The Use of Ecological Restoration Principles To Achieve Remedy Protection At the Fernald Preserve and Weldon Spring Sites - 8354

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ABSTRACT

At both the U.S. Department of Energy (DOE) Fernald Preserve and the Weldon Spring Site, the development of ecological restoration goals and objectives was used to complement and even enhance achievement of selected remedies. Warm-season native grasses and forbs were used for revegetation of remediated areas. The hardiness and ability to establish in low-nutrient conditions make native grasses ideal candidates for reestablishment of vegetation in excavated areas. At the Fernald Preserve, native grasses were used for vegetative cover on an on-site disposal facility as well.

Also at the Fernald Preserve, excavation footprints were optimized to increase the quantity and quality of created wetlands. Drainage features in a couple instances provide passive groundwater recharge, potentially accelerating groundwater remediation efforts. In addition, a number of clean materials and structures were beneficially reused as part of ecological restoration designs, including woodchip mulch and woody debris, clean concrete, and a rail trestle. At the Weldon Spring Site, several methods were used to control erosion for three years after the initial seeding of native species. A field evaluation of soil conditions and general species diversity was performed in 2007 and it was determined that erosion at the site was typical and repairing naturally. These approaches resulted in “win-win” strategies needed to successfully remediate and restore complex projects such as the Fernald Preserve and Weldon Spring.

INTRODUCTION

Background

The Fernald Preserve is situated on a 425-hectare (1,050-acre) tract of land, approximately 30 kilometers (18 miles) northwest of Cincinnati, Ohio. The Site is located near the unincorporated communities of Ross, Fernald, Shandon, and New Haven in Hamilton County. The Site is a former uranium processing facility that was shut down in 1991. Since then, the Site has undergone extensive remediation pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

Remedial activities and subsequent ecological restoration have converted the site from an industrial production facility to an undeveloped park, encompassing a series of wetlands, prairies, and forested communities. Following completion of large-scale soil and remediation and waste disposition in the fall of 2006, the site was successfully transitioned to DOE Office of Legacy Management. The Fernald Closure Project was then renamed the Fernald Preserve.

The DOE Weldon Spring Site Remedial Action Project (WSSRAP) was conducted for the purpose of remediating a portion of a former trinitrotoluene and dinitrotoluene production plant that was operational from 1941 to 1945 and a former uranium refinery that was operational from 1957 to 1966. Surface remediation activities under CERCLA concluded in 2001 with the completion of an 18-hectare (45-acre) on-site engineered disposal facility that contains 1.13 million cubic meters (1.48 million cubic yards) of waste materials. The 61 hectares (150 acres) surrounding the disposal facility has been planted and managed as a native prairie to provide effective erosion control and conservation benefits. Long-term surveillance and maintenance activities at the site were officially transferred to the DOE Office of Legacy Management in 2003. The site is open to the general public and has extensive community involvement through the operation of an on-site Interpretive Center and due to other educational and recreational opportunities that exist at the site.

Ecological restoration goals and objectives

The decision to convert the majority of the Fernald site into a nature preserve was originally envisioned as a means of resolving a natural resource damage claim filed by the State of Ohio under Section 7 of CERCLA. DOE and the other Natural Resource Trustees (NRT) developed a Natural Resource Restoration Plan for the Fernald Site. This plan presented a conceptual restoration design for the site and established goals for specific ecological restoration projects. The first goal was to establish native ecological communities representative of pre-settlement southwestern Ohio. The second goal was to promote onsite wildlife use. Lastly, ecological restoration projects were to satisfy all compliance and legal mitigation requirements. This plan, along with a great amount of stakeholder involvement and recommendations from the Fernald Citizens Advisory Board, resulted in the decision to move forward with the nature preserve final land use. As the planning and development of remediation activities progressed in parallel with NRT negotiations and stakeholder input, it became clear that certain decisions regarding ecological restoration may compliment and even enhance the achievement of remedy protection.

