ECOLOGICAL RISK ASSESSMENT FOR THE DOE FERNALD FACILITY

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ABSTRACT

Ecological risk assessment is an integral part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process for remediating hazardous waste sites, and of National Environmental Policy Act (NEPA) requirements for evaluating the environmental impacts of major federal actions. Ecological risk assessments in NEPA impact analyses and CERCLA Baseline Risk Assessments can serve in turn as the bases for CERCLA-required Preliminary Natural Resources Surveys and Natural Resources Damage Assessments (PNRS/NRDA). These documents attempt to directly assess the value of lost or damaged natural resources as the basis for a court award of monetary damages against the responsible parties. PNRS/NRDA is a significant issue for hazardous waste sites under the control of government agencies, because they are the designated trustees for the natural resources at their facilities. A variety of studies support ecological risk assessment for a CERCLA/NEPA investigation being conducted at the Department of Energy's (DOE) Feed Materials Production Center (FMPC) near Fernald, Ohio. These include radionuclide analyses of vegetation and aquatic organisms; threatened and endangered species surveys; toxicity tests of soils, sediments, and effluent; wetlands delineation; and surveys of aquatic invertebrate communities. Preliminary results suggest that the FMPC does not have a major ecological impact on the surrounding area, that wetlands are limited in extent, and that endangered species are not present. The breadth of ecological studies at Fernald, a 1,050 acre site without extensive wetlands or critical habitats, illustrates the potential importance of ecological risk assessment and PNRS/NRDA to larger and more complex sites.

INTRODUCTION

Ecological risk assessment is an integral part of documentation necessary to meet the requirements of both the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Environmental Policy Act (NEPA) for remedial actions at federally-owned facilities containing hazardous and radioactive waste (Fig. 1). In particular, ecological risk assessments appear in Remedial Investigation/Feasibility Study (RI/FS) documents prepared under CERCLA and in Environmental Impact Statements (EIS) required by NEPA. This paper describes the process and regulatory basis of ecological risk assessments being prepared in conjunction with a RI/FS and EIS for the Department of Energy's (DOE) Feed Materials Production Center (FMPC) near Fernald, Ohio. The paper further discusses the relationship between ecological risk assessment and CERCLA requirements for Natural Resources Damage Assessments (NRDA) at sites containing hazardous and/or radioactive waste.

The FMPC is a government-owned facility established in the early 1950s for the production of pure uranium metals, operated for the last five years by Westinghouse Materials Company of Ohio (WMCO) for DOE. Production at the facility is currently suspended. The FMPC is located on a 1,050-acre site in a rural area approximately 18 miles northwest of downtown Cincinnati, Ohio, in Hamilton and Butler counties (Fig. 2). Production facilities occupy approximately 136 acres in the center of the FMPC (Fig. 3). Land use outside the production area and waste storage areas includes 425 acres of grassland and woodlot leased for cattle grazing. Two pine plantations planted in 1973 are located in the northeast and southwest portions of the facility, and Paddys Run, an intermittent ungauged stream, runs roughly parallel to the western boundary of the FMPC. The storm sewer outfall ditch, a major tributary to Paddys Run, enters the stream near the southwest corner of the property, and a number of smaller ditches drain into the stream. Paddys Run and its main tributaries are bordered by a wooded corridor. Treated effluent from process operations and runoff collection systems is discharged to the nearby Great Miami River through an National Pollutant Discharge Elimination System (NPDES) permitted outfall.

In April 1990, DOE signed a Consent Agreement with the U.S. Environmental Protection Agency (EPA) under CERCLA Sections 120 and 106(a), concerning environmental impacts associated with the FMPC. These impacts are related to past activities, which have produced a variety of wastes, including general scrap and refuse, sanitary waste, contaminated and noncontaminated metal scrap, waste oils, asbestos, and fly ash. Additionally, radionuclide wastes have been disposed of in silos and in open pits. The major identified off-property impact of the FMPC is a plume of uranium-contaminated groundwater, the South Plume, which has maximum uranium concentrations of 907 ug per liter.

