WELDON SPRING QUARRY/PLANT/PITS (USDOE) SUPERFUND SITE

CLEANUP ENABLES CREATION OF RECREATION, ECOLOGICAL REVITALIZATION AND EDUCATION HUB

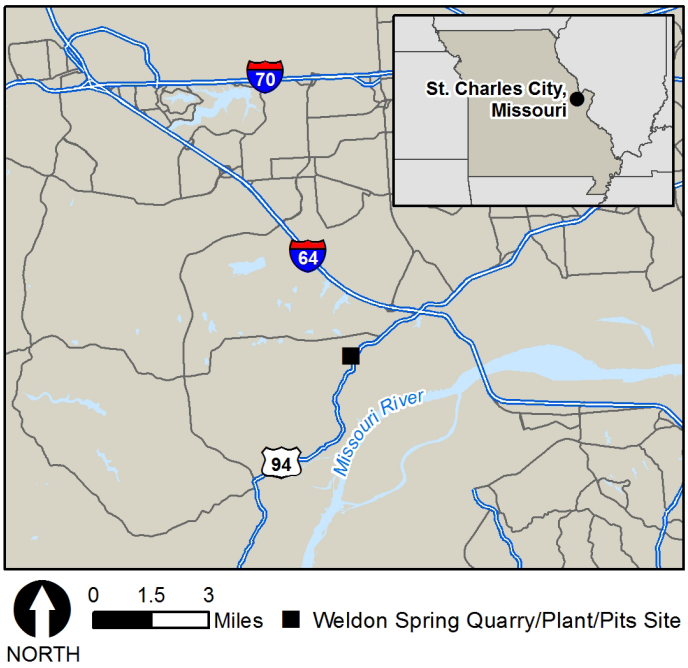
Introduction

The Weldon Spring Quarry/Plant/Pits (USDOE) Superfund site is located in St. Charles County, Missouri, about 30 miles from St. Louis. In 1940, the U.S. government acquired over 17,000 acres of land in the rural farming communities of Hamburg, Howell and Toonerville, displacing residents. Development of the Weldon Spring Ordnance Works followed. It was the largest munitions manufacturing facility in the United States during World War II. By the end of the war, the facility had manufactured over 750 million pounds of explosives for the war effort.

The Ordnance Works was decommissioned in 1945 following the end of the war. In 1956, the Army transferred 205 acres of the property to the U.S. Atomic Energy Commission (AEC) for construction of the Weldon Spring Uranium Feed Materials Plant, which is referred to as the chemical plant. The chemical plant converted processed uranium ore concentrates to pure uranium trioxide, intermediate compounds, and uranium metal. No enrichment took place at the site, but AEC shipped the uranium ores to facilities across the country for enrichment and eventual use in nuclear weapon development and nuclear energy production research. AEC's Weldon Spring Uranium Feed Materials Plant closed in 1966. AEC (later the U.S. Department of Energy, or DOE), took on a caretaker role at the vacant site until 1986. That year marked the beginning of cleanup investigations into nitroaromatic, radiological and chemical contamination at the site.

Historical operations by both the Army and AEC resulted in the listing of two National Priority List (NPL) sites—the Weldon Spring Ordnance Works site for contamination resulting from Army operations and the Weldon Spring Quarry/Plant/Pits site for contamination resulting from AEC operations. The Weldon Spring Quarry/Plant/Pits site includes about 220 acres around the former chemical plant and the quarry area. The site is wholly surrounded by the separate Weldon Spring Ordnance Works site. Through cleanup actions and site restoration efforts, DOE has transformed the Weldon Spring Quarry/Plant/Pits site, a once-contaminated wasteland, into a recreational and educational hive of activity, attracting birdwatchers, native-plant enthusiasts, hikers, mountain bikers, historians, anthropologists, and teachers and their students.

DOE's Office of Legacy Management opened the Weldon Spring Site Interpretive Center on site in 2002 as part of its commitment to maintaining strong community partnerships and sharing the history of the site with future generations. The interpretive center preserves the legacies of lost towns, the history of production plants during World War II and the Cold War, and the process of site remediation, as well as offering educational programming for children and adults.



Sources: Esri, DeLorme, AND, Tele Atlas, First American, UNEP-WCMC and USGS.

The Weldon Spring Quarry/Plant/Pits (USDOE) Superfund site is located about 30 miles outside of St. Louis, Missouri.

Many people hike to the top of the 41-acre, 70-foot-high disposal cell next to the interpretive center. The observation deck at the top offers stunning views and is one of the highest elevations in the area. A 150-acre native prairie rich with flowering forbs, grasses and wildlife has restored the area's original ecosystem, dating back to before European settlement. A native plant garden offers interpretive and self-guided tours to learn about native plantings. A former remedial haul road is now the Hamburg Trail, which connects the site with neighboring Missouri Department of Conservation (MDC) public lands, the Great Rivers Greenway trail network and Katy Trail State Park.

This case study explores the tools and partnerships that have led to the successful cleanup and transformation/restoration at the Weldon Spring Quarry/Plant/Pits Superfund site. The following pages trace the coordinated development of cleanup and reuse efforts, interagency and community partnerships, and a vision to preserve history while leaving a better place for generations to come. The case study provides information for parties interested in Superfund site reuse, ecosystem revitalization and restoring access to federal lands.

Site History, Contamination and Remediation

In anticipation of American involvement in World War II, the U.S. government acquired 17,232 acres of rural land in St. Charles County, Missouri, in 1940 for the Weldon Spring Ordnance Works. The Army built up a large complex for manufacturing trinitrotoluene (TNT) and dinitrotoluene (DNT) on these properties. The Army operated 18 TNT production lines and two DNT production lines. Four of the 18 TNT production lines were located on what is now DOE-owned property encompassing the former Chemical Plant. These plants operated from 1941 to 1945, producing almost 750 million pounds of TNT and DNT during World War II. The ordnance works ceased production at the end of the war, and the U.S. Army Corps of Engineers (Corps) began site decontamination efforts in 1946. At the time, burning was considered the safest way to dispose of structures contaminated with explosive dust and residues. Manufacturing and decontamination activities resulted in the nitroaromatic contamination of soil, groundwater, sediments and some area springs.

From 1947 to 1949, the Army transferred most of the facility's 17,000+ acres to public entities. The Army transferred 7,920 acres to the University of Missouri for agricultural research. MDC later purchased 7,200 acres from the university to create the Weldon Spring Conservation Area. MDC received an additional 6,944 acres of the original ordnance works property and created the August A. Busch Memorial Conservation Area. St. Charles County Public Schools received almost 38 acres of land, including the property where Francis Howell High School is located.

Figure 1: One of many TNT production buildings at the facility (left). Workers package TNT for shipment (right).