At Weldon Spring, the 61 hectares (150 acres) surrounding the disposal facility has been established as a native Missouri prairie. This approach for site re-vegetation provided several benefits. Once established, native grasses and forbs act as an extremely effective and low maintenance erosion control measure for the disposal cell. Because native prairie is considered an endangered ecosystem in Missouri, re-establishing a landscape that once existed in the area prior to European settlement not only ensures an environmentally ethical treatment of the land but also provides additional opportunities for beneficial

community re-use. Beneficial re-use is a key goal for the Office of Legacy Management and a part of the vision for the future of the site. The prairie was named Howell Prairie in keeping with the history of the land and formation of the Howell Prairie Council occurred in 2003. The Howell Prairie Council consists of experts in the field of Missouri prairie ecosystems as well as prairie advocates from the local community and county government. The council meets quarterly and provides necessary assistance in designing seasonal and long-term prairie management strategies at the site. To complement the prairie and to serve as an educational resource, approximately 3.2 hectares (8.0 acres) of gardens containing plants native to the state of Missouri surround the Interpretive Center.

This paper discusses several examples of how ecological restoration assisted in successful site closure and transition to long-term surveillance and maintenance.

HOW ECOLOGICAL RESTORATION HELPS TO ACHIEVE REMEDY PROTECTION

Use of Native Grasses

The use of native grasses is good example of how ecological restoration goals and remedy requirements are both met. Their ecology lends to several benefits. First, once established, warm season native grasses provide excellent erosion control. They establish extensive root systems that are very adept at holding soil in place. This extensive root system also results in exceptional drought tolerance.

Even though most prairie plants are bunch grasses and do not form sod mats across soil, their root system compensates for the gaps in cover. For instance, a single little bluestem (*Schizachyrium scoparium*) plant spreads roots to a one and half-foot lateral spread and a depth of 1.5 meters (1). The bunch-type habit also provides space for native forbs, which in turn provide additional food and cover for wildlife (2).

At the Fernald Preserve, native grasses and forbs have been used for practically all restoration projects undertaken since 1998. Much research went into the development of plant and seed lists for restoration activities at the site. It was essential to ensure that only vegetative communities and specific species native to southwestern Ohio be used. This region lies within a transition zone between the oak-hickory and beech-maple sections of the Eastern Deciduous Forest. Typically, vegetative communities are represented as a mosaic of these two forest types (3). The Fernald Preserve is located approximately 161 kilometers (100 miles) south of the prairie ecotype that extends into western Ohio (4). However, many prairie pockets were found extensively across southwestern Ohio. In addition, a large scale prairie and wetland restoration project that was undertaken just west of the Fernald Preserve revealed that a large amount of native warm season grass and forb seed was present in the soil seed bank (5). Therefore, prairie establishment was appropriate and consistent with ecological restoration goals for the site.

Ecological restoration efforts fall into one of three broad categories at the site; prairie establishment, forest restoration or wetland creation. In each case, prairie species were seeded to reestablish vegetation on disturbed land. Within each of these restoration types, specific grass and forb seed mixes were formulated based on a variety of factors, including soil type, topography and hydrology. Three main seed mixes were formulated; upland mesic, wetland and xeric. A shade-tolerant forest restoration mix was also developed as part of forest restoration/enhancement activities. Approximately 122 hectares (300 acres) of prairie and savanna habitats are in the process of being established across the Fernald Preserve.

Where topsoil was not present due to remediation or other disturbance, soil amendments were used. The application of soil amendments usually involved the incorporation of yard waste compost into the ground. Field personnel used a no-till seed drill to seed most areas. If conditions did not allow for use of a seed drill, native grass and forb mixes were broadcast seeded.