Pursuant to the Consent Agreement, DOE is conducting an RI/FS so that appropriate remedial activities at the FMPC can be formulated, assessed, and implemented. In addition, DOE is preparing an EIS to examine the impacts of potential remedial activities to comply with NEPA requirements for environmental evaluations of major federal actions. In order to expedite remedial actions at the FMPC, separate RI/FS reports are being prepared for each of five operable units (Fig. 4). They are:

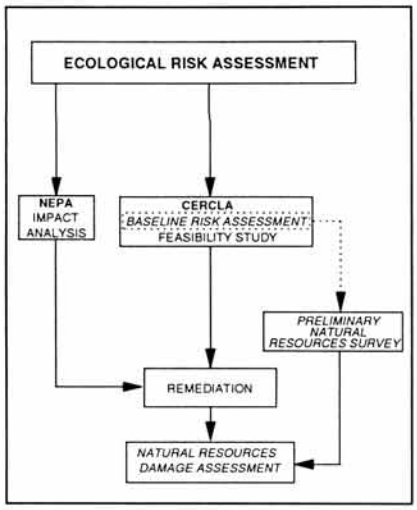

Fig. 1. Ecological risk assessment input to NEPA, CERCLA, and PNRS/NRDA requirments.

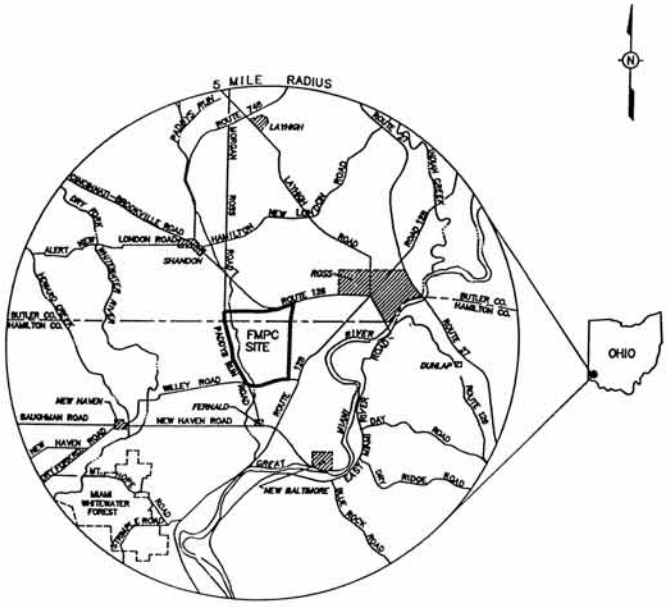

Fig. 2. Five-Mile radius map, feed materials production center.

- Operable Unit 1 - Waste Pits 1 through 6, Clearwell, and Burn Pit
- Operable Unit 2 - Other Waste Units
- Operable Unit 3 - Production Area and Suspect Areas
- Operable Unit 4 - Silos 1, 2, 3 and 4
- Operable Unit 5 - All Environmental Media

The EIS will function as the lead NEPA document, in which the sitewide environmental database will be presented and common issues across operable units and cumulative impacts will be discussed. In addition, a NEPA analysis of operable unit impacts will be incorporated into the RI/FS documentation for each operable unit (Fig. 5).

