5.1 Remedy Components

Remedy components can be implemented singly or in series (such as treatment trains) for treating the site as a whole or targeting specified segments. The long-term management plan decision logic describes any phased remedy components that focus on plume segments, such as the source area or an off-property groundwater plume. Reductions in contaminant mass or contaminant concentrations at compliance locations could be another area of focus. For example, the decision logic could consider a pilot study or interim action to reduce the extent of off-site groundwater migration.

The plan also includes the projected time frame required to accomplish the interim objectives for each major remedy component for the selected remedial approach. The plan should reference the site decision document, if needed, for a full description of the remedial strategy, site objectives, and possibly the interim objectives and corresponding performance metrics. This level of detail provides the basis for establishing effective monitoring program schedules and effective frequency of periodic evaluations. The planning process may involve changes in the remedy and thus be shared with stakeholders as part of the site's communication strategy. More details regarding the elements and process of developing a long-term strategy for the remedial approach and selection of specific remedy components are included in this guidance.

Both engineered and administrative remedy components are described in the decision document and listed in the long-term management plan, along with corresponding interim objectives and performance metrics. The plan describes how specific remedy components will reduce risks to human health or the environment, achieve protectiveness, and control direct exposure to contamination and migration to potential receptors (such as discharge of contaminated groundwater to surface water, or VI), as well as prevent migration that increases the volume of contamination.

Engineered remedy components include technologies designed to remove or degrade contaminants or prevent/contain subsurface contaminant movement. Examples of active engineered remedies include source excavation, soil vapor extraction, in situ treatment (such as chemical oxidation, bioremediation, or thermal treatment), and P&T systems to reduce contaminant mass or affect migration control. Passive engineered remedies can include landfill caps, impermeable barriers for containment, and MNA. Although administrative remedies (such as ICs) and passive engineered components do not entail day-to-day operation, they require periodic inspections and maintenance, monitoring, and administrative oversight, all of which are documented in the plan.

5.1.1 ICs

ICs are frequently used for long-term management of complex sites. ICs are nonengineered methods that include any type of physical, legal, or administrative mechanism that restricts the use of, or limits access to, real property to prevent or reduce risks to human health and the environment (USEPA 2010a). ICs are part of a remedial action, can be short-term or long-term, and are often placed in perpetuity. At complex sites, ICs may be useful in returning parts of a site to some form of beneficial reuse (for example, recreational use limitations). ICs may be used when contamination is first discovered, when remedies are ongoing, and when residual contamination remains on site at a level that does not allow for unrestricted future land use after remediation. ICs and other LUCs, such as fencing and security guards, are typically meant to supplement engineering controls and are rarely stand-alone remedies (USEPA 2010a). These controls will be clearly specified in the appropriate decision document.

At sites where ICs are part of environmental remediation activities, the use restriction needs to be clearly defined, documented, and enforceable. Implementing use restrictions through established real property and land use management mechanisms provides a means to ensure that the restrictions remain effective. ICs can be reviewed for compliance with legislation in individual states, local agencies requirements, and property law, as well as with remediation requirements. ICs can be implemented, maintained, and monitored at the local level whenever possible. ICs can be included in the appropriate documents such as real property records, maps, and land use and related planning documents. The following are the primary components to incorporate into a site IC management plan:

1. Establish appropriate mechanisms to manage ICs and incorporate ICs into the existing land use management processes. ICs are designed to prevent contact with contaminated media under current and future use. ICs also inform site visitors of locations of contamination and remedial system, as well as establish restrictions that prevent activities on site from damaging remedial components.
2. Develop a document that defines the responsibilities of all parties involved in implementing, maintaining, and

monitoring the ICs, and document or annotate a reference to the comprehensive plan.
3. Identify contingency actions if an IC is breached that include appropriate corrective measures that will be taken and notifications made to regulators and other stakeholders.
4. Record an environmental notice of contamination or place a location on a state IC registry or other similar location if available.
5. Budget for the necessary funding to implement, maintain, and monitor ICs.

If the integrity of the ICs cannot be maintained, then the IC will be modified or terminated and other remedy components modified as needed to ensure the remedy is protective of human health and the environment. If an IC is terminated, then it also will be removed from the mechanisms that recorded its existence (such as the Recorder of Deeds Office or master planning maps). Stakeholders and property owners affected by the ICs are involved in all restrictions placed on other properties. The IC register or other mechanism can be used to notify potential buyers of ICs when a property is listed for sale and notify the state when a property is sold.

5.1.2 Other Maintenance and Monitoring Considerations

A long-term management plan accounts for the useful life span of slurry walls, barriers, caps, and other remedial system components. Many elements of these systems undergo preventive maintenance and repairs or require periodic replacement. Monitoring wells are periodically redeveloped as well.

Maintenance activities for remedial strategies may include the following:

- O&M requirements for engineered remedy components for contaminated groundwater or soil are documented in the site O&M plan. The O&M plan specifies the system description, including but not limited to: facility operation and control records/reporting, contingency or emergency operation and response, utilities, and roles and responsibilities. Migration control/containment systems, such as engineered landfill caps, may need periodic repair. For engineered containment barriers (such as slurry walls), the projected expected life cycle can be validated by monitoring. For example, the slurry walls built at the MEW site to contain the most highly contaminated groundwater showed signs of leaking after about 30 years. Some of these slurry walls required extra pumping to maintain the required containment.
- Maintenance and repairs may be needed for IC components (such as signs and fences) or irrigation systems. Cover maintenance may include cutting vegetation or selectively applying fertilizer, herbicides, or rodent control. Additionally, the knowledge, data, and information required by the IC needs to be kept current.
- Long-term monitoring systems also have O&M requirements. Activities may include: maintaining electrical supplies; collecting multimedia samples; and redeveloping, repairing, and replacing monitoring wells, pumps, sensors, and other monitoring equipment. An O&M plan, similar to that required for engineered remedy components, can also be prepared for monitoring activities.

Groundwater monitoring conducted during long-term management (for example, before site objectives are achieved) is either associated with compliance or performance. Both compliance and performance monitoring are likely to improve by refreshing the DQOs and long-term management plan so that the right type, quantity, and quality of data are generated at the right time with zero data surplus.

Case Study: Passive Remediation Approach for Long-Term Monitoring at NWIRP McGregor

To address perchlorate in groundwater at the NWIRP McGregor site in 2002, the Navy used an innovative passive remediation approach in two drainage basins with low concentrations of perchlorate. Segmented three-foot-wide trenches were keyed into the non-water-bearing zone and filled with a mixture of gravel, wood chips, and mushroom compost soaked in vegetable oil. Piping in the trench allowed emulsified oil to be injected to rejuvenate the biowall. In total, 35 biowalls were constructed in up to three staggered lines (depending on the topography) totaling 11,200 feet of biowalls. The perchlorate plume footprint has receded over time. Biowall performance is also assessed *by semiannual sampling from biowall ports and analysis of total organic carbon, nitrate, methane, and perchlorate. Carbon is replenished if needed, in response to these data. Long-term monitoring optimization over time has reduced the number of site wells from 800 to approximately 100, with most sampled annually. More case study details are provided in the full case study.*