In 1956, the Army transferred about 200 acres to AEC for the Weldon Spring Uranium Feed Materials Plant, later known as the Weldon Spring Chemical Plant. AEC operated the plant from 1957 to 1966, acquiring an additional 14.9 acres in 1960 that included the quarry area of the site. Following the first wartime use of atomic bombs in Hiroshima and Nagasaki, Japan, in 1945, the United States continued to develop nuclear weapons and research nuclear power production. The chemical plant started the initial steps of uranium processing in support of these efforts. While operating, the plant converted processed uranium ore concentrates (also known as "yellow cake") to pure uranium trioxide, uranium metal and several intermediate products. This refining process generated a waste byproduct called raffinate. AEC stored raffinate in four pits (the Raffinate Pits) on the chemical plant property. Uranium-processing operations at the chemical plant resulted in radiological contamination of the property previously contaminated with nitroaromatics by the Army.

Today, the Weldon Spring Quarry/Plant/Pits Superfund site consists of two geographically separate properties that are owned by DOE: the 220-acre former Weldon Spring Chemical Plant and Raffinate Pits and the 8.7-acre former Weldon Spring Quarry, located about 4 miles southwest of the former chemical plant. The site is wholly encompassed within the separate, 17,000+-acre Weldon Spring Ordnance Works Superfund site, where the Army leads cleanup. Fifty-seven people live within a one-mile radius. Four percent of this population is considered low-income, compared to the state average of 13 percent.

Site History, Contamination and Remediation *(contd.)*

During construction of the Weldon Spring Ordnance Works in the early 1940s, the Army mined the quarry for limestone aggregate used to build roadways and building foundations. Later, the Army burned wastes from explosives manufacturing and disposed of TNT-contaminated rubble in the quarry. These disposal practices resulted in nitroaromatic contamination of the quarry. After the Army transferred quarry lands to AEC in 1960, AEC continued to use the quarry as a disposal site for uranium and thorium residues from the plant until 1969.

AEC transferred about 169 acres of the chemical plant back to the Army in 1967, retaining ownership of the Raffinate Pits and the quarry. The Army intended to use the chemical plant to produce Agent Orange, an herbicide used in the Vietnam War. However, the Army cancelled the Agent Orange project in 1969 after cleanup costs to decontaminate and renovate buildings at the chemical plant property escalated and demand for Agent Orange declined. The Army never produced herbicides at the site and the properties remained vacant from 1969 onward. AEC and DOE retained caretaking responsibilities at the site from 1968 to 1985.

Figure 2: Aerial view of the Weldon Spring Chemical Plant around 1960 (left). Workers pose with a uranium direct ingot ("dingot") weighing about 3,000 pounds (right).

Site Investigation and Cleanup

In 1986, the U.S. Office of Management and Budget directed the Army to transfer custody of the chemical plant to DOE for cleanup, with the Army responsible for funding part of the project. In 1986, EPA and DOE signed a Federal Facility Agreement to establish a procedural framework and schedule for developing, implementing and monitoring appropriate response actions at the site in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). EPA listed the Weldon Spring Quarry on the Superfund program's NPL in July 1987 and incorporated the chemical plant and Raffinate Pits as part of the site in March 1989. EPA and DOE updated the agreement to include the cleanup of the chemical plant and Raffinate Pits in 1992. A separate NPL site, the Weldon Spring Ordnance Works, surrounds the site. EPA added that site to the NPL in February 1990. The Army is responsible for the cleanup at the Weldon Spring Ordnance Works site.

CERCLA

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) is the law passed by Congress on December 11, 1980, that is commonly known as Superfund.

The EPA manages the national Federal Facility Superfund Program under CERCLA to facilitate faster, more effective and less costly cleanup and reuse of federal facilities while ensuring protection of human health and the environment from releases of hazardous substances. There are nearly 160 federal facility sites on the NPL. Examples of federal facility sites include military installations, former nuclear production plants, abandoned mines and landfills. Common types of contamination include radioactive waste, munitions and unexploded ordnance, mining waste, and solvents.

DOE cleaned up the southeast drainage area of the site under a CERCLA removal action to address immediate risks to public health and the environment. DOE removed radioactively contaminated soil and sediment from accessible areas of the drainage to the Missouri River, stockpiling these wastes in the chemical plant area until their ultimate disposal in the disposal cell. Risk-based cleanup goals developed for the drainage were designed to be protective for recreational uses and for a modified residential scenario where children living near the site play in the drainage occasionally. Confirmatory sampling following the removal found that the drainage is now protective of these future anticipated uses. However, contaminant concentrations remain above levels that allow for unlimited use/unrestricted exposure. For this reason, institutional controls have been implemented. Cleanup of the Southeast Drainage finished in 1999.

Figure 3: The quarry area during waste removal efforts prior to backfilling.

To manage the cleanup, DOE divided the site into four areas, or operable units (OUs): the Chemical Plant OU, the Quarry Bulk Waste OU, the Quarry Residuals OU and the Groundwater OU.

Figure 4: Removing abandoned materials for processing.

Quarry Bulk Waste OU

EPA and DOE selected the long-term remedy for the Quarry Bulk Waste OU in the site's September 1990 Record of Decision (ROD). The ROD specified that bulk waste be removed, transported along a dedicated haul road to the Chemical Plant, and placed in controlled storage in an engineered temporary storage facility. Prior to removing the bulk wastes, surface water that had pooled in the quarry needed to be drained and treated prior to discharge to the Missouri River. The Quarry Water Treatment Plant began operating in fall 1992. Between 1992 and 2001, the plant treated over 70 million gallons of water.

DOE built a dedicated haul road on site to transport bulk wastes from the quarry, four miles up to the chemical plant. These bulk wastes were then stored securely for later placement in the disposal cell. The removal of bulk wastes from May 1993 to October 1995 totaled more than 144,000 cubic yards of contaminated soil, metal, rock and building debris, eliminating the main source of groundwater contamination at the quarry. Remaining waste in soil and sediments as well as contaminated surface water and groundwater would be addressed in the remedy for the Quarry Residuals OU.

Figure 5: Chemical drums from raffinate pit 4.

Chemical Plant OU

EPA and DOE selected the long-term remedy for the Chemical Plant OU in the site's September 1993 ROD. It addressed principal threat wastes at the site, including Raffinate Pits sludges and soils. The three main parts of the remedy were to remove and consolidate dug-up wastes, to treat wastes with chemical stabilization and solidification, as needed, and to dispose of all site wastes from all OUs in a disposal facility on site.

DOE dredged sludges from the Raffinate Pits, excavated sediments from Frog Pond and Ash Pond, as well as soils from two former dump locations next to the chemical plant buildings on site and 10 nearby vicinity properties. The contents of the Raffinate Pits sludges were predominantly liquid with fine-grained sludge, and needed to be treated to ensure they would be structurally stable before disposal on site. DOE selected a chemical stabilization and solidification treatment. After removal of oversize materials, a polymer was added to thicken the sludge prior to mixing it with cement and fly ash. The final material for disposal was a grout-like product that is structurally and chemically stable. The chemical stabilization and solidification plant operated from June to November 1998, producing about 186,000 cubic yards of the grout-like end product.

In Honor and Remembrance

Settled in the mid-1800s, this rural area of St. Charles County was home to several small farming communities. The large open agricultural lands located near regional transportation networks met the U.S. government's essential selection criteria for the project. This part of St. Charles County offered good access to the Central-Missouri Railroad (depot in the town of Hamburg), good access to highways 94 and 40, and access to the Missouri River, which runs next to the site. The Daniel Boone Bridge, built in 1936, enabled direct access to this once relatively isolated area.

