THE USES OF COMPLETED LANDFILLS*

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Abstract — Completed landfills can provide the base for parks and other beneficial land uses, thus serving to recycle waste products into new forms. However, the conversion is not trouble-free. This paper examines some of the uses to which completed landfills have been put as well as the problems which have been encountered to date, and suggests actions which planners and solid waste managers can take to mitigate some of these problems in the future. Information is based largely on experiences in Los Angeles County, California, where landfilling has been both practised and studied over an extended period.

INTRODUCTION

To the sanitation industry, "the man who works a landfill site is engaged in an occupation almost as old as that of the ancient shepherd who guarded and guided his master's flock"[1]. Journals serving the industry point out that the present cities of Rome and Paris are built on the discards of long forgotten ancestors, while in more recent times New York has filled marshlands to create such well known landmarks as La Guardia Airport and Flushing Meadows Park, site of the 1939 World's Fair[2].

The introduction of heavy equipment to compact the waste, allowing a greater mass to be deposited in a given volume, and the regular application of an inert material as a cover, appeared to represent an improvement over the traditional "open dump". Not only was the new process initially promoted as odour-free, producing neither air nor water pollution, but it also enabled land to be reclaimed for eventual recreational or other uses[3]. Proponents of "sanitary landfilling" stressed the advantages to cities of acquiring land at no cost, on which traditionally underbudgeted recreation and park departments could then establish golf courses, bridle trails, baseball diamonds, and other desirable public facilities. Nevertheless, neighbours of prospective sites generally continued to oppose sanitary landfills just as they had dumps, protesting potential odours, noise, visual blight, etc.[4] More recently environmentalists joined the fray, talking of leachate problems, gas migration, and subsidence. Sanitary engineers believe that the public's opposition is most often based on its failure to understand the difference between a sanitary landfill and a dump, although many concede that even the best run sanitary landfill is likely to have some adverse environmental and aesthetic impacts.

In 1975 approximately 18 500 land disposal sites were known to exist in the United States[5], receiving more than 85% of the municipal solid wastes generated[6]. In that year, only *ca.* 5600 sites were recognized as being in compliance with state regulations for sanitary landfills[5], but there has been a steady increase in the number of open dumps converted or closed down, and the recently enacted Resource Conservation and Recovery Act of 1976[7] calls for a prohibition on all such dumps within the next few years. Although considerable attention is currently being focused on methods of waste reduction and/or resource recovery to reduce the quantities of solid waste going either to dumps or to landfills, and despite increasing public opposition to the establishment of new landfill sites, it is likely that most municipal waste will continue to be deposited on the land, with little or no treatment, for many years to come. It is a fact that under

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existing economic conditions, when reasonably accessible locations are available, this method of disposal frequently entails the least financial costs[8]. Furthermore, even when waste reduction or resource recovery systems are employed, there are almost invariably residues that require land disposal.

It is not the intention of this paper to compare landfilling with other approaches to solid waste disposal; thus, the paper does not present the relative costs of different disposal methods, nor does it explore such issues as the conflict between landfilling and the preservation of wilderness values. Rather, on the assumption that many communities will continue to landfill their wastes into the foreseeable future, the paper focuses on the potentially positive aspect of this situation. As mentioned earlier, completed landfills when properly planned can be used for beneficial purposes, thus giving rise to the claim that landfilling itself provides a method of recycling waste materials. While the materials, once buried, are obviously lost for reuse in their original applications, they can in effect be converted into the base for parks and other land uses.

Unfortunately, there are problems associated with this conversion. The present paper examines some completed landfills and the difficulties that have resulted from the decomposition of the underlying materials. In so doing, it demonstrates the need for planners and decision-makers to consider future impacts and ultimate costs in selecting the final surface use of a landfill, and to provide appropriate mitigating measures from the onset of waste disposal. The examples used in this paper are drawn from the United States, particularly from Los Angeles County which currently depends on a regional system comprising more than 21 sanitary landfills for the disposal of all of its municipal solid waste. Although the climatic and other conditions in Southern California obviously differ from those found in many places elsewhere, the extensive experience that Los Angeles County has accrued in operating sanitary landfills resulted in its use as a model by the U.S. Environmental Protection Agency when the latter was studying procedures for incorporation into national guidelines[9].

