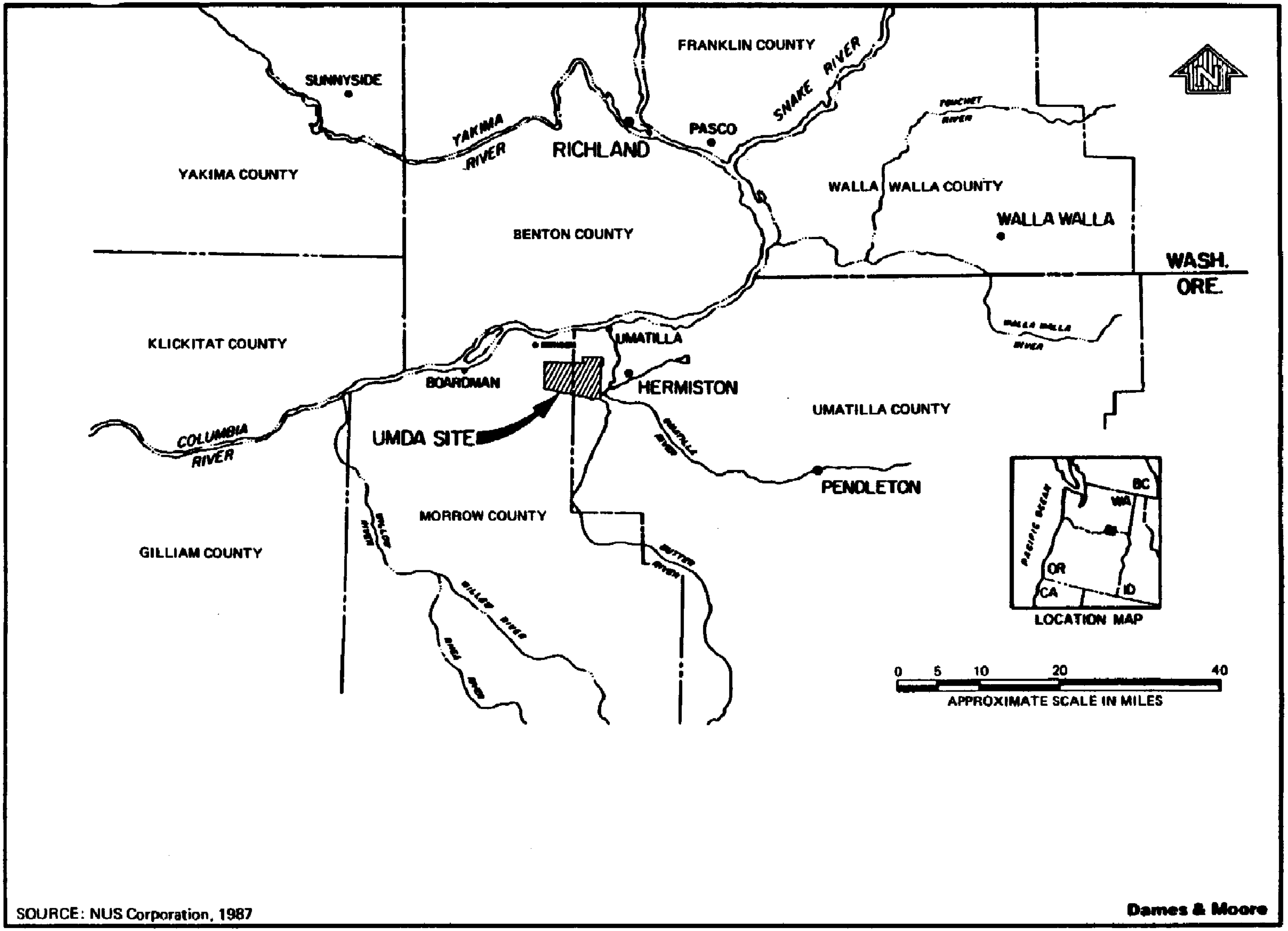


Fig. 3. Umatilla site location.