The Army's Weldon Spring Ordnance Works project displaced nearly 600 residents from the towns of Hamburg, Howell and Toonerville. Founded in 1833 by German immigrants, Hamburg provided a town center with rail and river access for nearby farming families to transport and sell agricultural goods. Descendants of pioneers to the area founded Howell, also a farming community, in 1864. Founded in the 1920s, the town of Toonerville gained its name from a comic strip of the same name that was popular at the time. A fourth town, Weldon Spring, lost land to the project, but its downtown remained intact.

Figure 6: Residents in Hamburg, Missouri, outside a local grocery store in 1935.

As the closest local town, Weldon Spring served as the main access point to the chemical plant. A town auction in Hamburg in November 1940 marked the beginning of the forced removal of these communities from their lands. The Army burned down the homes, businesses and other buildings in the towns of Hamburg, Howell and Toonerville to clear the land for construction. By July 1941, nothing remained of the three towns.

Treated Raffinate Pits sludges, along with the materials from the 11-acre temporary storage area for stockpiled wastes from the bulk waste removal at the quarry, would ultimately be disposed of in a disposal cell on site. The disposal cell prevents contaminant migration and is designed to remain stable for 1,000 years.

DOE incorporated six key elements into the cell design: an armored cover system, the consolidated waste, a surrounding clean-fill dike, a basal liner system, a geochemical barrier layer, and the leachate collection and removal system.

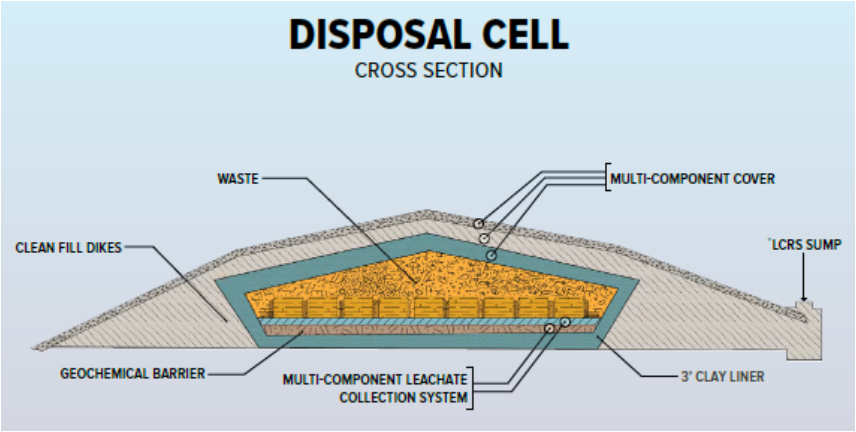


Figure 7: Cross-section view of the disposal cell.

DOE deposited the first load of waste into the lined disposal cell in March 1998. The cell cover was in place in October 2001. The cell contains about 1.48 million cubic yards of contaminated waste, which has a maximum thickness of 63 feet and covers an area of 24 acres, including the lower interior dike slopes. The exterior of the cell averages about 70 feet above the land surface and covers an area of 41 acres, the equivalent of 54 football fields.

DOE established a groundwater monitoring well network around the disposal cell to monitor cell performance. DOE continues to operate and monitor the leachate collection and removal system. A 300-foot buffer zone around the disposal cell is used for monitoring and maintenance activities and provides an extra area of erosion protection. DOE's Oak Ridge Office transferred long-term surveillance and monitoring activities to DOE's Long-Term Surveillance and Maintenance Program in 2002. In 2003, DOE's Office of Legacy Management took on responsibility for the site.

The reasonably anticipated future land use for this area is recreational use. A 2002 post-cleanup risk assessment found that the cleanup of the chemical plant and its vicinity was within the acceptable risk range for this future land use.

Former Site Area

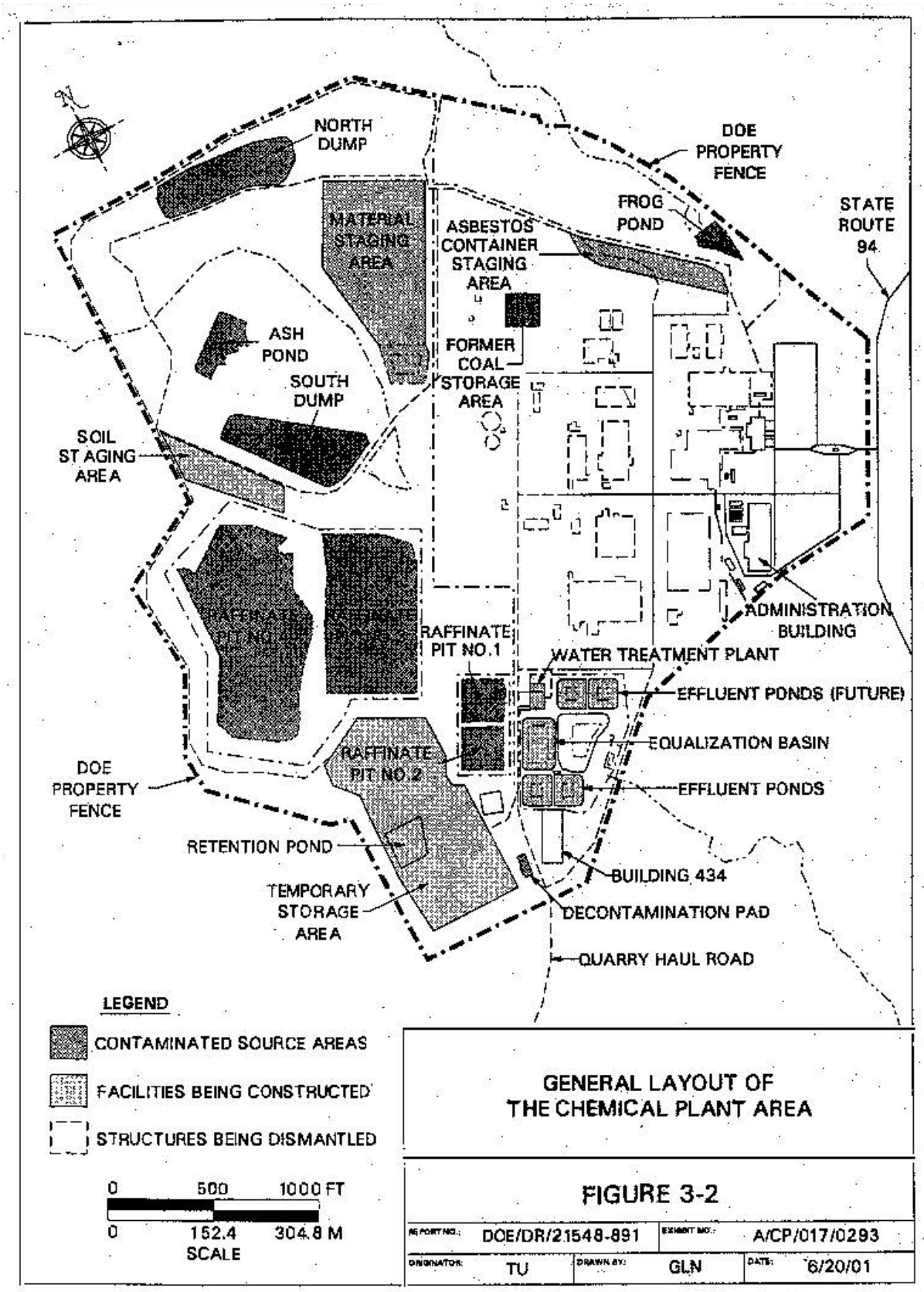


Figure 8: Layout of the chemical plant area during cleanup. (Source: Weldon Spring Site Remedial Action Project, Second Five-Year Review, August 2001)