USES OF COMPLETED LANDFILLS

Parks and recreation

Golf courses, parks, playgrounds and ball fields are the most popular uses for completed landfills[10]. Two golf courses are frequently mentioned: Detwiler Municipal Course in Toledo, Ohio, and Merrick Park on New York's Long Island. Detwiler is adjacent to a game preserve, also on a completed fill [11, 12]. In Bradenton, Florida, the city turned over the first completed 20 acres of a 100 acre site to the Pittsburgh Pirates baseball team for use as a training field. During the remainder of the year the ball diamonds are used as a city park[13].

Where land is flat, solid waste is sometimes being compacted into hills for recreational use. One hill that has received nationwide attention is in Virginia Beach, Virginia. Unable to place wastes below the surface because of high groundwater tables, city officials decided to build a 275 x 90m mountain of compacted trash. Now the highest point in the city and highly visible to local residents, the project, which was dubbed Mt. Trashmore, has retained the nickname as a permanent designation. When full developed, the site will have a 10 000 seat amphitheatre, soap box derby ramps, a hilltop garden, picnic areas and artificial lakes in sites from which cover material was removed. A second mountain is also planned[14].

A similar project has been underway for several years in DuPage County, Illinois, where the Forest Preserve District has completed a 45m recreational hill overlooking a boating and fishing lake excavated from three abandoned gravel pits. Also planned are two 75m ski hills, a 550m toboggan run, sledding runs, equestrian trails, hiking trails, picnic and camping areas, and an adjacent 22 hectare (55 acre) lake for boating and fishing. A third area in the county, Mallard Lake Forest Preserve, will feature a 70m ski hill and camping and picnic areas[15].

One of the largest recreational complexes on a fill in the United States is in Mountain View, California, where eventually a 220 hectare (544 acre) regional park will be completed. Five boating lakes, 22 holes of golf, a pitch and putt course, horseback and bicycle trails, and picnic areas are among the activities either under construction or planned. Development of topographic differentiation within the marshland site is to be accomplished through the addition of 200 000m³ of sanitary fill[16, 17].

Botanical gardens

Although botanical gardens are frequently listed as potential uses for completed sanitary landfills[18], the earliest, the South Coast Botanic Garden (SCBG) in Palos Verdes, California, appears to be the only such garden now in operation. A former diatomaceous earth mine, the site was purchased by the Los Angeles County Board of Supervisors in 1956 as a landfill site, but local interests received early assurance that the completed fill would be turned into a botanical garden. Planting began on a completed portion of the site in 1961; final cover was placed on the last of the 3.2 x 106 tonnes of trash in 1967. Today, the SCBG is a rolling, tree-studded landscape, highly compatible in appearance with neighboring residential areas. Among successful plant species are some 15 varieties of ficus, 29 species of palms, numerous deciduous flowering trees, and 17 species of pines.

Development

Cities throughout the country report residential and industrial developments atop sanitary landfills[10]. Mobile home parks are common[19]. Some more ambitious plans have also been formulated: in 1973, for example, a proposal was made to create an island in New York Bay out of trash to be collected over a 30-yr span from New York, New Jersey, and Connecticut. The island would contain parks, a power generating station, and an industrial complex[20].

Other

Land reclamation as a means of eliminating eyesores due to abandoned quarries, mines, stripmines and eroded gullies is a common and politically popular use[21]. Other completed sanitary landfills have been developed as parking areas, airport runways, and goods-transfer yards[10].

PROBLEMS WITH COMPLETED LANDFILLS

The reasons

Significant problems have been encountered with completed sanitary landfills, including subsidence, water pollution, and gas migration. Although all were known to exist before 1960, they are seldom mentioned in professional journal articles advocating beneficial uses of completed sites*[2]. If there has been an oversell of sanitary landfilling, much may simply have resulted from inadequate knowledge of the decomposition processes within a landfill. The substitution of the word "landfill" for "dump" has led to confusion in some cases over whether a reported use was actually on a sanitary landfill. Two major differences between the old and new

*To some extent there has been a conscious effort on the part of local solid waste managers to accentuate the positive and ignore the negative. An article in *Solid Waste Management Journal* set forth the strategy: "one important way to enhance the local public acceptance of a landfill in some specific location would be to have a beneficial purpose planned for the completed site and emphasize this goal before the undertaking is even begun"[4].