Given the benefits that native grasses and forbs provide, engineers decided to use these plants as cover for the On-site Disposal Facility (OSDF). The OSDF is an on-property engineered landfill that holds over 2.3 million cubic meters (3.0 million cubic yards) of contaminated soil and debris that was generated from remediation activities at the Fernald Preserve. The OSDF cap is a multi-layered barrier designed to keep this waste in place and protected. An integral part of the cap system is the vegetated cover. It was determined that native grasses were ideally suited for such a system.

While native grasses are a key component of successful ecological restoration, their establishment and maintenance provides several challenges. Seed germination is often limited, especially when compacted subsoil conditions are present. Successful establishment of native grasses and forbs is dependent on a variety of factors; sufficient organic matter, soil moisture, the presence of mycorrhizal fungi, proper soil temperature, and sufficient deterrents to seed and seedling predation. In virtually all seeding efforts at the Fernald Preserve, some or all of these factors were missing.

Once seeds germinate, they expend the majority of effort growing the deep, fibrous root systems described above. For the first several growing seasons, very little above-ground biomass may be observed. This growth habit leads to the eventual hardiness and drought tolerance that characterize native grasses. However, during the establishment phase, these plants are susceptible to a variety of factors, including competition from weeds, predation by birds and small mammals, flooding, or desiccation. Therefore, in the near term, erosion protection is greatly reduced.

At the Fernald Preserve, several actions are undertaken to address the challenges listed above. First, when possible and necessary, soil conditions were improved through import and incorporation of organic matter. Composted yard waste was used across much of the site to condition the soil. Topsoil was used in portions of the site as well. In each case, the increased organic matter provided nutrients, less compaction, and better water

holding capacity. In addition to the addition of organic matter, mycorrhizal inoculants were used to provide beneficial fungi that enhance root development.

Field personnel could not afford the luxury of timing when seeding restored areas. In order to meet schedule and sequencing requirements, prairie seeding efforts were often conducted at less than ideal timeframes. To compensate for this, Canada wild rye (*Elymus canadensis*) was added to the seed mix as a native cool-season grass. Annual rye grass (*Lolium multiflorum*) and a sterile winter wheat grass (*Triticum* sp.) were also added for quick-germinating cover. This also assisted with near-term erosion control.

Maintenance of native grasses provides can be an issue as well. Native prairie systems are maintained through periodic disturbance. Disturbance can be from several sources, including grazing mowing or periodic fire. At the Fernald Preserve, grazing has been ruled out. Therefore, prairie maintenance will need to be conducted through continued mowing and/or prescribed fire. DOE must decide which portions of the site should be maintained as prairie and which portions may be allowed to undergo ecological succession. Pursuant to the legacy management plan for the Fernald Preserve, woody vegetation is prohibited from establishment on the OSDF. Therefore, long-term management of the OSDF grass cover is required (6).

At Weldon Spring, the design for the prairie began in the early 1990s when native grasses were deemed to be the best solution for site restoration. Most of the site saw excavations of contaminated soil, foundations of old buildings, and removal of waste pits. Therefore, a large portion of the original site surface was removed and placed in the disposal cell. In many areas, several feet of earth were removed.

To maintain proper drainage away from the disposal cell, cut and fill activities along with borrow soils shaped the final contours of the land. The resulting surface was like a blank canvas waiting to be worked. Temporary plantings of cereal grains were used to help prevent erosion of the bare soil during the interim years of remediation.

In late spring of 2002, the first permanent planting of prairie grasses and forbs was conducted. Soil samples had been taken of the mainly clayey material and a fertilizer mix of 2-30-18 was specified at an application rate of 373 kg/ha (333 lb/ac). The low nitrogen content limited weed growth. No further application of fertilizer was anticipated.

Seed was sown using a broadcast spreader. Dominant in the planting mix were prairie grasses (e.g. *Schizachyrium scoparium* (Little Blue Stem)) along with forbs such as *Aster novae-angliae* (New England aster), *Chamaecrista fasciculata* ((Partridge pea), *Dalea purpurea* (Purple prairie clover), *Ratibida pinnata* (Gray-headed coneflower). One third of the area, next to the Hamburg Trail, was planted more heavily with forbs. This first planting included a nurse crop of annual rye.