Current Site Area

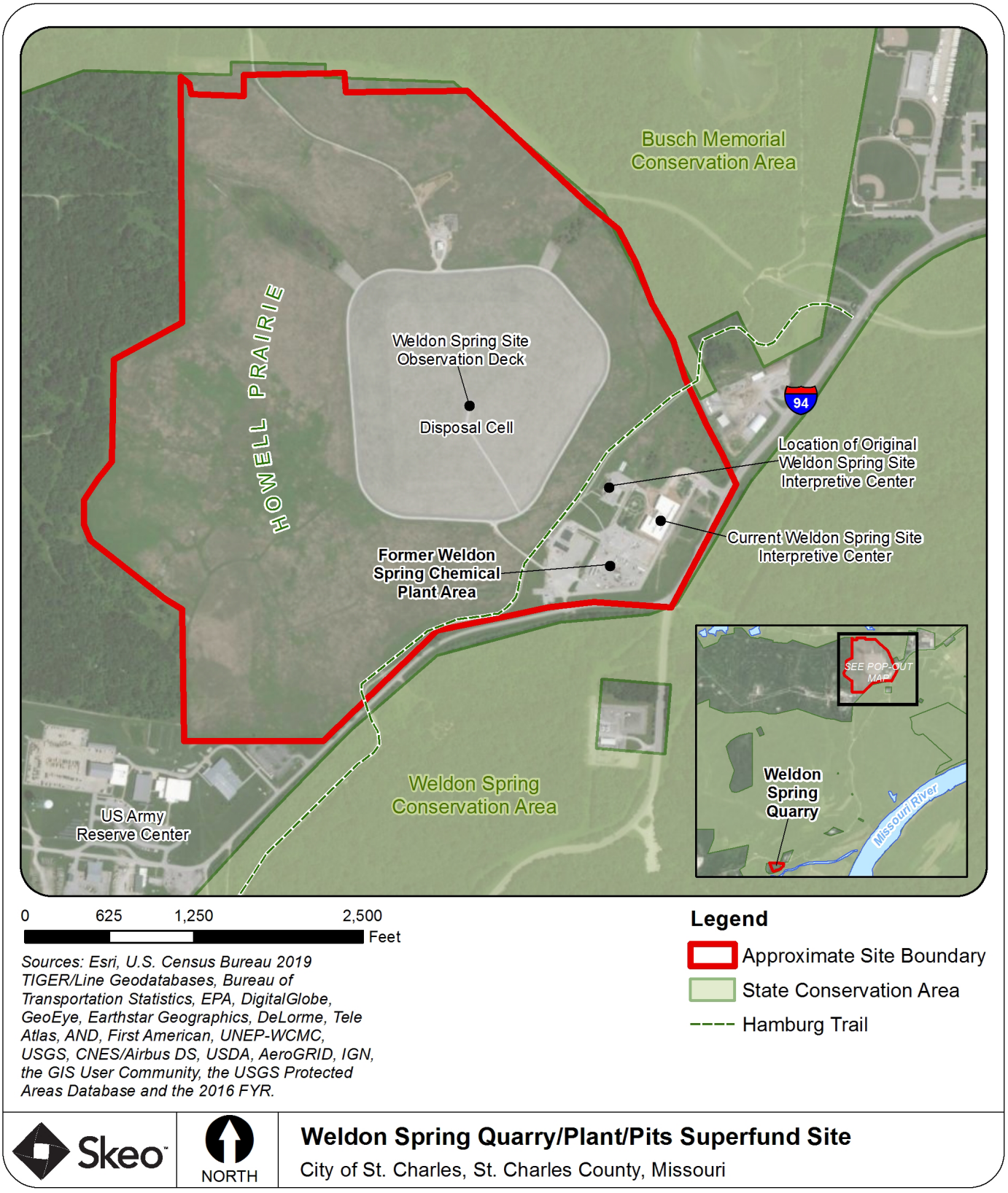


Figure 9: Remedial workers placing a liner system at base of disposal cell (left). The placement of the first load of waste in the disposal cell in March 1998 (right).

Figure 10: Consolidation of waste materials in the disposal cell (left). Workers placing the exterior cobble layer of the cover on the disposal cell (right).

Quarry Residuals OU

EPA and DOE selected the long-term remedy for the Quarry Residuals OU in the site's September 1998 ROD. Based on exposure assessments under current and reasonably anticipated uses, the selected remedy was long-term monitoring and ICs. The ROD also outlined groundwater field studies, which included the installation of a groundwater interceptor trench and operated for two years. Restoration of the quarry area included backfilling the quarry to reduce physical hazards, dismantling of the Quarry Water Treatment Plant, conversion of the former bulk waste haul road into a hiking and biking path (Hamburg Trail) and final grading of the quarry. DOE completed the restoration of the quarry in 2002.

Groundwater OU

In 1993, DOE and the Army decided to work jointly to address groundwater issues at the site and at the Weldon Spring Ordnance Works site. A remedial investigation and baseline risk assessment for the joint groundwater project finished in 1997. A feasibility study evaluated potential remedial options and identified a preferred alternative of long-term monitoring of groundwater with in-situ treatment of areas of the shallow aquifer impacted by trichloroethylene (TCE). A 1998 pumping test indicated that a pump-and-treat system would not work to address TCE contamination.

In 2000, EPA and DOE signed an interim ROD to explore options for active remediation of TCE-impacted groundwater at the chemical plant area with in-situ chemical oxidation and monitored natural attenuation.

EPA and DOE signed a final ROD for the Groundwater OU in 2004. The selected remedy is monitored natural attenuation of groundwater contaminants of concern and implementation of institutional controls to prohibit use of groundwater and spring water as a drinking water source during remediation. DOE installed a network of monitoring wells to measure progress of groundwater restoration.

Project History

1995 to 2001: Prepping New Beds

The chemical plant area of the site is located near three state conservation areas: the 6,988-acre Busch Conservation Area to the north, the 7,356-acre Weldon Spring Conservation Area to the east and south, and the 2,548-acre Howell Island Conservation Area, an island in the Missouri River. The quarry area of the site is located entirely within the Weldon Spring Conservation Area. Katy Trail State Park traverses the Weldon Spring Conservation Area along the route of an abandoned railroad bed that runs next to the quarry's southern edge. The Busch and Weldon Spring Conservation areas are open year-round and host about 1.2 million visitors each year. The areas support timber, fish and wildlife habitat and recreation spaces. Fishing is the main type of recreational use. For CERCLA remedy purposes, the current and future anticipated land use is recreational. The site location at the intersection of two large, established conservation areas illustrated the importance of and opportunity for creating and maintaining recreational and ecologically rich green spaces, especially close to a major metropolitan area.