## 3. Preliminary quantitative approach: High Plains Site along the Columbia River

### *3.1 Background and ecological setting*

The facility selected to illustrate the preliminary quantitative approach (Umatilla Depot Activity (UMDA)) is a 19,728-acre military reservation located in Morrow and Umatilla Counties, Oregon, as shown on Fig. 3. UMDA has operated since 1942 to receive, store, maintain, renovate, and destroy military ordnance materials. Ordnance that is obsolete, past useful age, or damaged beyond repair is destroyed by incineration, washout and recovery of explosives materials, or open burning and detonation. These are relatively safe and cost-effective methods; however, inadvertent discharges of raw explosives products, demolition byproducts, and other operational and maintenance chemicals have occurred. Discharged chemicals exist primarily as soil residues, because the activities causing releases have either been reduced in scale and frequency or discontinued.

Northeastern Oregon is in the Grass/Sagebrush Shrub-Step phyto-geographic province. The area is semiarid, receiving less than 12 inches of rainfall per year. UMDA is located in a sandy plain near the Columbia River, between the Cascade Mountains to the west and the Blue Mountains to the east. The area is subject to nearly continuous wind. Most of the land adjacent to the installation is irrigated and cultivated. Thus, in spite of the ordnance disposal operations, UMDA serves as an unintentional refuge for the original regional biota.

Resident native fauna, such as the badger and the burrowing owl, are well represented on the installation. The long-billed curlew, a candidate species for Federal protection status under the Endangered Species Act, nests annually at UMDA. Swainson's hawk, another high interest migratory species, is also present. Additionally, a herd of 250 pronghorn antelope resides at UMDA.

The installation was subdivided into four operable units for evaluation of exposure potential and risk characterization — the Ammunition Demolition Activity (ADA) area, the deactivation furnace, the explosives washout plant, and other miscellaneous areas, primarily the sewage treatment plant discharge. The operable units were defined on the basis of activity type (Fig. 4), likely contaminants, likelihood of wildlife exposure, and geographic location.

#### *3.1.1 Operable Unit 1 — ADA*

The 1,600-acre ADA area is a fenced security zone on the west side of UMDA. Burning occurs in the open air — primarily in the north-central area, on pads, or in pits and open trenches. Detonation is generally conducted in the south-central area. Explosives burning and detonation disposal have occurred at irregular intervals throughout the life of the facility. Materials burned have included pesticides, solvents, and other waste materials.

The area east of the ADA was also investigated during site visits and is included in the ADA operable unit. An apparent higher than normal mortality

