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WHEN HAZARDOUS WASTE THREATENS THE GROUNDWATER . . . .  
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ABSTRACT  

Hazardous Waste is a term being applied to the by-products of an increasing number of manufacturing and industrial concerns. Wastewater from a wide variety of processes now falls under regulatory controls. If the wastes are spilled, leaked, stored or otherwise brought into contact with the ground surface, there is always the possibility of groundwater contamination. Once wastes are in contact with the groundwater, they will move in the direction of local groundwater flow, and may contaminate water supplies or watercourses at some distance away. The liability problems associated with hazardous waste are tremendous.  

This paper examines the current groundwater protection regulatory requirements and climate regarding remedial work on existing lagoons and containments as well as for new siting and design of similar facilities. Remedial methods such as sludge stabilization, underground leachate barriers and waste removal are described. New containments usually involve lined facilities where synthetic or clay barriers with intervening drainage layers are used to protect the groundwater.  

Two case studies are used to illustrate typical problems. The first is located in Ohio and describes the cleanup of PCB oil-contaminated lagoons and the surrounding underground area. The work consisted of liquid disposal, sludge stabilization, removal, containment construction and permanent on-site disposal. The second site consists of a new lined disposal facility located in Oregon which incorporates many of the latest design and safety features required under the regulations. Synthetic liners with special drainage grids are used to minimize the risk to the environment.  

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INTRODUCTION

If there is any trend in the hazardous waste "industry", it has to be the realization on the part of government and corporations that the best available technology must be used to protect groundwater from hazardous wastes. A corollary to this might be that cookbook solutions are not the best; the complexities of above and below ground site conditions, characteristics of the wastes to be controlled, and other relevant factors dictate unique solutions on almost every project. There is clearly a difference between what is practical for remedial work and what can be done for new containments. For new installations, it is possible to design a system that will assure that wastes will not come into contact with groundwater. However, the options may be more limited in the case of remedial work on inadequately designed old sites. Only on relatively small sites is it possible to completely remove wastes from the site. Once the groundwater is contaminated, it is essentially impossible to flush it clean. To remove all the contaminated soil and waste from existing inadequate sites to new disposal areas would involve removing large chunks of America and creating vast numbers of new containments to hold wastes. Instead, the usual approach is to stabilize the wastes and/or to create on-site containments.

For the same reason that it is not possible to create a cookbook solution, it is also not possible to cover all eventualities in a short presentation. For this reason, this paper uses two case studies to illustrate solutions to two fairly typical problems.

The first case involves remediation of an existing disposal facility that had stored wastes in clay-lined pits. The principal pollutants in the oily sludges were PCB's. The liquid phase of the lagoon was pumped off and disposed of. The sludge was stabilized and removed to a temporary stockpile while the lagoons were properly lined. Eventually, a slurry cutoff wall would be constructed around the entire site as a backup containment measure.

The second case involves a new chemical disposal facility. It incorporates the latest in synthetic lining technology to protect the environment with backup liners and intervening drainage layers to collect any potential leakage.

CASE STUDY

REMEDIAL CLEANUP

A major chemical waste disposal facility used clay-lined lagoons to store liquid wastes prior to deep-well injection. New EPA guidelines mandated the closing of these lagoons.
The closure plan for the site included the following major activities:

1. Enactment of comprehensive health and safety plans and procedures to ensure worker well-being.

2. Stabilization and solidification of the liquids and sludges contained in the lagoons.

3. Transport and temporary stockpiling of the stabilized sludge to a secure staging area.

4. Construction of a secure landfill for the permanent disposal of the stabilized sludge.

Health and Safety

Due to the presence of heavy metals and toxic organic chemicals, including PCB's and Dioxin in the sludge, it was necessary to provide all workers with the best available safety training, equipment and monitoring.

In order to ensure personnel health and safety, all workers received a comprehensive training course to prepare them for working on hazardous waste clean-up. All personnel were subject to medical monitoring to evaluate their health, and personal protection was provided for them at each work station. All workers were equipped with a splash suit, self-contained breathing apparatus, and full face protection. Project safety was monitored by Site Safety Officers and Certified Industrial Hygienists.

The benefits of a comprehensive health and safety plan are obvious, but the cost can be measured in lost time, slower production, and extra manpower. Most of the work on sludge solidification required the workers to be equipped with EPA Level B or C personnel safety equipment, so a part of the working day was necessarily spent dressing, adjusting safety equipment and decontamination. When atmospheric conditions reach temperatures in excess of 80°F workers may fatigue easily when dressed in safety equipment and must be monitored for stress. Frequent rest breaks help reduce stress but may decrease productivity.