An example of this approach appeared in the *Los Angeles Times* in August 1964 ("Ugly Canyons Blossoming into Parks" by Ron Kenner). F. Bowerman of the Los Angeles County Sanitation Districts was quoted as saying, "Can you imagine getting into Bel-Air Brentwood (an affluent Los Angeles suburb) with a dump? We did it. We did it over strong objections, but now those people like us because we're building a golf course. They're going to be right on the edge of it, with a view of the greens. What more can you ask?" In 1977, Mission Canyon neighbors are still waiting for the golf course and meanwhile they are fighting to prevent the Districts from using the Canyon for many more years of waste disposal.

landfills are the depth and type of decomposition. Where earlier landfills on marshlands may have averaged 9m in depth, today's sanitary landfills are often 90m. Decomposition rates differ markedly between aerobic and anaerobic decay, thus requiring experience to predict long term impacts accurately.

Most of the materials in a sanitary landfill will eventually decompose, but at varying rates. Food wastes decompose rapidly and are moderately compactible, but they represent only a small portion of domestic waste in areas such as Los Angeles where home garbage disposal units are in widespread use[22]. Garden wastes also decompose rapidly, but are often resilient and difficult to compact. The decay rates of paper and wood products are slower than those of food wastes. Although car bodies and household appliances rust slowly, the process is aided by organic acids from decaying wastes. Rubber decomposes very slowly, most plastics not at all. Leather and textiles also decompose very slowly while inert rocks, dirt, ashes, and construction rubble, although usually easily worked and compacted, will not decay[23].

The density of solid waste in a landfill is quite variable. Although an inplace density of 890kg/m^3 (1500 lb per cu yd) can be achieved, moderate compactive efforts achieve only 475–590kg/m^3 (800–1000 lb per cu. yd)*. Subsidence in landfills is a function not only of initial compaction of refuse materials, but also of refuse compaction due to surcharge loads, volume reduction caused by biological decomposition of the organic constituents of the refuse, volume reduction caused by saturation and the nature of refuse materials themselves, including compressibility, and volume reduction resulting from removal of leachable materials[24].

THE NATURE OF PROBLEMS

Subsidence

Subsidence, the most common problem, has proved to be far more protracted than earlier believed. A 1960 article in *Public Works* declared: "as a rule, *ca.* 90% of the total settlement occurs in the first two to five years. The remaining 10% may be of such a long range character as to have little bearing on the planned grades for the site"[2]. However, the South Coast Botanic Garden in California reports that subsidence shows no evidence of slowing down, with the oldest (14 yr) section of the garden being the area most affected[25].

The City of Burbank had the first municipal sanitary landfill in Los Angeles County. Begun in 1949 and completed in 1968, the city finds that the best use of the completed fill is as an unpaved parking lot. The city's experience indicates few problems with a newly constructed landfill — 10 yr may elapse before serious troubles appear. Because of subsidence, no attempt has been made to pave the lot. Truckloads of dirt are brought in every two years and the surface regraded[26].

At the SCBG, differential settlement produces gently rolling surfaces that are quite pleasing to the eye of the casual observer. Garden officials believe that the effect could have been obtained more easily with a bulldozer, and with much less grief. Subsidence has resulted in almost constant water pipe breakage (2 or 3 times a week), regular jacking up of appurtenant structures, cracking and draining of the artificial lake, slumping of slopes, and loss of plant material. Especially serious is the impact on drainage patterns; the site is the natural drainage system for surrounding hills. With subsidence new depressions continually appear, creating spots where water can pond[25].

Gases

Biological decomposition in sanitary landfills and refuse dumps results in the production of gases, among which are methane, carbon dioxide and hydrogen sulfide. Control of these gases has been of increasing concern to those developing subsequent uses of landfill sites[27].

*Los Angeles County Sanitation Districts operate in the middle range. Bob Van Heuit, Chief Operating Engineer, considers the energy needed to reach the maximum density excessive and not practical.

Depending upon the permeability of the cover material or the soils at the boundaries of the fill, methane produced within a landfill may migrate and collect in nearby closed spaces. When this occurs, conflagration is possible given the right mixture of oxygen and methane and an ignition source. Several fatalities and cases of serious injury have been attributed to the escape of landfill gas[27]. Problems with gas emissions were anticipated by landfill designers and measures taken to prevent problems. Traditionally, engineers have sought to control the escape of methane through the use of "tiki" burners — pipes installed in and near the periphery of the landfill, with the surface around the pipes sealed to prevent leakage. Gas is collected through the pipes and burned at the top. The height of the burners varies, but should be at least 10 ft above grade for safety. (The flame is white and thus invisible.) A more sophisticated method of control is the installation of a network of perforated pipes buried in shallow, gravel-filled trenches on or around the landfill. Both of these methods are reasonably effective in reducing the danger of gas explosion or fire in the immediate vicinity of the landfill; they do not, however, significantly restrict the flow of gas through the soil into surrounding areas[19].

