

**GOLF COURSES TO GREENHOUSES — AND BEYOND
RE-DEVELOPMENT OF CLOSED LANDFILLS**

**James J. Walsh, P.E.
Anthony J. DiPuccio, P.E.
Regina A. Simon**

**SCS Engineers
2060 Reading Road
Cincinnati, Ohio 45202
(513) 421-5353
Fax (513) 421-2847**

**GOLF COURSES TO GREENHOUSES — AND BEYOND
RE-DEVELOPMENT OF CLOSED LANDFILLS**

INTRODUCTION

There has been much recent interest in reclaiming real estate formerly occupied by municipal landfills. Recent changes to regulatory programs offer both opportunity and new challenges for converting old landfills into productive real estate development.

Throughout North America, agencies of Federal, State and Local government have begun new initiatives to redevelop formerly used sites which are “tainted” environmentally. The initiatives have been given various names, including Land Recycling in Pennsylvania, and Brownfield at the U.S. Environmental Protection Agency.

From the legal perspective, there are several concerns which must be addressed when redeveloping a former landfill site for a productive use. Liability concerns regarding potential environmental claims under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund) can dissuade private developers and their lenders. Technical challenges to reusing landfills include the problems presented by settlement, foundation support, gas generation, and worker health and safety.

LEGAL ISSUES

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund), owners or lessees of facilities from which there has been a

release or a threatened release of a hazardous substance can be liable for all public and private costs of response to the release, even if the release took place many years earlier. The liability can be imposed even if the facility owner or operator was not negligent (the liability is "strict"). And response costs for typical landfill sites under Superfund can be substantial (e.g., the U.S. Environmental Protection Agency assumes an average \$25-30 million for sites listed on the Superfund National Priorities List).

The prospect of strict, joint, several, retroactive, and substantial liability for Superfund response costs presents a challenge for anyone seeking to redevelop a landfill. Of course, such environmental stigma are not unique to landfills; many former industrial properties also lie dormant and undeveloped due to Superfund concerns. A new term, "Brownfield," has been given to restoring tainted properties to productive use by overcoming the stigma associated with limited or moderate environmental contamination caused by previous site uses.

Federal and state agencies have begun to address the Brownfield problem with a series of initiatives. The U.S. Environmental Protection Agency announced a series of new policies and initiatives in 1995 to promote redevelopment of Brownfield areas. These include increased use of negotiated covenants not to use Superfund to sue developers trying to redevelop tainted lands, and new policies not to pursue innocent landowners affected by migration beneath their property of contaminated groundwater from offsite.

Municipal owners of landfills also will benefit from several EPA Superfund initiatives which recognize the unique position municipalities hold as government agencies primarily responsible for the health and welfare of their citizens. Superfund is not well-suited to municipal landfill sites, in which large quantities of household trash are mixed with relatively small amounts of hazardous substances from industry. EPA has announced a presumptive remedy for landfill sites (capping), and has demonstrated a new flexibility in dealing with municipalities which own landfills.

TECHNICAL ISSUES

As it ages, municipal solid waste in a landfill decomposes and consolidates. Active settlement can take place for many years, depending upon the depth of the trash fill, the types of wastes present (e.g., construction and demolition waste versus municipal solid waste), and the method of placement (e.g., trench versus area fill). Before buildings or other improvements can be constructed on a landfill site, estimates of expected settlement must be made based upon experience, empirical settlement observations, and numerical models.

Heavy loads will surcharge the waste mass and accelerate consolidation and settlement. Many site operators stockpile cover soils or excess waste, on portions of the landfill prior to final closure; such operating practices should be identified and considered when estimating settlement and differential settlement rates.

Although some buildings have been constructed using floating foundations (normally after replacing a few feet of the underlying trash with structural fill), most larger buildings and sensitive structures constructed over landfills utilize deep foundations (e.g., piles or caissons). A combination of the two approaches has been used over old shallow

landfills, in which building walls are constructed on piles or caissons, while a floating slab is used for the building floor.

The result often is a stable building, surrounded by a settling ground surface as the underlying landfill consolidates. At one California landfill, a hinged slab was connected to a retail building on one side, and allowed to “float” with the land surface on the other side. If settlement causes the slab to sink too far on the floating side, it can be jacked up and the land surface regraded to create a proper entranceway to the building.

