ADDRESSING TECHNOLOGIES AND CONTROLS

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I am a faculty member in civil and environmental engineering at the University of Utah. It is my job to provide a brief overview of Chapter 5 of the report, which addressed interim and long-term technologies and controls. As we begin talking about technologies, I want to reemphasize a statement made earlier: There is no "silver bullet."

A nice thing about working on a report like this is that we did not have to deal with day-to-day issues. Frank Bohlen referred to this as the geopolitical context. To some extent, the committee members were able to look at things as if we were "emperors for a day." The committee organized the technologies and controls into categories, which are not perfect but are illustrative of where each one fits: interim controls; in situ management options; sediment removal and transport technologies; and ex situ management. To some degree, these categories represent increasing complexity, and one can anticipate increasing or decreasing risk in terms of the end product.

Many options are available for managing contaminated sediments. Although actions such as deep ocean dumping of contaminated sediments are illegal, I will mention a multitude of other practical and possible technologies. As Dr. Bohlen pointed out, it is important to remember that spatial variations within any single site can be very dramatic. Therefore, the same answer may not be the right answer for the entire site. When you combine that variation with the number of options available, the result, in almost all cases, is a very complex solution.

In my view, this suggests that a systems approach is the only way to investigate the alternatives fairly. Unfortunately, we do not always have quite enough information to do that in the way we would like, but the tools are still useful. I want to emphasize, as we go through the various categories, that the applicability (i.e., the number of applications) of a technology goes down as the complexity increases, primarily because the costs increase so dramatically.

As a committee, one of the first things we discussed and concluded was that the nation cannot afford to treat all sediments to a clean state, particularly because we may not even know what "clean" is. Nor would this make sense, because we seldom know what the end use is going to be. That issue is beyond the focus of my remarks; however, it is certainly something to be concerned about—trying to better define the real objective.

I will focus first on interim controls. Joe Zelibor mentioned the time frame from the beginning of a project to the point when something really happens. If you have been associated with these types of projects, then you know it is a long time, and nothing happens in a hurry. In this context, "fast track" is measured in years, and decades are the norm. This gives rise to the rational use of interim controls. If there is truly an ecological and biological impact occurring, then it is often necessary to intercede and do something to reduce the risk associated with the site *while* we are deciding what to do in the long term; hence, the introduction of interim controls.

A number of examples can be cited from around the country. An example of an administrative control is the posting of a "no swimming" sign to keep people out of an area. An example of a technological interim control is the use of sediment traps to reduce additional contamination or the addition of uncontaminated sediments to an area. Yet another example is removal of hot spots. If one spot is dramatically increasing the risk posed by the entire contaminated area, then it may be necessary to move faster and do something with a small portion of the site, leaving the larger decision until later. Other possibilities, such as temporary caps, have not been thoroughly examined.

There may be other in situ methods that also could reduce the risk. This is the first category of long-term remediation technology that I will discuss. As USACE officials and others in this audience know, there are contaminated sediments in channels, and channels are dredged on a regular basis. The most highly contaminated sites tend to be those that are not dredged and may not necessarily impede navigation. In these cases, in situ options are possible but—at least in my view—have not been looked at very carefully or scientifically.

The committee discussed at length the option of natural recovery and the distinction between it and "no action." Unfortunately, these options are too easily confused. Some argue that natural recovery is a decision, and along with that decision goes long-term monitoring to make sure the decision was correct. It is an action that says (a) the contaminants are there because they are at the lowest-energy area in the environment, (b) they are stable, (c) there is no evidence of ecological damage from their presence, and (d) they should be monitored to ensure they do not go anywhere and are not distributed by storms or other events. In some instances, this may be the best option.

If natural recovery is not an option or not the best option, then in-place capping may be a possibility, using some type of cover or cap or possibly in situ treatment. There are a few examples of in situ treatment, which involves adding various components to the sediments that will cause the contaminants to be more tightly bound and less bioavailable. There are concerns associated with this approach, including limited experience and uncertainty with respect to the risk.

