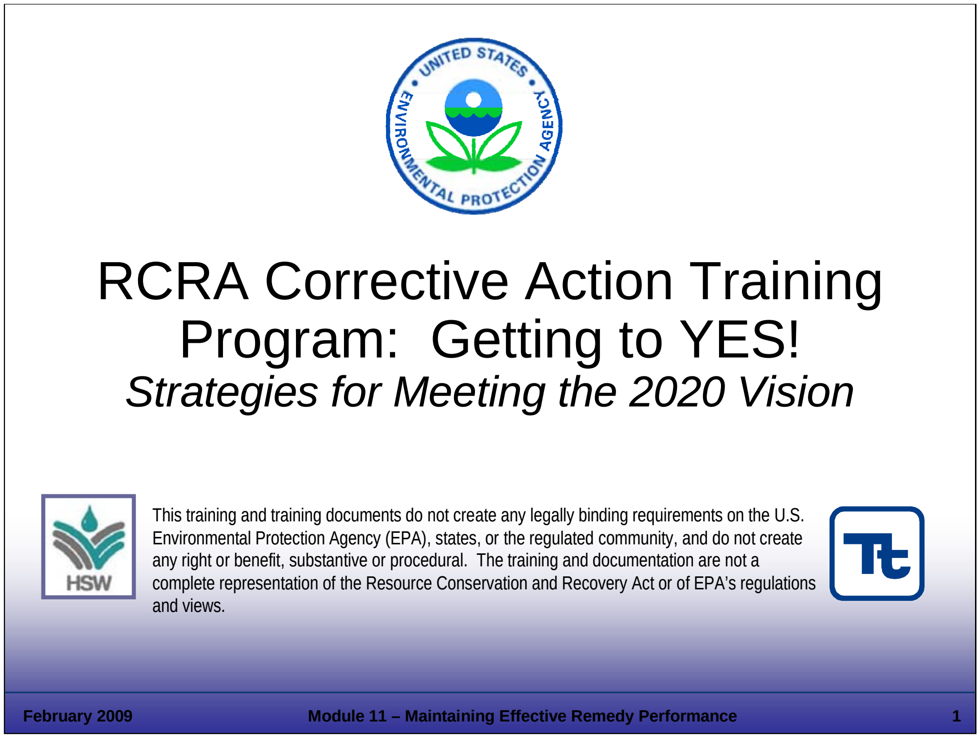
# Module 11
# Maintaining Effective Remedy Performance




**Notes:**

Purpose of Slide

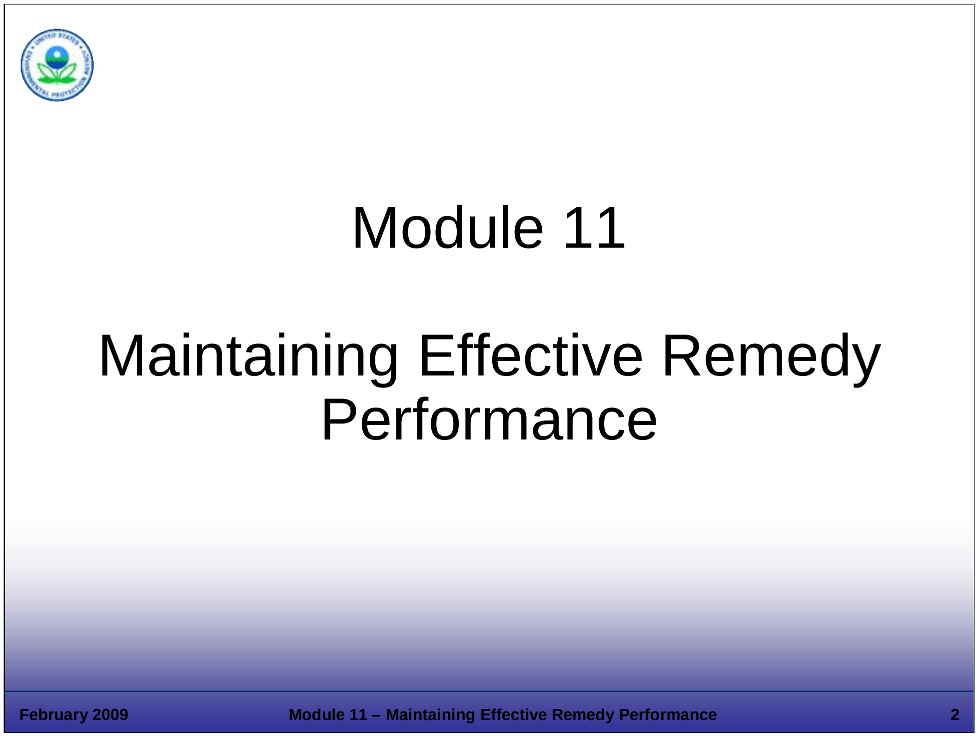
- Holder slide for Module 11, Maintaining Effective Remedy Performance.

Key Points

- This is a holder slide. No specific key points.

References

- None.




**Notes:**

Purpose of Slide

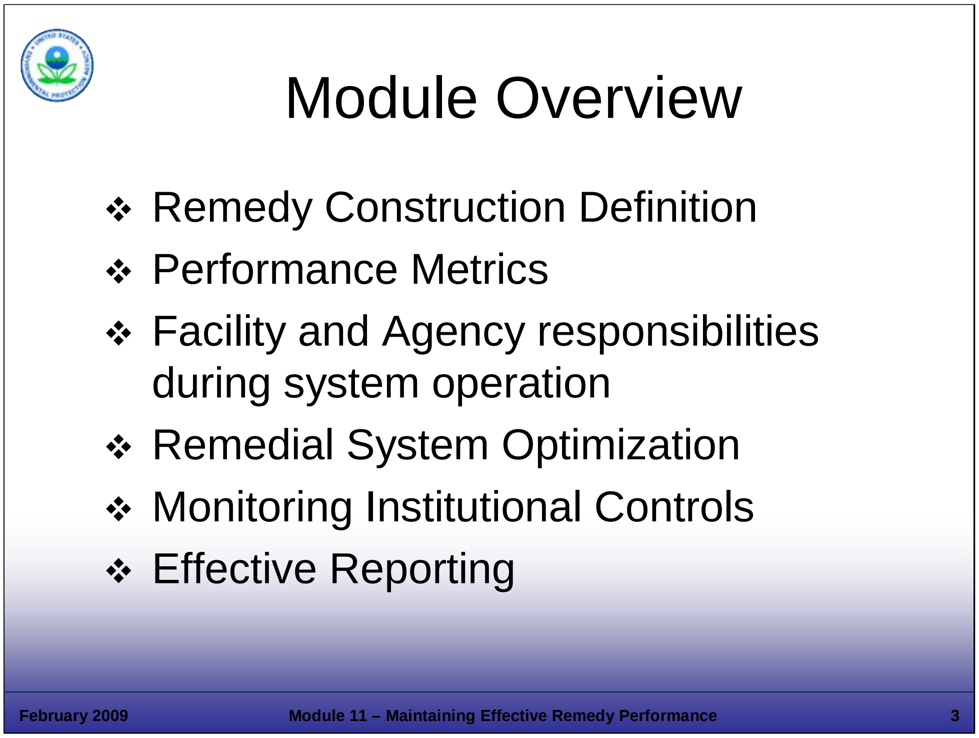
- Holder slide for Module 11, Maintaining Effective Remedy Performance

Key Points

- This is a holder slide. No specific key points.

References

- None.




**Notes:**

Purpose of Slide

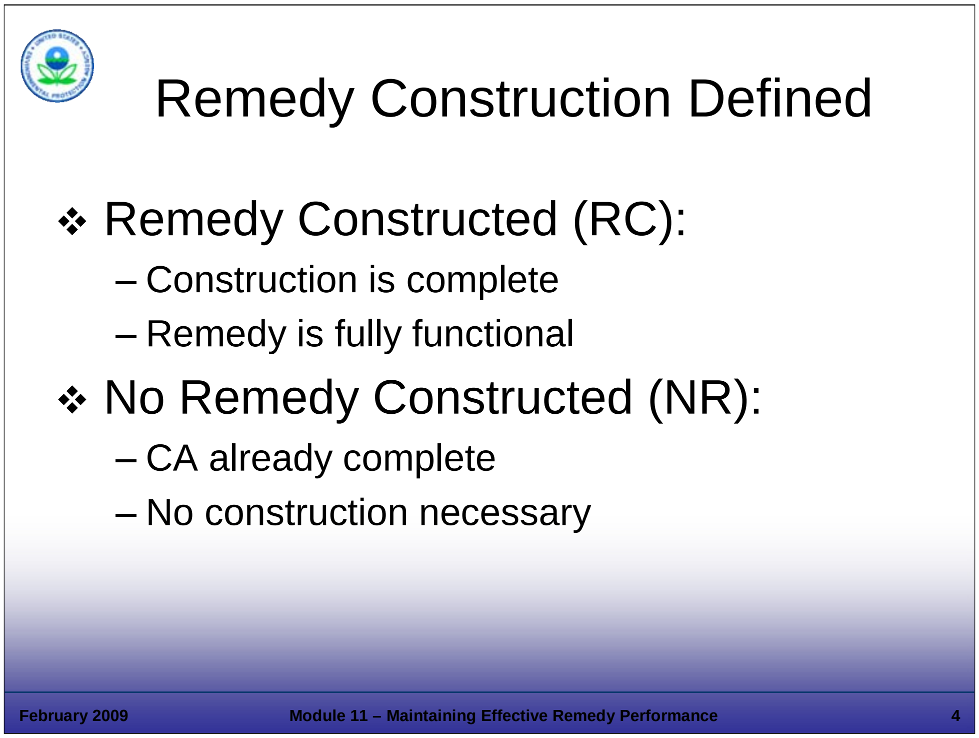
- Provide an overview of Module 11, Maintaining Effective Remedy Performance.

Key Points

- We covered the remedy decision determination (CA 400) in Module 7 and remediation technologies in Module 8. In this module, we will review the Remedy Construction determination (CA 550) and then focus on long-term operation and oversight of remedies.
- Performance metrics are established and used to determine if remediation is effective. It is important to have an operation and maintenance (O&M) plan and sampling program in place to provide the data necessary for performance metrics evaluation.
- A remedial system may operate for months, years, decades, or possibly even centuries (recall our Casper, WY example, where cleanup is anticipated to take 400 years). The facility is responsible for properly operating the system; the agency can help make operations run efficiently by working with the facility to establish clear performance standards, allowing flexible sampling, and accepting streamlined reports. A results-based approach during remedy operations is most effective and we will discuss examples of what this means.
- Remedial system optimization means evaluating system performance in terms of progress toward meeting goals and cost effectiveness. Optimization occurs at multiple levels. There is a continuous aspect of optimization during regular performance evaluations (for example, monthly maintenance visits or semiannual sampling events), but there is also a formal optimization process that occurs less frequently known as Remedial System Evaluation; we will discuss both in this module.
- It is important that the institutional control (ICs) components of the remedy that are necessary during remedy construction and/or operation are implemented during this phase of corrective action (CA). In some cases, ICs may not be necessary until subsequent phases of CA. Evaluation of ICs occurs early in the CA process, before remedy selection or construction, as we have discussed in Module 7. In this module we will discuss implementation of ICs and monitoring and maintaining ICs during remedy operation; this responsibility falls on both the facility and the regulatory agency.
- We will also discuss effective reporting approaches that provide the regulatory agency with appropriate information to perform its oversight responsibilities. These reports can include meetings, teleconferences, e-mails, letters, and reports. Effective reporting focuses on providing the right information to support progress, in a clear, succinct, and usable format.

References

- None.




## Notes:

Purpose of Slide

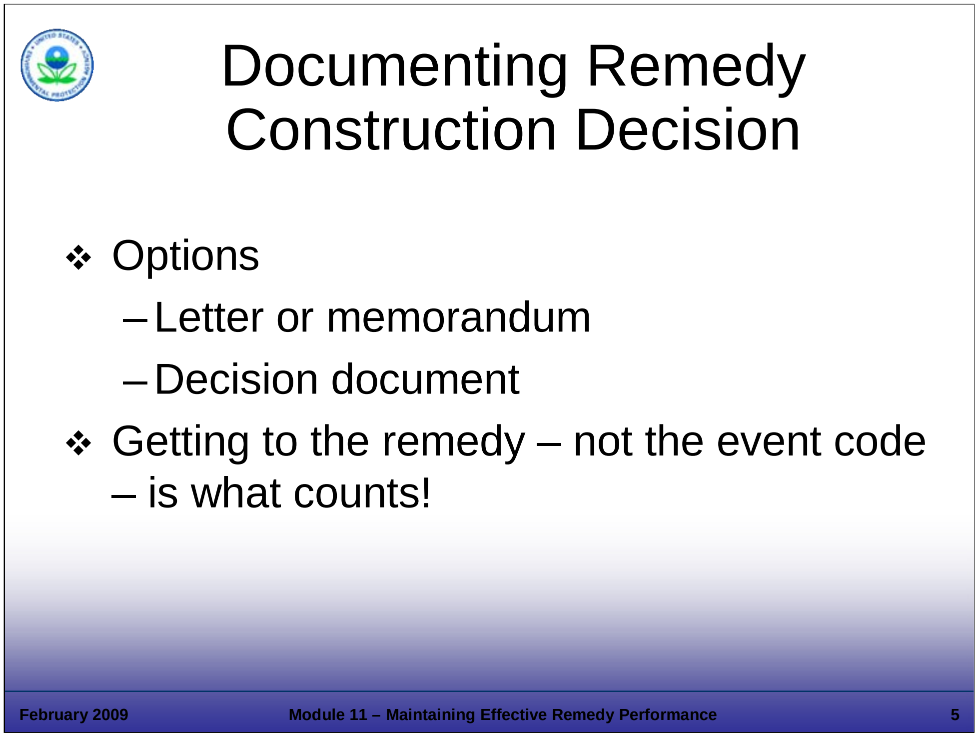
- Review the Remedy Construction event code (CA550) and definition. This code is also discussed in Modules 2 and 7.

Key Points

- The Remedy Construction milestone is achieved when construction of a facility's remedy is complete and the remedy is fully functional as designed, whether or not final cleanup criteria or other requirements have been achieved.
- The Remedy Construction milestone may also be achieved if construction is not needed to meet the remedial goals.
- The RCRA Code 550 applies when: (1) construction of the remedy(ies) have been completed (RCRA Event Code RC), or (2) the Remedy Decision or other appropriate decision document indicates that no physical construction of a remedy is needed (RCRA Event Code NR).
  - RC – Remedy Constructed. This status code applies after the actual date of the CA 400 - Remedy Decision when either: (1) all necessary physical construction of the last corrective measure has been completed and all remedial systems are fully functional as designed, whether or not final cleanup levels or other requirements have been achieved, or (2) all necessary physical construction and all remedial systems are fully functional as designed as a result of actions prior to the actual date of the CA 400 Remedy Decision, whether or not final cleanup levels or other requirements have been achieved.
  - NR – No Remedy Constructed. This status code applies on the actual date of the CA 400 Remedy Decision if no physical construction of a remedy has been needed since site characterization activities began.
- Remedy Construction for remedies that address the entire facility (including off-site migration of contaminants) should be linked to the "Entire Facility" area. Phased or partial remedies are to be attached to specific areas of implementation and not to the "Entire Facility" area.