Sludge Stabilization

Solidification/stabilization is the treatment process by which a sludge is chemically altered to detoxify, limit solubility, and to improve handling and physical characteristics.
Before construction began, a bench scale mixing experiment was performed to evaluate various reagents and their compatibility with the sludge. In order to be considered as a solidification reagent, a material must be available in sufficient quantity, quality, and in a readily usable form. The reagents usually considered for solidification are:

- Flyash
- Sodium Silicates
- Lime
- Pozzalonic Cement
- Cement
- Kiln Dust
- Proprietary chemical additives to any of the above.

The objectives of these experiments were as follows:

1. Determine the most cost effective reagent or combination of reagents.

2. Determine the cure time of the stabilized sludge, i.e., time between mixing with reagent and the time stabilized sludge achieves a "soil-like" strength.

3. Determine the final stabilized sludge properties; i.e. leachability, strength, permeability, etc.

4. Determine the increased volume of the stabilized sludge.

Preliminary laboratory results indicated that a combination of reagents would give satisfactory results. However, due to the extremely variable nature of the sludge, the mixing scheme and reagents would have to be adjustable to handle variations in sludge liquid content and chemical composition. Simply, this meant that more reagent and mixing would be needed for thick sludge than thin sludge. Typically, the density of the sludge increased with depth and the chemical variation was unpredictable.

An earlier attempt by the owner at solidification using a central mix plant had proven unsuccessful. The difficulty of handling the sludge and adjusting the amount of mixing had doomed this effort. Pneumatic placement and mixing methods had been given serious consideration; however, no method of controlling the dust generated by this method was found which was both effective and practical. Pneumatic placement methods were also considered to be considerably slower than the method which was finally implemented. Hydraulic excavators and custom built reagent applicators were chosen to mix and place the reagent.

To further test the reagents and the proposed method of application, a pilot project was undertaken to solidify a small lagoon. It was demonstrated during the pilot project that hydraulic excavators could effectively accomplish the mixing. Reagent was applied to selected grids of the pond and measured amounts of reagent applied through custom-designed applicators. (See Fig. 1) By continuously mixing the sludge while adding reagent, it was possible to
determine by observation when a sufficient amount of reagent was used. In this way, the sludge was solidified in-place, without the need for curing ponds, long waiting periods, or the possibility of additional applications of reagent. In-place solidification also eliminated the need to work from on top of the sludge. After the sludge was mixed, it quickly obtained a "soil-like" consistency, and therefore could be transported to the staging area.

It was found to be advantageous to draw off as much liquid as possible from on top of the sludge before solidification. This resulted in decreased reagent usage. The liquid was disposed of by deep well injection. Sludges with as little as 20% solids were solidified.

Three large ponds containing approximately 180,000 c.y. of sludge were eventually solidified. The hydraulic excavators mixed reagent into sludge as deep as 15 ft. (See Fig. 2)

Solidified sludge was transported from the lagoons to a secure staging area. In the staging area, the solidified sludge was compacted into a stockpile. This permitted additional curing of the sludge and reduced the required storage area. By emptying the lagoons, it was possible to refit and reuse the lagoon space for the permanent disposal of the stabilized sludge.

Lagoon Containment

Before the lagoons could be reused, it was first necessary to remove all the contaminated soil beneath the sludge. Once this was accomplished, the side slopes and lagoon floors were reshaped for the new containment.

The refitted lagoons employ at least three hydraulic barriers and four monitoring/collection systems. The principle features of the secure landfill are as follows:

1. Leachate collection systems above and below the liner system.
2. Double liner system of HDPE geomembrane and compacted clay.
3. Soil-bentonite slurry wall surrounding the site.
4. HDPE geomembrane cap and soil layer over the compacted solidified sludge.
5. Monitoring wells through the cap, around the sludge, and outside of the slurry wall. A typical cross section of the system is illustrated in Figure 3.
The function of the leachate collection system on top of the liner was to minimize leachate contact and eliminate hydraulic pressure on the liner. The leachate collection system could also be connected to a treatment plant. The leak/detection layer beneath the liner system provided a monitoring system directly beneath the liner to alert the operators in case of a primary liner failure. This layer also served to collect leachate or groundwater which may enter the containment.

The liners chosen for this project were HDPE (High Density Polyethylene) and a native compacted clay. It is believed that, by providing two liners of dissimilar materials, the liner system will be more resistant to chemical attack. HDPE was chosen for its superior chemical resistant properties and because of the seaming system: fusion-extrusion welding. The native clay was also found to be compatible with the expected leachates and thus acceptable when properly compacted.