There are a variety of dredging alternatives. Dredging is a proven technology that has been used extensively. My work has focused on contaminant release and resuspension and environmental impacts during the dredging operation. In many cases, the effects are far less than what may be expected. In general, the cost to pick up and move sediments is low compared to treatment cost; however, once you pick them up, you have to do something with them. Previous speakers touched on the issue of source control. One of the strange things about sediments is that, once you pick them up, you own them, whether you were the original source of the contamination or not.

There are concerns about contaminant losses and overall volume increases due to the addition of the water. There are issues of accuracy and precision. Reiterating what Dr. Bohlen said previously, there should be some correspondence between the precision of the site characterization and the precision at which we require the dredge to remove sediment. There is concern about overdredging, or taking sediments that are not contaminated but, once removed, essentially become defined as contaminated. There have been advances in this area, particularly in Europe. Some new dredges have been developed, such as bottom-crawling dredges, which reduce overcutting of the bottom because of their potential for high accuracy and precision. In general, this is a fairly well-developed science.

Once sediments are moved, something must be done with them. Certainly the most prevalent technology is ex situ containment. Contained aquatic disposal (CAD) is a fairly new technology based on the concept that, if we have to move sediment, then keep it in the environment the contaminants like, because they are probably more stable there. Although CAD has been applied in a few cases, it is still categorized as an emerging technology. It is not widely accepted by the public as being standard practice; certainly there is a need to increase the experience base and the data available on it.

On the other hand, confined disposal facilities (CDFs) have been used for years and can be categorized as proven technology. Although some people would argue about the capability of a CDF to contain the contaminants, we know how to implement it. Not all sites are necessarily designed for that purpose, but if that is the choice, then it can be done. The real problem is that CDFs are difficult to site—nobody wants one in the backyard. On the positive side, CDFs are generally affordable, or fairly inexpensive.

A wide array of ex situ treatment technologies is being tested, and the state of proof is debatable. Very few of these technologies have been proven in a full-scale environment. Consequently, little is known about what the real costs will be. We have done lab tests, bench tests, and pilot tests, and those data have been extrapolated; however, it is not known what the costs will be on a larger scale.

There are physical methods, chemical methods, and biological methods. Bioremediation is an up-and-coming area of interest that holds a lot of promise, but at present the science is immature in terms of whether it provides a true long-term solution. Physical methods are more common and have been used in the mining industry for a long time, but the costs are higher than most probably would expect. More experience is needed to prove whether some of these technologies will really work. They will be expensive because, at a minimum, thermodynamic energy is required to remove the contaminants from the sediment, and that costs money. It is doubtful that a silver bullet can be found; more full-scale experience is needed, and concerns about disposing of the residuals must be addressed.

I will close my remarks by focusing on the issue of cost, which is perhaps the biggest problem we face. Administrative interim controls, such as signs, are inexpensive relative to other options. There is less experience with technological interim controls; however, some could be quite expensive, especially hot-spot dredging. Moving on to long-term controls, cost estimates for in situ management are largely guesses because there is limited experience on which to base them. Removal and transport costs probably fall in the \$10/yd^3 (\$13/m^3) range.

Ex situ containment is expensive, ranging from \$20 to \$50/yd^3 (\$26 to \$65/m^3) However, it appears less expensive when compared to the cost of ex situ treatment options, which start at around \$300/yd^3 (\$392/m^3) and can range as high as \$1,000/yd^3 (\$1307/m^3). This is a dramatic difference; in the long term, it suggests that, for large quantities of sediment, there is little choice but to focus on removal and transport and ex situ containment, with treatment applied to the small quantities that are highly contaminated.

In closing, I want to emphasize that decision analysis is an important tool because of the spatial variations and the wide range of costs. Because of the costs, it is important not to arbitrarily apply one solution to a very large volume of sediment. Care must be taken to apply the right solutions for the right portion of the area.