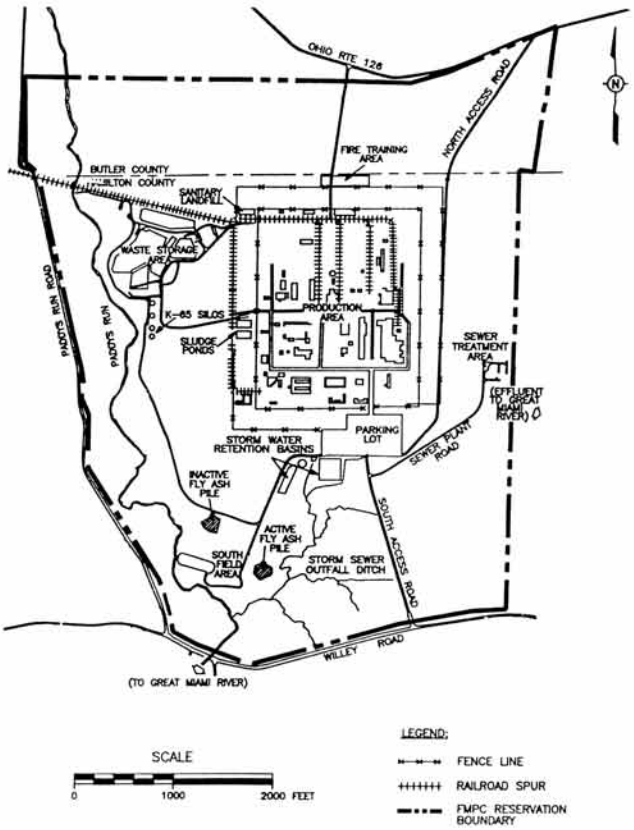

Fig. 3. Major features of the FMPC.

NEPA REQUIREMENTS FOR ECOLOGICAL RISK ASSESSMENT

NEPA requires that the environmental impacts of all proposed major federal actions be formally evaluated, along with potential alternative actions, including no action. Such major federal actions include remedial actions under CERCLA. Ecological risk assessment, as defined and developed by EPA guidance (1,2) and investigators in the field (3,4), provides the basic tool for examining potential short- and long-term effects of proposed remedial actions on the natural environment (Fig. 1).

Ecological risk assessment also plays a role in two more specific NEPA concerns. The first is protection of sensitive environments, such as wetlands and habitats critical to threatened and endangered species. The second is the NEPA requirement for evaluation of cumulative impacts. This is of particular concern for complex projects such as the Fernald RI/FS, where separate remedial actions for different operable units may have cumulative effects not accounted for in the individual FS reports.

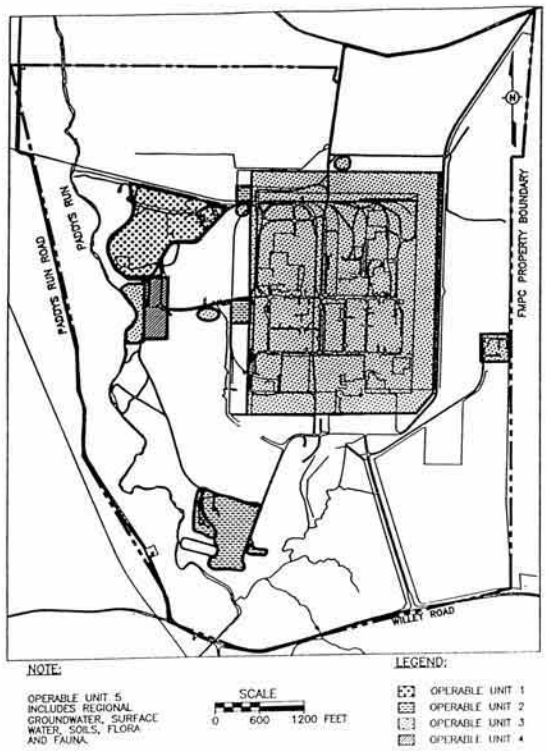

Fig. 4. Source operable units.

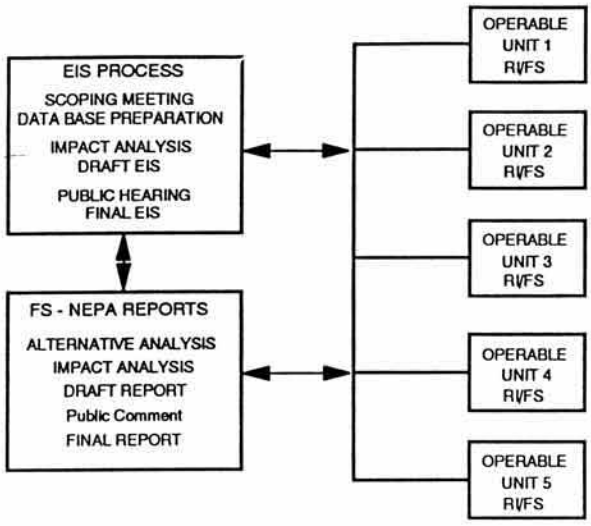

Fig. 5. EIS process and relationship to operable unit RI/FS process.