References

- EPA. 2005. Permitting and Corrective Action (PCA) Program Area Analysis (PAA) Report: Appendix D, National Details for Corrective Action Event Codes. Final Report. Win/Informed Executive Steering Committee. July 28.




**Notes:**

Purpose of Slide

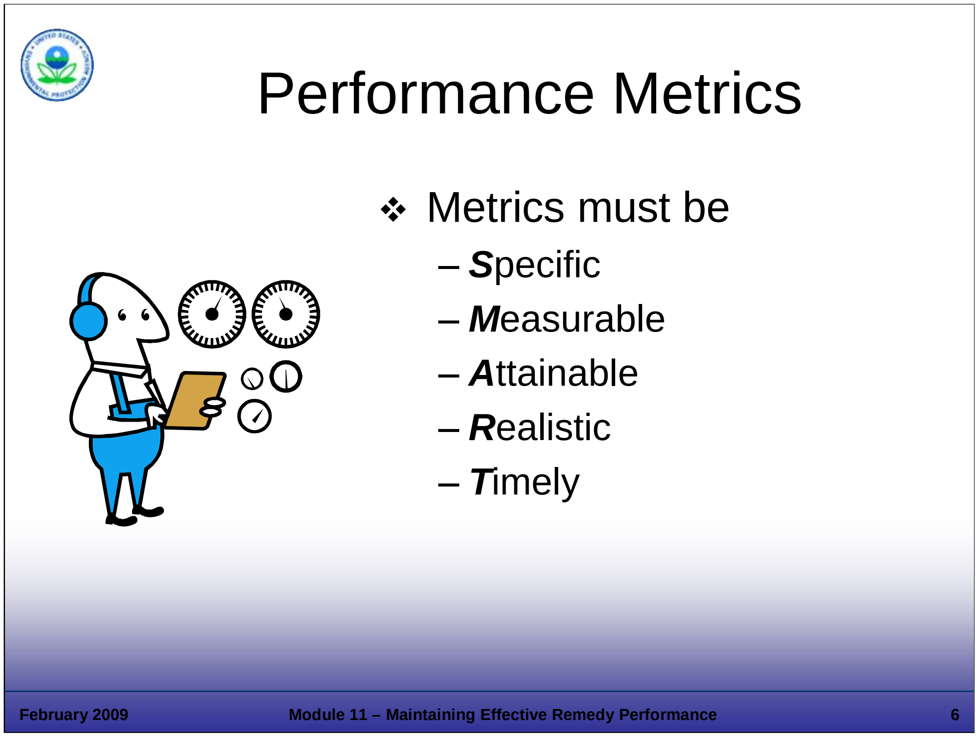
- Explain the process of documenting Remedy Construction.

Key Points

- Options for documentation include a letter or memorandum to the facility or the file or a decision document. To receive recognition for Remedy Constructed as a facility accomplishment, the overseeing agency should provide either: (1) a document (for example, letter to facility, memorandum to file, etc.) confirming the completed construction of the final remedy or (2) an appropriate decision document prepared to indicate that no further remedy is needed.
- Getting to the remedy is the goal. The event code tracks that the goal is being achieved.

References

- EPA. 2005. Permitting and Corrective Action (PCA) Program Area Analysis (PAA) Report: Appendix D, National Details for Corrective Action Event Codes. Final Report. Win/Informed Executive Steering Committee. July 28.




**Notes:**

Purpose of Slide

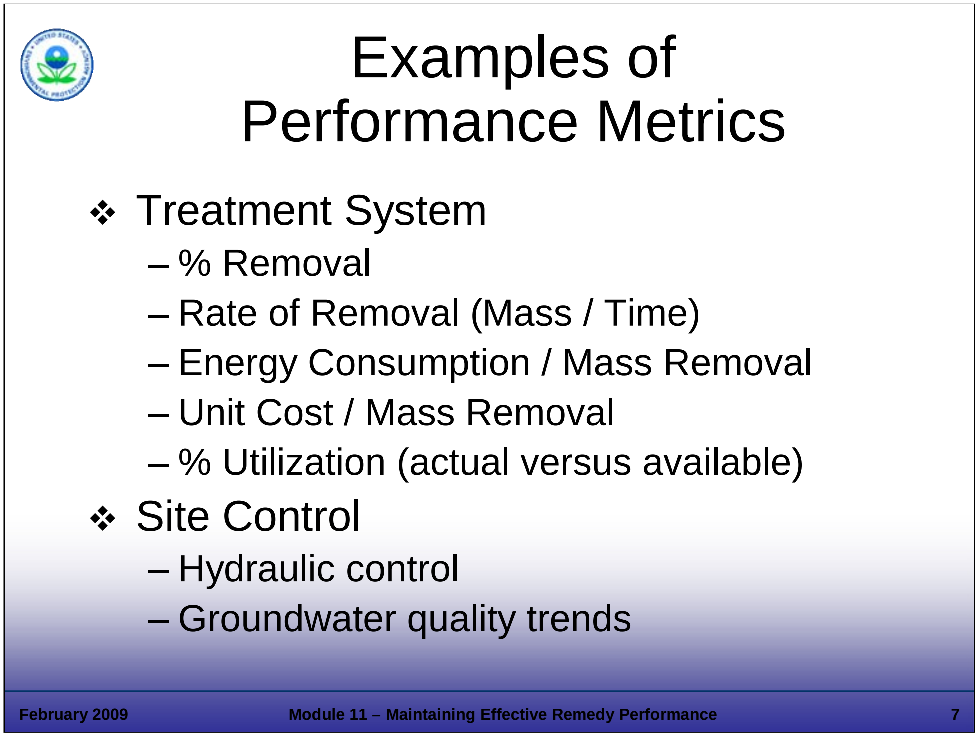
- Introduce the concept of performance metrics.

Key Points

- Site and remedial system effectiveness is evaluated against performance metrics.
- In addition to *evaluating* effectiveness, performance metrics should provide information for *improving* effectiveness.
- Metrics should be:
  - **S**pecific to avoid ambiguity or misunderstanding;
  - **M**easurable so they can be quantified and compared to standards;
  - **A**ttainable because they are reasonable and achievable;
  - **R**ealistic because they are possible and cost effective; and
  - **T**imely because they can be achieved in the required time frame.

References

- None.




## Notes:

Purpose of Slide

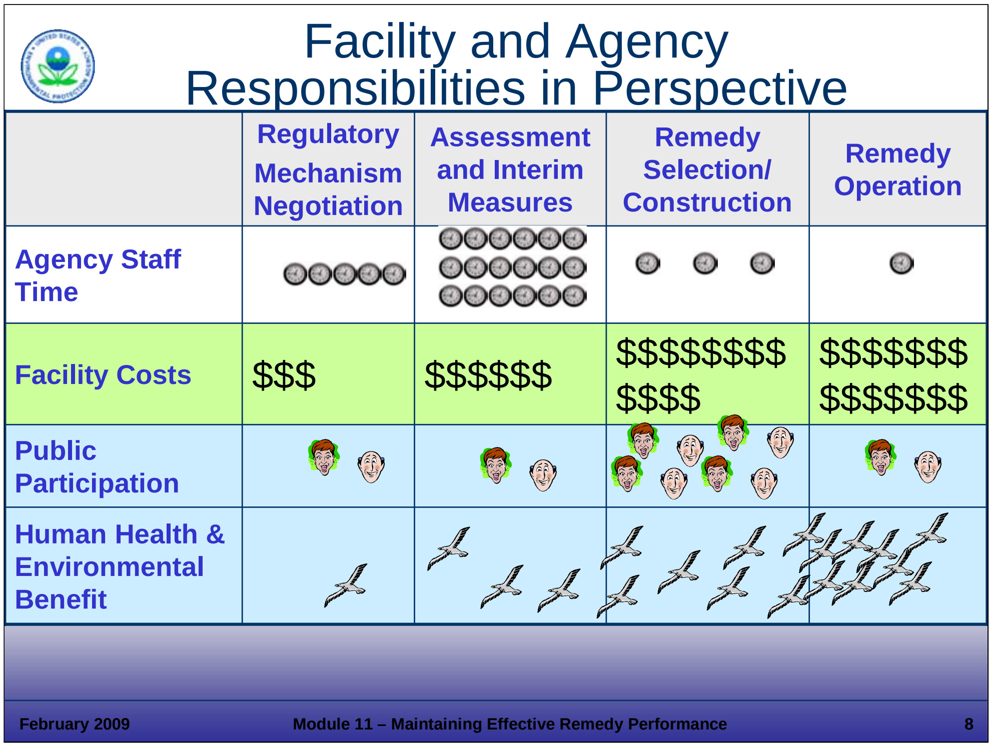
- Discuss examples of performance metrics.

Key Points

- This slide provides examples of the types of calculations that are made to evaluate system effectiveness. Calculated values are compared to reasonably expected values or are used in trend analysis. Developing spreadsheet templates is an effective means to perform calculations and present results. Tables, graphs, and other visual comparisons against baseline data or standards also are useful.
  - Treatment system metrics include the following:
  - % Removal – This refers to treatment system effectiveness. This metric can be tracked with influent/effluent data and is generally reported to the agency.
  - Rate of removal – Concentrations over time or rate of mass removal over time are common metrics used in evaluating treatment system effectiveness. Absolute values and trends can suggest a variety of conclusions:
    - If mass removal is decreasing over time, the reason can be insufficient maintenance (for example, iron fouling) or successful operation (that is., the mass in the aquifer has significantly diminished). In the latter case, there may be a point where the data indicate that a new technology may be needed as a polishing step.
    - Concentrations not decreasing with time might indicate that the wrong technology was selected, or an unknown source is present.
  - Energy Consumption or Unit Cost per Mass Removed – These metrics generally increase with time when system optimization does not occur. For instance, if a pump and treat (P&T) system is effective in removing the area of highest concentration, but equipment usage and energy costs are not streamlined, then the cost per unit of mass removed would increase.
  - % Utilization – This tracks the amount of time systems are operating compared to available time. Systems that are down frequently are generally not efficient or effective.
- Site Control – These metrics relate to the effectiveness of the treatment system in meeting cleanup objectives. Plume containment (hydraulic control) and contamination reduction (groundwater quality trends) are two primary metrics related to site control.

References

- None.




## Notes:

Purpose of Slide

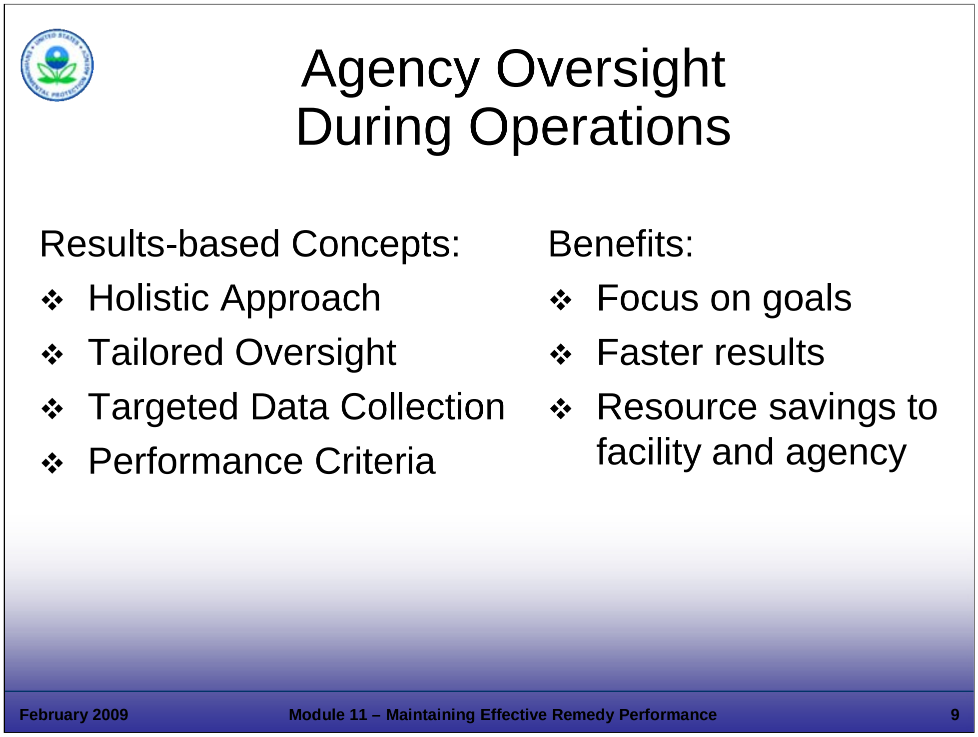
- Remember, although we may think of the most intense regulatory involvement as occurring during assessment and interim measures, the greatest facility expenditures and most significant environmental benefits often occur during remedy operation. Therefore, it is important that the relationship between the facility and regulatory agency be maintained throughout operation so that decisions can be made and implemented efficiently.

Key Points

- This slide was shown in an earlier module; we will review it here – focusing on the Remedy Operation column.
- The regulatory agency and the facility should work together to streamline activities during remedy operation. This can be accomplished through:
  - Regular, but not overly burdensome, communications;
  - Self-implementing decisions, that is, remedial decisions can be made by the facility without the need for agency approval because clear performance standards have been established. Examples of these types of decisions will be provided in slides to follow; and
  - Streamlined reporting.
- The next slide illustrates the importance of self-implementing decisions.

References

- None.




## Notes:

Purpose of Slide

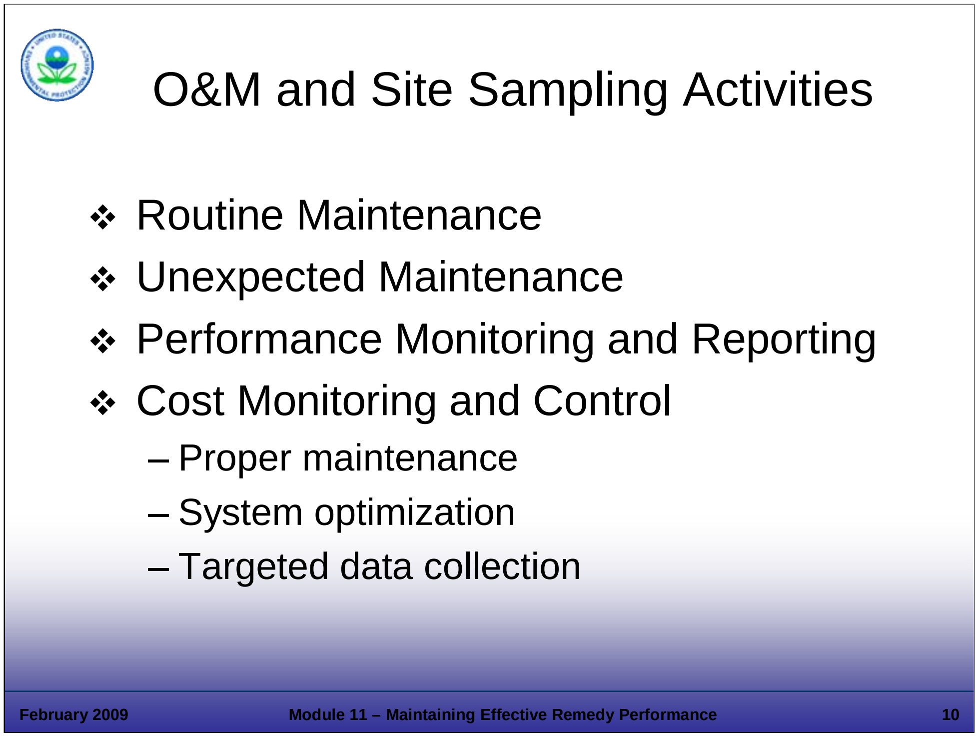
- Reiterate the major concepts of results-based CA and the importance of this approach during remedy operation.

