# Adaptation Measures Implemented at Superfund Sites

## FRTR Fall Meeting

**November 15, 2021**

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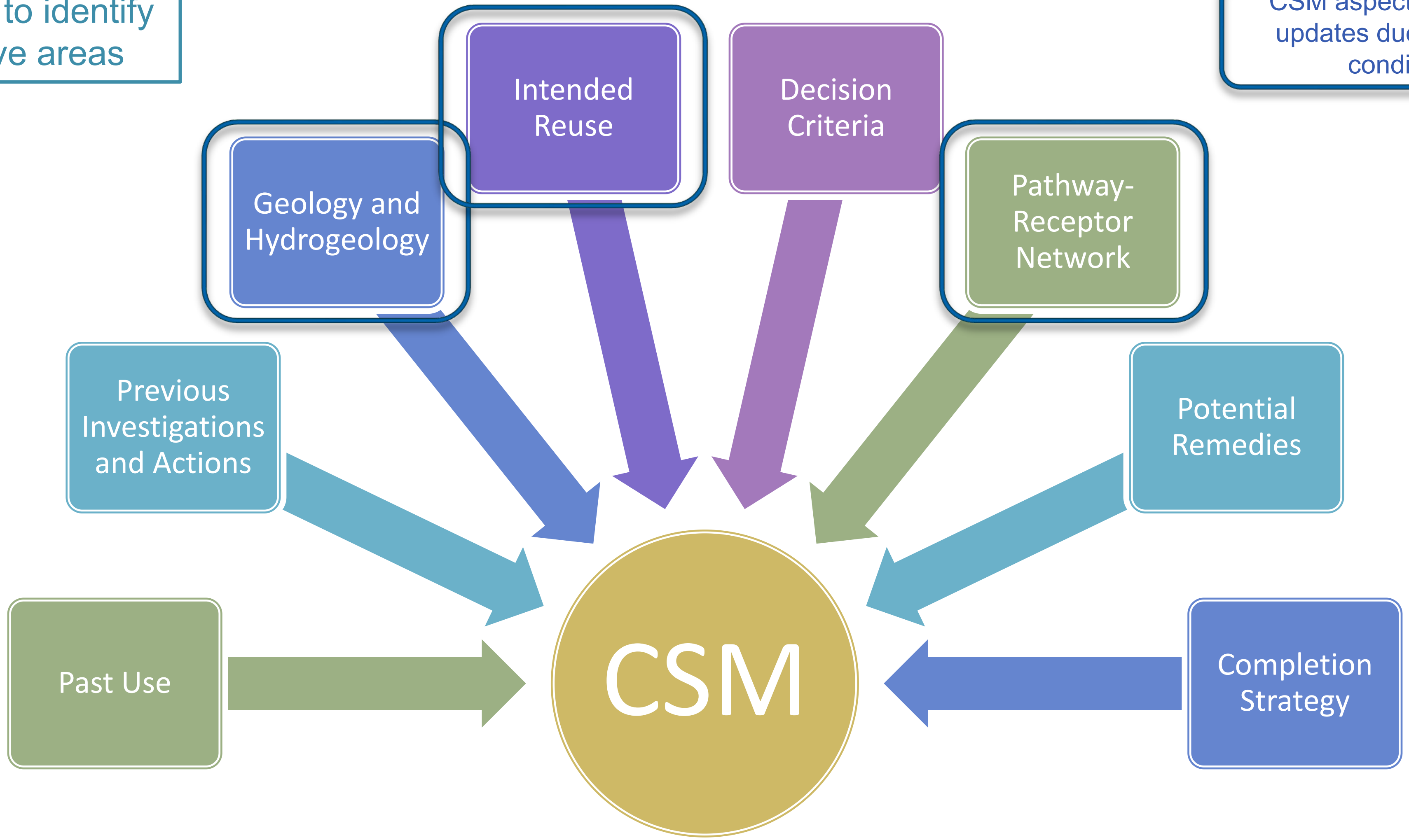
EPA

# The Conceptual Site Model (CSM)

An opportunity to identify climate-sensitive areas

CSM aspects potentially requiring updates due to changing climate conditions over time



# Resilience Integration Along the Superfund Pipeline: RODs

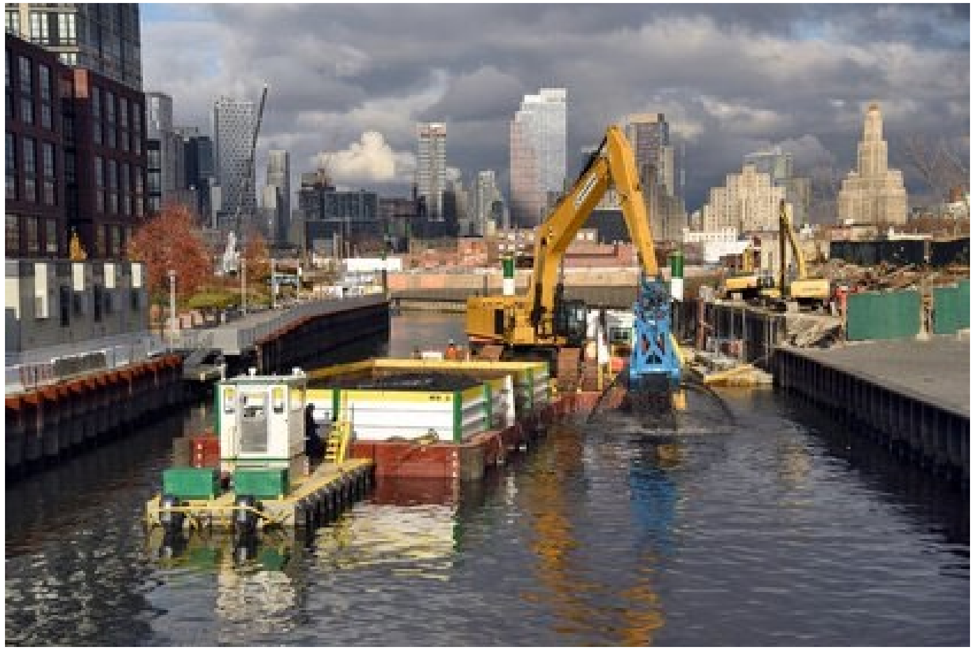
**Gowanus Canal** (Brooklyn, NY) (2013 ROD)