CERCLA REQUIREMENTS FOR ECOLOGICAL RISK ASSESSMENT

CERCLA requires that remedial actions at hazardous waste sites be protective of both human health and the environment. Ecological risk assessment plays a role in meeting this requirement at a number of points specified by EPA guidance (5) and by the National Oil and Hazardous Substance Pollution Contingency Plan (NCP, 40CFR300.xxx). EPA guidance on the RI/FS process requires that the Baseline Risk Assessment, which analyzes the existing and future risks of taking no action at a site, include an environmental evaluation, synonymous with an ecological risk assessment (Fig. 1). Ecological risk assessment is thus integral to the RI phase of the remedial process.

Ecological risk assessment is also integral to the FS phase (Fig. 1). The NCP provides that remedial actions be evaluated against nine criteria -- two threshold criteria, which all remedial actions must meet; five balancing criteria, which establish the relative effectiveness of alternative remedial actions; and state and community acceptance, modifying criteria which are addressed following public comment on the RI/FS report and proposed remedial action. The NCP requires, as one of its two threshold criteria, that any remedial action must provide for overall protection of human health and the environment. In addition, two of the balancing criteria -- long-term effectiveness and short-term effectiveness -- require that potential remedial actions be evaluated in part on the basis of their providing for a low magnitude of residual risk to the environment (long-term effectiveness), while minimizing environmental impacts of the remedial actions themselves (short-term effectiveness). Ecological risk assessment is requisite to determining whether proposed remedial actions meet these requirements.

Ecological risk assessment plays a further role in determining whether potential remedial actions meet the second NCP threshold criterion, compliance with applicable, relevant, and appropriate requirements (ARARs) of other federal and state laws. In particular, compliance with location-specific ARARs, such as protection of wetlands or habitats critical to endangered species, may require ecological information for determining whether an ARAR is met.

NATURAL RESOURCES DAMAGE ASSESSMENT

CERCLA provides that the designated trustee for natural resources at a site may seek recovery of any damages to natural resources from the principal responsible parties (PRPs). The documentary basis for such action is a Preliminary Natural Resources Survey (PNRS), which may be followed by a NRDA (Fig. 1). These documents, which would be based in part on the ecological portion of the Baseline Risk Assessment, attempt to directly assess the value of lost or damaged natural resources as the basis for a court award of monetary damages against the PRPs.

Executive Order 12580 designates the Secretary of Energy as a federal trustee, making DOE responsible for natural resources located on, over or under lands owned or controlled by DOE. The NCP authorizes the states as trustees for all natural resources within or controlled by the state, and designates Native American tribal chairmen, or their designees, as having trusteeship over natural resources which belong to the tribe. CERCLA authorizes natural

TABLE I

Radionuclide Concentrations In Vegetation and Aquatic Organisms Collected For the FMPC RI/FS

Sample Type	Radionuclide	Detection Frequency	Concentration Range (pCi/g)
Vegetation	Total Uranium	64/96	<0.6 - 35.5
Vegetation	Cesium-137	24/89	<0.2 - 1.4
Vegetation	Strontium-90	7/97	<0.2 - 0.9
Paddys Run Fish	Total Uranium	3/10	<0.6 - 3.7
Great Miami River Fish	Total Uranium	0/16	<0.6
Paddys Run Invertebrates	Total Uranium	4/5	<0.6 - 6.4
Great Miami River Invertebrates	Total Uranium	2/3	<0.6 - 6.5

