Hazardous Chemical Site Remediation Through Capping: Problems with Long Term Protection

Published in: Remediation 7(4):51-57 (1997)

G. Fred Lee, PhD, PE, DEE and Anne Jones-Lee, PhD
G. Fred Lee & Associates
El Macero, CA

1997

Abstract

The capping of waste management units and contaminated soils is receiving increasing attention as a low cost method for hazardous chemical site remediation. Capping is used to prevent further groundwater pollution by existing waste management units and contaminated soils through limiting the moisture that enters the wastes. In principal for wastes located above the water table, the construction of an impermeable cap can prevent leaching of the wastes (leachate generation) and groundwater pollution. In practice, appropriately designed and constructed RCRA caps can only provide for short term prevention of groundwater pollution. Alternative approaches are available for capping of wastes that can be effective in preventing moisture from entering the wastes and concomitant groundwater pollution. These approaches recognize the inability of the typical RCRA cap to keep wastes dry for as long as waste constituents will be a threat and most importantly provide the necessary funds to effectively address all plausible worst case scenario failures that could occur at a capped waste management unit or contaminated soil area.

Introduction

Considerable attention is being given today to the redevelopment of hazardous chemical sites (brownfield property) as part of the federal and state Superfund program site remediation. Whitman (1996), in an editorial in the Winter 1996 issue of *Environmental Progress,* discussed this issue from a PRP short-term perspective in which the tone of the editorial is minimizing costs and rapid remediation. While it is important to minimize unnecessary costs in site remediation relative to and needed for projected future property use, we have found as the result of being involved in a number of brownfield property remediation projects from a future property user perspective, that the short-term, limited remediation approach that is frequently being advocated today carries with it a number of significant potential problems that should be fully understood by the PRP(s) and future property owners/users.

Whitman states in his editorial,

"The key to the success of voluntary cleanup efforts for Brownfield sites is to tie future use *of the property and its surrounding environs to the environmental condition and remedial approaches designed to protect against the* risks of environmental hazards*."*

He further states,

"Capping urban sites through construction of an impermeable barrier at the surface provides an engineering control approach that is cost effective, environmentally sound and in concert with the future use of the Brownfield property."

It has been our experience that frequently PRP approaches for remediation of hazardous chemical sites are increasingly directed toward "capping" the waste management units-contaminated area. For example, at the University of California, Davis - Department of Energy national Superfund site located on the University of California campus in Davis, the Department of Energy contractor proposed, as a possible remediation approach for various waste management areas, the capping of these waste management units - contaminated areas, including former campus landfills, with a "RCRA" cap or a "less than RCRA" cap. While the proposed design for the "less than RCRA" cap was not delineated, it is presumed that it would be something less than the conventional composite compacted clay and plastic sheeting low permeability layer overlain by a drainage layer and a topsoil layer.

Those familiar with RCRA landfill caps for Subtitle C (hazardous waste) and D (municipal solid waste) landfills know that as being developed today, they, at best, only postpone when future groundwater pollution will occur by leachable waste constituents in contaminated soils or waste management units that are capped as part of site remediation. This applies not only to in-place capping of soils and waste management units, but also to on-site RCRA landfills that are constructed specifically for the purpose of site remediation where the wastes/contaminated soils at the site are moved to an on-site landfill (Lee and Jones-Lee, 1996).

While in-place capping of wastes and contaminated areas is certainly one of the least expensive short-term approaches for hazardous chemical site/brownfield remediation, it carries with it potentially significant long-term issues that should and must be addressed in developing a properly remediated site. Those familiar with the longer-term properties of RCRA landfill covers know that, at best, they provide a temporary impediment to moisture entering the contaminated area/wastes. The length of time that they are satisfactory in preventing moisture from entering the wastes depends on a variety of factors, the most important of which is the structural stability of the base upon which the cover is developed. These issues have been reviewed in detail in several papers/reports (Lee and Jones-Lee, 1994a, 1995a, 1995b, 1996) and in an ASCE conference proceedings (Dunn and Singh, 1995).