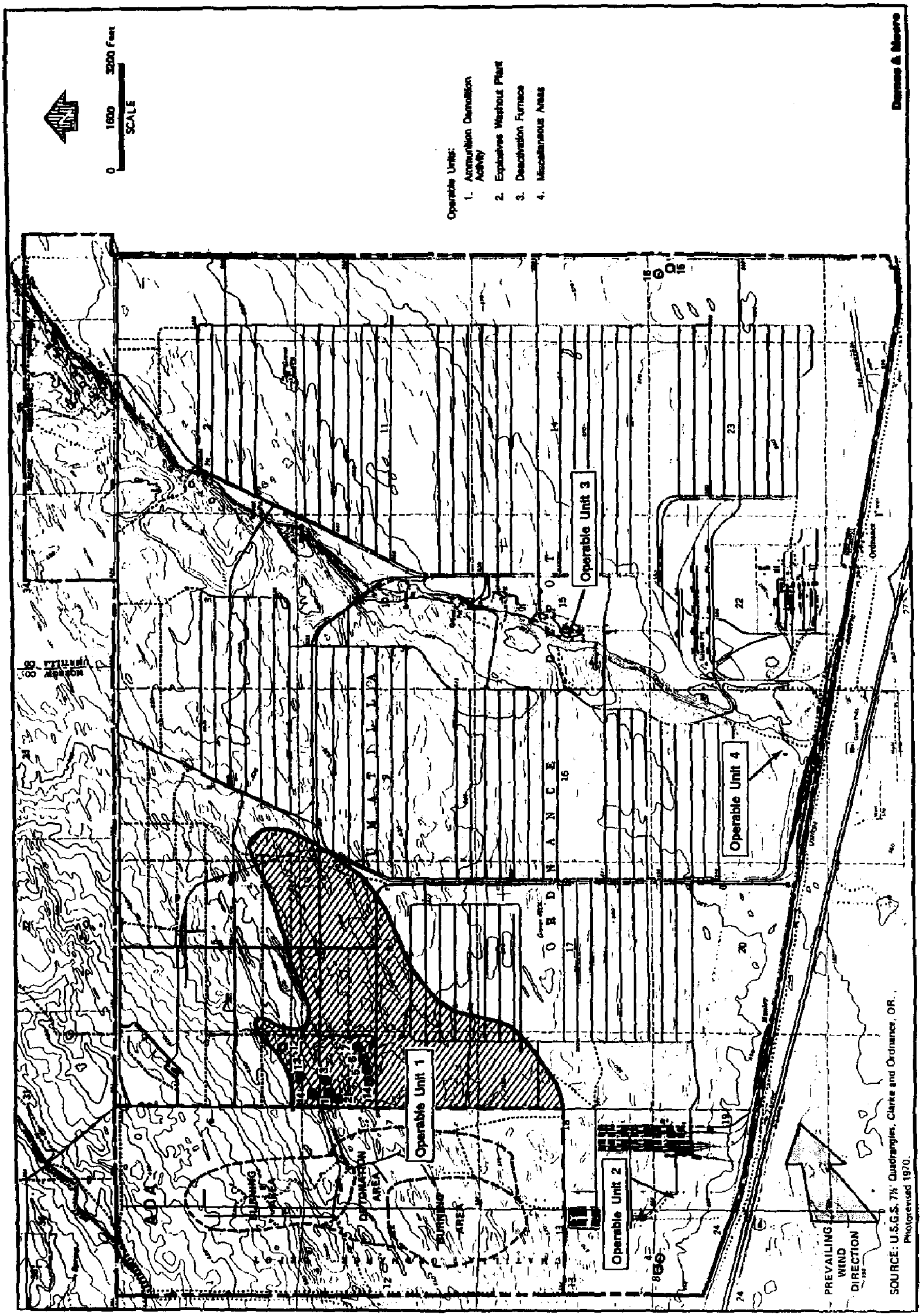


Fig. 4. Umatilla operable units.

of antelope bitterbrush (*Purshia tridentata*) was noted near the ADA east access control gate. Further investigation revealed that the extent of apparent high mortality covered an area of nearly 1,000 acres, stretching about 1.7 miles east from the ADA perimeter and about 1.5 miles wide along the ADA perimeter road.

Vegetation was sampled to confirm the apparent high mortality rates. Sampling data collected in the area downwind of the ADA were compared to data collected at physically similar control sites (i.e., sites not downwind of the ADA area). Mortality downwind of the ADA area was found to be 77 percent. Mortality in the control sites was found to be about 20 percent. Other community-level differences were noted, including a higher percentage of annual and nonnative species in the ADA downwind area than in the undisturbed control sites on the east side of UMDA.

Selective stem mortality was also observed outside UMDA in a Lombardy poplar grove that encircles the apple orchard located along the northern site perimeter. This grove is about 50 feet tall and is also downwind of the ADA. In the upper one- to two-thirds of the canopies, several hundred poplars displayed dead, leafless branches on the windward side facing the ADA.

The location and pattern of bitterbrush mortality and poplar stem death, the availability of a contaminant source, and the existence of a reliable contaminant transport mechanism (wind) suggested that contaminants may have been made available over a large area to plant and, possibly, animal populations. Other possible causes of plant mortality were considered, including fire, pathogens, insects, simple wind effects, abrasive wind-transported sediments, serial change/competitive pressure, topographic differences, and soil differences. The localized environmental causes were dismissed as unlikely or insignificant, but pathogens and insects could not be dismissed as possible causes.