Source: Reference (6)

resources trustees to act in the public interest to ensure that PRPs restore or replace the injured resources, and provides for PRP liability to include the costs of assessing the injury, destruction or loss of natural resources as well as damages for the injury to the natural resource. The trustee can petition only for "residual damages," that is, injuries to the natural resources remaining after remedial activities have been implemented (Fig. 1). Based on the multiple, and in some cases overlapping authority for natural resources, CERCLA, as amended, requires the EPA or the lead agency (at federal facilities) at a CERCLA site to promptly notify all appropriate trustees of possible injuries to natural resources. The primary federal natural resources trustee must ensure that all cognizant natural resources trustees have been notified. Further, the primary trustee should coordinate a joint NRDA in the case of multiple trustees.

Before initiating the formal NRDA, the PNRS will be conducted to determine whether a more detailed investigation is warranted. The CERCLA requirement to prepare an ecological assessment as part of the Baseline Risk Assessment can provide either the foundation for the NRDA, or serve as the basis for determining that no natural resource injury has occurred. In draft guidance for NRDA, DOE recommends performing the CERCLA-required ecological assessment as a substitute for the preliminary survey.

The process of drafting a NRDA begins with guidance contained in 43CFR11. Assessments are divided into three phases: Injury Determination, Quantification and Damage Determination. The Injury Determination phase establishes that one or more natural resources have been injured as a result of the discharge or release of oil or a hazardous substance. The Quantification phase establishes the extent of injury to the resource in terms of the loss of services that the injured resource would have provided had the release not occurred. The Damage Determination phase establishes the appropriate compensation for the natural resource injuries expressed as a dollar amount. The residual damages limitation provides allowance for the implementation of remedial action to rehabilitate the injured resource. The NRDA guidance has been challenged in Ohio v. U.S. Department of Interior (DOI) (880 F.2.d. 432, D.C. Cir. 1989), and the court has remanded the current guidance to DOI for revisions, which are expected to expand the recoverable damages provisions.

RI/FS-SPECIFIC ECOLOGICAL INVESTIGATIONS AT THE FMPC

A number of ecological investigations have been conducted at the FMPC specifically to support the requirements of NEPA, CERCLA, and PNRS/NRDA, as outlined above. These studies, some preliminary results, and their specific roles in the remedial process are outlined below.

Radionuclide Uptake by Ecological Receptors

Vegetation and aquatic organisms within and adjacent to the FMPC were analyzed for isotopic uranium, cesium, and strontium. Uranium is the primary contaminant of concern at the site, while cesium and strontium were included because of their ready uptake and concentration by organisms. Total isotopic uranium concentrations in vegetation collected from the FMPC ranged from detection limits of 0.6 pCi/g to 35.5 pCi/g (Table I). Cesium and strontium were found less frequently at lower levels, consistent with uranium being the primary concern at the FMPC. Low levels of radionuclides were found in aquatic organisms collected from Paddys Run, the stream traversing the western boundary of the property (Fig. 3), and were detected in only two samples from the Great Miami River, the receiving stream for Paddys Run and for the NPDES-permitted discharge from the site (Table I).

These data contribute to RI assessments of the nature and extent of contamination at the site, and serve in Baseline

Risk Assessments as a partial basis for estimating the risks of radionuclides to ecological receptors. As a baseline for the effects of past releases of radionuclides from the FMPC, the study contributes to evaluations of the overall protectiveness and long-term effectiveness of proposed remedial actions, as well as to NEPA evaluations of the ecological impacts of the no-action alternative. These assessments in turn contribute to the PNRS and NRDA.

Threatened and Endangered Species Surveys

Among the ARARs with which remedial actions at CERCLA sites must comply is the Endangered Species Act (ESA). Section 7(a)(2) of the ESA requires federal agencies to ensure that their actions not jeopardize the continued existence of any endangered or threatened species or any critical habitat of such species. Further, EPA guidance on ecological risk assessment at CERCLA sites (1) emphasizes identification of threatened and endangered species resident on a site, including delineation of any critical habitat essential to the survival of these organisms.