To support the site's revitalization as a recreational, educational and ecological resource, DOE conducted a biological assessment for the chemical plant area of the site in 1992, identifying several endangered species. As of July 2021, eight species at the site are listed as threatened or endangered in St. Charles County, Missouri[1]. All three bird species below are protected under the Endangered Species Act in the continental United States[2].

The quarry area of the site had most recently been a woodland habitat. Historically, a native prairie named Howell's Prairie had occupied what later became the chemical plant area of the site, as well as the larger former Weldon Spring Ordnance Works property. In the early 1990s, DOE began exploring options for prairie restoration by planting native grasses on the Chemical Plant area of the site after remediation. Restoration of the property to its original pre-settlement prairie ecosystem, now quite rare in Missouri, would bring the property full circle while also supporting conservation efforts for flora and fauna at the neighboring Busch and Weldon Spring Conservation areas. In addition, the deeply rooted native prairie plants would strengthen the long-term protection of the cell disposal area by resisting erosion and holding soils in place.

Another key DOE objective was to maintain open communications and engage with the community. The site had been vacant for 20 years. Prior to that, it was fenced off to the public during the manufacture of explosives and uranium ore. Now, DOE was putting in an enormous waste disposal cell in clear view of Highway 64. There were bound to be questions from the community. DOE chose to proactively invite the community into the site to learn more.

"The Weldon Spring site demonstrates the importance of DOE's work and how cooperation and communication with local communities can generate opportunities for smart reuse."

– Rebecca Roberts,
Weldon Spring Site Manager

Species	Group	2011 Status	Current Status
Decurrent false aster *(Boltonia decurrens)*	Flowering plants	Threatened	Threatened
Indiana bat *(Myotis sodalis)*	Mammals	Not listed	Endangered
Interior least tern *(Sterna antillarum)*	Birds	Endangered	Endangered
Northern long-eared bat *(Myotis septentrionalis)*	Mammals	Not listed	Threatened
Pallid sturgeon *(Scaphirhynchus albus)*	Fishes	Endangered	Endangered
Piping plover *(Charadrius melodus)*	Birds	Not listed	Endangered
Rufa red knot *(Calidris canutus rufa)*	Birds	Not listed	Threatened
Running buffalo clover *(Trifolium stoloniferum)*	Flowering plants	Endangered	Endangered
Scaleshell mussel *(Leptodea leptodon)*	Clams	Endangered	Endangered, but no longer identified as occurring in St. Charles County

1. U.S. Fish and Wildlife Service's Information for Planning and Consultation (IPaC) database: ecos.fws.gov/ipac/location/index.
2. U.S. Fish and Wildlife listing of Bird of Conservation Concern: www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php.

Timeline of Events

1940	The U.S. government acquires 17,232 acres of rural land in St. Charles County for the Weldon Spring Ordnance Works.
1941 to 1945	The Army produces TNT and DNT to support World War II efforts.
July 1946	The Atomic Energy Act passes Congress and establishes AEC, transferring nuclear technology from military to civilian control.
1956	The Army transfers 205 acres to AEC for the Weldon Spring Uranium Feed Materials Plant (chemical plant).
1960	The Army transfers 14.88 acres to AEC, including the quarry.
1963 to 1969	AEC uses the quarry for disposal of uranium and thorium residues from the chemical plant.
1966	Uranium processing stops.
December 31, 1967	AEC returns the facility to the Army.
1968 to 1985	AEC, and later DOE, manages the site, including the chemical plant, under caretaker status.
October 1974	The Energy Reorganization Act of 1974 abolishes AEC and creates the Energy Research and Development Administration and the Nuclear Regulatory Commission.
October 1977	DOE replaces the Energy Research and Development Administration, consolidating federal energy programs and activities.
November 1978	The Uranium Mill Tailings Radiation Control Act of 1978 directs DOE to stabilize and control uranium mill tailings at inactive milling sites and vicinity properties.
December 1980	Congress passes CERCLA (commonly referred to as Superfund) in response to the discovery of a large number of abandoned, leaking hazardous waste dumps.
October 15, 1984	EPA proposes the site for listing on the NPL.
1985	The Army transfers the chemical plant to DOE.
August 22, 1986	DOE takes custody of the former Weldon Spring Uranium Feed Materials Plant and starts the site's remedial investigation.
July 30, 1987	EPA finalizes the site's listing on the NPL.
March 1989	EPA includes the chemical plant and Raffinate Pits as part of the site.
September 1990	EPA selects remedy for management of bulk wastes at the Weldon Spring Quarry.
June 3, 1991	DOE begins remedial activities.
January 28, 1992	EPA and DOE amend the Federal Facility Agreement for site cleanup.
September 1993	EPA selects the remedy for the chemical plant area.
September 1998	EPA selects the remedy for quarry residuals.
September 2000	EPA selects the interim remedy for groundwater in the chemical plant area.
2001	DOE completes construction of the disposal cell.
August 2, 2002	The Weldon Spring Site Interpretive Center opens to the public.
December 2003	DOE establishes the Office of Legacy Management.
January 2004	EPA selects the final remedy for groundwater in the chemical plant area.
August 22, 2005	Remedy construction finishes.
March 2006	EPA, DOE and Missouri Department of Natural Resources (MDNR) sign a revised Federal Facility Agreement focused on long-term surveillance and maintenance activities.
February 13, 2013	The site achieves EPA's Sitewide Ready for Anticipated Use performance measure.
May 9, 2019	Groundbreaking ceremony celebrates the beginning of construction of the interpretive center and administrative offices.
October 28, 2020	The site receives EPA's Federal Facility Excellence in Site Reuse Award.

Figure 11: The Weldon Spring Site Interpretive Center is located along the Hamburg Trail and has easy access to the disposal cell observation deck.

2002 to 2018: New Beginnings Take Root

Dedicated in August 2002, the Weldon Spring Site Interpretive Center provides a window into the area's history as well as DOE's commitment to strong community partnerships and engagement. An exhibit gallery honors the site's history, as well as site contamination, cleanup and restoration. Through educational programming, guided tours and research opportunities, center staff engage with visitors every day. The center's focus on risk communication shows how cleanup activities made the site safe for public use. In addition to extensive programming to engage with area schoolchildren during the school year, the center also provides meeting room space for naturalist groups, hobbyists, crafters, trail users and community organizations.

The 41-acre Weldon Spring Disposal Cell is next to the center. With an average height of 70 feet, the cell is one of the highest points of elevation in the area. During daylight hours, visitors can access an observation deck at the top of the disposal cell via a staircase and crushed gravel walkway. The viewing platform provides panoramic views of St. Charles and St. Louis counties as well as the Howell Prairie restoration project surrounding the disposal cell. A mile-long gravel walking path circles the disposal cell, providing eye-level views of the prairie.