♦ "Site Name, Location and Description"

"During major storm events, canal flooding affects broad areas which are industrial, residential and commercial in nature."

♦ "Selected Remedy"

"The capacity of the retention tanks will need to accommodate the projected additional loads to the combined sewer system as a result of current and future residential development, as well as a result of periods of high rainfall, including future rainfall increases that may result from climate change."



*Dredging startup in 2020*

♦ "Summary of Remedial Alternatives"

"Current and future high density residential redevelopment along the banks of the canal and within the sewershed would need to … be consistent with recently adopted NYC criteria for on-site stormwater control and green infrastructure (NYCDEP, 2012) so as to ensure that hazardous substances and solids from additional sewage loads do not compromise the effectiveness of the permanent CSO control measures by exceeding their design capacity."

# Resilience Integration Along the Superfund Pipeline: RODs

**Naval Station Newport Naval – Site 22 (OU10) Carr Point Storage Area** (Portsmouth, RI) (2020 ROD)

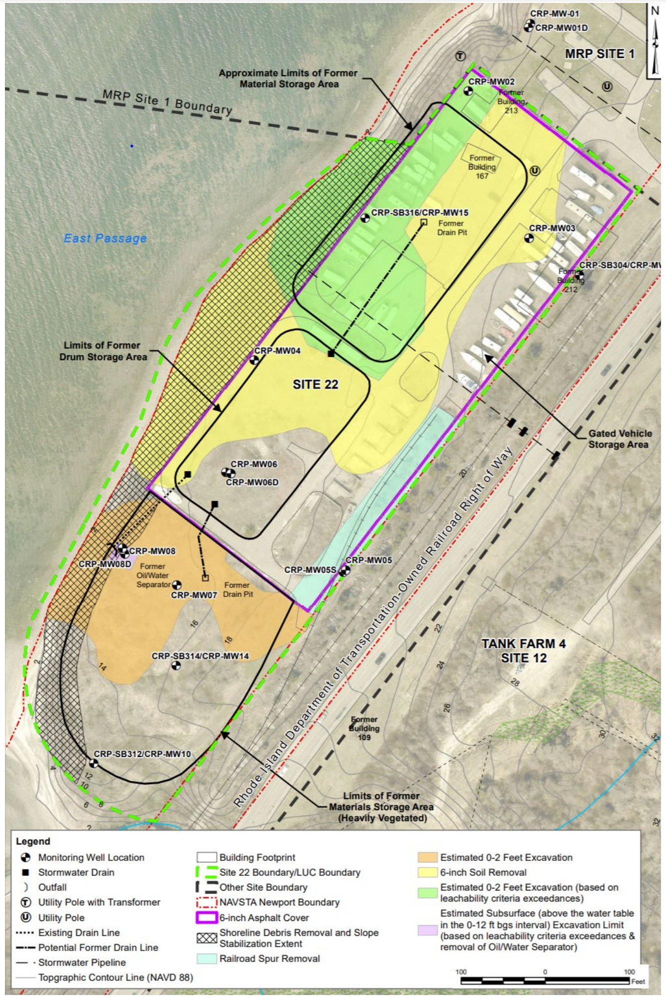
- "Description of Selected Remedy" (asphalt/soil cover system)

  "The design will ensure no net loss of beach or flood storage and will include storm and sea level rise considerations."

  "The remedy will be designed to withstand a 500-year storm and will meet substantive requirements of the Coastal Zone Management Act."

  "Monitoring wells will be installed and maintained in a manner to withstand potential damage from up to a 500-year storm and potential flood events for the duration of the monitoring program."

- Responsiveness summary (Navy response): "Current forecasts anticipate approximately 6 inches of sea level rise by 2033 and possibly 12 inches by 2050"




*Site Plan, Site 22 Carr Point Storage Area, Final Remedial Design Work Plan (2021)*

# Resilience Integration Along the Superfund Pipeline: RODs

**Portland Harbor Superfund Site** (Portland, OR) (2017 ROD)

*Portions of the nearly 11-mile Williamette River stretch with contaminated in-river and upland areas*

- "Selected Remedy"

  "Caps will also be designed to withstand more frequent floods with higher peak flows more common with climate change."

  "Caps will also factor in appropriate earthquake design elements for contingency level events."

- "Statutory Determinations"

  "… evaluations of flood rise will need to consider 500-year flood elevation and freeboard and be based on the best-available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science."