Where utilities enter natural ground or fixed structures supported on deep foundations, allowance must be made for differential settlement. Flexible utility connections have been developed for such applications. Pipe runs beneath buildings constructed on deep foundations should be hung from the overlying structural concrete slabs with non-corrosive hangers, and surrounded by non-cohesive backfill material. Otherwise, settlement of the underlying fill could cause the pipe to be pulled away from the building.

As solid waste decomposes, landfill gas (LFG), consisting of methane and carbon dioxide, is produced. If allowed to accumulate within a confined area in the presence of an ignition source, methane can explode. Any improvements constructed on or near a landfill should incorporate appropriate LFG protection measures.

Several approaches are available to protect structures from LFG. Active control technologies include LFG extraction (normally followed by flaring, if gas production rates warrant treatment) to remove landfill gases before they reach structures, and air injection or air curtain systems to create positive pressures, driving landfill gases away from structures.

Passive control technologies include use of membrane barriers and vents to prevent gases from entering structures, and monitoring and alarm systems to warn of accumulating gases. Passive systems are commonly used where the landfill is old, and most of the decomposition has occurred (i.e., gas production rates are low). Passive systems also may be appropriate where the building will have limited usage, or is of open construction (e.g. open parking structures having six or more air changes per hour).

LFG control systems protecting higher occupancy buildings often have redundant systems (e.g., barriers, active extraction, and monitoring alarms), especially when the landfill is not old. Special care must be taken where utilities or other site features penetrate barrier systems; LFG will follow preferential flow paths along utility trenches and enter buildings at points of penetration unless properly sealed.

LFG protection systems require proper operation, monitoring, and maintenance. Monitoring alarm sensors can become “poisoned” by LFG constituents and rendered useless. LFG condensate and corrosive gas constituents can affect mechanical systems. As the closed landfill ages, LFG production patterns change, requiring adjustments in extraction system operation.

Landfills contain wastes, some of which may be hazardous. Older landfills--those which predate regulations requiring hazardous wastes to be managed in separate hazardous waste facilities--can contain a variety of industrial wastes such as solvents and sludges

which require special handling and care if excavated. Many landfills were used to dispose asbestos-containing building materials, which also require special handling and regulatory notifications.

Workers who may be exposed to hazardous substances during excavation of utility trenches or other subsurface site features should be properly trained to handle such materials safely. Work space air monitoring and perimeter air monitoring may be necessary to assure that site workers and neighbors are not harmed by migrating chemicals. Documentation of training, monitoring, and medical monitoring may be required by Federal or state regulations. If drums of liquid wastes or other special materials are encountered during the construction activities, special contingency plans should be put into effect to characterize and stockpile such materials.

A written health and safety plan, specific to work on landfills, should be prepared and followed during construction. The Solid Waste Association of North America has published "A Compilation of Landfill Gas Field Practices and Procedures" (March 1992) which provides some common-sense elements for such plans.

CASE STUDIES

This section will present brief descriptions of case studies of re-development atop closed landfills. As the title suggests, individual case studies will address applications such as golf courses, greenhouses, and other construction. This paper will describe the following projects:

- City of Industry, a golf course development.
- Renaissance Park, another golf course development.
- Willow Run Farms, a greenhouse.
- Westport, an office building development.

City of Industry

The Industry Hills Recreation and Conference Center is located on the same development as two of southern California's most prestigious golf courses. The development also contains a conference center, Olympic-sized swimming pool, a tennis complex, equestrian center, laundry facility, and 11-story hotel. The 617 acre site includes 155 acres formerly used for sanitary land filling purposes between 1951 and 1969. The facility is located approximately 10 miles east of downtown Los Angeles, California. About 3.6 million tons of municipal waste were deposited into the landfill, which has an average refuse fill depth of approximately 35 ft.

The LFG management facilities at the project consist of two main systems, with the initial installation in February 1974. The first system prevents the accumulation of methane gas beneath on-site structures, and migration beyond property lines. Migrating LFG is collected and then destroyed at a blower/flare station capable of burning 500 cfm of LFG.