Key Points

- These slides provide a refresher on the concepts associated with results-based CA that were discussed in previous modules. The benefits of these concepts include:
  - A focus on goals, rather than a predetermined process;
  - Results that are generally achieved more quickly; and
  - Resource savings to both the facility and the regulatory agency by focusing scarce oversight resources on the most important problems.
- The next set of slides explain facility responsibilities for operating a remedy efficiently and cost effectively and the regulatory agency's responsibilities for providing reasonable oversight. Without the ability to make operational decisions, the facility cannot operate the remedy efficiently or cost effectively. Similarly, the agency needs appropriate information to perform oversight of remedy implementation.

References

- None.




## Notes:

Purpose of Slide

- Proper O&M is important to the successful operation of a remedial technology. Site sampling and monitoring are conducted to evaluate progress toward overall goals – for example, are concentrations declining? Is the zone of capture sufficient? It is the facility's responsibility to maintain remedial systems.

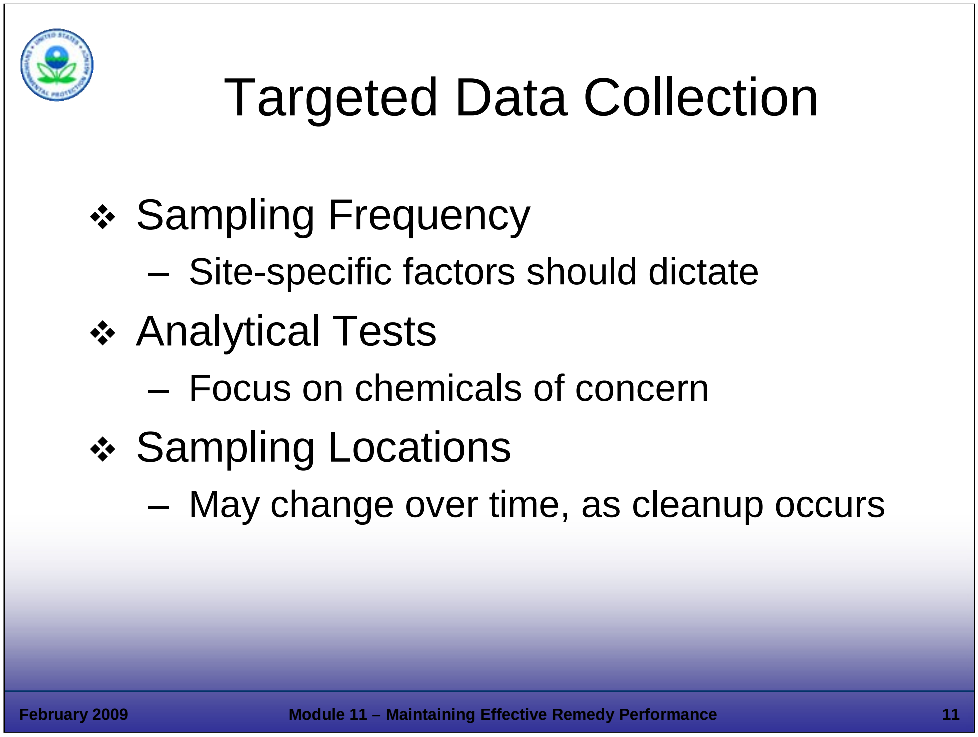
Key Points

- Successful remediation requires close attention to the long-term O&M of any systems installed. When systems are down, there can be long-term effects such as increasing the timeline to achieve cleanup goals. Some remedies, such as an asphalt cap, may require minimal maintenance efforts; others, such as those necessary for complex contamination (for example, dense nonaqueous phase liquids (DNAPLs)), will require active oversight.
- Routine, daily O&M is required on some systems. For others, weekly or monthly maintenance may be sufficient.
- The facility can ensure unexpected O&M needs are met by planning for manpower, supplies, and tools to operate and maintain the remediation system properly.
- Performance monitoring methods will vary depending upon the technologies in use. Examples include:
  - Mechanical – are motors, pumps, and blower pumps running properly?
  - Chemical – are biological conditions being maintained? Are contaminants being removed or destroyed?
  - Regulatory – Are National Pollutant Discharge Elimination System (NPDES) requirements for effluent met? Are air emission limits met?
- Some performance monitoring data will be reported to the regulatory agency, such as:
  - Significant system downtime; and
  - Operational parameters such as: flow rates (P&T), injection rates (bioremediation), and excavation volumes.

  Some facilities will track additional data to maximize system efficiency. For example, some facilities will track reasons for system downtime to determine what back-ups should be in place to keep the system running.
- System O&M costs can far exceed construction costs, so cost controls are important to facilities;
  - Inefficient or improper maintenance can lead to longer cleanup timeframes and more costly cleanups;
  - System optimization means efficiency in all aspects – keeping energy costs, sampling costs, and disposal costs to a minimum while maintaining system performance and site progress toward remediation goals; and
  - Sampling generally represents a significant portion of O&M costs, so it is important to facilities to have an efficient and effective sampling program.

References

- None.




## Notes:

Purpose of Slide

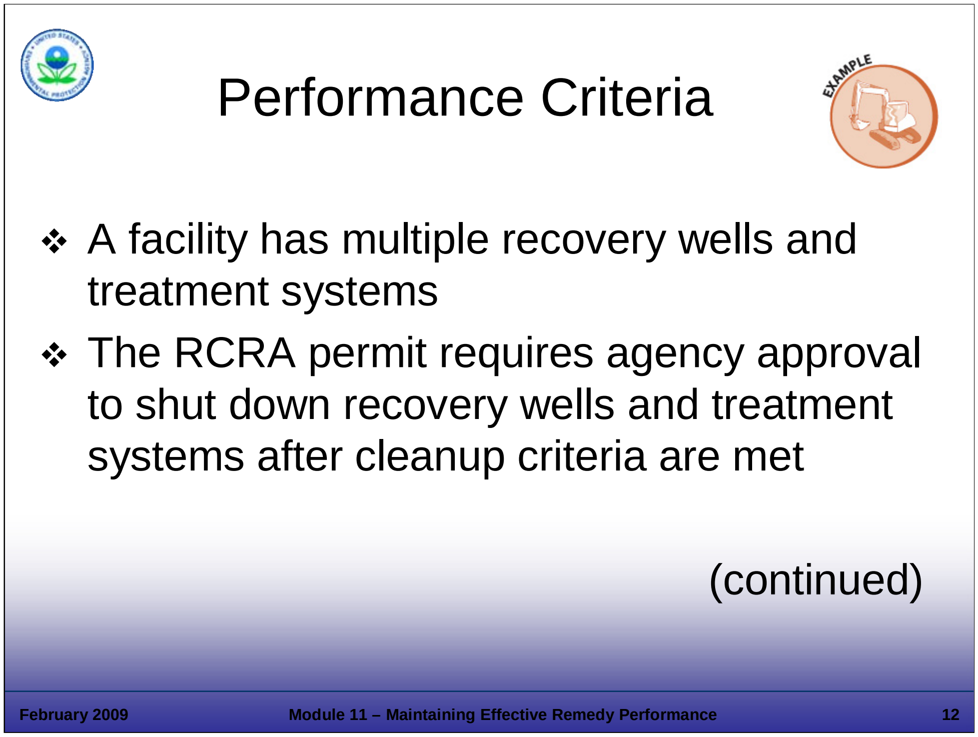
- Site monitoring is required to ensure that the long-term objectives of containment and cleanup are on track, where contamination is left in place and remedial goals have not been met. Targeted data collection will reduce resource needs (time, money) without sacrificing data quality, and will provide quicker understanding of system performance.

Key Points

- Sampling should focus on the locations, frequency, and parameters that are necessary to evaluate the system performance.
  - Are concentrations in monitoring wells declining over time?
  - Are anaerobic conditions maintained for biological activity?
- It may not be necessary to sample all wells during all sampling events. For instance, if the estimated cleanup time is many years, then annual or biannual sampling for monitoring wells in the center of the plume may be sufficient.
- Lab analyses for plume delineation should focus on chemicals of concern. Some additional analyses may need to be run for performance evaluation. For instance, geochemical parameters may be necessary when bioremediation is utilized, or additional parameters may need to be sampled to verify compliance with discharge permits.
- Monitoring well locations should serve a purpose, such as:
  - Demonstrate progress toward meeting groundwater cleanup goals (cleanup); or
  - Ensure that the plume is not expanding or moving off-site (containment).
- Appropriate locations for wells may change over time. For instance, as plumes reduce in size, it may be possible to stop sampling and even abandon wells where concentrations meet cleanup criteria. The next several slides will show how the agency and facility can work together to establish self-implementing approaches for sampling.

References

- None.




**Notes:**

Purpose of Slide

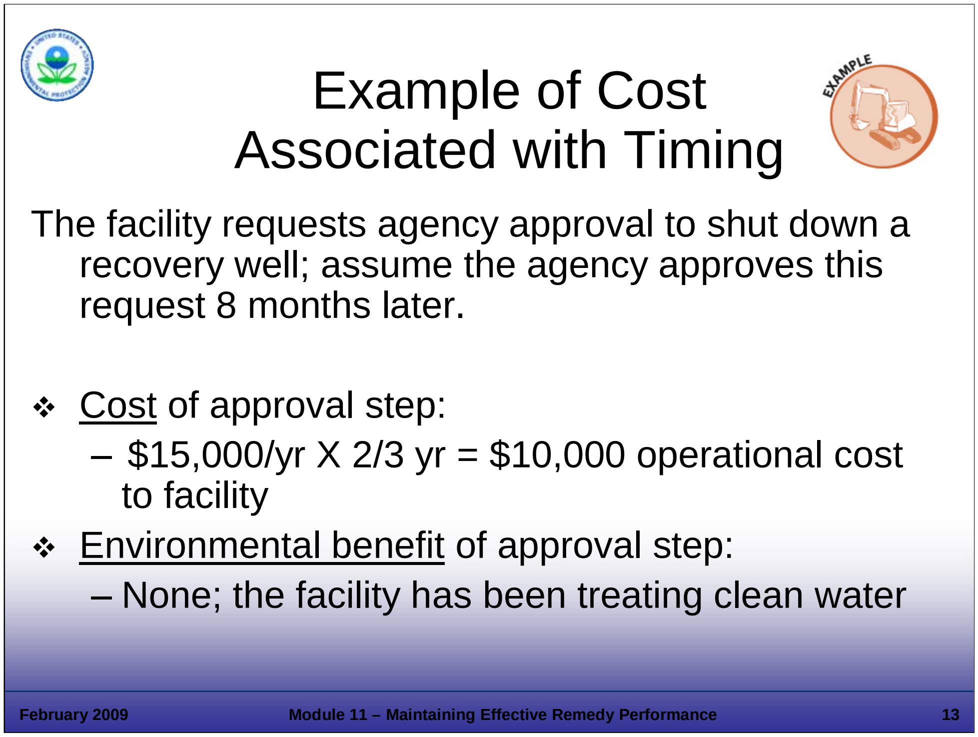
- Illustrate the usefulness of establishing performance criteria that allow remedial system optimization.

Key Points

- This is a real-world example. A facility has multiple recovery wells and treatment systems.
- The facility cannot automatically shut down recovery wells when cleanup criteria are met; the RCRA permit requires that the facility request agency approval to shut down recovery wells once cleanup criteria are met.

References

- None.




**Notes:**

Purpose of Slide

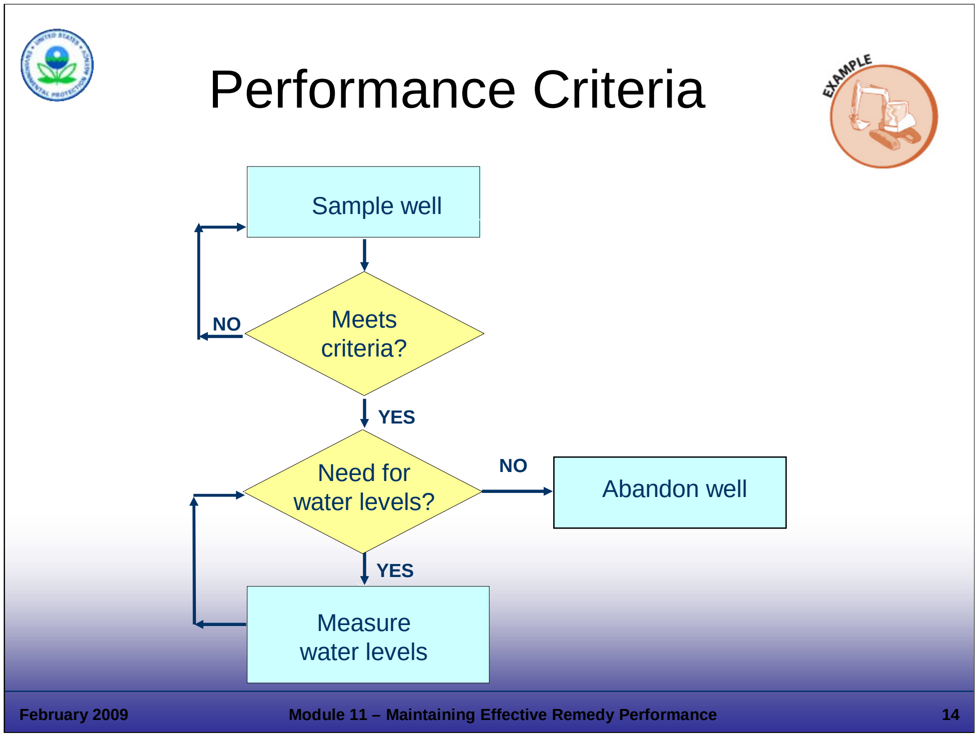
- Example continued.

Key Points

- If we assume that the request to the agency takes 8 months to process, and the cost of operating the recovery well and treatment system is $15,000 per year, then the 8 months waiting period before agency approval could cost the facility $10,000 in operational costs, with little or no environmental benefit.
- If a permit or agreement for CA is established with clear performance standards, such as when a well can be shut down, the burden for agency review and approval and the cost to the facility while waiting could be avoided. The environmental outcome is the same.