Additional seeding was performed in January of 2003 and 2004 utilizing a seed drill (Fig. 1). Seed mixes consisted primarily of forbs supplemented by grasses. In 2004, a

micorrhizal inoculant was utilized as a seed coat to enhance root development. Limited spot-seeding of harvested and donated seed was performed in 2005, 2006, and 2007. Approximately 9 kilograms per hectare (8 pounds per acre) of pure live seed have been sown at the site to date with more than 80 species total.

Fig.1. A seed drill was utilized at the Fernald Preserve and Weldon Spring Site for seeding operations.

High mowing was performed from 2002 – 2005 to limit annual weed establishment and encourage natives. The prairie was mowed to a height of approximately 30 centimeters (12 inches) during early summer. Prescribed burning was performed in limited areas with greatest fuel load in 2006 and it is expected that this will be the primary long-term management tool. (Fig. 2)

Fig. 2. Prescribed burning is being performed in the drainage outlet area of the Weldon Spring Site in February, 2006.

Invasive weeds have been on on-going concern since the early days of prairie establishment at both Fernald and Weldon Spring. Spot spraying of individual plants has been performed from 2002 to the present. Targeted species at Weldon Spring include: Johnson grass (*Sorghum halepense),* black locust *(Robinia pseudoacacia),* and *Sericea lespedeza*. The *Sericea lespedeza* population was mapped in 2005 to aid in tracking eradication efforts. This map has proven to be an invaluable tool in ensuring proactive control of this species. At the Fernald Preserve, efforts have focused primarily on Canada thistle (*Cirsium arvense*)

Optimization of Grading Plans

Remediation work at the Fernald Preserve required extensive earth moving and excavation. Relatively level land was converted into a series of deep excavations and spoil piles. The heavy clay content in much of the soil at the Fernald Preserve allows for easy retention of surface water. Early on, these conditions were used to maximize wetland creation and the establishment of open water areas. The first wetland mitigation project conducted onsite, in 1999, utilized a deep excavation resulting from test excavations for the OSDF design. The use of existing topography continued through the

remainder of remediation and restoration. Today, approximately 57 hectares (140 acres) of wetland and open water communities are present at the Fernald Preserve.

This approach provided several benefits. First, significant cost and schedule reductions were realized. Cost was saved both from minimizing the amount of grading needed for restoration and also (for open water areas) from reducing the amount of hectares that require reseeding and planting. Second, the aquatic communities provide forage and cover for a great variety of wildlife. For instance, over 160 bird species have been observed at the Fernald Preserve, including migratory waterfowl and shorebirds. Third, several excavations associated with remedial activities were deep enough to intercept the Great Miami Aquifer. In such instances, these excavations were used to provide passive groundwater recharge.

The drawback to optimizing grading plans is that the landscape may appear unnatural in places. Former stormwater drainage channels, engineered (i.e. rectangular) excavation footprints, and uniform slopes are visible across the former production area. Certainly, emergent wetlands and open water communities are appropriate for southwestern Ohio. However, at times, the goal of restoring native ecosystems is met more by function than form.

Erosion Control Issues

At the Weldon Spring Site, efforts to monitor and control erosion are considered to be a critical component to ensuring the long-term integrity of the on-site disposal facility. A comprehensive program is in place to monitor erosion of the prairie and several repairs of gullies have been instituted since the prairie was established.

Erosion rills were first observed in the fall of 2002 and by 2003, developed into gullies that required repair while vegetation was establishing. This initial repair of erosion channels was performed by filling the gullies with composted materials, applying a geo-net and then seeding with cereal grains to stabilize. However, due to greater than average rainfall during the summer, cereal grains were not able to establish and most of the composted material was swept out of the gullies.