  "… climate change is expected to result in increased winter flow, decreased summer flow, lower snow packs and earlier peak within the Willamette River. In addition, because of a lower snow pack and more frequent fall and winter rain events, more high flow events are expected but of less magnitude than the large flood events observed in the 1900s. Uncertainties associated with potential climate change will be incorporated into the flood rise evaluation and cap design elements."

# Resilience Integration Along the Superfund Pipeline: RODs

**San Jacinto River Waste Pits** (Houston, TX) (2018 ROD)

- ♦ "Summary of the Rationale for the Selected Remedy"

"The area has a high threat of repeated storm surges and flooding from hurricanes and tropical storms, which if the material was left in place, could result in a release of hazardous substances. Modeling by the U.S. Army Corps of Engineers projects a significant erosion of cap armor, even with the two most robust capping alternatives, as result of combined hurricane and flood conditions."

*Approximate boundary of temporary armored cap constructed in 2020-2011*

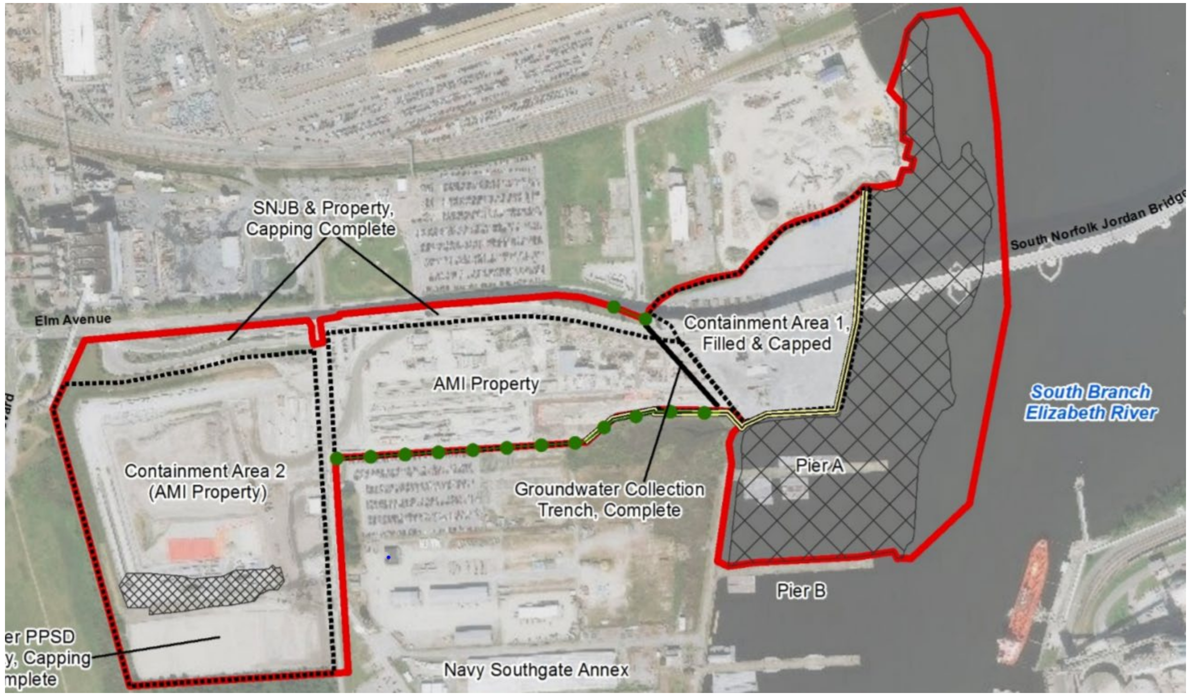
"EPA considered several options for addressing contaminated materials at the site. EPA selected a remedy that includes removal of contaminated materials above cleanup levels for the waste impoundments and MNR for the lower contamination level in the Sand Separation Area."


*Historical changes in river conditions (1966, 1997, 2006)*

# Resilience Integration Along the Superfund Pipeline: Remedy Design & Construction

**Atlantic Wood Industries, Inc.** (Portsmouth, VA) (2021 ESD, 2018 ESD, 2012 ESD, 2008 ROD)

- Primary hazards: sea level rise, storm surge
- Increased the design height of an offshore pile wall to 12.5 feet (from locally traditional 10-12 feet) above MSL; the wall prevents DNAPL migration to the Elizabeth River
- Constructed two berms with grassed swales to collect and convey stormwater runoff from two areas where dredged sediment was placed for later capping
- Installed a groundwater collection trench to help control the water table; groundwater in the trench is passively discharged to the river
- Planted trees for phyto-pumping to help contain groundwater contamination in a target area




*Detailed site map (based on Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, the GIS user community, and 2018 remedial design): site boundary (red), sheet pile wall (yellow), planted tree line (green)*

*Source of updated information: 2020 and 2015 five-year reviews*

# Resilience Integration Along the Superfund Pipeline: Remedy Design & Construction

**Davisville Naval Construction Battalion Center – Site 9**
**Allen Harbor Landfill** (North Kingstown, RI) (1997 ROD)

- Primary hazards: storm surge, tidal force, wave action
- Raised the former landfill cap to an elevation higher than feasibility study criteria, to at least 14 feet instead of 10 feet above MSL
- Graded waste cap surfaces to a minimum slope of 3% to promote precipitation runoff into swales that empty into Allen Harbor
- Constructed a revetment along the capped landfill's shoreline to protect the landfill face from erosion during tidal rise and storm surges
- Installed an offshore breakwater structure that reduces the height of waves potentially reaching the revetment during storms
- Created wetland strips that reduce wave action in parts of the intertidal zone most vulnerable to erosion due to storm surge