The second gas control system was designed for LFG energy recovery. While this system aids in LFG migration and surface emission control, it also supplies medium Btu fuel for convention center boilers and water heaters for the Olympic-size pool and

laundry complex. The LFG process facility compresses and cools the gas to remove free liquids, and is capable of supplying approximately 2,100 MM Btu fuel each month. This saves the City of Industry approximately \$10,000 to \$15,000 each month in displacing natural gas demands.

Operation and maintenance of the gas system is regulated by strict guidelines from a number of different state and local enforcement agencies. In addition to these strict guidelines, the design engineers have developed numerous operating criteria that present unique challenges to the facility's operators. Some of the major challenges are health and safety; coordination with numerous on-site personnel like security guards and ground maintenance crews; odor control; and maintenance repair and access.

Evidence of the development's success is apparent in the project having received two separate prestigious awards. The facility was awarded the "ASCE Outstanding Civil Engineering Achievement Award" in 1981. In 1997, it received the "SWANA Gold Award for Landfill Gas Projects".

Renaissance Park

Renaissance Park is a community recreation complex constructed atop a closed landfill in Charlotte, North Carolina. Facilities over the former landfill include soccer fields, softball fields, and a tournament level golf course. The City of Charlotte had owned and operated the site as a municipal solid waste landfill since the late 1960's. The landfilling operation was closed in 1986. The landfill comprises several discrete areas totaling approximately 375 acres of landfill footprint.

Several migration control systems were installed subsequent to landfill closure, including a passive LFG venting system around the golf club house, a passive vent trench along the northeast property line, and an active LFG migration control system along York Road (which contains several subterranean utility pathways and has occupied office buildings beyond).

Due to the open air nature of the recreational facilities placed atop the landfill, the original design concept did not entail comprehensive LFG collection through the landfill's interior surface areas. As a result, recreational facilities and other site improvements were left largely unprotected by LFG control systems. Theoretically, the absence of occupied structures atop the landfill proper, mitigated the opportunity for LFG combustion hazards, or other deleterious impacts due to landfill settlement.

In practice, several hazards have developed since the time the recreational facility at Renaissance Park (atop the landfill) was placed in service in the late 1980's. These problems, and their accompanying solutions, are delineated below:

- **Periodic Fire Hazards.** Renaissance Park has experienced periodic ground fires caused by the ignition of LFG emitting through surface cracks. Reports of periodic fires have developed over the years. Normally, LFG dissipates quickly into the atmosphere, so that such instances are not anticipated and do not occur. Other precautions have been taken including banning of open air fires and camp-outs atop the closed landfill, for obvious reasons. Continued attentiveness to this matter is required for the future.

- Fencing. Chain link fencing is common around the ball fields at Renaissance Park, and typically includes galvanized steel pipe for the fencing posts. These posts invariably fill with LFG, and present a potentially hazardous condition. Technicians have monitored methane accumulations in the fence posts to levels approaching 50 percent gas around the soft ball fields at Renaissance Park. As with many such conditions, the chances for ignition or other human hazards are low, unless fencing post caps are intentionally removed by vandals. An easy solution to this problem is to specify that each column fence post not have a hollow interior in which LFG can accumulate.
- Electric Boxes. Electric power is most often used for lighting and concession stands at recreational facilities. Panel box explosions have occurred at landfills due to the accumulation of methane entering via underground electrical conduit. Conduit seals should be used between underground conduits and electric panel boxes, to prevent this pathway for LFG migration. Outdoor panel boxes atop the landfill are not normally considered to be in a classified location per the National Electric Code. Hence, conduit seals are not required for the purpose of isolating combustible hazards, but rather serve as a barrier to block LFG potentially migrating through the conduit.

In 1993, a woman was injured in an explosion at Renaissance Park when she lit a cigarette lighter to find a soccer ball that had rolled under a flood light footer pad. The explosion is believed to have been fueled by LFG entering the void space created by landfill settlement around the footer pad. Several other fires on the golf course, and within an off-site utility trench have also resulted with the ignition of LFG accumulations and emissions.