The FMPC lies within the range of the Indiana bat (Myotis sodalis), a federally listed endangered species, and the cave salamander (Eurycea lucifuga), an Ohio state-listed threatened species. Habitat and population surveys of these organisms were conducted at and adjacent to the FMPC, but no individuals were captured on the property and no critical habitat was identified. Indiana bats were captured three miles east of the facility, but the nesting colony was not located.

The Indiana bat and cave salamander surveys contribute to the Baseline Risk Assessment in that risks to these species have been shown to be not of concern. The study addresses the NCP requirement that remedial actions meet ARARs by eliminating the ESA as a concern. Thirdly, protection of threatened and endangered species and critical habitat would be a concern for both long-term and short-term effectiveness in the FS, as well as for NEPA analyses of impacts of remedial actions on these organisms. PNRS and NRDA concerns are also addressed insofar as impacts on endangered species, if present, could be a key issue in a NRDA-based suit for damages.

Toxicity Tests of FMPC Effluent

Runoff and wastewater from plant process operations is collected in a general sump, treated, and discharged under a NPDES permit into the Great Miami River. This effluent carries uranium at an average concentration of 560 pCi/l (7). This effluent was tested for acute and chronic toxicity to algae, invertebrates, and fathead minnows, following EPA protocols (8,9). Preliminary results indicate that (1) the effluent would not be toxic to aquatic organisms following dilution in the river, (2) there was no correlation of uranium concentrations in effluent with effects on organisms, and (3) the effluent may occasionally be stimulatory to algal growth, presumably due to nutrients present, such as nitrate and phosphate.

This study provides a baseline for determining the possible effects of existing uranium loading on the biota of the Great Miami River. It thus contributes to the Baseline Risk Assessment in the RI and to evaluations of overall environmental protection and long-term effectiveness in the FS, and potentially to the PNRS/NRDA. In addition, proposed remedial actions, for example pumping of contaminated groundwater, may affect the quality or quantity of effluent discharged to the river. A study of the potential toxicity of existing effluent provides information important to evaluating the environmental impacts of any changes in the nature of the effluent.

Toxicity Tests of Soils and Sediments

Soils and sediments at the FMPC have been contaminated with a variety of substances, principally radionuclides (6,7). Although radionuclide levels have been extensively characterized, data on inorganic and organic contaminants are limited. Further, because of the complex nature of soils and sediments and their interactions with organisms, it is difficult to predict the effects of contaminants in these media using only data on contaminant levels. The results of toxicity tests reflect not only the concentrations of the materials present, but also their availability to organisms (10), thus simultaneously addressing the problems of both multiple contaminants and complex media.

A preliminary study was therefore conducted to determine the toxicity of soils and sediments at the FMPC. Two soil and two sediment samples were collected from the facility, based on their expected relative radionuclide levels, and tested following standard protocols (10,11). Preliminary results indicate that substances leachable from soils and sediments with a range of total isotopic uranium from 1.8 to 115 pCi/g do not pose an acute toxic hazard to ecological receptors.

This study contributes directly to the Baseline Risk Assessment and to the evaluations of overall environmental protection and long-term effectiveness in the FS. In addition, proposed remedial actions involving excavation of contaminated soils may have ecological effects not predicted from contaminant data alone. This study therefore provides information important to the short-term effectiveness (environmental) section of the FS, to the EIS, and to NRDA evaluations of residual damage to natural resources.

Wetlands Delineation

Remedial actions at the FMPC must comply with the dredge and fill provisions of the Clean Water Act and associated regulations and executive orders (E.O.),

including E.O. 11990, Protection of Wetlands. NEPA also requires particular attention to the environmental impacts of proposed actions on sensitive environments such as wetlands. Wetlands, like endangered species, could be of particular concern for the NRDA as environments of unusual ecological value. It was therefore necessary to identify and delineate any wetlands currently affected by the FMPC or likely to be affected by remedial actions.