*Map of shoreline protection structures*

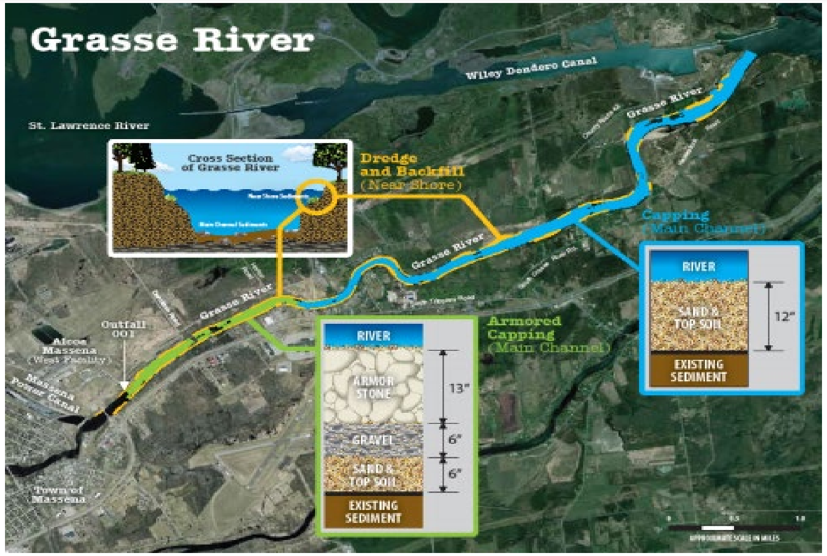

*Revetment, constructed wetland and breakwater structure*

*Source of updated information: 2018 five-year review*

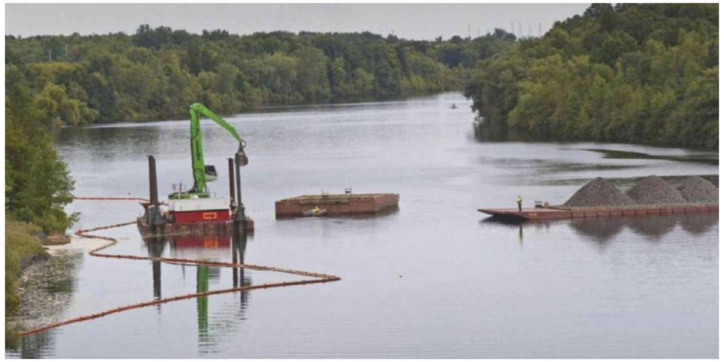
# Resilience Integration Along the Superfund Pipeline: Remedy Design & Construction

**Grasse River Superfund Site** (Massena, NY) (2013 ROD, 2020 ESD)

- Primary hazard: severe ice jam events
- Vulnerability to sediment scour and resuspension due to increased flow and turbulence below toes of ice jams, which were not considered during initial RI/FS
- Upper 2 miles of the 7.2-mile lower Grasse River stretch (59 acres) most vulnerable to ice-induced scour commonly occuring once every 8-10 years
- Sediment cap design and construction specifications modified to include a 13-inch stone layer armoring the sand/topsoil and gravel layers as well as underlying sediment in the vulnerable upper stretch
- Habitat reconstruction involving placement of rock clusters, rootwads and fish cribs in dredged areas, in accordance with 2019 NY state stipulation/settlement



*Modified cap design*


*Cap construction startup in 2019*

*Source of updated information: Grasse River Project, www.thegrasseriver.com; April 1, 2015, CLU-IN "Climate Change Adaptation" webinar*

# Resilience Integration Along the Superfund Pipeline: Remedy Design & Construction

**Malone Services Company Superfund Site** (Texas City, TX) (2009 ROD)

- Primary hazards: flooding due to hurricane storm surge or sea level rise (SLR) along Galveston Bay
- Used NOAA and other published storm surge simulation models to analyze storm surge and wave run-up for different hurricane tracks, intensities and forward speeds and for different SLR predictions
- Combined modeling results with published data on past hurricane landfalls at nearby weather stations and buoys, to identify the worst-case hurricane track
- Constructed an 18-foot-high levee to enclose two waste containment cells
- Installed armor along most vulnerable sides of the cells and levee
- Replaced topsoil and hydromulch in eroded or washed-out cell areas after 2017 Hurricane Harvey

*Aerial view of waste cells*

*Source of updated information: Geosyntec, "Sea Level Rise, Storm Surge Analysis, and Protection Design for Malone Superfund Site in Texas"*

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# Resilience Integration Along the Superfund Pipeline: Remedy Design & Construction

**Pine Street Canal NPL Site** (Burlington, VT) (1998 ROD)

- ♦ Primary hazards: storm surge, inundation, ice buildup
- ♦ More than half of the 38-acre site located in a 100-year floodplain
- ♦ Seasonal flooding exacerbated by hydraulic connection to Lake Champlain
- ♦ Resilience measures:
  - » Constructed a weir at the canal’s outlet to Lake Champlain to maintain minimum water depth that protects an emplaced remedial sand cap from scour, wave action and erosion
  - » Designed the weir to withstand worst-case ice forces or a 100-year (4.0) earthquake
  - » Installed retention basins near the canal to store stormwater or slow stormwater flow close to municipal sewer discharge points
  - » Selected flood-tolerant plant species for wetland and upland habitat restoration
- ♦ Bi-weekly inspections during each field season (Apr-Nov) as part of long-term monitoring