The key issue that has to be addressed in evaluating whether a RCRA cap can be used for a waste management area for the remediation approach that will be protective of groundwater quality for as long as the residual wastes in the area are a threat is whether the wastes, prior to placing the cover over the area, have polluted groundwaters. If groundwater pollution has occurred, then a RCRA cap will only slow down to suspend the pollution for a period of time while the integrity of the cap is intact and thereby precludes moisture from entering the wastes. The key to preventing moisture from entering the wastes in a RCRA-capped waste area is the integrity of the low permeability layer(s) in the cap. If a cap consisting of compacted clay is used, then the integrity is lost usually within one to two years through desiccation cracking. Even in wet climates, desiccation cracking has been documented to a sufficient extent to allow substantial rapid transport of moisture through the cap into the underlying wastes. For a cap containing a flexible membrane liner (FML), while the longevity of the plastic sheeting liners (layers) is improving, it is still certain that, except in rare situations, the FML in the cap will deteriorate long before the wastes are no longer a threat. This deterioration will lead to moisture entering the wastes and generating leachate that will cause to further groundwater pollution.

Adequacy of Post-Closure Funding

One of the most significant problems associated with on-site waste or contaminated soil management using capping as a remediation approach is that funds for maintenance of the cap are only assured for 30 years. The magnitude of the 30 year post-closure funding is typically not adequate to replace the cap should deterioration proceed at a rate faster than expected. While in virtually all waste management units the wastes will be a threat far beyond 30 years, there is no assurance that funds will be available to continue to maintain the cap, monitor the groundwaters and provide for remediation of polluted groundwaters when the pollution occurs. In most situations the wastes will be a threat, effectively, forever. If groundwater quality protection is to be achieved from the remediated capped wastes, funding mechanisms through a dedicated trust fund to address plausible worst case scenario failures must be developed that have a high degree of assurance that it will provide the needed funds in perpetuity. This deficiency in long-term funding has been recognized for many years. The GAO in 1990 issued a report to Congress entitled, "Hazardous Waste: Funding of Postclosure Liabilities Remains Uncertain." Congress, the US EPA and others have still not addressed this significant problem.

Another significant problem with waste management caps as remediation approaches is that the integrity of the low permeability layer, as would be inspected by the approaches that are typically being used today, i.e. visual inspection of the topsoil layer, cannot discern the holes, cracks or points of deterioration in the low permeability layer since it is buried below at least one and sometimes several feet of topsoil and drainage material. Therefore, leaks in the cap cannot be detected except after further groundwater pollution occurs by the wastes underlying the cap.

Adequacy of Groundwater Monitoring to Detect Groundwater Pollution from Capped Waste Management Areas

Once a low permeability cap is placed on a landfill or waste management unit, the typical approach used for monitoring groundwater pollution from the area is no longer reliable. This approach involves placing a few monitoring wells hundreds to a thousand or more feet apart at the point of compliance for groundwater monitoring. This point of compliance is located near the down-groundwater gradient edge of the waste management unit. This approach, while satisfactory for unlined landfills which have caps that allow moisture to enter at essentially all locations, is not satisfactory for plastic sheeting lined landfills or capped waste management units.

It was pointed out by Cherry (1990) and Lee and Jones-Lee (1994b) that the cap restricts the amount of moisture entering the wastes, with the result that plumes generated under the landfill from the moisture that penetrates the cap will not be wide plumes as occur in unlined - uncapped systems, but will be smaller discreet plumes of limited dimensions compared to the typical monitoring well spacing downgradient from the waste area. The typical groundwater monitoring wells have zones of capture of about one foot on each side. When monitoring wells are spaced hundreds or more feet apart, there is substantial area between monitoring wells through which polluted groundwaters can pass and not be detected by the wells. Therefore it will usually be off-site water supply wells that will detect failure of the cap to prevent further groundwater pollution by waste constituents.

Fundamentally, RCRA or less-than-RCRA caps for contaminated soil or waste management units is a flawed technological approach as it is being practiced today that will do nothing more than postpone when further groundwater pollution occurs at those sites where groundwater pollution is inevitably possible. This means that future brownfield property owners at sometime in the future will likely become PRPs for future Superfund sites where they face the possibility of having to spend substantial funds cleaning up polluted groundwaters that arise from failure to properly remediate/close the site.