As a solution, the City of Charlotte responded with an intense investigation of LFG hazards at Renaissance Park. With identification of areas in which combustible gas can accumulate, a remediation program was designed, and is routinely implemented. The key is to avoid the accumulation of combustible gas inside settlement cracks, settlement cavities, and other man-made structures as delineated previously.

Willow Run Farms

Development of greenhouses atop and adjacent to sanitary landfills has been suggested for many years. Energy represents a significant cost of operation for greenhouse installations. The availability of cheap energy from LFG recovery operation can create an opportunity to provide energy to greenhouse operations on a discounted basis. In addition, the settlement and other environmental and technical impacts from sanitary landfills can be better accommodated by most greenhouse operations, than would be the case with other more rigid structures.

Still, the opportunity exists for the uncontrolled entry of combustible gas to the greenhouse operation, due to its proximity to the landfill. Under these circumstances, the LFG collection system used for energy supply must be examined, and its comprehensive performance ensured for the safe occupancy of the greenhouse operation.

With these conditions as background, Wayne Disposal developed a greenhouse operation known as Willow Run Farms in Belleville, Michigan (Detroit metro area). The greenhouse consists of a 45,000 sq ft development, atop a 70-acre closed municipal solid waste landfill cell.

An active LFG extraction system including vertical wells has been installed throughout the 70-acre landfill development. LFG collected from this system is used to generate electricity on year-round basis. However, the LFG-to-electricity-operation generates revenue at a poor rate of only \$0.02 per kW-hour. During winter months when demand for cheap energy is highest from greenhouse operations, part of this fuel is diverted to a medium Btu application of greenhouse heating.

Willow Run Farms has spent more than \$500,000 on capital and operating costs associated with the greenhouse operation through its first four years. The investment includes the cost of erecting a 1 acre, 10-bay greenhouse supplied by Clover Greenhouse of Smyrna, Tennessee. Specialty crops including watercress, chives, basil, osaka red mustard, bib lettuce, and other items are grown in the greenhouse. Growth is enhanced at the Willow Run operation hydroponically, in a medium of water and nutrients. Thanks to this controlled environment, no herbicides or insecticides are needed. Since this is such a highly productive method, the farm is able to grow a crop from seed to package in only 5 to 8 weeks.

Westport Office Park

The Westport Office Park is a proposed development currently under construction in Redwood City, California. It is a 20-building, 980,000 sq ft project in a park-like setting planned for R&D facilities, office, and biotech applications. The 85-acre site was initially used as a municipal solid waste landfill beginning in the 1940's until 1970. The presence of underlying refuse has created challenging engineering issues for site development, including protection of structures from explosive gases, site settlement, and preservation of the clay liner.

The Westport project is one of the most ambitious projects ever undertaken on a former landfill site. The estimated site development cost of over \$100 million makes it the fifth largest project under construction in northern California. The target completion date is 1999.

SCS Engineers was retained by the general construction contractor to provide various landfill engineering, permitting, and construction management services. SCS prepared design plans and specifications for protecting site structures from potential explosive hazards associated with LFG infiltration. Construction observation services were provided thereafter to verify that the protection features were installed per the design plans and regulatory requirements. A comprehensive landscaping and drainage plan was also prepared. The objective of this plan was to protect the landfill cap from water infiltration and root damage, while promoting healthy long-term plant growth in a distressed environment.

Key protection and monitoring features have been designed and incorporated into the development. These include:

- Subfloor membrane, passive gas venting system, and a continuous automated combustible gas sensor network installed in each building.
- Subsurface gas migration barriers installed in site utility corridors.
- A venting system to relieve gas pressure build-up in parking lot areas overlying the deeper portions of the landfill.
- A leachate cut-off trench and subsurface gas venting and monitoring system installed at the development's property line.

CONCLUSION

Closed landfills have been successfully developed into productive land uses. However, the challenges inherent in development of a closed landfill are substantial. Experience has shown that technical challenges such as settlement, deep foundations, gas protection, and health and safety issues, can be met. Legal liability challenges continue to present impediments to landfill redevelopment. However, recent "brownfield" policy initiatives at the Federal and state levels, coupled with increasing experience on the part of national lending institutions, suggest that such impediments also can be overcome.