*Aerial view of site*

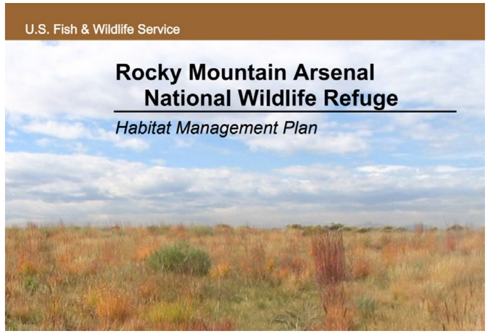
*Wier at canal outlet*

*Source of updated information: 2016 five-year review; 2015 (fall) "Technology News and Trends"*

# Resilience Integration Along the Superfund Pipeline: Remedy Design & Construction

**Rocky Mountain Arsenal** (Denver, CO) (1996 ROD)

- Primary hazards: drought, flooding
- Hazardous waste landfill covers designed to withstand a 1,000-year storm:
  - A water storage layer with increased thickness accounting for erosional loss
  - A rock-amended vegetative soil layer
  - Surface water controls such as terraces and concrete perimeter channels
- Green infrastructure such as erosion control logs to slow stormwater or grassed berms and swales to divert stormwater
- Withstood effects of a 500- to 1,000-year storm event in 2013, which followed drought conditions and preceded heavy precipitation in 2014
- 100 acres deeded for municipal stormwater retention and open space
- Implementing a habitat management plan to restore native prairie ecosystem on 15,000 (of 17,000) acres converted to a national wildlife refuge
- Periodically conducting prescribed burns to mitigate potential wildfire damage




*Source of updated information: 2014 (spring) "Technology News & Trends"*

# Resilience Integration Along the Superfund Pipeline: Remedy Design & Construction

**Summitville Mine** (Rio Grande County, CO) (2001 ROD)

- Primary hazard: higher generation of acid mine drainage each spring due to snowmelt
- Modified original design of the remedy:
  - Used predictive snow water equivalent data to estimate onsite water requiring management each spring and associated early-summer flow in the Alamosa River
  - Positioned the water treatment plant outside the 500-year floodplain
  - Elevated the water impoundment spillway by 3 feet (16% more storage)
  - Constructed turn-out structures enabling diversion of surface water to an offsite location instead of the impoundment during high flow
- Updated the water balance model to reflect more recent data on spring runoff
  - Added water control channels with erosion control mats and riprap to protect vegetation and avoid gully formation on steep slopes
  - Upgraded the site's culverts and other water conveyance systems to withstand a 100-year snowmelt or 500-year 24-hour rainfall event

*Water impoundment and upgradient water treatment plant*

*Upgraded water pipeline*

*Source of updated information: 2015 five-year review; 2002 remediation system evaluation*

# Resilience Integration Along the Superfund Pipeline: Remedy Design & Construction

**Van Dale Junkyard** (Marietta, OH) (1994 ROD)

- ♦ Primary hazards: Precipitation-induced erosion and landslides
- ♦ Vulnerability of a 4-acre waste cover is exacerbated by underlying sandstone and mudstone sequences and bedrock fractures
- ♦ Surface water management structures:
  - » Perimeter drainage ditches to control stormwater
  - » Intermediate benches on an extreme slope of the waste cap to increase infiltration of precipitation where it lands
  - » An earth and crushed rock buttress keyed into bedrock near the slope's toe to reduce landslide potential
  - » Ground cover consisting of native vegetation that reduces potential stormwater runoff outside the waste cover perimeter

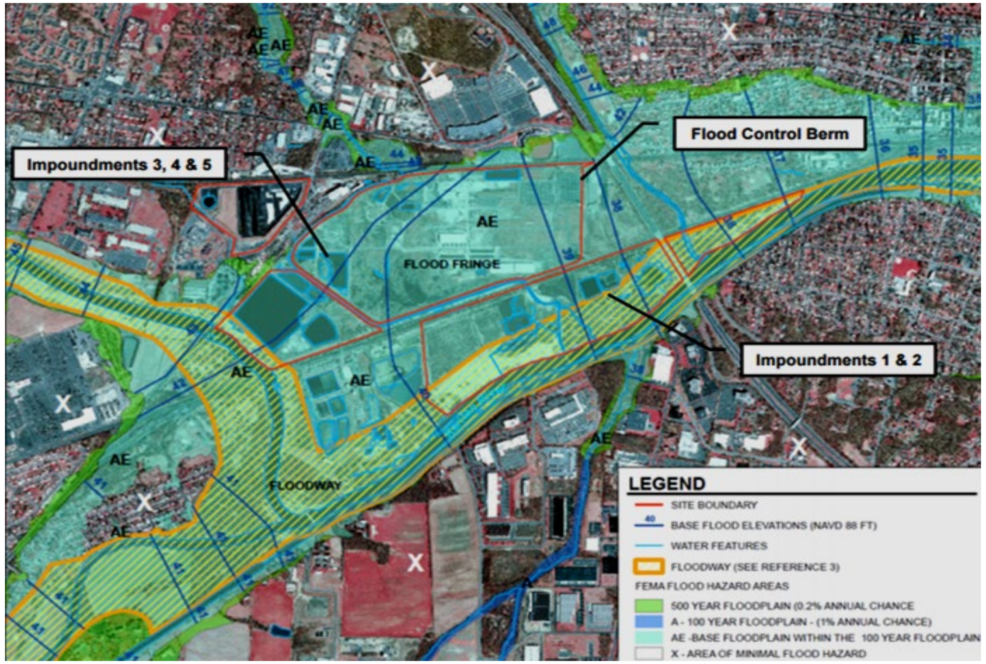
*Stabilized 150-foot slope of waste cover*