Adequacy of Regulatory Oversight

It is our experience that regulatory agencies are under such high pressure to demonstrate that they are remediating brownfield sites that often inadequate attention is given to long-term problems that will occur for future property owners due to the failure to consider the ability of the remediation approach to contain the hazardous chemicals for as long as they will be a threat to public health, the environment and groundwater resources. Even with deed restrictions that are intended to prevent future property owners/users from disrupting the integrity of the waste management unit, there is little assurance that future problems due to site activities will not occur.

Even with adequate monitoring, there are insufficient funds made available in the post-closure funding to ensure that funds will be available to monitor and maintain the area for as long as the wastes represent a threat. This means that ultimately the brownfield property owners will almost certainly become responsible for substantial post-closure funding obligations that rarely are planned for in property acquisition.

Another aspect of brownfield property remediation that is not now being adequately addressed is the periodic (five-year) review of the adequacy of remediation. As discussed by Lee and Jones (1994a,c) it can never be assumed that because the site is remediated and closed in accord with today's standards that five, ten, fifteen, or twenty years from now with the discovery of new hazardous constituents that were not known today being present at the site or changes in the assessment of the hazards of constituents from that considered today, that sites that are now considered adequately remediated will not be adequately remediated in the future. This will likely require additional remediation. Again, the issue will be who will pay for this? While current property owners may agree to indemnify future property owners from such obligations, such indemnifications are likely to have limited reliability in providing the necessary funding for future site investigations and remediation that will almost certainly have to occur at every brownfield site if public health and the environment are to be protected from the residual waste constituents left at the site as part of site closure.

Alternative Approaches

It is possible with a somewhat different design and, most importantly, post-closure funding assurances to remediate and close contaminated properties in such a way as to provide high degrees of protection for public health and the environment as well as property owners' interests from potential problems that will likely occur at some time in the future. Rather than a conventional RCRA cap based on a composite liner approach of an FML underlain by a compacted clay layer and sufficient funding for post-closure care maintenance to kick some dirt in any obvious cracks that develop in the topsoil layer for a period of 30 years, it is possible to install leak detectable caps on landfills that will, if operated properly, provide for true protection of the underlying wastes from future exposure to moisture for as long as the wastes represent a threat. There are now about half a dozen commercial leak detectable capping systems that can be installed on waste management units. While the initial cost is somewhat more expensive than current minimum RCRA caps, the major increase in cost with this approach is in the operation and maintenance of the leak detection system and the eventual periodic replacement of the cap whenever leaks are detected for as long as the wastes underlying the cap are a threat, which in most situations will be forever.

As described by Lee and Jones-Lee (1995a) it is possible to develop "dry tomb" type landfills that will, in fact, have a high degree of reliability in preventing further groundwater pollution by wastes. Rather than relying on groundwater monitoring wells to detect when liner leakage occurs, a double composite liner system in which the lower composite liner is the leak detection system for the upper composite liner can be used. Whenever leakage through the upper composite liner into the leak detection system between the two liners is sufficient to potentially pollute the groundwaters, then if those responsible for maintenance and post-closure remediation cannot stop further leakage through the upper composite liner, the wastes in the waste management unit will have to be removed since it is only a matter of time until leakage through the lower composite liner also occurs.

Sufficient funds have to be set aside by both public and private responsible parties in a dedicated trust as part of closure of a contaminated area to ensure that adequate funds will be available in perpetuity for monitoring and maintenance of the site and eventually waste exhumation when the entity responsible for managing the waste management area can no longer prevent moisture from entering the waste management area or contaminated soil that generates leachate that is detected in the leak detection system between the two composite liners for new waste management units.

For existing unlined landfills or contaminated soil areas horizontal drilling under the wastes can be used to install a sampling grid and devices such as the system developed by the Flexible Liner Underground Technologies, Ltd. (Keller, 1995, 1996) to determine if saturated or unsaturated transport of waste derived constituents is occurring.

Conclusion

The pressure to bring about rapid remediation/closure of hazardous chemical sites is leading to the use of remediation approaches such as the capping of the contaminated areas by RCRA for less than RCRA caps. While this approach can provide for short term prevention of moisture from entering the wastes or contaminated soils, as it is being implemented today it provides an unreliable approach for site remediation that will prevent groundwater pollution by capped wastes for as long as the wastes will be a threat. Any capped waste management unit should be capped with a leak detectable cover that is operated and maintained for as long as the wastes in the capped area represent a threat. For planning purposes it should be assumed, unless it can be demonstrated with a high degree of reliability otherwise, that the wastes in a capped waste management unit will be a threat forever.