*3.1.2 Operable Unit 2 — Deactivation furnace*

Incineration as a disposal method is limited to small-arms ammunition. These materials are burned at high temperatures in a deactivation furnace located in the southwestern part of UMDA. Gases and ash generated by burning are discharged through a stack to the open air. Soil chemical testing revealed significantly higher-than-background concentrations of metals — particularly lead and zinc — in the area downwind of the furnace.

*3.1.3 Operable Unit 3 — Explosives washout facility*

Washout and explosives materials recovery activities occurred at the explosives washout facility located in the east-central part of UMDA. This was an industrial-type operation using high-pressure, heated water to scour bulk explosives from projectile casings. Contaminated wastewater was discharged via an open trough and later a pipeline to a series of two lagoons. The wastewater carried high concentrations of unrecoverable explosives materials, primarily TNT and RDX. Water collected in the unlined lagoons was allowed to evaporate and infiltrate into the soil, leaving concentrated explosives residues at and near the surface. Accumulated explosives residues were routinely excavated from the lagoons and hauled to the ADA to be burned.

Observations of habitat disruptions were not possible for this operable unit. Much of the area near the facility had been drastically disturbed by grading and construction. The primary concern with this site was direct contaminant uptake through soil ingestion by fauna.

#### *3.1.4 Operable Unit 4 — Miscellaneous sites*

Of the two sites included in this unit, only the sewage treatment plant basin presented an exposure potential to wildlife. Soil and occasional standing water are potentially contaminated with DDT from pest control operations.

### *3.2 Technical approach*

The investigations conducted by Dames & Moore to assess the relative ecological impacts from these chemical discharges required a multistep process to evaluate the observed and potential effects to site biota. The steps to evaluate *observed* ecological effects included:

- Characterization of the installation's physical features, habitats, and potentially exposed biota, and identification of indicator species.
- Observation of habitat disruptions potentially related to toxic effects.

The steps to evaluate *potential* ecological effects included:

- Identification of contaminants of concern and potential exposure pathways.
- Summary of environmental fate for the contaminants of concern.
- Assessment of the exposure and toxicity potential of contaminants of concern to selected indicator species.
- Characterization of risk.

#### *3.2.1 Installation characterization and observation of disruptions*

One of the principal purposes of the field study was to determine whether any signs of ecological stress were obvious. Physical characteristics, habitats, and biota were evaluated for the installation as a whole, and limited field studies were conducted to corroborate existing regional studies of native biota. Plant species were quantitatively measured to evaluate suspected impacts observed in the field.

#### *3.2.2 Selection of contaminants of concern and evaluation of fate and transport properties*

Contaminants were determined to be of concern if they were above background soil levels and were suspected of being site related. Environmental fates and behaviors were evaluated for each of the contaminants of concern. The basic philosophy inherent in this process was to consider a chemical as a contaminant of concern unless there were unequivocal data to the contrary. Labeling a chemical as a "concern" at this point in the overall assessment process does not imply that it is a concern in a remedial sense. This is determined in later portions of the assessment.

*3.2.3 Toxicity assessment*

The relative toxicities of the contaminants of concern — that is, their potential toxicity to environmental receptors — were assessed by conducting literature reviews and identifying No Observed Adverse Effect Levels (NOAELs) for laboratory animals determined to be appropriate surrogates for the site-specific indicator species. Four indicator species (field mouse, pronghorn antelope, American badger, and Swainson's hawk) were considered. $LD_{50}$ data were considered representative of acute toxicity potential.

NOAELs were determined by methods analogous to human health risk assessment methods. The primary points of interest were factors that could potentially affect population viability, including toxicity to neurological systems, reproduction, and growth and development. When available, data from laboratory feeding studies were used, under the assumption that this exposure scenario is approximately equivalent to the soil uptake scenario. The choice of a surrogate laboratory species was based on both phylogenetic considerations and body size similarities. The frank effect level (FEL) was used as a measure of long-term effects for contaminants whose more subtle long-term toxicological effects were not well characterized.

*3.2.4 Risk characterization*

Two components of the risk characterization process are determination of contaminant intake for each of the indicator species and estimation of resultant risk potential.