References

- None.




## Notes:

Purpose of Slide

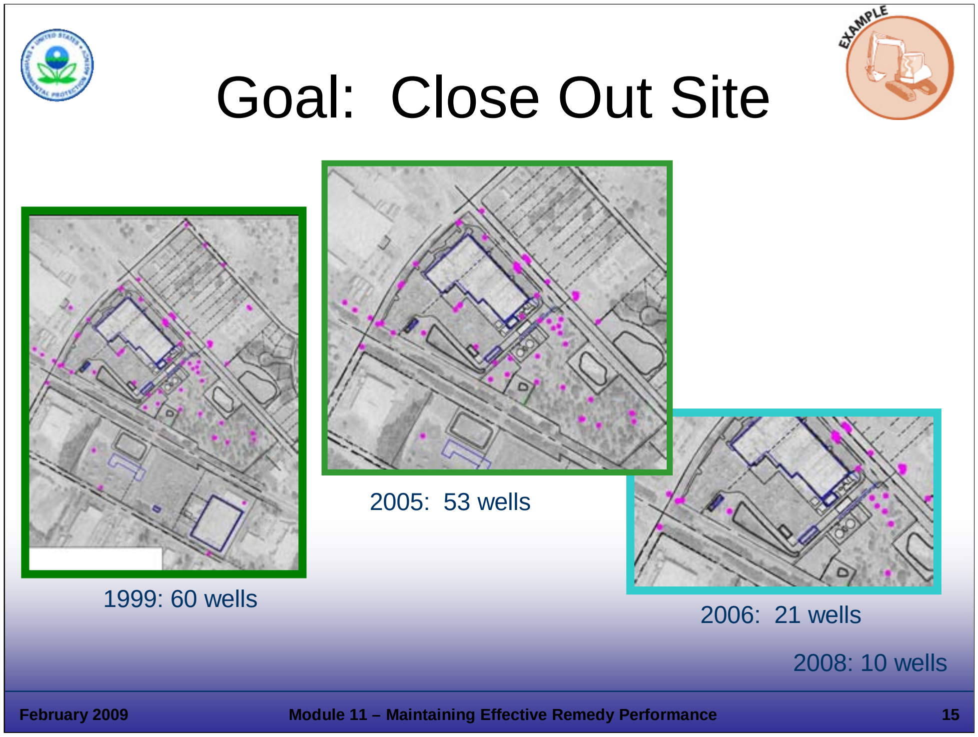
- Show a decision flow chart (which is simplified for illustration purposes) developed cooperatively by a facility and state agency, so that monitoring decisions can be made without the requirement for separate approvals, based on performance criteria.

Key Points

- The subject facility samples for chemicals of concern, and must meet cleanup criteria for "X" rounds before considering well abandonment. "X" would be agreed upon by the regulatory authority and the facility. (There are some details not shown on this slide, such as sampling frequency and cleanup criteria that are in the expanded version of the flowchart).
- If the samples are below cleanup criteria for "X" rounds, then the facility must determine if the well is needed for water levels – if not, it can be abandoned.
- This type of streamlined decision-making approach could be adopted for multiple aspects of CA (for example, including when recovery wells can be shut down, relating to the previous example).

References

- None.




## Notes:

Purpose of Slide

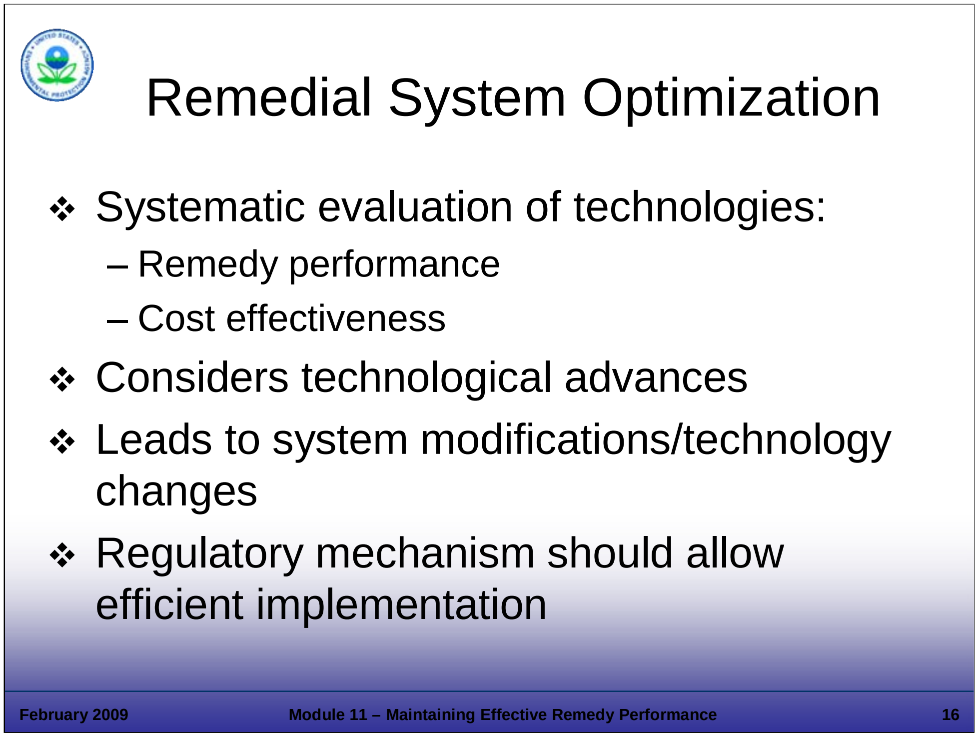
- Show how a decision flow chart streamlined decisions and actions at the subject facility.

Key Points

- The facility was moving successfully toward meeting cleanup criteria and set a goal of achieving CA complete without controls by 2008.
- In 1999, there were 60 monitoring wells, represented by the pink dots. Six years later, there were 53 monitoring wells – well abandonment decisions required an arduous decision-making process among the parties.
- The agency and facility realized that a streamlined decision-making process relating to well abandonment could be developed – hence, the flowchart.
- Between 2005 and 2006, 32 wells were abandoned using the flowchart approach.
- The point is that up-front planning and creativity can achieve success and maintain momentum toward achieving cleanup goals.

References

- None.




**Notes:**

Purpose of Slide

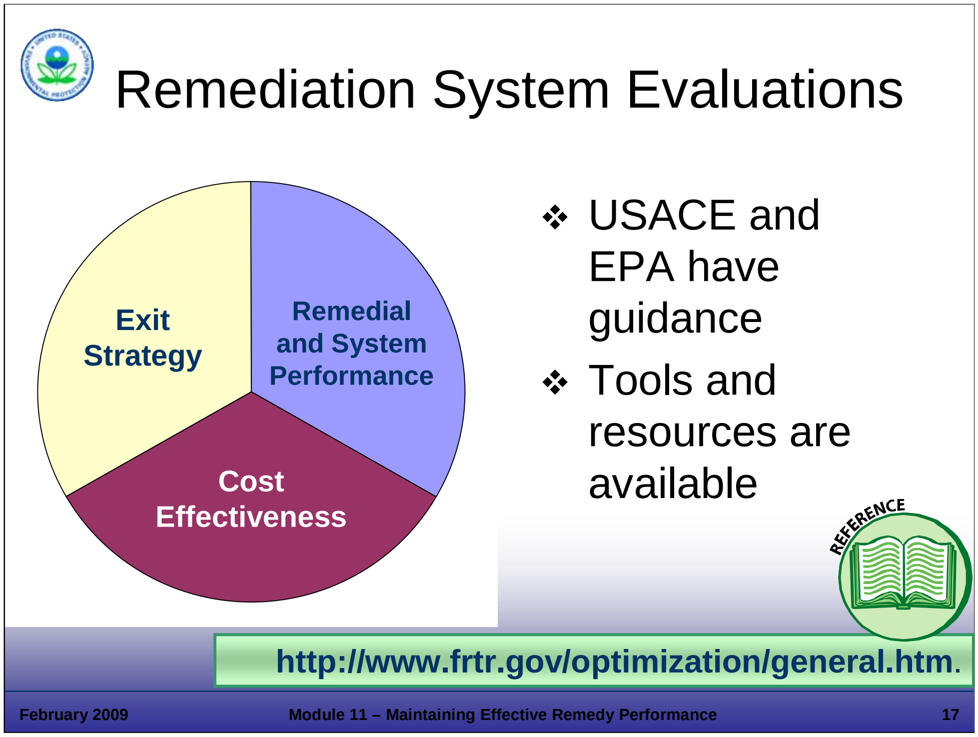
- Introduce the concept of remedial system optimization to improve remedial system performance and cost efficiency.

Key Points

- Once a selected technology has been operating for a period of time (generally a few years), it is usually prudent to perform a Remedial System Evaluation (RSE), also known as Remedial System Optimization (RSO). Site conditions change over time, and remedial systems should reflect the changes.
- Technological advances in remediation are being made continuously. Optimization studies open the door to consider new technologies, sampling methods, and other improvements.
- RSEs generally lead to system modifications that improve performance and reduce overall costs. The agency and facility should work together to allow changes to take place.

References

- EPA. 2001. Groundwater Pump and Treat Systems: Summary of Selected Cost and Performance Information at Superfund-financed Sites. EPA 542-R-01-021b. December.
- EPA. 2005. Roadmap to long-Term Monitoring Optimization. EPA-542-R-05-003. May.
- EPA. 2002. Pilot Project to Optimize Superfund-financed Pump and Treat Systems: Summary Report and Lessons Learned. EPA 542-R-02-008a.
- EPA. 2002. Elements for Effective Management of Operating Pump and Treat Systems. EPA 542-R-02-009.
- EPA. 2005. Cost-Effective Design of Pump and Treat Systems. EPA-542-R-05-008. April.




## Notes:

Purpose of Slide:

- Discuss the formal optimization process developed by the U.S. Army Corps of Engineers (USACE) and used by EPA. This is not an activity that the regulatory agency would undertake during RCRA CA. However, understanding the process is helpful because the process leads to system modifications, which the agency generally needs to approve.

Key Points

- A formal RSE process grew out of a need to better use limited resources and reduce costs. More formalized approaches began in 1999 with the USACE and expanded through 2003 with the EPA.
- The initial focus was on P&T systems – 89% of EPA fund-led sites were P&T only; 6% were P&T plus an in situ technology.
- The formal process is known as RSE or can be called RSO. Within the context of this course, RSE and RSO are equivalent. The three key areas of evaluation and optimization are discussed below.
- The Exit Strategy is reviewed for completeness: goals and milestones should be clear (for example, starting with the end in mind). As we learned in earlier modules, the Exit Strategy impacts how and when technologies are implemented.
- Remedial and system performance are evaluated, including: (1) progress toward meeting cleanup goals; (2) degree to which a system component is meeting design expectations; and (3) operational history.
- Cost effectiveness is evaluated, including: labor needs, fuel requirements, life-cycle costs, and disposal costs.
- Each of these items will be discussed on the following slides. Resources available to support these efforts are listed below and include websites, guidance, and case studies.

References

- USACE. Web Site. USACE Remediation System Evaluation (RSE) Checklists. Accessed On-line at: http://www.frtr.gov/optimization/general/methods.htm.
- Interstate Technology and Regulatory Council (ITRC). 2004. Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation (RPO-1). September.
- Federal Technologies Remediation Roundtable (FRTR). Web Site. Remediation System Optimization General Web Page. Accessed On-line at: http://www.frtr.gov/optimization/general.htm.
- EPA. 2000. USEPA Superfund Reform Strategy, Implementation Memorandum: Optimization of Fund-lead Ground Water Pump and Treat (P&T) Systems. OSWER 9283.1-13. Signed October 31.

## RSEs - Exit Strategy

- Continued use or revitalization (residential or industrial?)
- Cleanup timeframe, including milestones
- Cleanup criteria (soil, groundwater)
- Are cleanup goals the same for the entire facility?

February 2009 Module 11 – Maintaining Effective Remedy Performance 18

**Notes:**

Purpose of Slide

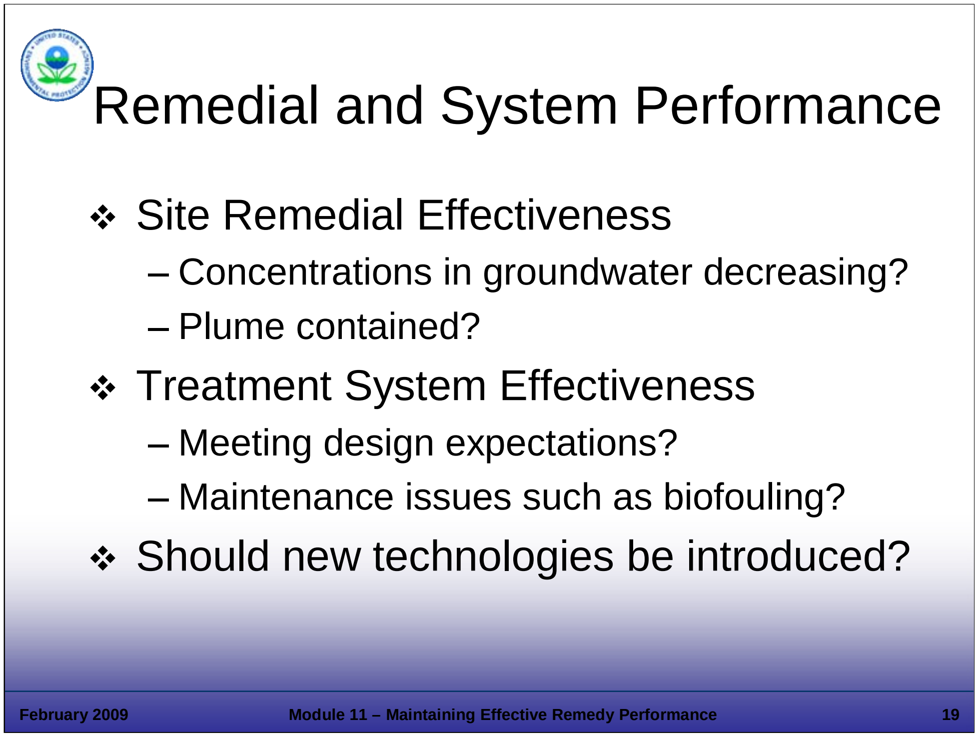
- To optimize a remedial system, it is important to understand the facility's goals. These are expressed through the facility's Exit Strategy.

Key Points

- The RSE should involve *reviewing* the Exit Strategy.
- In evaluating the effectiveness of a remedial system, progress is compared to cleanup goals (remember: goals were discussed in a previous module – goals are the what, where, when of CA). And cleanup goals are established based on the facility's planned uses.
- The cleanup timeframe affects an engineer's view of remediation effectiveness. For instance, if a facility will continue with its current use, there are no exposures, and a plume is not expanding, it may not be as important to show rapid progress toward meeting cleanup levels. It is important to compare progress to milestones, however.
- Understanding the final (or intermediate) cleanup criteria is important in evaluating progress toward meeting those goals.
- Similarly, it is important for the reviewing engineer to be familiar with where cleanup criteria apply (for instance, industrial soil criteria may apply on a part of a facility under continued use, but residential soil criteria may be necessary for parcels that will be sold for unrestricted use).