The solidified sludge will be compacted into a monolithic mass in the containment and capped with HDPE geomembrane and a soil cap. The cap is graded to drain runoff away from the containment, and prevent any ponding.

The containment is hydraulically isolated from nearby clean areas by a slurry wall. The slurry wall also provides a final barrier to pollutant migration should the lagoon liners fail. It is possible to create a reverse gradient system by lowering the water table inside the slurry wall. The local hydraulic gradient would then be toward the containment, thus eliminating the possibility of pollutant migration off site.

Monitor wells are strategically placed to permit sampling and evaluation of the solidified sludge and the containment. Movement of leachate can be quickly detected.

CASE STUDY - NEW FACILITY

A waste disposal company has a number of hazardous waste lagoons and containments throughout the country, one of which is in northern Oregon. This site required an extension to its capacity in the form of a new cell with a "state of the art" liner system. The system was designed to meet new EPA guidelines which require a double liner with a leak detection layer between the liners and a leachate collection system above the top liner. The guidelines do not specify what type of liner or drainage material that is to be used but set performance criteria that must be met by each layer of the system.

The design of the liner system chosen called for a synthetic liner, leak detection and leak collection system. The following is a description of each layer of the system (starting from the bottom going to the surface) describing its function, type of material, method of installation and on site testing methods and equipment. (See Figures 4 & 5).
Secondary Liner

This liner was a 60 mil High Density Polyethylene membrane. The function of this layer was to intercept any possible leakage through the primary (top) liner and channel it to sumps where it can be removed. Seams were welded using a double hot wedge welder that produced a weld with an air space between two strips of weld. This air space was sealed at each end of the seam, a needle pushed into the space and the space pressurized. The pressurization of the seam area showed if there were leaks and also stressed the weld, thereby testing its strength.

All cross joints were welded with extrusion welders which were vacuum box tested to check the seam's airtightness. Destructive testing was performed on daily test welds. Coupons were taken from these samples and tested in shear and peel; only when these tests passed was the welding machine deemed ready for use. Further tests were carried out on sections cut out of the insitu welds at regular intervals. Finally, all seams and sheets were visually checked for defects and holes.

Leachate Detection

This layer was provided for the collection and transport of any possible leakage through the primary liner. The material used was a high density polyethylene geonet which permits the flow of liquids even when sandwiched under high loads between two membranes. The advantages of this material are its ability to withstand attack by a large range of chemicals and that it allows high transmissivity despite its very thin cross section. The latter property provided a significant advantage over a thicker layer of porous sand. A sand drainage layer takes up valuable volume and also requires the use of heavy equipment to place it. The use of heavy equipment introduces the possibility of damaging the liner. A single layer of net was used on the sideslopes and a triple layer on the bottom of the cell. The extra layers of net on the floor were necessary as grades were much flatter.

Primary Liner

This liner was laid directly on the geonet and was identical to the secondary liner. Its function was to prevent the leakage of rainwater and any of the contents of the landfill into the leak detection system.

Leachate Collection System

This is a drainage/collection system on top of the primary liner that enables the collection of leachate which can then be pumped out of the landfill and treated. This layer was made up of a geonet on the bottom and a geotextile at the top. The geotextile is to prevent dirt and debris from getting into the net and preventing flow.
The Composite System

Both leak detection and leachate collection systems drain to sumps from where the liquid is pumped out through risers. This enables the operators to collect leachate for treatment and also to determine if the primary liner is leaking and how much. The sideslopes were covered with a 100 mil HDPE cover and the floor was covered with three feet of soil to protect the liner system during its operating life.

The unusual feature of this liner system is its all-synthetic composition. (See Fig. 6) This greatly reduces the volume taken up by the liner/drainage system. Another advantage is that the total system is installed by the liner installer who has an appreciation of the requirements that are needed to prevent damage to the liners.

CONCLUSION

These case studies illustrate a number of important points. Solutions must be site and waste specific; there is not one solution that will work like a vaccine for all situations. There are many recent technical advances that have improved the safety and reliability of hazardous waste containments. It is usually in everybody's best interest to use the best solution available; the impact of leaks is too great to cut corners.
FIGURE 1
Reagent Applicator
FIGURE 2
Sludge Stabilization
FIGURE 3
Typical In situ Landfill Section
FIGURE 4
Liner And Drainage System

FIGURE 5
Detail Liner Cross Section
FIGURE 6
Cross Section of Liner and Drainage System