Contaminant intake was calculated from the consumption of soil, vegetation, and prey. Intake doses for each of these three pathways were based on species-specific calculated ingestion rates or values obtained from the literature. The calculated ingestion rates were based on percentages of body weight or measures of total diet. Contaminant uptake in vegetation was determined through the use of contaminant-specific bioconcentration factors. The total intakes from all three pathways were subsequently summed and divided by average body weights to obtain an intake dose in milligrams per kilogram body weight per day.

NOAELs are standardized reference levels that theoretically represent the highest exposure concentration not associated with adverse health effects. Hazard quotients (HQs) — defined as the ratio of the contaminant intake, in milligrams per kilogram body weight per day, to the NOAEL — are measures of the relative toxicity of an environmental contaminant to that standardized reference level. An HQ of greater than 1.0, therefore, indicates the possibility of adverse health effects from exposure to a specific contaminant. Depending on the quality of individual toxicity data bases, contaminant-specific HQs were calculated for each operable unit and each indicator species. For multiple contaminants that affected toxicity through common mechanisms of action (nitroaromatics and two pairs of metals), hazard indices — defined as the sum of the individual HQs — were used as the measure of health risk.

*3.3 Findings*

Health risks for chronic exposure were characterized on an operable unit-specific basis. For all operable units, the most extensive toxicity data bases were available for field mice. Using a worst case soil ingestion model, lead, RDX, and TNT dominated the risk assessment for field mice, with chronic HQs ranging from 178 to 497. Although 10 other metals produced HQs greater than 1.0, the toxicological data supporting some of these HQs is highly questionable. Copper and TNT were the principal contaminants of concern for badgers. Although appropriate toxicity data were limited for hawks, the available data suggest that lead and cadmium may be significant potential health hazards. Pronghorns are excluded from the ADA area by a restraining fence.

The only contaminants that resulted in health concerns at the washout plant and lagoons were RDX, TNT, TNB (field mice), and TNT (badgers). Data were inadequate for the health risk characterization of pronghorns and hawks. Lead was a serious health concern for field mice, badgers, and hawks exposed to the deactivation furnace. Lead was also a moderate health hazard for field mice and hawks at the stormwater drainage area. In general, the appropriate toxicity data were not available for an assessment of health risk of pronghorns and hawks exposed at operable units 3 and 4. Pesticides were not a health risk at any operable unit.

Lead was the only contaminant that showed a consistent health risk at multiple sites. Based on an analysis of health effects, the most contaminated ADA areas were Sites 15 and 19 for metals and Sites 15 and 31 for explosives. Operable unit 2 was the most heavily contaminated area for explosives.

The findings of highly elevated HQs for several contaminants were based on conservative exposure and extrapolation assumptions, including lifetime exposure, constant residency, and use of the upper 95 percent confidence limits for soil ingestion. These assumptions should be modified by known feeding behavior and habitat ranges for the indicator species. An analysis of these parameters indicates that only the field mouse is likely to be continually exposed to a contaminated site, and that the exposure potential for the pronghorn and the migratory hawk are extremely limited. Conclusions regarding the adverse health effects of contaminant exposure were modified by several uncertainties associated with that exposure, including adequacy of the laboratory study used for NOAEL determination, bioavailability of the soil-bound contaminant, and contaminant-specific soil background levels.

While adverse health effects were strongly suggested for some portions of the UMDA biota at some contaminated sites, it was deemed inappropriate to estimate cleanup levels on the basis of the existing data, primarily because of uncertainties related to the actual bio-uptake of contaminants. Plant and animal tissue testing was recommended for confirmation of exposure estimates.