Where gases migrate to the surface of a landfill they create fissures. At the SCBG, several of these fissures criss-cross the garden and have resulted in structural damage. However, the most serious problem there resulting from the upward migration of gases is abnormally high soil temperatures. Throughout the garden, fill decomposition results in soil temperatures between 21 and 32°C, compared with average temperatures ranging between 13 and 21° on neighbouring property. Although vegetation has been selected to tolerate this higher temperature range, no plants are able to withstand temperatures near existing active fissures or in hot spots which appear prior to the development of a fissure. In these locations soil temperatures range from 49 to 71° [28]. Plants suddenly wilt and die within a matter of three or four days. Vents are installed as plant indicators show the emergence of a new hot spot.*

Gas may also be present in concentrations below the level of either flammability or toxicity but sufficient to cause headaches in occupants of buildings on or near a landfill site.

Water pollution

Completed sanitary landfills have the potential to pollute surface and underground water supplies. Contamination can occur from the percolation of leachates to underground aquifers, from surface runoff, from contact by groundwater on exposed wastes, and through the emission of carbon dioxide gas. Prevention of groundwater contamination has proved to be more complex than was originally anticipated. At first, it was believed that a lining of clay or some other impermeable material† at the landfill base would provide a barrier to leachates, but it has since been demonstrated that sides must also be lined to prevent seepage if the fill is near a groundwater supply. Mounding under fills has caused groundwater tables to rise until water is in contact with the landfill sides. Carbon dioxide escaping through landfills results in increased calcium hardness in adjacent groundwater if solid calcium carbonate is present within the soil[30]. Carbon dioxide will also corrode metal casings of nearby well linings.

Water pollution has little or no impact on the use of completed landfills, but the type of use affects the potential for contamination. Leachate is not produced until the refuse is saturated by infiltration. Studies have shown that in arid and semi-arid climates precipitation is generally lost to evaporation and unlikely to reach groundwater[31]. However, irrigation can simulate a wetter climate. Constructing the final fill surface and slope for maximum runoff is an inexpensive way to reduce infiltration, but such a slope may not be consistent with the final use. Subsidence, as noted

*Although technically the Los Angeles County Arboreta Department is responsible for correcting all problems at the South Coast Botanic Garden, the Sanitation Districts have continued to install vents and wells as needed.

†Linings made of various materials, including asphalt, rubber, and plastic have been tried in the U.S. and elsewhere. However, the process of lining a landfill effectively is both difficult and costly[29].

earlier, leads to ponding and excess percolation. Compaction of the top cover was formerly considered sufficient to provide an impermeable layer; however, tree roots and fissures caused by gases working to the surface provide openings whereby irrigation water can reach refuse layers. Leaks from breaking water pipes also result in added moisture reaching the fill[32].

Odours

Mercaptans, which are malodorous gases, are found in lower concentrations than are methane and carbon dioxide, but can be annoying, if not particularly dangerous. Venting is required to dissipate these gases into the air; if they are allowed to concentrate, the problem intensifies. Even with precautionary measures that confine the problem to small areas, odours are present in sections of the South Coast Botanic Garden, most noticeably near hot spots.

In Burbank the unpaved parking lot is adjacent to the city's outdoor theatre. As long as the parking lot's surface was regularly scarified to permit gas release, there were no problems. When the lot was oiled to keep down dust, gases collected below the surface and an odour problem developed[26].

Cover material

Depth and availability of final cover can be a problem, depending on the planned ultimate use. The Environmental Protection Agency recommends 0.6m as a minimum cover[33]. In rural areas or mountain canyons where the tops of adjacent mountains can be leveled, procurement of this soil is relatively simple, but, in developed areas, availability of cover material may be expensive: in 1950 the City of New York estimated it would cost $8,500,000 to import sufficient top soil for the 770 hectares (1900 acres) of landfill then nearing completion[2]. Sand was dredged from offshore and mixed with sewage sludge to provide a growing medium.

Abandoned mines and quarries are desirable sites from a land reclamation point of view, but may present other problems. (Quarries are usually located near old river beds and are frequently above aquifers, thus presenting greater risks of water pollution.) Soil in and around abandoned mines may contain toxic material which could inhibit plant growth; in the case of the South Coast Botanic Garden, the diatomaceous earth was void of nutrients and has necessitated heavy maintenance to ensure productivity.