The repurposed remedial haul road is now part of the 6-mile Hamburg Trail. The new trail links the site to a network of trails through MDC conservation areas and the Great Rivers Greenway, and to the wildlife center at the Busch Conservation Area. To the north, the new Hamburg Trail connects the site with the historic Katy Trail State Park, a 200-mile multi-use trail along the Missouri River. DOE put in historical markers along the Hamburg Trail and at the observation deck. They provide cultural and historical information about the site's history, cleanup and reuse.

> ***"The Weldon Spring Interpretive Center provides historical and scientific educational opportunities about the site and its cleanup that will inform future generations about the area's unique history."***
>
> – Jim Gulliford, Former EPA Region 7 Administrator

Howell Prairie

When disposal cell construction finished in 2001, attention turned to the planned restoration of site lands with native grasses. DOE planted the first prairie grasses and forbs in spring 2002. Seeds of native prairie plants were also sown in the winter months of 2003 and 2004. DOE planted about 80 species of native forbs and prairie grasses, continued overseeding and put measures in place to control invasive, non-native weeds in 2004. Many of these prairie species require an extended period of cold weather to germinate. Seeds are worked into the top layer of soil via the natural freeze and thaw cycles of Missouri winters, setting up ideal spring germination conditions. To ensure the establishment of prairie plants, the prairie area was mown to prevent any non-native plants from setting seed. Mowing also allowed the establishing plants preferential access to sunlight and rainwater.

Once the prairie had been established, a program of prescribed burns was scheduled. The burns reduce the dry, aboveground biomass accumulation from annual plant dieback. The burn reduces this thatch layer that can shade out new growth and also helps the material decompose more quickly, returning stored nutrients to the soil. The charred black surface of the soil

can absorb more sunlight, warming the soil and helping seeds germinate, reducing the chances of wildfires. The burns also eliminate opportunistic non-native plants emerging from an old seed bank or carried in by wind or wildlife. Invasive species are fast growers that can quickly outpace and shade out native prairie plants. Burning out invasives, as well as any shrubs or saplings that germinate in the prairie, will ensure that the native species can have needed access to sunlight. Prairie plants are adapted to routine burns, whether a wildfire in nature or a prescribed burn on managed lands. The principal adaptations are that the main growth points of these species are underground – the growth point where new shoots or stems emerge and the deep root system. As a result, invasive, non-native plants are eliminated. Established native prairie plants begin growing above the surface almost immediately after the burn.

Today, the Howell Prairie covers more than 150 acres at the site and includes over 80 species of native prairie grasses and wildflowers, which serve as ideal habitat for wildlife and pollinators. Plants such as prairie blazing star, little bluestem and wild bergamot will once again dominate this area. The prairie surrounds the disposal cell and can be viewed from an access trail that extends around the cell. Through agriculture, urban sprawl and habitat deterioration due to fire suppression, the vast majority of Missouri's prairie land has been lost, with only 1% of prairie land undisturbed. These native prairie grasslands were once a dominant feature of the American landscape in this area; now they are rare. DOE has continued to develop and manage the prairie as an outdoor classroom for area schoolchildren and families. DOE has also developed self-guided and interpreter-led programming about pollination, food webs, life cycles, soil science, prairie studies and related topics.

DOE also partnered with Missourians for Monarchs to co-host the first Monarch Madness pollinator festival at the Weldon Spring Interpretive Center in 2015. The Howell Prairie is located along the Monarch butterfly's migration flyway. These events allow butterfly tagging and release, as well as guided hikes and education opportunities to learn more about the Howell Prairie.

"The area is frequented by school groups, bird watchers, native-plant enthusiasts, hikers, mountain bikers and many others."

– Padraic Benson, Program Analyst,
DOE's Office of Legacy Management

What is the Office of Legacy Management?

In 2003, DOE established the Office of Legacy Management to provide a long-term, sustainable solution to the legacy of World War II and the Cold War. The Office currently manages more than 100 sites where DOE's mission and all environmental cleanups have been completed. The Office has six goals:

1. Protect human health and the environment.
2. Preserve, protect, and share records and information.
3. Safeguard former contractor workers' retirement benefits.
4. Sustainably manage and optimize the use of land and assets.
5. Sustain management excellence.
6. Engage the public, governments, and interested parties.

The site achieved EPA's construction completion milestone in August 2005, marking the transition to long-term surveillance and maintenance. Long-term groundwater restoration and monitoring is ongoing.

Figure 13: The interpretive center offers many activities and facilities for schoolchildren and families, such as this butterfly walk.

2019 to Present: Blooming and Growing

A highly valued community resource, the Weldon Spring Site Interpretive Center has hosted more than 346,000 visitors to date. Over time, it has also expanded community and school programming. Since its opening in 2001, the interpretive center has been located in a refurbished temporary building built during cleanup. In May 2019, DOE's Office of Legacy Management and the U.S. Army Corps of Engineers, St. Louis District, celebrated the groundbreaking for a brand-new interpretive center and office complex. The $7.4 million facility includes an exhibit hall, four state-of-the-art classrooms and an auditorium. A support agreement between DOE's Office of Legacy Management and the Corps enabled the design and construction of the new facility.

At the groundbreaking event, DOE's Office of Legacy Management Director Carmelo Melendez remarked on how this collaborative project between the two agencies demonstrates their commitment to projects that provide beneficial use to the public. Community speakers included Alice Wolf, coordinator of events for TNT Families whose loved ones worked at the ordnance works, Angel Stahr, a volunteer naturalist with MDC and second-grade teacher Melissa Young who was joined by about 60 of her students from McKelvey Elementary School. Director Melendez thanked the many stakeholders gathered at the event "for being part of the success of transforming the site from a national security center that assured our liberties to today, where we protect human health and the environment and are able to educate future leaders and future citizens of the state and the nation." Construction of the new Weldon Spring Site Interpretive Center and Office Complex finished in 2020. The new facility will open to the public once COVID-19 public health emergency restrictions are lifted and indoor gatherings are permitted. Community members engaged in the cleanup, visioning, acquisition and redevelopment process pointed to a combination of important factors in the project's success.

> ***"The groundbreaking ceremony for the new Weldon Spring Site Interpretive Center signifies the Office of Legacy Management's long-term commitment to the community through preservation of history and STEM education for students."***
>
> – Carmelo Melendez, DOE Office of Legacy Management Director

Figure 14: A bluebird sighting (left) and a coyote foraging (right) in the Howell Prairie.

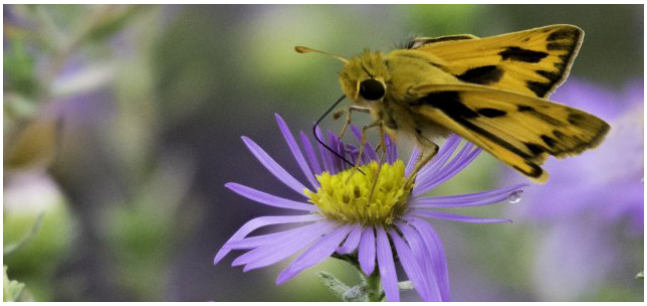


Figure 15: Native pollinators include the Fiery Skipper on a purple aster (top left) and a bee collecting nectar from common milkweed (bottom left). DOE has hosted Monarch Madness events at Howell Prairie, where monarchs are tagged and released to track their migration (right).