## 4. Quantitative approach: Mississippi River Bottomlands and Tall-Grass Prairie Site

### *4.1 Background and ecological setting*

The facility selected to represent the quantitative approach — the 14,000-acre Savanna Army Depot Activity (SVADA) — is located in the unglaciated portion of northwestern Illinois, as shown on Fig. 5. About 40 percent of the installation is a braided, backwater, bottomland–hardwood forest system within Pool 13 of the Mississippi River (Fig. 6). Mature silver maple- and cottonwood-cloaked islands are formed between sloughs, lakes, ponds, and emergent wetlands complexes. This rich backwater complex provides high quality habitat for many species, including the rebounding river otter and a winter transient population of nearly 300 bald eagles. A great blue heron rookery has flourished in the area, along with deer, wild turkey, and beaver. In addition to support of wildlife populations, the numerous sloughs and lakes are heavily used by commercial and recreational fisheries.

In sharp contrast to the bottomlands, the remaining 60 percent of the installation is a relict tall-grass prairie/dry oak forest complex. Much of this

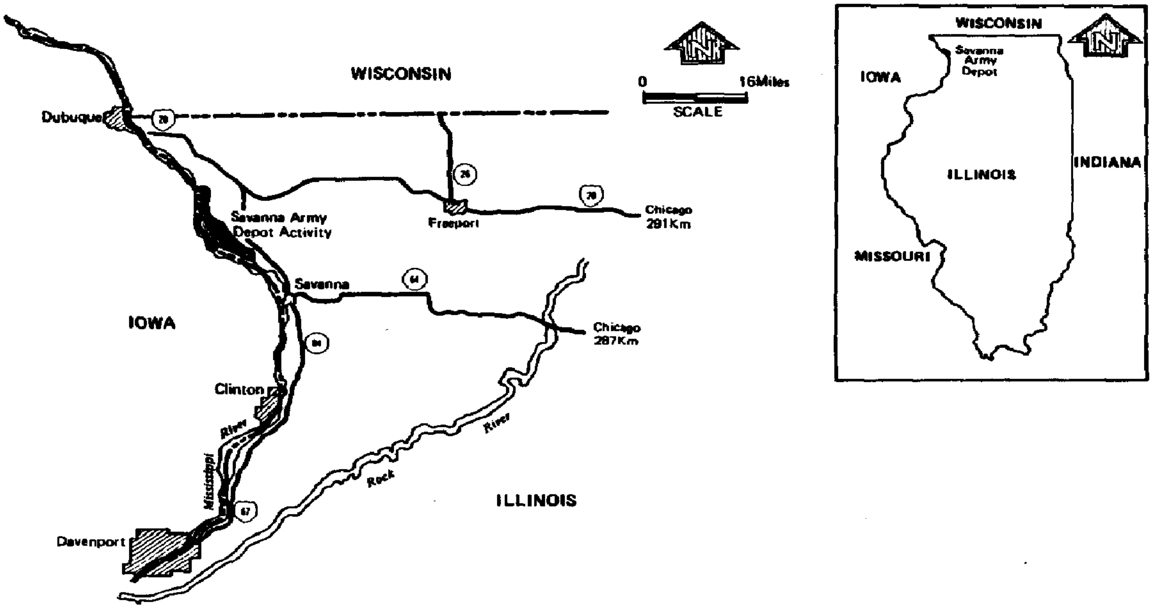


Fig. 5. Savanna site location.