Associated with the development of any remediation approach involving capping of wastes, it will be necessary for both public and private entities to develop a dedicated trust fund of sufficient magnitude to ensure that funds will be available when needed to operate and maintain the leak detectable cover, reliably monitor groundwaters including the vadose zone under the waste management unit and to exhume the wastes if at some time in the future those responsible for the wastes fail to prevent moisture from entering the wastes that can lead to groundwater pollution. If groundwater pollution does occur, then the funds must be available in the dedicated trust to remediate the contaminated areas. Basically, the dedicated trust should be developed based on plausible worst case scenario failures that could occur associated with the capped waste management unit for as long as the wastes in the capped area will be a threat.

References

Cherry, J.A., 1990. "Groundwater Monitoring: Some Deficiencies and Opportunities," In: Hazardous Waste Site Investigations: Towards Better Decisions, Lewis Pub. Berven & Gammage, eds., proceedings of 10th ORNL Life Sciences Symposium, Gatlinburg, TN, May 21-24.

Dunn, R.J. and Singh, U.P. eds. 1995. *Landfill Closures: Environmental Protection and Land Recovery*, Geoptechnical Special Publication No. 53, ASCE, New York.

GAO. 1990. "Hazardous Waste: Funding of Postclousre Liabilities Remains Uncertain, Report to Congress, GAO/RCED-90-64, US General Accounting Office, Washington D.C.

Keller, C. 1995. "How Well Can, and Should, Landfills be Monitored? A Summary of Several Landfill Monitoring Designs Developed by Flexible Liner Underground Technologies," Flexible Liner Underground Technologies Ltd., Santa Fe, NM.

Keller, C. 1996. "A Reliable Landfill Monitoring System, Leakage Barrier, Plus Remediation Method, in One Design, Flexible Liner Underground Technologies Ltd., Santa Fe, NM, presented at Geological Society of America, Austin, TX.

Lee, G.F. and Jones-Lee, A. 1994a. "Landfills of Solid & Hazardous Waste: Facing Long-Term Liability," proceedings of 1994 Federal Environmental Restoration III and Waste Minimization II conference, Hazardous Materials Control Resources Institute, Rockville, MD, pp. 1610-1618.

Lee, G.F. and Jones-Lee, A. 1994b. "A Groundwater Protection Strategy for Lined Landfills," *Environ. Sci. Technol.* 28(13)584-585.

Lee, G.F. and Jones-Lee, A. 1994c. "Does meeting Cleanup Standards Mean Protection of Public Health and the Environment?" *In: Superfund XV Conference Proceedings*, Hazardous Materials Control Resources Institute, Rockville, MD, pp. 531-540.

Lee, G.F. and Jones-Lee, A. 1995a. "Recommended Design, Operation, Closure and Post-Closure Approaches for Municipal Solid Waste and Hazardous Waste Landfills," Report to Greenpeace Mexico, G. Fred Lee & Associates, El Macero, CA.

Lee, G.F. and Jones-Lee, A. 1995b. "Overview of Landfill Post Closure Issues," presented at ASCE national conference session devoted to "Landfill Closures-Environmental Protection and Land Recovery," San Diego, CA, Report G. Fred Lee & Associates, El Macero, CA.

Lee, G.F. and Jones-Lee, A. 1996. "Superfund Site Remediation by On-Site RCRA Landfills: Inadequacies in Providing Groundwater Quality Protection," proc. Environmental Industry Association's Superfund/Hazwaste Management West Conference, Las Vegas, NV, pp. 311-329.

Whitman, I.L., "Brownfields Initiatives: Progressive Approach to Solving Urban Environmental Problems," *Environmental Progress*, 15(4) W3, Winter (1996).

~~~~~~~~~

Reference as: "Lee, G.F., and Jones-Lee, A., 'Hazardous Chemical Site Remediation Through Capping: Problems with Long Term Protection,' Remediation 7(4):51-57 (1997)."
~~~~~~~~~