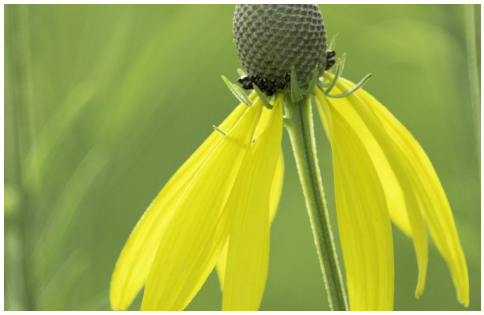


Figure 16: Wildflowers in the restored Howell Prairie (left) include gray-headed coneflower (top right) and foxglove penstemon (bottom right).

Life in a Pandemic

Due to the COVID-19 public health emergency, the Weldon Spring Site Interpretive Center closed its doors to in-person, indoor visits in March 2020. Until it can reopen, DOE's Office of Legacy Management provides virtual and self-guided tour opportunities: www.energy.gov/lm/weldon-spring-site-interpretive-center. Site interpreters have been hard at work creating and sharing virtual programming with schools, community groups and the public. Interpretive center staff members are proud to have achieved the Certified Interpretive Guide professional level certification through the National Association for Interpretation (NAI). The center hosts a complete curriculum of science, technology, engineering and mathematics (STEM) programs as well as history programs for kindergarten through high-school and collegiate students.

Outdoor areas of the site remain open to the public, with social distancing and mask-wearing best practices per Centers for Disease Control recommendations. This includes access to the Howell Prairie, the Jennie Moe Memorial Garden, hiking and biking along the Hamburg Trail, and hiking to the observation deck at the top of the disposal cell. Instructional materials for self-guided activities such as hiking to the top of the disposal cell, finding butterflies at home and learning about groundwater protection are also available.

"Beneficial reuse is a key tenet of the Superfund program under which the site was remediated. The site has been transformed from a contaminated World War II explosives manufacturing plant and Cold War Era uranium processing facility to an educational and recreational resource. It is truly an amazing transformation and a tremendous asset to the community."

– Ken Starr, Former Weldon Spring Site Manager

Figure 17: Entrance to the original interpretive center's gallery exhibit chronicling the history and evolution of activities at the site (left). Speakers from the groundbreaking ceremony (right) for the new interpretive center included Ken Starr, DOE's Office of Legacy Management site manager, Colonel Bryan Sizemore from the U.S. Army Corps of Engineers, Alice Wolf, event Coordinator for TNT Families, Carmelo Melendez, DOE's Office of Legacy Management Director, and Angel Stahr, a volunteer naturalist with MDC

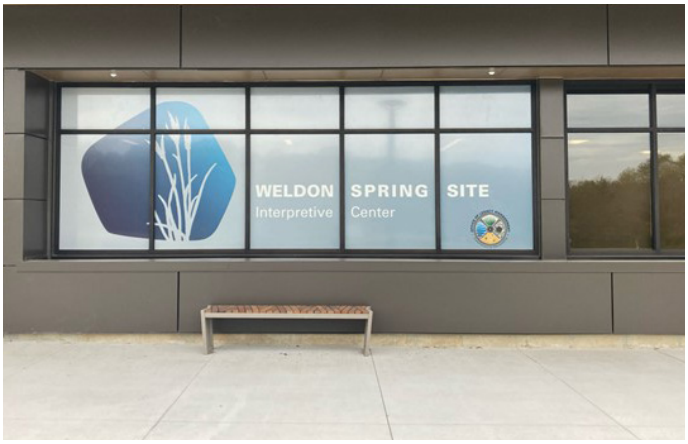


Figure 18: Construction on the new interpretative center began in 2019 (left) and completed in 2020. The new Weldon Spring Site Interpretive Center and Office Complex (right) will open to the public once COVID restrictions are lifted.

EPA Federal Facility Excellence in Site Reuse Award

In 2020, DOE's Office of Legacy Management team received EPA's Federal Facility Excellence in Site Reuse Award recognizing the reuse successes at the Weldon Spring Quarry/Plant/Pits site. EPA established this award program in 2018 to recognize teams and partnerships that have supported the reuse and restoration of Federal Facility sites through outstanding efforts to ensure that sites are remediated to promote continued property use or to support reuse. The award also provides opportunities for education about the cleanup process at sites as well sharing best practices and lessons learned for other projects around the country. The award is divided into four categories: NPL sites, non-NPL cleanup sites, NPL Base Realignment and Closure (BRAC) sites and non-NPL BRAC sites.

The site received the 2020 award in the NPL site category for DOE's Office of Legacy Management's revitalization of the chemical plant property into a community education center, a wellspring of recreation opportunities and a natural prairie habitat that promotes wildlife conservation. Due to the COVID-19 public health emergency, EPA hosted a virtual event in October 2020 and mailed the awards to the recipients.

> ***"We're doing the right thing across the country. We all must be stewards to take care of what we've been given."***
>
> – Colonel Bryan Sizemore,
> U.S. Army Corps of Engineers

Lessons Learned

Today, the Weldon Spring/Quarry/Plants/Pits site is a nationally recognized Superfund reuse success story, one where site cleanup and restoration have literally returned the area to its roots. Key factors that have made the project such a success include:

- From the start of cleanup investigations, DOE focused on the long-term future use of the site.
- Nestled between two large, well-established conservation areas, the site was ideally situated to facilitate connectivity for wildlife and people.
- Interagency partnerships and collaboration between DOE, the Army, EPA, the Corps and MDC facilitated a streamlining of remedial activities and enhanced the interconnectivity of area conservation areas.
- Risk assessments informed the basis for the reasonably anticipated future use of the site and DOE considered remedial activities with a recreational end use in mind.
- Educational and outreach efforts through the Weldon Spring Site Interpretive Center have addressed community questions and concerns effectively.
- DOE's Office of Legacy Management used the interpretive center to provide visitors with a deeper understanding of the site's history, cleanup and restoration. Expanding educational programming to related environmental topics, such as food webs, pollination and life cycles, has attracted an even wider range of visitors to the site, where they learn about site history through exhibits, programs and tours.

Figure 19: Sunset at the Howell Prairie.

> ***"There is no such thing as a bystander. Stewardship is more than just responsible management conducted by one organization. We all play a role in protecting human health and environment and creating beneficial reuse at sites like Weldon Spring."***
>
> – Carmelo Melendez, DOE Office of Legacy Management Director

Bigger Picture

There are also a range of broader lessons learned from the successful cleanup and redevelopment of the site that can help guide similar projects at contaminated lands across the country:

Work with what you have.

DOE repurposed remedial components for the site's revitalization as a hub of recreation and environmental education activities. The former haul road used to transport bulk wastes from the Quarry to the Chemical Plant is now a 6-mile hiking and biking trail that connects the site to several nearby trails. A temporary building used to secure site access became the home of an interpretive center that brought nearly 350,000 visitors to the site. The level of interest and demand for educational programming has now far exceeded expectations, necessitating the construction of a new, larger, state-of-the-art interpretive center. The prominently located, massive disposal cell is highly visible from Highway 64. DOE gave the disposal cell a second, recreational purpose as an observation deck providing stunning panoramic views.