*Native vegetation and drainage system*

*Source of updated information: 2018 five-year review; Geosyntec, "Geotechnical Investigation and Landslide Stabilization at Van Dale Junkyard Superfund Siite"*

# Resilience Integration Along the Superfund Pipeline: Remedy O&M

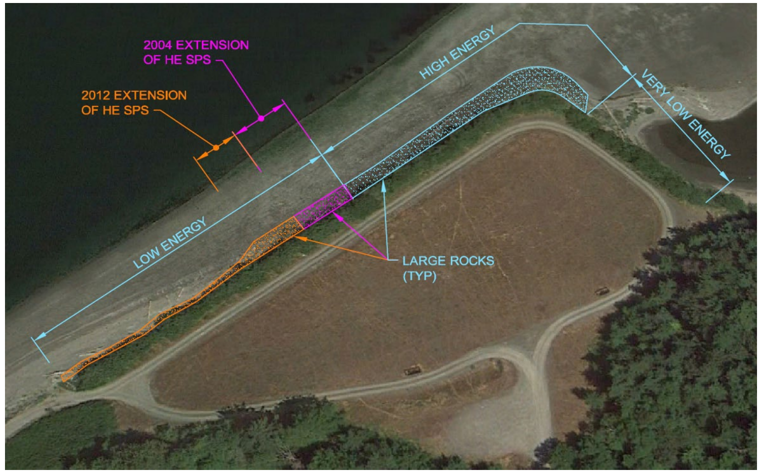
**American Cyanamid Superfund Site** (Bridgewater, NJ) (2012, 2018 RODs)




- Primary hazard: Inundation due to river flooding
- 2012 ROD: "All engineered caps will be designed and constructed to withstand the effects of a 500-year flood event."
- Major goal of remedy design: minimize flood storage loss
- 2015 five-year review evaluated 2011 Hurricane Irene-related flooding/response and recommended:
  - Elevate critical electrical instrumentation 5 feet higher than Hurricane Irene flood waters
  - Install submersible pumps in bedrock wells to maintain hydraulic control during floods
  - Reinforce earthen berms surrounding two highly contaminated waste impoundments

*Source of updated information: 2015 five-year review*

**Port Hadlock – Site 10 North End Landfill** (Naval Magazine Indian Island, WA) (1995 ROD)




- ♦ Primary hazard: Potential erosion of covered landfill due to tidal action and storm surge
- ♦ Maintaining a 900-ft shoreline protection system (SPS) based on 3 wave-energy regimes
  - » High energy: armor of large stones at northernmost beach
  - » Low energy: armor of large anchored logs at westernmost beach
  - » Very low energy: armor of riprap at tidal lagoon northeast of landfill
- ♦ Maintaining a vegetated buffer strip containing wave- and saltwater-tolerant willow whips and dune-building grasses salvaged during remedy construction
- ♦ Inspecting the landfill cover and SPS routinely and after storm events, and adding additional stone armor as needed in areas vulnerable to erosion
- ♦ Conducting quantitative surveys of the site (including beach transects) every 5 years to assess potential settling of the landfill or vegetated buffer

*Source of updated information: NAVFAC Environmental Restoration, April 2016,"Sustainable Long-Term Management of Landfills under the Navy's Environmental Restoration Program"*

# Mitigation-Adaption Synergy of Green Remediation: Renewable Energy

**Solvents Recovery Service of New England Superfund Site**

(Southington, CN) (2005 ROD)

Mitigation of GHG emission

- ♦ Solar energy system integrated into design and construction of 2-acre soil cap completed in 2017:
  - » 53-kW photovoltaic array
  - » Directly powers four groundwater extraction wells used for hydraulic containment at a minimum constant pumping rate of 30 GPM
  - » 2020 five-year review found no evidence of undesired vegetation, animal damage, or differential settlement of capping materials due to presence of solar panels/pad
- ♦ Riprap-lined vegetative swale directs stormwater flow away from the cap
- ♦ 1,000 feet of the soil cap linked to 80-mile rails-to-trails greenway (Farmington Canal Heritage Trail)

*Source of updated information: CLU-IN Green Remediation Focus, Solvents Recovery Service of New England, Inc. Superfund Site, 2021 profile*

# Mitigation-Adaptation Synergy of Green Remediation: Revegetation

**Ballard Mine Site** (Caribou County, ID) (2019 ROD)

Carbon sequestration across 500 acres

- Design and construction of evapotranspiration cover
  - Prevent contaminant migration or entrance to shallow aquifer due to contact between waste rock and rainwater/snowmelt
  - Promote clean runoff while preventing erosion
  - Store water during wet periods and releases water to atmosphere during dry periods
- Upper cover layer of native seed mixes and plantings
  - Provide roots penetrating most of vertical cover profile without penetrating waste rock
  - Slow flow of stormwater and snowmelt runoff
  - Limit soil erosion
  - Require minimal maintenance
  - Provide wildlife habitat

# Mitigation-Adaptation Synergy of Green Remediation: Green Infrastructure

- **Bunker Hill Mining & Metallurgical Complex – Gray's Meadow** (Smelterville, ID) (2012 interim ROD)
  - » About 700 acres of monotypic agricultural lands are being converted to wetland and riparian habitat. The wetland filters stormwater, provides flood storage, and helps reduce lead contamination in soil. Nature-based processes and structures are used to manage the water levels.