References

- None.




**Notes:**

Purpose of Slide

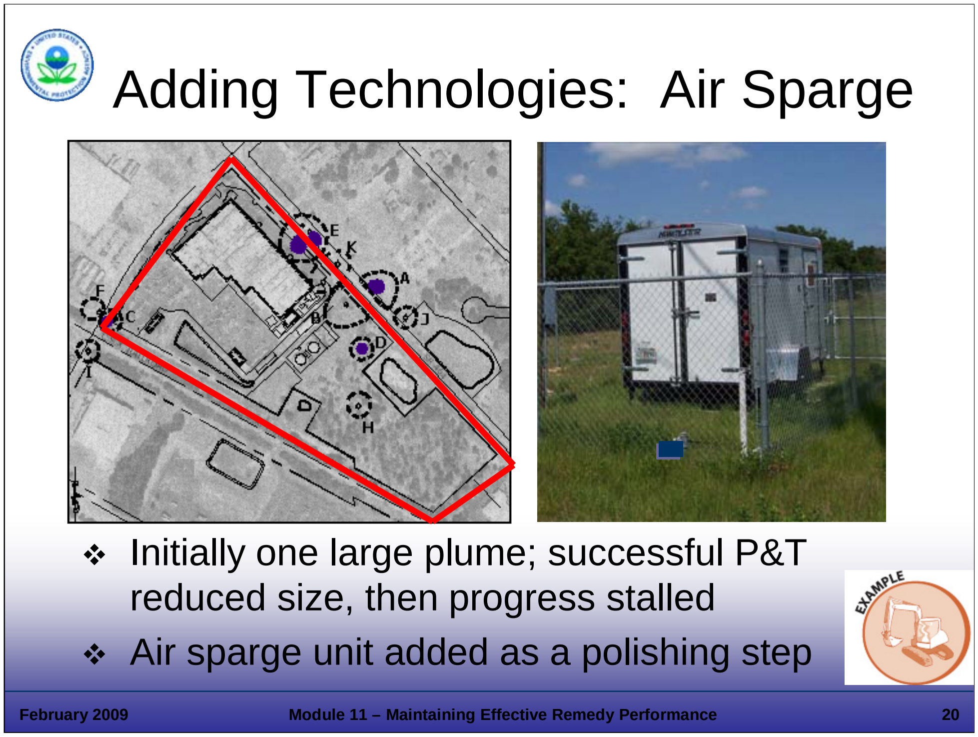
- Discuss the second component of RSEs, evaluation of site remedial effectiveness and treatment system effectiveness.

Key Points

- Site remedial effectiveness is a big-picture look at how well the chosen technology is progressing and meeting milestones. Look at concentration versus time – graph the results and look at the rate of change (slope).
- In the case of P&T systems, capture zones should be reviewed through routine water level measurements and construction of groundwater contour maps to show flow patterns. This information is used to determine if containment is achieved.
- Treatment system effectiveness is a detailed look at whether or not the system meets design requirements (for example, effluent discharge limits or flow rates) and operates efficiently.
- An RSE might identify declining system performance (such as, decreasing flow rates) and recommend system modifications to improve flow rates (such as, more frequent maintenance).
- Contaminant concentrations and flow rates should be used to calculate mass removal rates over time (for example, pounds of volatile organic compounds (VOCs) per month). This is a good metric for system effectiveness.
- The evaluation of site and system effectiveness may lead to a conclusion that different or supplemental technologies should be considered. Complex sites generally may require multiple technologies.

References

- None.




## Notes:

Purpose of Slide

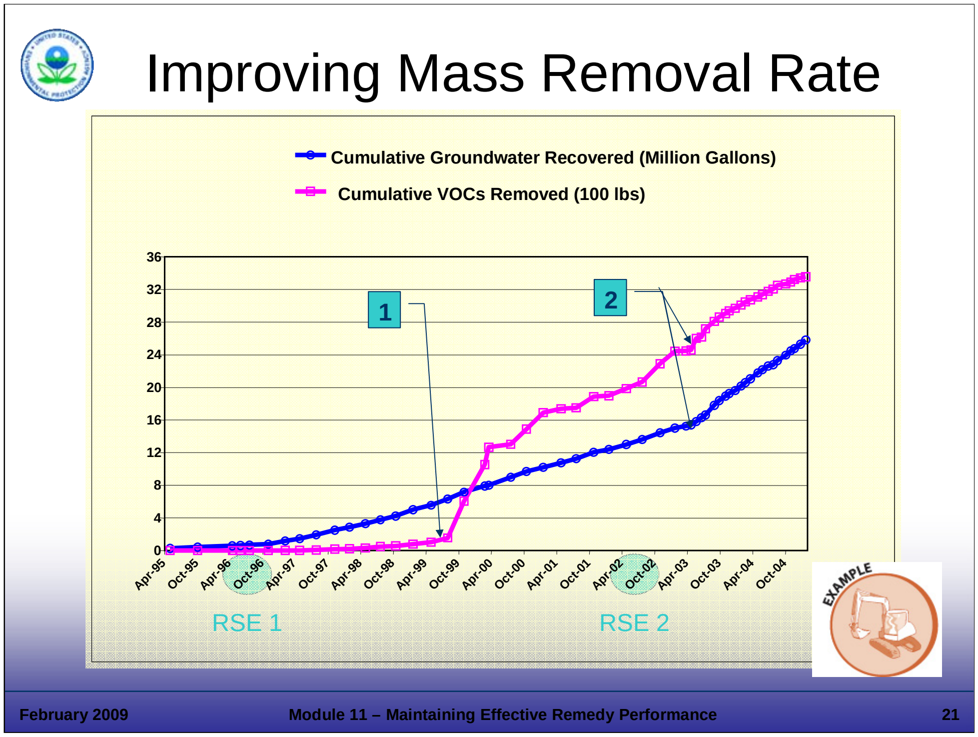
- Describe an example of a remedial technology that was very effective in the early- and mid-stages of remediation. However, progress towards cleanup goals stalled as the concentrations of contaminants (chlorinated ethenes) in groundwater approached maximum contaminant levels (MCLs). (The significant metric is time versus concentration).

Key Points

- In the late 1980s, there was one large plume covering about 1/3 of the site.
- The Exit Strategy called for meeting MCLs, given the facility's location near residences and public water supply wells. No ICs would be used.
- A P&T system was installed, and the plume was reduced to a few "pockets" where groundwater continues to exceed MCLs.
- An RSE was conducted, and air sparging was selected as the final polishing step. A portable unit was constructed and moved from one target location to the next. Since 2005, three "pockets" have been eliminated.
- The facility has performance-based permits, so permit modifications were not necessary to implement the additional technology. During an earlier permit renewal, the facility and agency had incorporated multiple remedial technologies as options for use at the site. Therefore, when the decision to implement a polishing step was made, it could be implemented without a permit modification. Financial assurance obligations actually decreased because the life-cycle cleanup cost estimate decreased with the addition of the air sparge unit (estimated time to cleanup was reduced).
- Estimated savings from implementing this polishing step are $1.4 million over 8 years. Most of the savings are on the back-end, meaning that cleanup criteria are achieved earlier than they would be if the facility continued with P&T.
- This illustrates one of the guiding principles of this course – that a remedy can change, even if it was designed properly and operated effectively.

References

- None.




## Notes:

Purpose of Slide

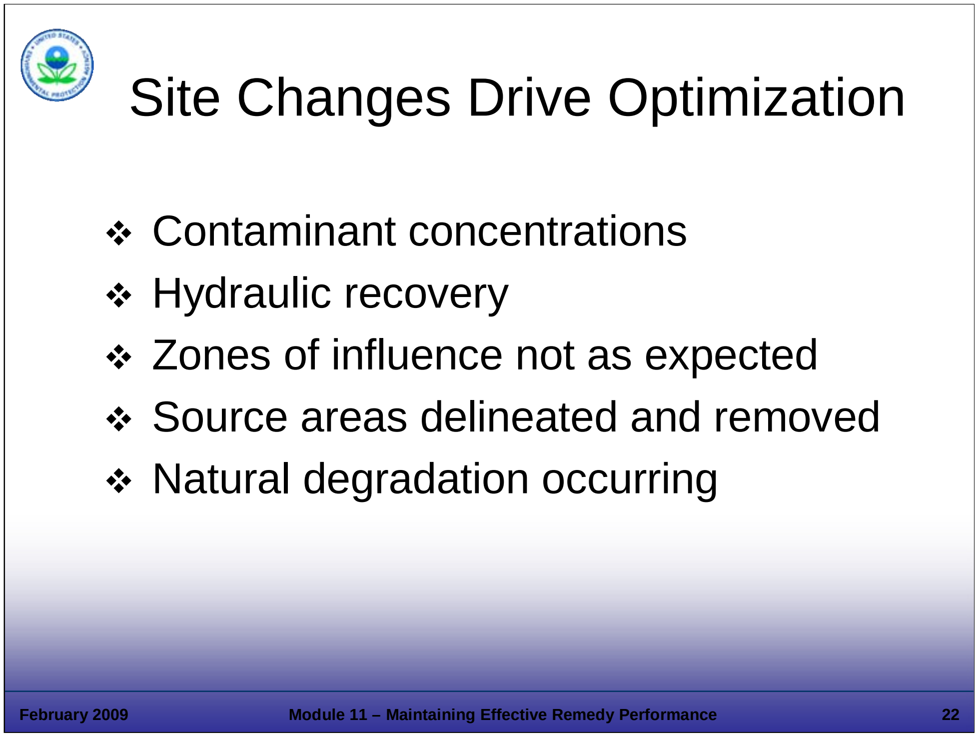
- Discuss how technology improvements affect progress toward meeting remedial goals using a real world example.

Key Points

- This graph demonstrates mass removal over time.
- The X-axis is the date (covers the period from April 1995 through October 2005).
- The Y-axis shows cumulative groundwater recovered (in millions of gallons) in blue.
- The Y-axis also shows cumulative VOCs removed (in 100 pound increments) in magenta.
- By looking at this graph we see the following:
  - A flattening of the slope of either line (reduction of slope) is an indication of performance fall-off. The slopes represent the rates of groundwater recovery and VOCs removed, which are metrics.
  - Sharp or sudden changes in slope occur as a result of improved performance. These resulted from major process changes implemented after a RSE/RSO. We will look at two specific points in time.
    - The first change (1) in the magenta line (mass removed) indicates the results of bringing a new treatment process on-line that allowed the removal and destruction of highly contaminated groundwater (millions of parts per billion (ppb)). The rate of groundwater processed did not increase, but the mass removed did. This change took about 3 years to implement, because the site remediation was operating under the old "command and control" approach and permit modification requirements required time before proposed changes could be implemented.
    - The second major change (2) in the magenta and blue lines occurred when new horizontal wells located in a source area were brought on-line. As a result, the volume and mass removal rates both increased. This change was brought on-line much more quickly (in less than one year) under a results-based approach.

References

- None.




## Notes:

Purpose of Slide

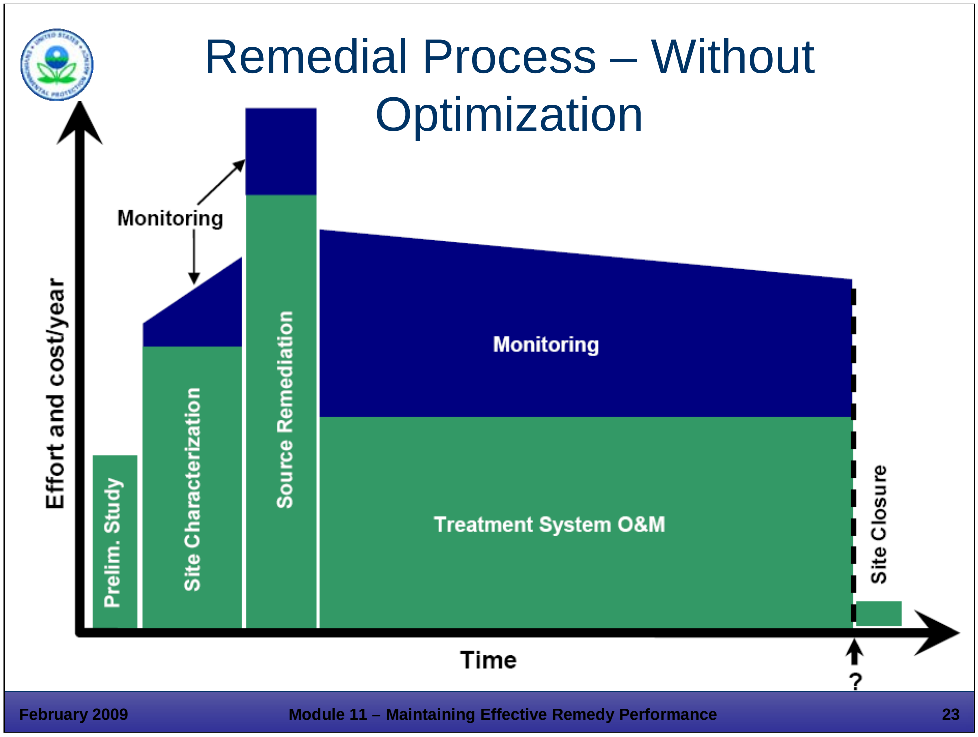
- Discuss the reasons why optimizing remedial systems is important, particularly for those systems that operate for long periods of time or lead to dramatic changes in site conditions. Discussion applies mostly to groundwater.

Key Points

- Site conditions can change over long or short periods of time. For instance, an air sparging unit may achieve rapid reductions in contaminant levels. If the system is modular, sections can be turned off and/or moved to optimize contaminant removal. Site changes that can drive optimization include:
  - Typically contaminant levels (and plume dimensions) decline after years of treatment. Systems and components can be modified, adjusted, consolidated, or even eliminated to reduce operating costs because of reduced treatment needs.
  - In the case of P&T, hydraulic capture needs change with time. Some recovery wells may no longer be required or may need to be modified to perform effectively. Recovery efficiency also declines with time as wells foul and pumps wear out.
  - Sometimes we discover that zones of influence for air sparge or P&T units are not as expected due to unknown geological conditions. Modifications – additions or deletions – may improve the efficiency.
  - Source areas may not be well delineated initially or may change with time. The removal of a large contaminant mass will also change site needs for further remediation work.
  - Natural degradation may change the geometry or chemistry of a plume.
- Optimization is an approach that an be used to efficiently respond to changes as they occur over time.

References

- None.