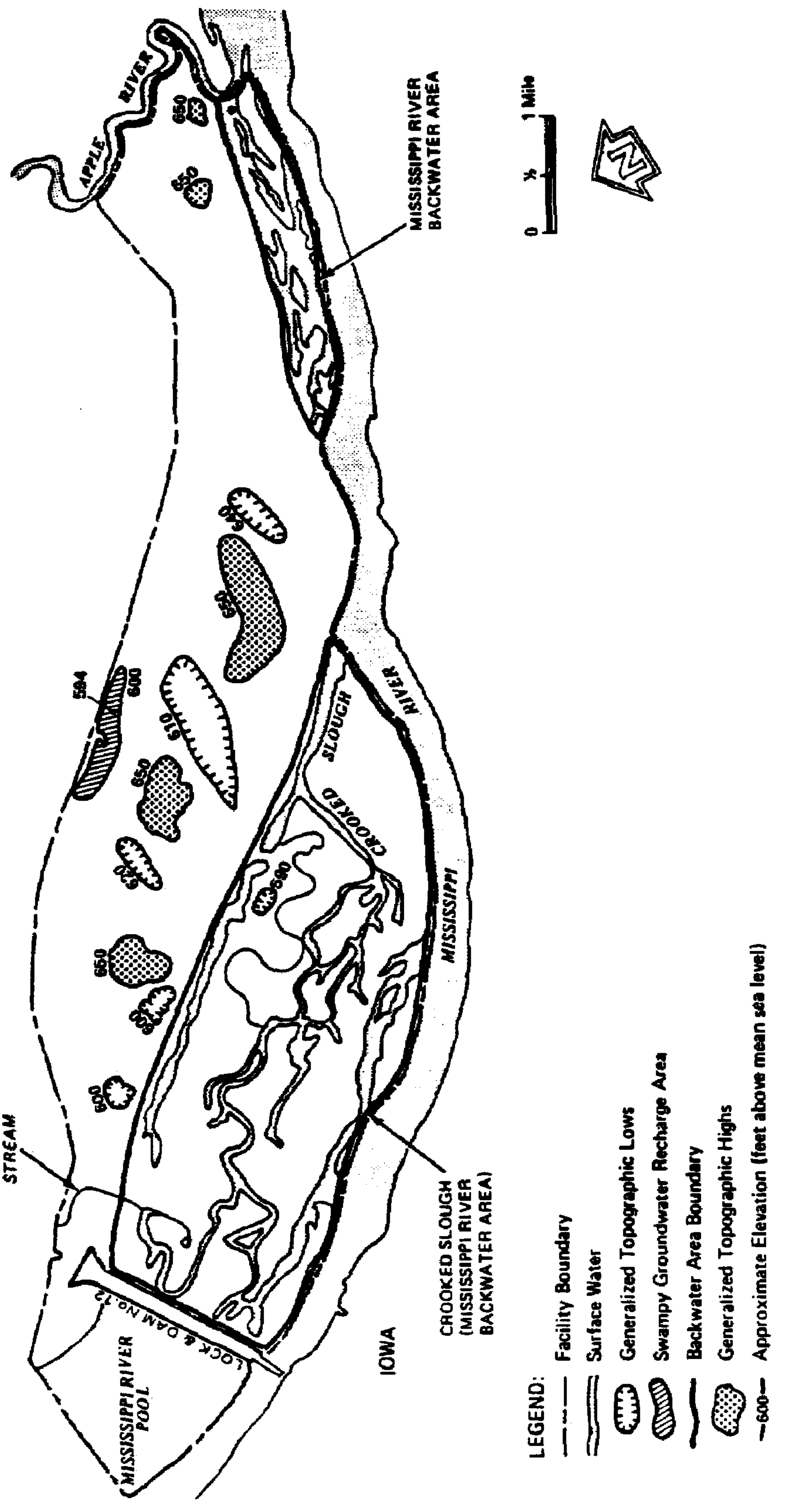


Fig. 6. Dominant surface water drainage features at Savanna.

area is a well drained, sandy loess bluff. Several plant and animal species eliminated from the prairie biome by agriculture reside here in spite of facility operations, including some species listed as rare and endangered.

The high permeability of the loess bluff area suggested that waterborne chemicals might migrate rapidly to the water table. The water table potentially discharges to the backwater area, providing a pathway for contaminants to aquatic systems.

Two major facilities discharged explosives-laden wastewater over a period of about 25 years — one to a leach field constructed high in the loess bluff area, the other initially to the bottomland forest area and later to a series of earthen settling lagoons. The lagoons became highly contaminated with TNT and RDX residues and are presently undergoing remediation through excavation and burning. The potential for deposition of explosives downstream is a matter of environmental concern.

The burning and detonation area, while small compared to the Umatilla operation, is also located in the rich bottomlands. The proximity of many identified ecological receptors to numerous important habitats raised this area to a high level of concern. Several other potentially contaminated sites had also been identified, including several landfills, explosives and mustard gas burial areas, a small-arms ammunition deactivation furnace, and scattered surface burning areas. Within the past 10 years, SVADA has stopped most contaminant-generating activities.