Erosion prevention and water storage

- **Continental Steel Corp. – Kokomo** (Kokomo, IN) (1996 ROD)
  - » An excavated 4-acre former quarry pond was repurposed as a new stormwater retention basin for the municipality's combined sewer system. The 58,000 cubic-yard stormwater basin was created by backfilling the excavated area to levels 8-10 feet below surrounding grades.

- **Murdock Groundwater Plume Site** (Murdock, NE) (2005 removal action)
  - » Vegetated buffers of native drought/flood-tolerant prairie plants detain stormwater and withstand 100-year flooding of a wetland basin used for remediation polishing. The site was contaminated by operations at a nearby grain storage facility and is now equipped as an outdoor "living" classroom.

- **Pharmacia & Upjohn Company LLC Site** (North Haven, CN) (1989, 1994 RCRA AOs)
  - » A six-acre constructed wetland is used for long-term stormwater management across the 78-acre former manufacturing site. The wetland was planned in cooperation with local environmental groups. Maintenance of the wetland requires no active pumping.

# Walking Through the Adaptation Process

- EPA climate resilience technical fact sheets
  - » Contaminated sediment sites
  - » Contaminated waste containment systems
  - » Groundwater remediation systems

United States Environmental Protection Agency

Office of Superfund Remediation and Technology Innovation

EPA 542-F-19-003

October 2019 Update

## Climate Resilience Technical Fact Sheet: Contaminated Sediment Sites

In June 2014, the U.S. Environmental Protection Agency (EPA) released the *U.S. Environmental Protection Agency Climate Change Adaptation Plan*.[1] The plan examines how EPA programs may be vulnerable to a changing climate and how the Agency can accordingly adapt in order to continue meeting its mission of protecting human health and the environment. Under the Superfund Program, existing processes for planning and implementing site remedies provide a robust structure that allows consideration of climate change effects. Examination of the associated implications on site remedies is most effective through use of a place-based strategy due to wide variations in the hydrogeologic characteristics of sites, the nature of remediation systems operating at contaminated sites, and local or regional climate and weather regimes. Measures to increase resilience to a changing climate may be integrated throughout the Superfund process, including feasibility studies, remedy designs and remedy performance reviews.

As one in a series, this fact sheet addresses the climate resilience of Superfund remedies at sites with contaminated sediment. It is intended to serve as a site-specific planning tool by (1) describing an approach to assessing potential vulnerability of a sediment remedy, (2) providing examples of measures that may increase resilience of a sediment remedy, and (3) outlining steps to assure adaptive capacity of a sediment remedy as climate conditions continue to change. Concepts described in this tool may also apply to site cleanups conducted under other regulatory programs or through voluntary efforts.

Cleanup at many sites involves remediating contaminated a...
sediment – the clay, silt, sand and organic matter at the bo...
along the banks of rivers, lakes, estuaries, harbors or other
bodies. Common sediment remediation technologies are d...
excavation with off-site treatment or disposal, capping to is...
contaminated sediment, and application of amendments th...
destroy the contaminants.[2] Excavation is similar to dredgin...
partial dewatering of the sediment. Dewatering is accompli...
diverting water from the targeted area of a water body or c...
coffer dam around the area, thereby allowing use of conve...
construction equipment to remove the contaminated sedin...

In situ capping involves placing clean material on top of co...
material remaining in place on a water body floor or at adja...
which are often situated within the site's floodplains. In some cases, it includes a habitat layer designed
native sediment and promote recovery of benthic communities. In a reactive cap, the isolation layer incl...
amendment such as an organoclay or activated carbon mat that binds or sequesters contaminants exiti...
sediment pore water and thereby prevents contaminant release to surface water. Other in situ remedie...
monitored natural recovery (MNR) or enhanced MNR (EMNR). MNR relies on the site's naturally occurri...
chemical and biological processes to contain, destroy or otherwise reduce bioavailability or toxicity of c...
in sediment. EMNR involves placing a thin layer of clean sediment or additives above contaminated sedi...
accelerate contaminant transformation to less toxic or bioavailable compounds.

Climate resilience planning for a sediment remedy generally involves:

(1) Assessing vulnerability of the remedy's elements and site's infrastructure.
(2) Evaluating measures potentially increasing the remedy's resilience to a changing climate.
(3) Assuring the remedy's capacity to adapt to a changing climate, which helps the remedy continue to be protective of human health and the environment (Figure 1).

**Resilience:** A capability to an...
prepare for, respond to, and...
significant multi-hazard thre...
minimum damage to social w...
economy, and the environm...