## Notes:

Purpose of Slide

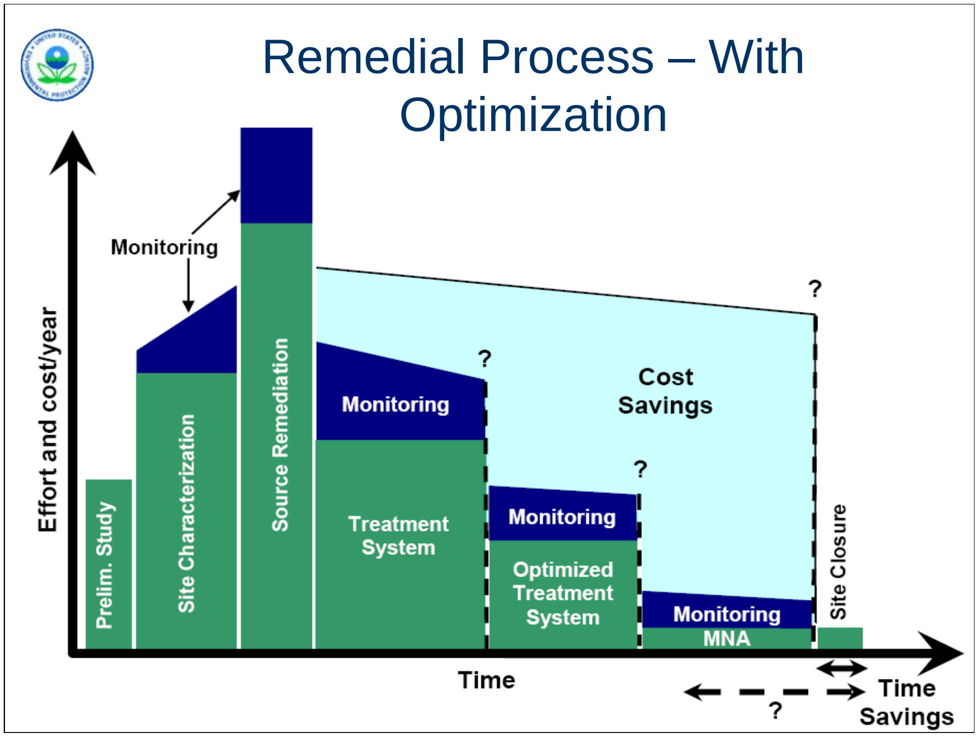
- Review Remedial Process Optimization (similar to RSO and RSE, but focusing on the entire remedial process (including monitoring approaches) to support efficiency in site remediation.

Key Points

- This slide shows the traditional linear approach to site investigation and remediation, without process optimization. In this process, the effort proceeds from characterization to source remediation with on-going monitoring but without reviews for optimization and associated system modifications.
- As the project matures, most of the resources are spent on O&M and monitoring and, for most sites, the project duration is unknown.

References

- ITRC. 2004. Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation.




**Notes:**

Purpose of Slide

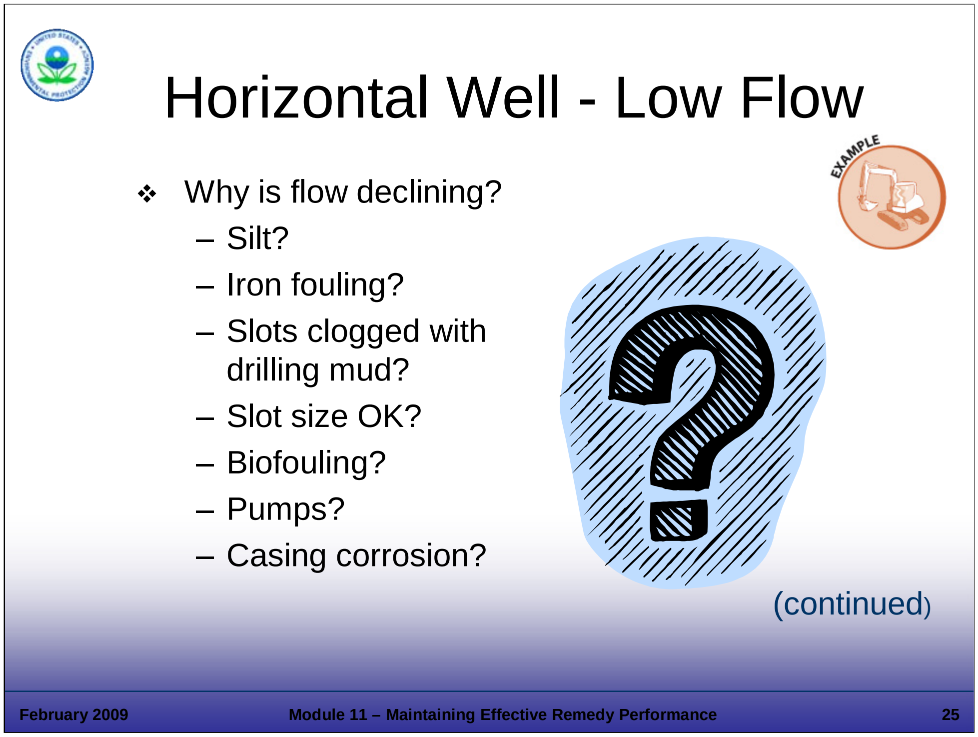
- Show the non-linear remediation paradigm, when remediation process optimization steps are implemented.

Key Points

- Discuss, in general terms, how on-going remediation process optimization can reduce cleanup time and cost.
- Under this approach, site and treatment system metrics are systematically evaluated in order to improve both system operation efficiency and cleanup efficiency.
- The result is a shorter cleanup time, lower cost, and improved predictability.

References

- ITRC. 2004. Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation.




**Notes:**

Purpose of Slide

- Provide an example of examining operations to improve efficiency. In this example, horizontal recovery wells had been operating for several years and the flow rate was steadily dropping. The total estimated time of cleanup is directly related to flow rates (mass removal rates), so it was important for the facility to trouble-shoot the system to determine the cause and correct it.

Key Points

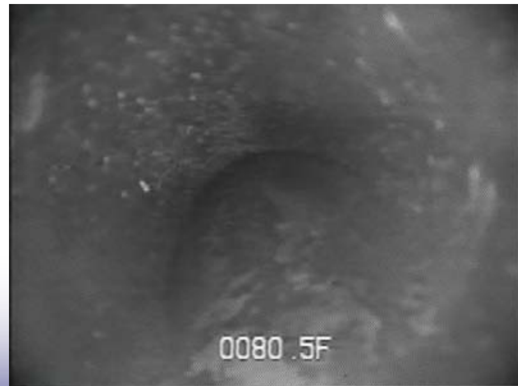
- The engineers identified several possible reasons for flow rates declining, as illustrated in the slide.
- The horizontal well was located in a lithologically tight environment, so the wells were designed with small slot sizes. This helps prevent silt from clogging the well, but the downside is that the well is more sensitive to fouling or clogging.

References

- None.

# Horizontal Well - Inspection

**Decided to have the horizontal wells video inspected:**




(continued)



**Notes:**

Purpose of Slide

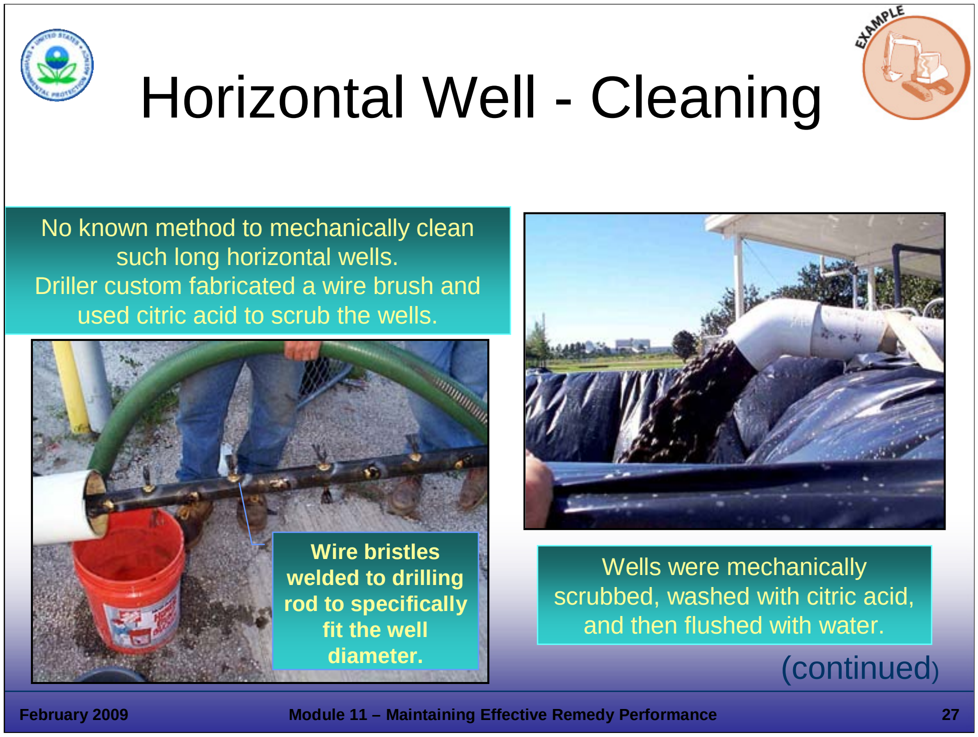
- Continue example of trouble-shooting problems to improve operational efficiency (note: video clip).

Key Points

- This is a video taken of the horizontal well.
- The video shows a build up of material on the well; this is the cause of the flow rate decrease.

References

- None.




**Notes:**

Purpose of Slide

- Continue example and illustrate the solution implemented to increase flow rates and improve system performance.

Key Points

- The wells were mechanically scrubbed, washed with citric acid and flushed with water using a 400 gallon per minute (GPM) pump.
- The driller had to custom fabricate a cleaning tool for the wells.

References

- None.


**Notes:**

Purpose of Slide

- Continue the example and illustrate the success of the optimization effort (video clip).

Key Points

- This is another video clip taken after the well was scrubbed.
- It shows that the build up has been reduced.
- Flow rates increased and the site was back on track in terms of its Exit Strategy and estimated time to cleanup.

References

- None.

# RSE - Cost Effectiveness Evaluation

- Identify Major Cost Categories
- Focus on the Highest Percentages
  - 40 to 60% of Costs: Energy Consumption
  - 20 to 40% of Costs: Sampling and Analysis
- Analyze for Cost Reduction Opportunities
  - Start with the largest costs first

February 2009 Module 11 – Maintaining Effective Remedy Performance 29

**Notes:**

Purpose of Slide

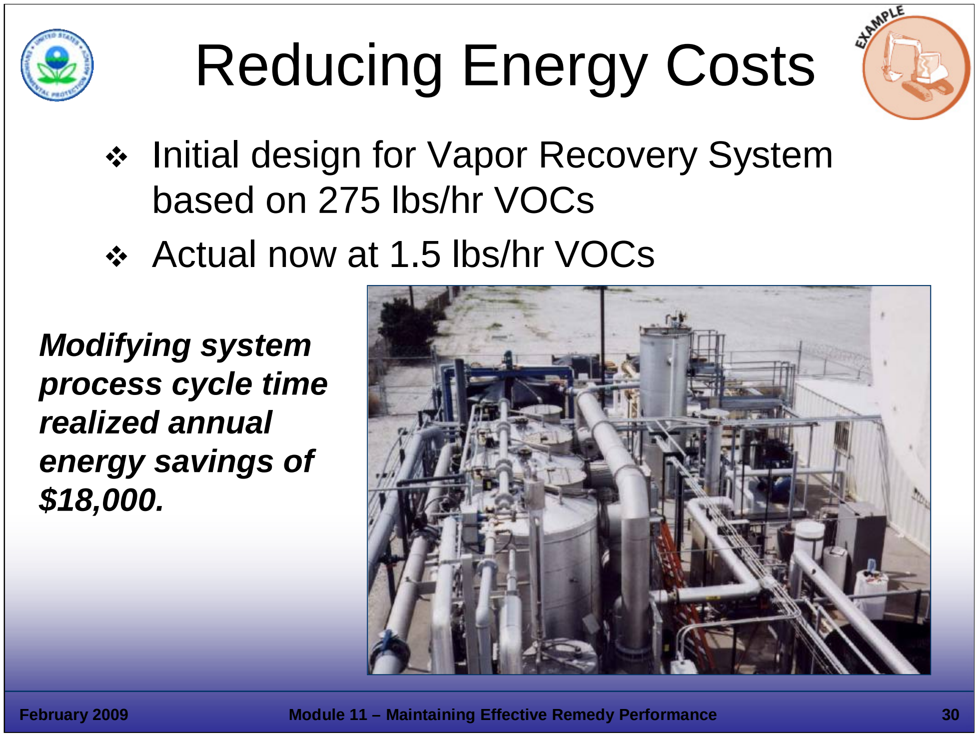
- Remind participants that there are three aspects to RSEs – review the Exit Strategy, complete the system and site performance evaluation, and evaluate cost effectiveness. It is incumbent on facility managers to make prudent decisions relating to CA.

Key Points

- The RSE typically involves performing a cost analysis on an existing facility using historical data.
- Costs are broken into categories and analyzed in detail.
- Identifying the most costly items helps to focus the detailed cost evaluation. It is prudent to focus on the highest cost items first – where there is the best chance of savings.
- The following slides provide examples of modifications recommended in RSEs that lead to significant cost savings and improved system operation. Such changes save resources, while also maintaining or improving the system's environmental performance.

References


- EPA. 2006. 2005 Annual Progress Report for Ground Water Remedy Optimization. EPA 540-R-06-066.
- EPA. 2005. Cost-effective Design of Pump and Treat Systems. EPA 542-R-05-008.




## Notes:

Purpose of Slide

- Provide an example where the energy/cost evaluation led to optimizing an air stripping / granular activated carbon (GAC) off-gas treatment system to reduce energy consumption (operating costs).

Key Points

- This system was installed and operated for ten years with no significant changes.
- Design loading for the system was based on initial groundwater concentration data and expected VOC loading.
- Contaminant concentrations dropped dramatically over time (from design conditions) as the site remediation progressed (normal occurrence).
- Steam regeneration of the carbon beds is a major energy cost and occurs on a fixed cycle time. Regeneration was being performed based on initial system design volatile organic compound (VOC) loading (for example, too frequently for current conditions).
- Adjusting the cycle time to reduce the frequency of regeneration based on current VOC loading conditions resulted in a dramatic reduction of energy usage and utility costs, with no change in environmental performance.

References

- None.

# Reducing Equipment Needs

- Air stripping system initially designed for 4 lbs/hr VOC – two towers in series
- Actual rate now at 1 lb/hr

(continued)

***Modifying system to use one tower and reducing blower size realized annual energy savings of $10,000.***

February 2009 Module 11 – Maintaining Effective Remedy Performance 31

## Notes:

Purpose of Slide

- This is an example where the cost evaluation led to optimization of a treatment system, given that operating conditions had significantly changed – flow rate and concentrations had declined dramatically from design conditions.

Key Points

- The system was designed for higher influent concentrations than current conditions.
- Significant savings were possible by reducing treatment from two air stripping towers in sequence to one and changing out other equipment.
- The regulatory agency will be involved in these types of system changes – through effectiveness reports that describe conditions or recommended modifications, or regulatory issues relevant to the changes. It is prudent to develop lines of communication that will allow these changes to occur expeditiously. Development of performance standards is one mechanism that allows a facility to proceed with reasonable changes in an efficient manner.