Depth of cover is the critical factor. The 0.6m minimum is adequate only for pasture and hay grasses[23]. When the completed fill is used for agriculture, the final cover must be deep enough for the fill to be undisturbed by plows and be sufficient to allow for the root growth of the anticipated crop. The SCBG site received 0.9m of final cover. Shallow rooted plant material was selected accordingly. Inability to put down deep roots results in plants that are somewhat stunted in growth compared to the same plants outside the fill. More serious is the loss of trees during spring windstorms which follow the rainy season. The garden's director believes that 1.5m of soil should be used throughout a botanical garden, with 3m available for speciment trees[25].

Not only is it necessary to provide an adequate initial final cover, but it is important to recognize a continuing need for a soil supply. Filling in recurring depressions is necessary to maintain drainage and to insure integrity of final design contours. Further, final and intermediate covers are gradually depleted as soil particles seep into small voids created by decomposition of the organic fraction[31].

PLANNING AND ENFORCEMENT

Nearly all the listed problems can be corrected through proper planning. However, in many cases the expense of implementing controls will preclude certain uses. Local governments which will have the responsibility for maintaining a complete sanitary landfill should be aware of potential trouble areas from the beginning and take steps to design out as many adverse impacts as possible.

Landfill operating fees should be set to include not only the cost of land acquisition but also the landfill-related costs of development and maintenance.

In 1974 the United States Environmental Protection Agency issued guidelines for landfill design[33]. Included in the guidelines, which are binding on Federal agencies but are only recommended to State, regional, and local agencies, are the following:

> "Plans should describe projected use of completed disposal site. In addition to maintenance programs and provisions, where necessary, for monitoring and controlling gases and leachates, plans should address the following ultimate use criteria:
>
> 1. *Cultivated area.* The major concern if the completed site is to be cultivated is that the integrity of the final cover not be disturbed by agricultural cultivation activities. In this regard a sufficient depth of cover material to allow cultivation and to support vegetation should be applied in addition to that recommended for final cover.
>
> 2. *Structures.* It is not recommended practice to construct major structures on a completed land disposal site. If major structures are to be built near a completed land disposal site, a professional engineer should approve their design and construction including provision for protection against potential hazards of solid waste decomposition gases"[33].

In California, the State Solid Waste Management Board has issued similar guidelines in the form of Minimum Standards for Solid Waste Handling and Disposal[34]. Legislation giving the Board authority to enforce these standards throughout the State was enacted in 1976[35].

In addition to planning a completed use which will be in conformity with the community's general plan, the final planning for the site should consider the following:

1. *Subsidence.* Differential settlement of completed fills can be minimized through landfill construction practices. One method is the development of greater heterogenity of refuse layers by mixing refuse with inert materials. Although this practice will diminish the effects of subsidence, it is usually not considered to be politically feasible because of the shortened life of the landfill. Thicker daily cover is also recommended to minimize settlement. A study conducted by Engineering Science, Inc. for the Los Angeles County Engineer recommends a minimum compacted daily cover of 0.3m of soil.*[9].

It is advantageous to plan for utility corridors, roads, and building pads on natural soil. Surveys of previous landfills indicate that planning has usually been cognizant only of initial subsidence[9]. Because of the variables affecting decomposition, the total amount of subsidence cannot yet be predicted with reliability; estimates in the literature range from 25 to more than 75%.

Subsurface improvements are susceptible to the effects of differential settlement. Placing utilities in an openable trench may minimize the difficulty of correcting problems. Monitoring subsidence of underground utility lines can be facilitated by providing risers to the ground surface. The use of flexible piping reduces breakage problems. Any subsurface improvement that might come into contact with active materials should be protectively coated[9]. Engineers at the Palos Verdes, California, landfill have designed telescoping tubing for methane recovery wells.

Where structures must be built on fill, it is necessary to predict the potential loading. According to the Engineering Science report for Los Angeles County: "Piling should be designed for all vertical and horizontal loading, the down drag effects of frictional resistance to subsidence and settlement, and any floor loads transmitted directly to the fill adjacent to piling. Raft foundations

*Operators differ in the amount of cover applied to landfills in Los Angeles County, according to a report prepared for the County Engineer in 1968[19]. The Los Angeles County Sanitation Districts apply 15 cm of daily cover; the City of Burbank applies the same amount, but also places 0.6m of earth cover on each 1.2m of compacted refuse. The City of Los Angeles applies 23cm of earth cover to each 2.7m of compacted rubbish, plus daily cover if under 2.7m at close of working day. Burbank and Los Angeles (City) apply 0.6m of final cover while the Los Angeles County Sanitation Districts use an 0.9m final cover.

upon which the total stability of the structure is dependent are less desirable than piling foundations, but may be permissible. Spread footing and pads should not be permitted to rotate." Buildings founded on piles to bedrock will settle less than surface improvements over landfill cells. while buildings not founded on piles will settle more than surface improvements. Therefore, in both cases, it is necessary that flexible connections be provided between the building and the improvement[9].