**Figure 1. Climate Change Adaptation Management**

**Table 1. Considerations for Sensitivity Assessment of a Waste Containment System**

| Examples of System Components | | Physical Damage | Water Damage | Power Interruption | Reduced Access |
|---|---|---|---|---|---|
| | | Potential Vulnerabilities Due to Extreme Weather | | | |
| Underground and At-Grade Components | Synthetic materials such as geomembrane in a composite liner or cover system, geonet for drainage, or geotextile for leachate filtration | ◆ | ◆ | | |
| | Bottom layer of unlined waste | | ◆ | | |
| | Vegetative layer integral to an evapotranspiration cover or overlaying a conventional cover | ◆ | ◆ | | |
| | Vertical and horizontal wells for LFG extraction | ◆ | | | ◆ |
| | Pipe networks for leachate and/or LFG collection | ◆ | ◆ | | ◆ |
| | Wells for monitoring groundwater or LFG | ◆ | | | ◆ |
| | Vertical barriers | ◆ | | | ◆ |
| Aboveground Components | Electrical controls for leachate and LFG management systems | ◆ | ◆ | ◆ | ◆ |
| | Pipe systems for leachate treatment and disposal and for LFG collection and transfer | ◆ | | | ◆ |
| | Transfer pumps for leachate and LFG | ◆ | ◆ | ◆ | ◆ |
| | Flow-through units for leachate treatment processes such as coagulation/flocculation, chemical precipitation or ozonation | ◆ | ◆ | ◆ | ◆ |
| | Leachate treatment or evaporation pond | ◆ | | | ◆ |
| | LFG pre-treatment equipment such as blowers, coolers and condensers | ◆ | ◆ | ◆ | ◆ |
| | LFG flares | ◆ | ◆ | ◆ | ◆ |
| | LFG-to-energy turbines | ◆ | ◆ | ◆ | ◆ |
| | Chemical storage containers | ◆ | ◆ | | ◆ |
| | Treatment residuals disposal system | ◆ | ◆ | | ◆ |
| | Treated leachate discharge system | ◆ | ◆ | ◆ | ◆ |
| | Auxiliary equipment powered by electricity, natural gas or diesel fuel | ◆ | ◆ | ◆ | ◆ |
| | Monitoring equipment | ◆ | ◆ | ◆ | ◆ |
| Site Operations and Infrastructure | Buildings, sheds or housing | ◆ | ◆ | ◆ | ◆ |
| | Electricity and natural gas lines | ◆ | ◆ | | ◆ |
| | Liquid fuel storage and transfer | ◆ | ◆ | ◆ | ◆ |
| | Water supplies | ◆ | ◆ | ◆ | ◆ |
| | Exposed machinery and vehicles | ◆ | ◆ | | ◆ |
| | Surface water drainage systems | ◆ | ◆ | | ◆ |
| | Fencing for access control and litter prevention | ◆ | | | ◆ |

**Table 2. Examples of Climate Resilience Measures**

| | Temperature | Precipitation | Wind | Sea Level Rise | Wildfires | Potential Climate Resilience Measures for System Components |
|---|---|---|---|---|---|---|
| | Climate Change Effects | | | | | |
| Groundwater Extraction and Control System | | ◆ | | | | **Dewatering well system** *Installing additional boreholes at critical locations and depths to maintain target groundwater levels in the extraction/containment zone and reduce groundwater upwelling without compromising the remediation system* |
| | ◆ | ◆ | ◆ | ◆ | ◆ | **Remote access** *Integrating electronic devices that enable workers to remotely suspend pumping during extreme weather events, periods of impeded access or unexpected hydrologic conditions* |
| | ◆ | ◆ | ◆ | | | **Well-head housing** *Building insulated cover systems made of high density polyethylene or concrete for control devices and sensitive equipment situated aboveground for long periods* |
| Aboveground Components of the Treatment System | ◆ | ◆ | ◆ | ◆ | ◆ | **Alarm networks** *Integrating a series of sensors linked to electronic control devices that trigger shutdown of the system, or linked to audible/visual alarms that alert workers of the need to manually shut down the system, when specified operating or ambient parameters are exceeded* |
| | ◆ | ◆ | | | ◆ | **Building envelope upgrades** *Replacing highly flammable materials with (or adding) fire- and mold/mildew-resistant insulating materials in a building, shed or housing envelope* |
| | ◆ | ◆ | | ◆ | | **Concrete pad fortification** *Repairing concrete cracks, replacing pads of insufficient size or with insufficient anchorage, or integrating retaining walls along the pad perimeter* |
| | | | | | ◆ | **Fire barriers** *Creating buffer areas (land free of dried vegetation and other flammable materials) around the treatment system and installing manufactured systems (such as radiant energy shields and raceway fire barriers) around heat-sensitive components* |
| | | ◆ | | ◆ | | **Flood controls** *Building one or more structures to retain or divert floodwater, such as vegetated berms, drainage swales, levees, dams or retention ponds* |
| | ◆ | ◆ | ◆ | ◆ | ◆ | **Hazard alerts** *Using electronic systems that actively inform subscribers of extreme weather events or provide updated Internet postings on local/regional weather and related conditions* |
| | | ◆ | ◆ | ◆ | | **Hurricane straps** *Integrating or adding heavy metal brackets that reinforce physical connection between the roof and walls of a building, shed or housing unit* |
| | ◆ | ◆ | ◆ | ◆ | ◆ | **Power from off-grid sources** *Constructing a permanent system or using portable equipment that provides power generated from onsite renewable resources, as a primary or redundant power supply that can operate independent of the utility grid when needed* |
| | | ◆ | ◆ | ◆ | | **Relocation** *Moving the system or its critical components to positions more distant or protected from potential hazards; for flooding threats, this may involve elevations higher than specified in the community's flood insurance study* |
| | | ◆ | ◆ | | | **Tie down systems** *Installing permanent mounts that allow rapid deployment of a cable system extending from the top of a unit to ground surface* |
| | | ◆ | | | | **Treatment water reuse** *Reclaiming treated groundwater for the purpose of recharging the aquifer or meeting onsite water needs such as irrigation, heating or cooling, wetlands replenishment or wildlife/habitat support* |