Jurisdictionally defined wetlands (12) are identified by the presence of hydric soils, which are periodically depleted of oxygen as a result of flooding; hydrophytic plants, which are tolerant of these conditions; and wetlands hydrology, defined by permanent or periodic flooding or soil saturation. Wetlands may be delineated either offsite, using information such as topographic maps, aerial photographs, soil surveys, and site-specific vegetation surveys; or onsite, using detailed field studies to establish precise wetland boundaries. Wetlands at the FMPC were identified using the former method, with a limited onsite field reconnaissance to check some areas left in question by the offsite delineation.

Wetlands at the FMPC are restricted to a forested area of approximately 50 acres in the northern portion of the facility and emergent wetlands (containing cattails and sedges) associated with drainages on the property (Fig. 6). The two major surface water features of the FMPC, Paddys Run and the storm sewer outfall ditch (Fig. 3), do not meet the wetlands criteria and would not be subject to E.O. 11990, although they would still be covered by the Clean Water Act, which applies to all "waters of the United States."

Macroinvertebrate Surveys

Potentially contaminated runoff from the FMPC drains into Paddys Run, and treated effluent from the facility is discharged to the Great Miami River, as described above. The FMPC may therefore affect aquatic communities in these two streams. This is an immediate concern for the CERCLA evaluation of ecological risks, and is also important to the PNRS/NRDA, particularly since the Ohio Environmental Protection Agency (OEPA) evaluates water quality in streams partially on the basis of the health of fish and macroinvertebrate communities (13).

The species composition and abundance of organisms in the macroinvertebrate community provides a sensitive and general measure of the health of aquatic communities. An assessment of the macroinvertebrate communities in Paddys Run and the Great Miami River was conducted in areas above, adjacent to, and below the influence of the FMPC. Organisms were sampled five times over two years, both from the natural substrate and via artificial substrate samplers, which provide a quantitative estimate of the health of the aquatic communities. Hester-Dendy artificial substrates, which consist of wooden blocks of defined area bolted together and anchored to the stream bottom, were placed in Paddys Run and the Great Miami River for six-week periods to be colonized by indigenous organisms. The substrates were then retrieved, returned to the laboratory, and all organisms counted and identified. Preliminary results indicate that the FMPC has no negative impact on the macroinvertebrate communities of Paddys Run or the Great Miami River. A sampling site immediately downstream from the FMPC outfall in the river may be enriched by nutrients in the effluent, consistent with the observation above that effluent may stimulate algal growth in laboratory toxicity tests.

Macroinvertebrate surveys address concerns about the effects of FMPC contaminants on aquatic communities for purposes of the Baseline Risk Assessment and PNRS/NRDA, as well as the overall environmental protection and long-term effectiveness criteria in the FS process. In addition, potential remedial actions, for example, excavation of contaminated sediments, may affect the macroinvertebrate community, which would be of concern to the CERCLA evaluation of short-term effectiveness and to NEPA analyses of environmental impacts.

DISCUSSION AND CONCLUSIONS

Ecological risk assessment has a central role to play in CERCLA and NEPA investigations at sites containing radioactive and hazardous waste. NEPA, CERCLA, the NCP, and associated EPA guidance require ecological input to assess the potential impacts and effectiveness of proposed remedial actions and to address regulatory issues such as compliance with ARARs. Additionally, ecological risk assessment plays a major role in the PNRS/NRDA provisions of CERCLA. Regulatory guidance on PNRS/NRDA is limited and preliminary. However, these requirements should be of significant concern to PRPs, particularly to DOE in its role as a trustee of natural resources at its facilities. CERCLA allows any person to seek relief from the United States Government or any of its officers for an alleged inadequate response to release of a hazardous substance, including an inadequate execution of natural resource trustee responsibilities. Further, even if the lead agency or PRP agrees to perform remedial actions, such a suit could force unplanned remedial actions or restoration of the damaged natural resource. It is therefore clearly in the best interest of the lead agency or PRP to ensure that all natural resource trustee responsibilities are fully and properly implemented. Early and extensive identification of ecological risks is vital to fulfilling that role. The breadth of ecological studies conducted at the FMPC, a 1,050 acre site without extensive wetlands or critical habitats, suggests the future importance of PNRS/NRDA to larger and more complex sites.