The following questions were developed as the focus of this investigation because of the virtually uncontrolled and long-term nature of chemical releases, the probable location of residual contaminants in soil and sediment, and the existence of rich habitat for many important species.

- Are the residual contaminants in soil and sediment available to terrestrial and aquatic fauna in concentrations sufficient to induce chronic and acute toxicity?
- Are residual contaminants migrating via surface water and groundwater in sufficient concentrations to induce toxic responses in aquatic organisms?
- Is food-chain transfer/bioaccumulation a functional pathway for contaminants to higher order receptors?

### *4.2 Technical approach*

Because of the rich nature of the SVADA habitat, a fully quantitative ecological assessment approach was implemented, consisting of the following components:

- *Toxicity modeling*: Similar to the methods used at Umatilla, exposures were calculated using media concentrations and assumptions concerning soil, water, vegetation, and prey ingestion rates. LOAELs and NOAELs derived from laboratory studies were used to facilitate toxicity comparisons for 12 indicator species representing major trophic levels. The uncertainties inherent in structure – activity-based bioconcentration and exposure assumptions were reduced by direct tissue sampling of lower trophic levels at the most likely sites of contamination and at control sites remote from contaminant sources. Sampling included: plant roots, plant shoots and fruit, terrestrial invertebrates collected from the soil and ground surface, rodent urine for body burden calculation, aquatic vegetation, aquatic invertebrates (mussels), and fish.

- *Toxicity testing:* Water samples collected from background sites and groundwater seeps, pools, ponds, and river segments close to contaminated areas were used in 96-hour flow-through toxicity tests.
- *Histopathological studies:* Organs from randomly chosen rodent specimens collected for urine samples were preserved and forwarded for histopathology work.
- *Historical data references:* Collected fish and rodent population/distribution data were compared to locally obtained, agency-provided data.
- *Comparative vegetation investigations:* Contaminated and uncontaminated plant communities were compared in terms of density, diversity, and several measures of general vigor.
- *Media testing:* Samples of surface soil, sediment, and water were collected at tissue sampling locations. These samples will be used to estimate exposure point concentrations and to develop site-specific bio-uptake and bioconcentration factors.

### 4.3 Findings

The laboratory results for most samples have not yet been received, nor have all measurements and comparisons been completed. Three elements are complete and available — vegetation community data, histopathological results, and fish population comparisons.

Collected fish data compared favorably with Illinois Wildlife Agency data for high-quality, well-balanced fisheries. Comparisons included size and species distribution, numbers caught per sampling period, and incidence of anatomical lesions. Rodent histopathological studies concluded that cellular observations were typical for wild rodent populations and that no signs of chemical stress were evident. Vegetation comparisons for three sites, however, revealed clear community stress in terms of mortality, ground density, and species composition.

These observations suggest that neither fish nor rodents are presently being exposed to significant environmental concentrations of historically released contaminants. However, vegetative stress observations may reflect long past contamination events or the selective toxicity of the contaminants to vegetation. Other potential causes of stressed vegetation, such as natural hydrologic changes, are also being considered. In general, presently available observations support a preliminary hypothesis that contaminant dilution or biodegradation is reducing toxic chemical exposure hazards at this site.

## 5. Summary and conclusions

EPA's approach to performing ecological assessments is becoming similar to the human health risk assessment approach. This includes an increased emphasis on identification of contaminants of concern, indicator species, and surrogate species; estimation of chemical uptake; and characterization of risk. This move toward a more fully quantitative approach requires prudent application of professional judgment to avoid "false positives" and concurrent implementation of otherwise unnecessary remedial programs. Factors that can influence the scope of the ecological assessment include funding, schedule, suspected sensitivity of the habitat, occurrence of threatened and endangered species, and occurrence of potentially affected game and commercial species.

## Reference

1 U.S. Environmental Protection Agency, Risk Assessment Guidance for Superfund, Volume II: Environmental Evaluation Manual, EPA/540-1-89/001, Washington, DC, 1989.