In 2004, a more aggressive strategy was employed for controlling erosion in the worst gullies. Erosion in two areas of the site was repaired by performing limited excavation, applying geo-fabric, digging rock boxes, and then filling gullies and boxes with rock. An extensive summer drought hampered further plant establishment for the season. In 2005, new erosion channels were noted and repaired by digging rock boxes and filling channels with rock. Summer drought conditions continued to hamper plant growth and establishment. In 2006, all erosion areas were monitored and appeared to be stable. However, by late winter of 2007, erosion in one portion of the site appeared to increasing rapidly and areas repaired with rock were observed to be silting in and new erosion channels starting to cut around the sides. (Fig. 3)

Fig. 3. Erosion channel observed in late winter, 2007. Significant plant establishment has since occurred along the sides and bottom of the channel.

It was decided to evaluate several different components of the prairie to determine if additional similar repairs needed to be performed or if a different approach was necessary. The entire prairie area had previously been segregated into ten different management units to assist in performing prescribed burns and other miscellaneous management activities. In March, 2007, soil samples were obtained from each management unit and analyzed for nutrient value. The results of the tests indicated that the average soil pH was 8.2 and an overabundance of calcium existed. In July, all erosion channels were mapped with GPS coordinates in order to provide an objective means to perform future monitoring of conditions. Utilizing the soil analysis results and erosion map, a field survey team of soil reclamation and prairie ecosystem subject matter experts performed a walkover of the erosion areas in August. After evaluating soil conditions, plant diversity, and plant density, it was determined that overall vegetation establishment was excellent and significant plant establishment along the bottom and sides of all the gullies observed indicated a lack of recent erosion and a trend towards stabilization. It is believed that the rock channels installed to repair erosion will likely fill in with vegetation within the next several years.

In addition to monitoring and re-mapping all erosion areas in 2008, several other activities may be implemented in order to ensure stable conditions. These may include applying soil amendments to the most significant erosion channels to encourage plant growth and performing a formal plant diversity/density survey.

Beneficial Reuse of Materials

The reuse of clean materials in ecological restoration projects provided several economic and environmental benefits. For instance, several remediation and restoration projects resulted in large-scale clearing and chipping of vegetation. The resulting woodchip

mulch was used across the site for landscaping and soil amendments. Large woody debris is often placed in wetlands and open water areas to provide habitat substrate for aquatic organisms.

More recently, DOE worked with state and federal regulators to identify economically feasible opportunities for reuse of the clean structures that satisfy the long-term needs of the site. A number of structures and materials were agreed on. First, several existing clean remediation support buildings were left onsite for incorporation into the final land use configuration. Restoration field personnel use these facilities for meeting rooms and for storage of tools, equipment and materials. In addition, a former train trestle that crosses Paddys Run (the primary onsite drainage feature) was left in place and enhanced to provide summer roosting habitat for a variety of bats, including the federally-endangered Indiana bat (*Myotis sodalis*). Also, by leaving the trestle in place, stream quality impacts and the loss of state-threatened Sloan's crayfish (*Orconectes sloanii*) habitat was avoided.

The second beneficial reuse decision involved keeping clean, intact portions of concrete pads remaining from demolition of an onsite treatment facility for conversion into long-term parking areas for the Fernald Preserve Visitors Center, which will be opening in June 2008. Third, additional clean concrete and railroad ballast was beneficially reused as clean hard fill to provide engineered erosion control in several ecological restoration projects. One of the key uses of this clean concrete was to address a large, eroded area within an Operable Unit 2 excavation area (the Southern Waste Units) by using properly layered clean concrete debris to create habitat for the endangered Cave Salamander and other amphibians and reptiles.

CONCLUSION

The examples above demonstrate the "win-win" strategies required to successfully remediate and restore complex projects such as the Fernald Preserve and Weldon Spring. Remediation goals may not have been achieved without incorporation of complimentary restoration goals.

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