References

- None.

## Evaluating Costs: A Different Perspective

- O&M Costs
  - Routine
  - Major Repairs / Replacements
- Capital Costs
  - Modifications
  - Upgrades
- Life Cycle Costs
- $$$ per Unit Mass Removed

February 2009 Module 11 – Maintaining Effective Remedy Performance 32

### Notes:

Purpose of Slide

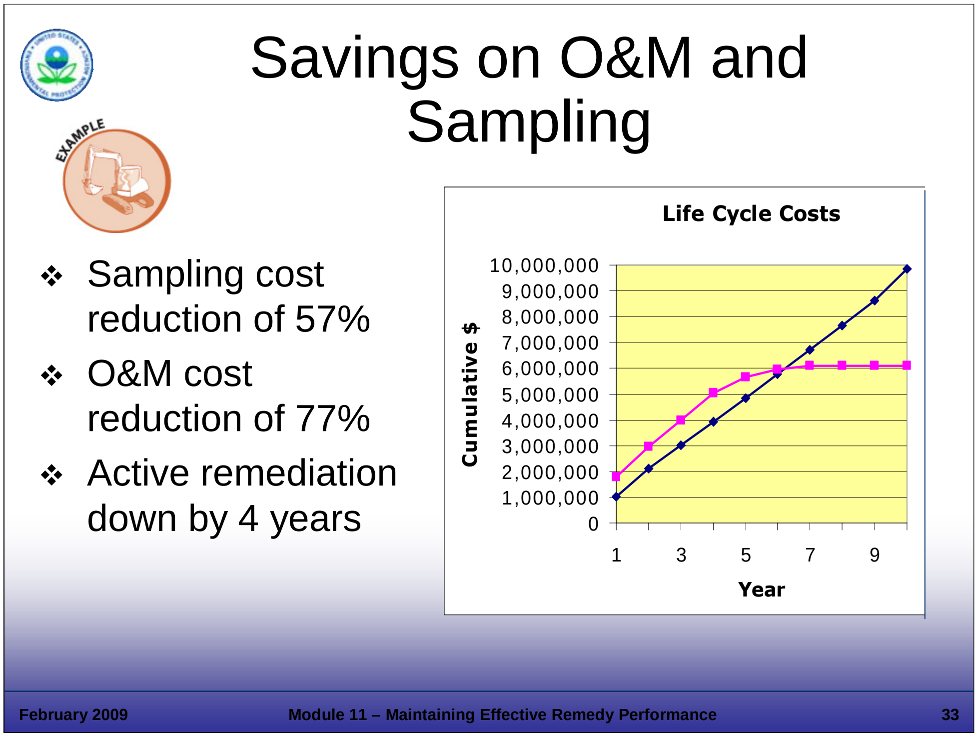
- Illustrate another perspective on cost evaluation, and how priorities vary among facilities.

Key Points

- Previously we looked a number of different cost categories – power, equipment, etc.
- Recurring annual costs are also important to facilities (for example, O&M, capital costs for major improvements or modifications, and life cycle costs).
- Facilities will budget for normal expenses (for example, monthly O&M and annual sampling) but also plan on infrequent major expenses (for example, pump failure every five years).
- Major upgrades and improvements are evaluated as long term investments with a payback or savings.
  - The cost of repairing an old component is compared to the cost of replacement with an improved version. A repair seldom lasts as long as a new unit.
  - Replacing a 5 horsepower (HP) pump with a 1 ½ HP pump may cost $1,500; however, it may save $2,000 per year in energy costs (a simple payback of 9 months).
- Some facilities consider life cycle costs most important in evaluating options - more up-front spending may mean lower spending overall as the length of time of treatment or system operation is reduced.
- Other facilities will prefer to keep recurring annual costs at a minimum, even if the life cycle cost is higher.
- Performance can be evaluated on a unit cost basis ($/ pound, $/ cubic yard, $/ hour).

References


- ITRC. 2006. Life Cycle Cost Analysis.
- ITRC. 2006. Above Ground Treatment Technologies.




## Notes:

Purpose of Slide

- Show the significant impact that the level of O&M and sampling activities can have on CA costs and cleanup times through a site-specific example.

Key Points

- An RSE was conducted and implemented in years 4 to 5.
- The RSE identified improvements in the sampling plan for the facility, resulting in a 57% reduction in sampling costs:
  - Use of passive diffusion bags (PDBs) for sampling (discussed on the next slide).
  - Elimination of some wells that had been sampled and met cleanup criteria for years.
  - Reduced sampling frequency for all wells, and development of a 2-tiered sampling program, where some wells were sampled less frequently than others.
- O&M costs were reduced by 77%, based on multiple system improvements:
  - The P&T system was treating a fraction of the volume it was designed to treat; the plume was much smaller than it had been. Therefore, influent streams were rerouted and combined.
  - System utilization time was increased by replacing parts, proactive maintenance, and expanding the parts inventory. The effect of these activities was to reduce total estimated time to cleanup by 4 years.
- These savings in cleanup time and life-cycle costs could not have been realized without the results-based approach adopted by the agency.

References

- None.

## Sampling Savings: Passive Diffusion Bags

- VOC sampling of groundwater
- Permeable bag containing deionized water
- Contaminants diffuse into DI water
- Bag retrieved from well and sampled

February 2009 Module 11 – Maintaining Effective Remedy Performance 34

**Notes:**

Purpose of Slide

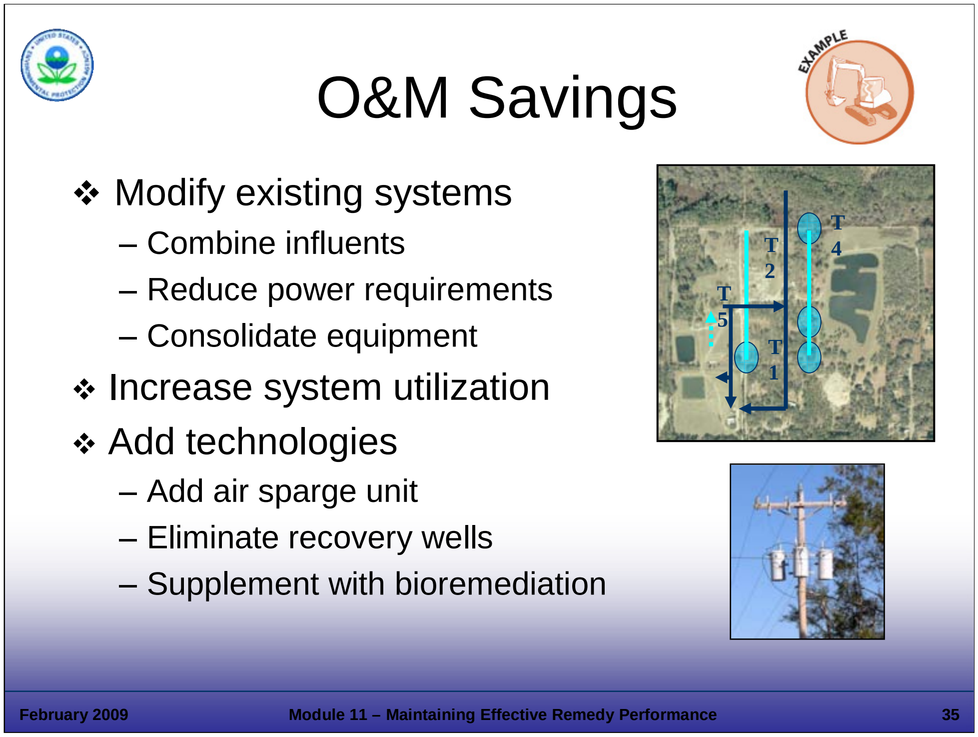
- Describe the use and advantages of PDBs, such as reduction in costs as illustrated in the previous slide.

Key Points

- PDBs are used for VOC sampling of groundwater.
- A permeable polyethylene bag contains deionized (DI) water.
- The PDB is suspended on a weighted polypropylene line next to the well screen.
- Wells with long screens can have more than one PDB on the same or different lines.
- Contaminants in well water diffuse through the bag into DI water until equilibrium is reached .
- The PDB is retrieved from the well and emptied into sample bottles.
- Use of PDBs generally cuts labor costs associated with sampling by over 50%.
- Many states consider PDB sampling results equivalent to traditional purge and pump sampling results.

References

- ITRC. Diffusion Sampler Page of Website. Accessed on-line at: http://www.itrcweb.org/teampublic_DPS.asp.




**Notes:**

Purpose of Slide

- Describe the basis of the O&M cost savings using an example.

Key Points

- By combining influent from several recovery wells into one treatment system, the facility saved on power, monitoring, and equipment costs.
- Increasing system utilization (the time the system is operating) reduced the estimated time to cleanup, eliminating years of operating costs.
- Adding technologies also reduced the estimated time to cleanup. This adds significant capital costs but reduces life-cycle costs.

References

- None.

## System Design Modification

- Initial design for 200 gpm, batch before disposal
- Actual now 25 gpm, direct injection

***Capital costs recouped in two years, based on energy savings***

February 2009 Module 11 – Maintaining Effective Remedy Performance 36

**Notes:**

Purpose of Slide

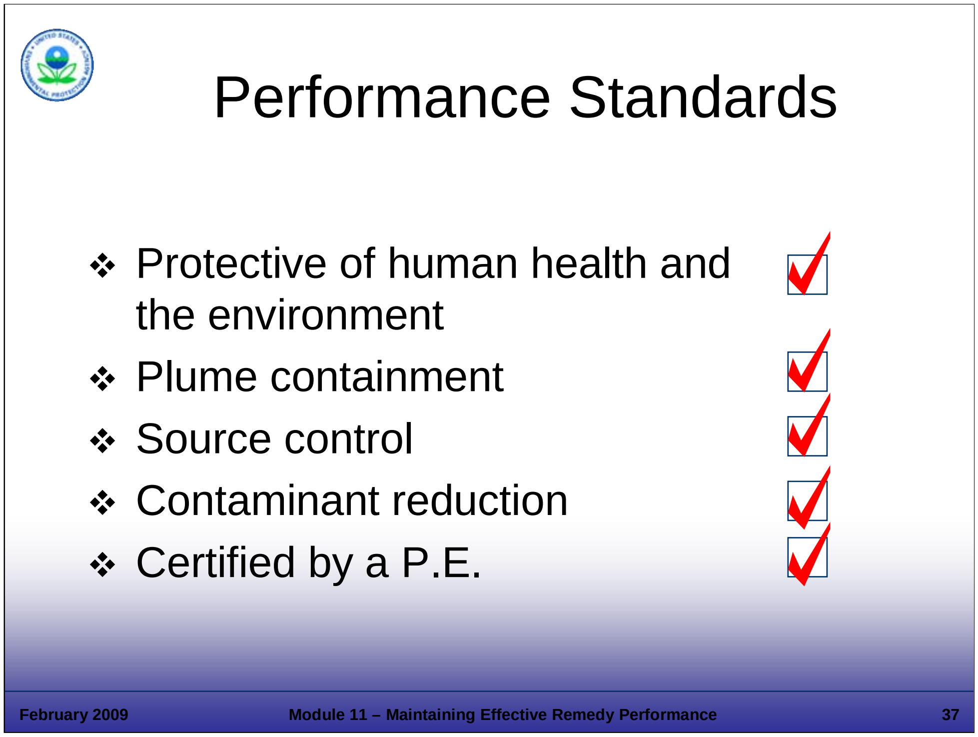
- Illustrates a site where a P&T system had operated successfully for many years, warranting system review and modification.

Key Points

- The plume had been reduced in size and groundwater recovery rates were much lower than design conditions.
- The holding tank was eliminated and two air strippers were replaced with trays.
- The payback for capital costs was only 2 years, based on energy savings and reductions in effluent sampling.

References

- None.




**Notes:**

Purpose of Slide

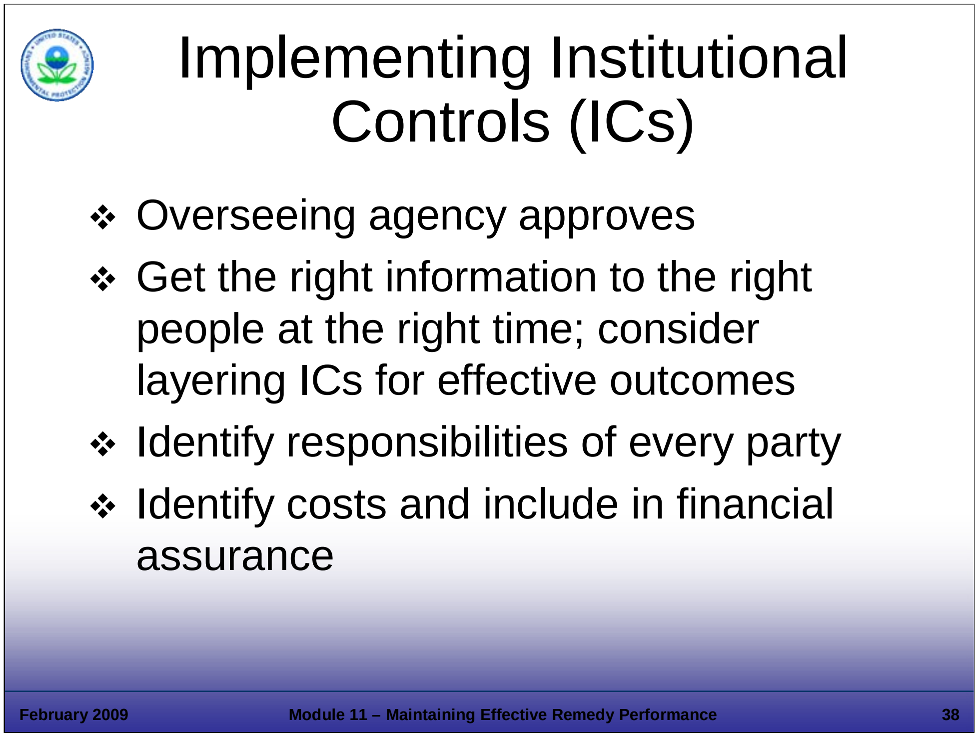
- Show how one of the principles of this course – "Think performance standards" (Principle 3 from Module 2) – can positively impact the operation of a remediation system.  This approach (using performance standards as tailored oversight tools) illustrates results-based CA.