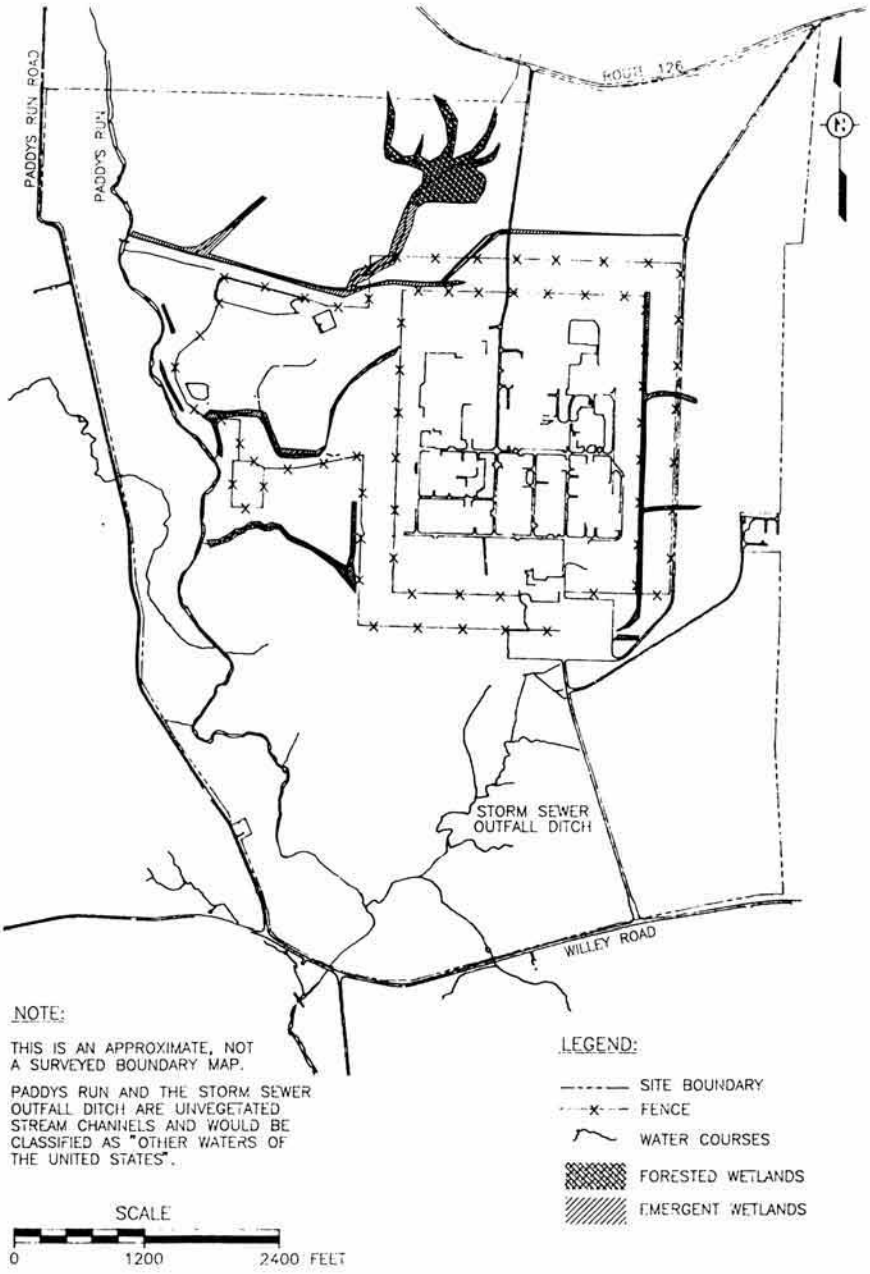

Fig. 6. Approximate boundaries of jurisdictional wetlands and other waters of the United States at the FMPC.

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