Return to your roots.

The question of how to restore the chemical plant area following remediation led DOE to learn about the historical Howell Prairie that thrived at this location prior to the arrival of European settlers. Research into native prairie systems revealed that this habitat has now shrunk to less than 1% of its former land coverage in Missouri. This provided an opportunity to restore the land to pre-settlement conditions and provide critical habitat for pollinators and other wildlife that depend upon prairie land for survival. The discovery that native prairie plants are usually deep rooted was an added bonus, providing another layer of protection to prevent erosion of site soils. Today, Howell Prairie includes over 80 species of native plants, recreating an almost extinct local habitat.

Jeannie Moe Memorial Garden

This 8-acre native species demonstration garden is located next to the Weldon Spring Interpretive Center. Named in remembrance of site horticulturalist Jeannie Moe, who passed away in 2015, this environmental education resource attracts visitors and enhances the overall educational mission of the site. Jeannie specialized in native plant demonstration gardening, managing gardens at the site as well as at the August A. Busch Memorial Conservation Area and the Jim Ziebol Butterfly Garden (also in the Busch Conservation Area). Designed and planted in 2004, the memorial garden consists entirely of plants native to Missouri, including extensive plantings of species from the Howell Prairie, as well as other native perennials, shrubs and trees. Walking paths meander through the garden, passing signs that help people learn about the plants. Known for her warmth and caring, Jeannie worked tirelessly to nurture and care for the garden and share information with visitors and volunteers.

Figure 20: Sections of the Jeannie Moe Memorial Garden near the entrance to the Weldon Spring Site Interpretive Center.

Bring them back.

Sixty years after the government mandated that residents in Hamburg, Howell and Toonerville leave their homes, DOE reopened public access to the Weldon Spring Quarry/Plant/Pits site. The star attraction at the site, the panoramic views from the observation deck atop the disposal cell, has drawn several hundred thousand visitors to the site. The interpretive center provides historical, geographical and cultural context while also providing clear, easily accessible information so that everyone can learn about the site's history, cleanup and restoration. This open invitation to the public, as well as targeted outreach to schools, naturalist groups and local governments, has supported DOE's Office of Legacy Management's commitment to maintain strong community partnerships and ensure that current and future generations have a good understanding of the site's history.

"DOE is revitalizing the site as a natural and native ecosystem as part of its long-term commitment as a responsible steward of the land."

– Rebecca Roberts,
Weldon Spring Site Manager

Long-term stewardship is essential to successful reuse.

The site's disposal cell is built to last over 1,000 years. Howell Prairie has become well established over the past 20 years. The new interpretive center and office complex will open to the public after emergency public health restrictions are lifted. Looking forward, this thriving project will continue to need regular care, maintenance and attention. DOE's Office of Legacy Management continues to take care of long-term surveillance and maintenance activities for remedial and restoration areas. The involvement of an engaged community with vested interest and pride in the site's continued use and environmental, educational and recreational enhancements also provides maintenance, security, collaboration and support services. The community plays an essential role in the long-term stewardship of the site by participating in educational opportunities and disseminating current, accurate information regarding the site to the larger area.

Figure 21: Groundwater monitoring wells ensure the site remedy continues to protect human health and the environment.

Conclusion

From wartime explosives production and uranium ore processing to a restored native prairie ecosystem and beacon of environmental education, the reuse transformation of the Weldon Spring Quarry/Plant/Pits site is stunning. Shuttered for two decades, this property was an eyesore with dilapidated structures and significant contamination. With EPA and DOE's signing of the first Federal Facility Agreement for the site, DOE embarked on cleanup investigations and designs that facilitated the beneficial reuse of the site as a recreational gem connecting the Weldon Spring and Busch Conservation Areas.

Prior to the COVID-19 public health emergency, the Weldon Spring Site Interpretive Center provided educational opportunities for about 25,000 visitors a year, including large school groups participating in STEM programming and learning about the legacy of this Superfund site. A transition to online classes has enabled programming to remain available; outdoor spaces remain open to the public. Bird watchers, cyclists, hikers, naturalists, photographers and other visitors continue to climb up to the observation deck at the disposal cell, walk the ring trail around the disposal cell, visit Howell Prairie and the Jennie Moe Memorial Garden, and hike and bike the Hamburg Trail.

The conversion of this Federal Facility site to a native habitat that supports pollinators, conservation, understanding of native plants and educational opportunities makes this an exemplary reuse success story. As recognized in 2020 by EPA's Federal Facility Excellence in Site Reuse Award, it is clear that the reuse roots of this project run deep. The site will continue its mission of strong community partnership and education for generations to come.

EPA and Reuse: Lessons Learned

Since the inception of the Superfund program, EPA has been building on its expertise in conducting site characterization and remediation to ensure that contamination is not a barrier to the reuse of property. Today, consideration of future use is an integral part of EPA's cleanup programs from initial site investigations and remedy selection through to the design, implementation, and operation and maintenance of a site's remedy.

At older sites, EPA did not focus on considering reuse during the cleanup design process. At the Weldon Spring Quarry/Plant/Pits site, DOE began reuse considerations in the early 1990s during the development of RODs for the Bulk Quarry Waste and Chemical Plant OUs. The disposal cell design factored in the long-term protectiveness of the remedy (up to 1,000 years!) as well as the opportunity to engage with the community through public access to the site. Soil restoration with a deep-rooted, native prairie provides critical habitat to pollinators and other area wildlife, and also prevents soil erosion around the disposal cell. DOE repurposed a temporary cleanup building to house the Weldon Spring Site Interpretive Center, providing education opportunities focused on the site's history, remediation and restoration.

EPA also works with site stakeholders to consider how future land use considerations can inform the implementation and long-term stewardship of site remedies as well as cleanup planning. At some sites, for example, reuse considerations can inform the future location of groundwater monitoring wells and other operation and maintenance equipment that might inadvertently hinder redevelopment efforts. At other sites, detailed site reuse plans have provided additional benefits that save time and reduce redevelopment costs. For example, future infrastructure corridors or building footers can be installed in coordination with site cleanup activities.

Figure 22: Workers at the former chemical plant (top left). Placement of gravel over the fabric liner (top right). A photo timeline depicting the cleanup process at the new Weldon Spring Site Interpretive Center (bottom left). A caterpillar on a milkweed plant outside the new Weldon Spring Site Interpretive Center (bottom right).

WELDON SPRING QUARRY/PLANT/PITS (USDOE) SUPERFUND SITE

CLEANUP ENABLES CREATION OF RECREATION, ECOLOGICAL REVITALIZATION AND EDUCATION HUB

Sources and Resources

Sources

Images and maps for this case study are from the U.S. Department of Energy's Office of Legacy Management.

Resources

EPA site webpage: www.epa.gov/superfund/weldonspringquarry

U.S. DOE Office of Legacy Management site webpage: www.lm.doe.gov/Weldon/Documents.aspx

EPA Superfund Redevelopment Program: www.epa.gov/superfund-redevelopment

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