Key Points

- As we have shown, remediation systems are likely to need modifications or even change completely over time (Remember, another course principle is "Okay for remedy to change").  Therefore, the facility and agency should anticipate the need for change and develop a process that allows the facility to respond quickly to needed modifications.
- While certain significant treatment system modifications may require permit modifications under 240 CFR 270.42, this course focuses on the flexibility that can be built into permits, through up-front planning.  Examples are provided to illustrate how adjustments to field activities and treatment technologies can be planned for by including clear and appropriate performance standards in permits.  The facility can then make changes within the specified parameters and report the changes to the agency, which provides review and oversight during the implementation process.
- One approach is to develop a set of performance standards. If the treatment system modification or technology change meets the performance standards, then the facility can proceed without agency approval (remember, the agency already has approved the performance standards).  Here are some examples of how these types of standards have been implemented:
  - A facility was planning to dismantle an air sparge unit and allow monitored natural attenuation as a polishing step.  The facility evaluated the change against the above performance standards – the action was protective of human health and the environment (HH&E), the plume was contained, the source had been eliminated, and contaminant reduction would continue to occur.  The plan was certified by a P.E.  The facility notified the agency; separate agency approval was not necessary.
  - A facility was planning to dismantle recovery wells.  It determined that the resulting system (fewer recovery wells) would continue to meet these performance criteria.  The facility notified the regulatory agency; separate approval was not necessary.
  - A facility selected excavation as a technology to remove DNAPL contamination.  The facility determined that the activity would meet the performance standards.  The facility notified the agency; separate approval was not necessary.

References

- None.




**Notes:**

Purpose of Slide

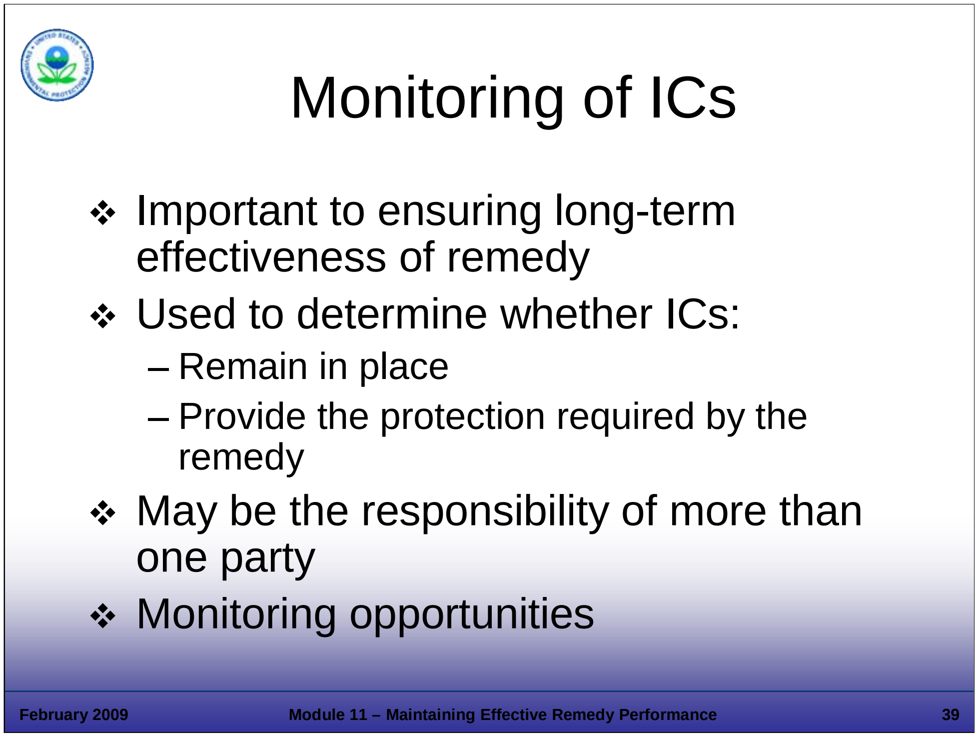
- Often, the ICs are implemented once active remediation is completed, but ICs are sometimes implemented during remedy operation.

Key Points

- Selection of ICs will vary. Sometimes the o/o will recommend them; sometimes the o/o will analyze and establish them; sometimes ICs will be prescribed by law, or worked out by interested parties. The overseeing agency then reviews and approves the ICs.
- The key to effective ICs is getting the right information to the right people at the right time. EPA recommends layering to achieve this goal. For example, if the remedial objective is to restrict excavation, a possible approach may include a restrictive covenant, and the local government notifies future owners through a “one call” system. The land use restriction may serve to alert future landowners of the land or resource use limitations, and the one call system can provide a warning to excavators or others using the property that may not have access to or knowledge of what is recorded in land records (for example, utility contractors). Other approaches also are possible.
- All parties should have the understanding, authority, and financial capacity to fulfill their responsibilities relating to identifying, evaluating, implementing, and monitoring ICs.
- Cost for ICs must be identified and included in financial assurance.

References

- EPA. 2007. Final Memorandum. Ensuring Effective and Reliable ICs at RCRA Facilities. June 14.




**Notes:**

Purpose of Slide:

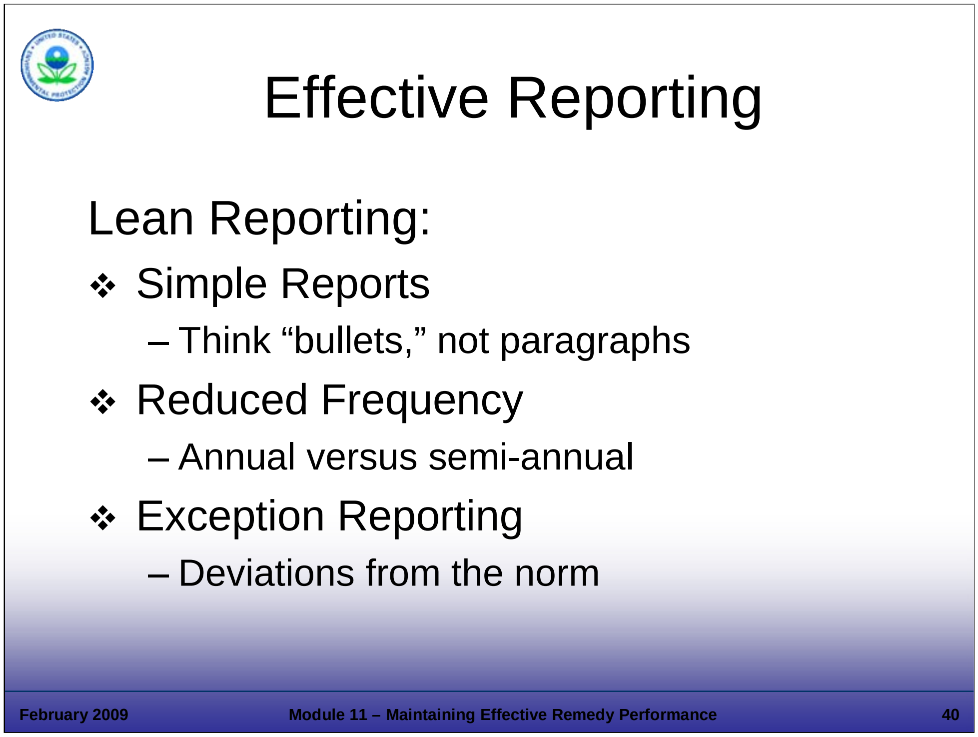
- Discuss the importance of monitoring ICs.

Key Points

- In addition to active remediation and engineering controls, ICs will play an important role in many final remedies. Identification and selection of appropriate ICs have been discussed in earlier modules.
- The most critical post-implementation aspect to ensuring the long-term effectiveness of ICs is monitoring as often as necessary to ensure effectiveness.
- The objectives of monitoring are to determine: (1) whether the mechanism remains in place; and (2) whether the ICs are providing the protection as required by the remedy.
- For added protection of HH&E, and to minimize risk, EPA recommends layering (that is, use of more than one IC) and considering different types of ICs. For example, to restrict land use, the regulatory agency may issue an enforcement tool (order), the facility o/o may obtain an easement, and the facility may discuss options with local governments for zoning and assuring awareness of restrictions by recording them in a deed notice and in a state registry of contaminated sites.
- Ongoing site activities present an opportunity for monitoring. For example, monitoring of ICs may occur in conjunction with facility inspections, multimedia inspections, or sampling.

References

- EPA. 2005. Institutional Controls Bibliography: Institutional Control, Remedy Selection, and Post-Construction Completion Guidance and Policy. December.
- EPA. 2007. Final Memorandum. Ensuring Effective and Reliable ICs at RCRA Facilities. June 14.




## Notes:

Purpose of Slide

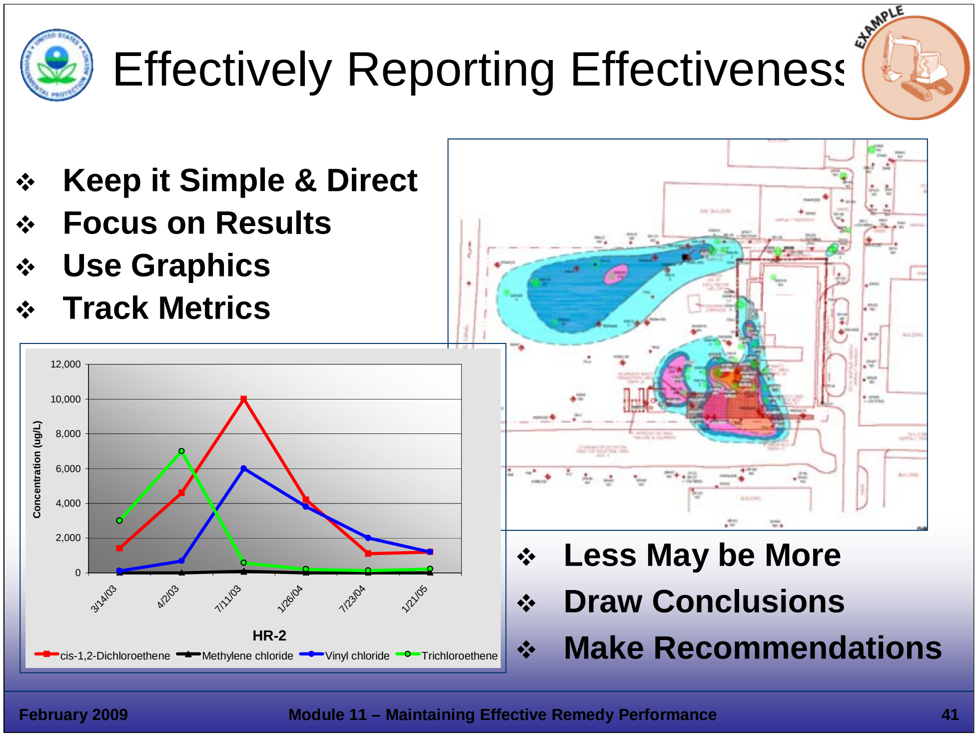
- It is necessary for facilities to provide performance data and system effectiveness information to the regulatory agency, but the reporting format should be simple. Lean reports are preferred by facilities because they can be produced at lower cost than reports with extensive text and generally are preferred by the regulatory agency because the data are presented in a concise format for review.

Key Points

- Historically reports have been voluminous, with much detail and supporting documentation. Facility time to prepare this data and agency time to review this information and provide comments can be lengthy. Lean reporting focuses on efficient and effective reporting. This includes:
  - Simple Reports - Simplification of reports can speed up review effort and time considerably and is more cost efficient. Parties can agree on the most important data items and best formats to support adequate oversight and protective outcomes. Concepts include:
    - Consider bullets, not paragraphs;
    - Use tables, charts, and graph to convey information in lieu of text;
    - Use graphics to describe conditions – for example, plume maps; and
    - Reference standard operating procedures for sampling and other activities, rather than providing lengthy descriptions.
  - Reduced Frequency - Quarterly reports were once common, now semi-annual are the norm.
    - Most older sites are stable and do not change rapidly.
    - Consider changing to annual or even less reporting, when justified.
  - Exception Reporting - Emphasize reports that focus on exceptions or deviations from expected results, rather than many pages of reporting to document non-events (that is, all metrics meeting expectations).
- Lean reporting can also be used for reports associated with system modifications or implementation of new technologies.

References

- None.




**Notes:**

<u>Purpose of Slide</u>

Provide an example of how to report **remediation system** effectiveness using a lean reporting format.

<u>Key Points</u>

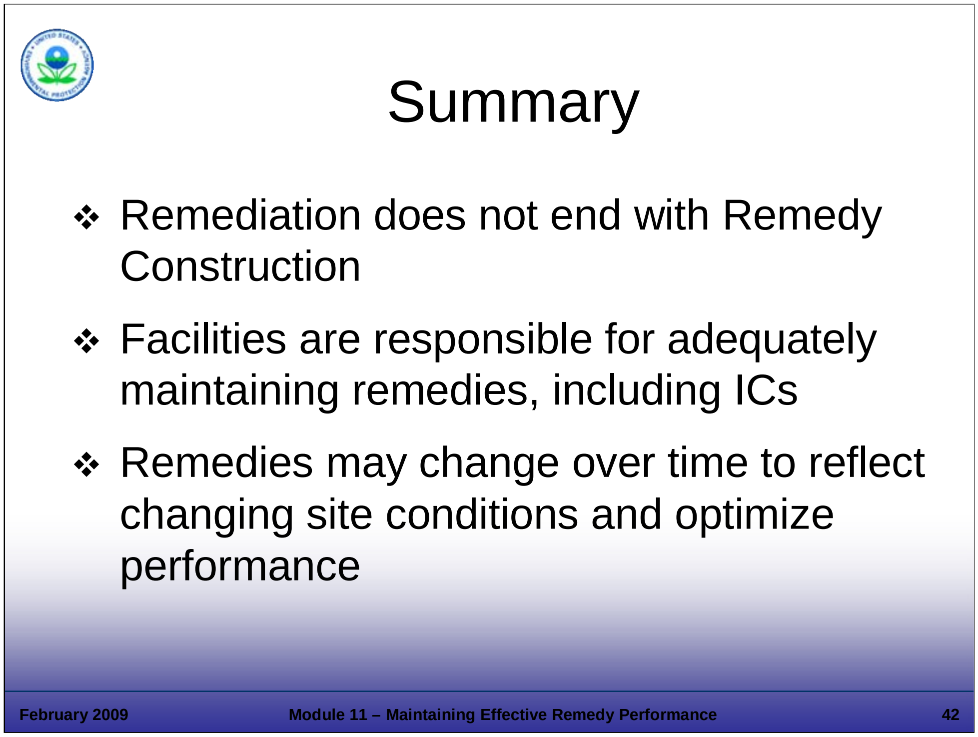
Effectiveness in achieving goals is the primary information to report.

The bullets on this slide illustrate key data use and a leaner approach to reporting.

The instructor will elaborate on this example.

<u>References</u>

None.




**Notes:**

Purpose of Slide

- Summarize the key points addressed in the module.

Key Points

- It will take considerable effort from all stakeholders to meet the ambitious goals of 2020. Once construction is complete, there is still much effort necessary to achieve remediation goals.
- Remediation systems need to be maintained for efficient operation. As plumes decrease in size and concentration, treatment systems should be adjusted accordingly and sometimes technologies should be changed. ICs must be implemented and maintained.
- Over time, remedies may need to be adjusted to reflect changing site conditions and to optimize performance. Facilities and agencies should plan ahead to establish clear performance standards and goals for protective remedies. These results-based approaches can support efficient and effective system optimization and modifications as conditions dictate (for example, through performance-based permits).

References

- None.