2. *Gas control.* New landfills should provide both a gas barrier and a venting system. A successful gas control programme for landfills should include, as a minimum, careful investigations of landfill-produced gases and gas migration; a determination of the feasibility of gas control services; preparation of a design criterion for gas control; preparation of engineering details and drawings; construction supervision of facilities; and post-construction monitoring[36].

To sanitation engineers, the recent energy crisis has proven beneficial in one respect: the scarcity of natural gas has made it practical to consider recovering, purifying, and selling, commercially, methane produced in landfills[37].

3. *Water pollution.* In California, possible landfill contamination of groundwater is monitored. In order to obtain a "permit to construct" a landfill, plans must be submitted to the California Regional Water Quality Control Board (RWQCB) for the area, showing the hydrology and geology of the site, as well as the steps that will be taken to monitor, collect, treat and effectively dispose of leachates and runoff. The fill must be located above the highest anticipated elevation of the capillary fringe of the groundwater and must provide protection from 100 year floods. The burden of proof of incorporation of these features into landfill design rests with the landfill owners[31].

4. *Enforcement.* Regardless of the complexity of advanced planning, the measures will be effective only if they are adhered to in the day-to-day operation of the landfills. Groundwater contamination has occured in at least one incidence when a private California landfill operator violated the terms of the RWQCB permit by placing fill below the prescribed level[30].

Permits are also required in California from the local government in which the fill is located. In general, publicly operated landfills conform to established standards, and undergo regular inspection. Public agencies are continuing to conduct research and take action to reduce attendant problems.

Cities which issue permits for private, profit-making landfill operations are the most variable in the level of enforcement.* Recently, some cities have begun to tighten control over day-to-day operations of these private landfills and to set fees covering administration of enforcement activities. Of major concern is the determination of who will be responsible for the site after the landfilling is completed, and what, if any, plans have been made for the site's ultimate use †

CONCLUSIONS

Sanitary landfills are likely to continue to play an important role in solid waste disposal for many years to come, despite increased efforts at waste reduction and resource recovery. With care,

*Both the City of Montebello, California, and the State Solid Waste Management Board questioned the 1975 renewal of a conditional use permit to a private landfill operator by the City of Monterey Park because of the operator's violation of earlier permits [38, 39]. Neighboring Montebello was especially concerned about plans for the ultimate use of the site, asking "what do you do with a pyramid?" Although the permit was renewed, stricter controls were imposed.

† The City of Burbank is unusual among smaller cities in Los Angeles County in that it operates its own sanitation system, from collection to landfill. Since all costs, present and future, will be borne by local taxpayers, there is an incentive to develop a master park plan which will minimize total expense. In the Stowe Canyon landfill just getting under way, park officials are developing a master plan which will permit the golf clubhouse and other structures to be built on solid bedrock where topsoil has been removed to provide landfill cover. Park officials have asked that the city's Department of Public Works retain responsibility for necessary maintenance after completion of the fill, a departure from the more common practice throughout Los Angeles County where the agency which assumes responsibility for the surface must also correct any subsurface problems.

completed sites can and should be converted to beneficial uses. However, planners should not look to these sites as a panacea for solving other land use needs, but should be aware of their inherent limitations when determining how they might ultimately be used.

Compatibility of ultimate use with a community's general plan should be one criterion used in reviewing a planning application for the establishment of a new landfill. In particular, planners should consider the opportunities foregone for land committed in this manner. Assuming that this criterion is satisfactorily met, measures should be taken in advance to ensure that the landfill is designed and operated in ways that anticipate and mitigate problems likely to arise following completion. Admittedly, this may add to the cost of landfilling, since precautions such as gas and leachate barriers and thicker soil cover can be expensive to introduce; however, communities which fail to impose and enforce strict requirements on landfill operators should realize that they may be faced with even more expensive remedial measures in the future. Assignment of the responsibility for ultimate conversion and maintenance of the site should also be made at an early date.

If proper attention is given to these considerations, completed sanitary landfills (although not trouble-free) can become community assets rather than potential liabilities.

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