

Sanitary Landfills

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INTRODUCTION

Reduced to its simplest terms, refuse collection and disposal consists of the acceptance of the solid waste that results from processes of urban life, the transportation of such material to disposal sites, and the processing and disposal of the material so that nuisances are not created. The entire process must be carried out in such a manner that the public health of the community is protected, that the extent and character of the service is in accord with the desires of the people, and that the operation is conducted effectively and economically.

Surveys have shown that many communities, large and small, do not follow sanitary refuse practices. There are many reasons why these communities have not taken steps to protect the health and welfare of their citizens from the hazards associated with the inadequate and insanitary collection and disposal of refuse. Predominate among the basic causes, however, is the belief that adequate service is too expensive, and a lack of information on how to establish and operate a satisfactory system.

A practical refuse control program is within the means of any community. In rapidly growing communities a *master plan* for the collection and disposal of refuse, based on a thorough engineering analysis, is vital. The alternative is almost insurmountable future problems. Even the best planned refuse collection and disposal system will be one of the costliest services provided by a municipality. Few services so directly affect the individual citizen and taxpayer. A poorly planned system is certain to place a continuous, undue burden on financial resources and create ill-will in the community.

THE PROBLEM

The problem of designing the most economical refuse collection and disposal program for a heavily urbanized area has become increasingly complex in recent years. The problem mounts each year because of several trends: population growth, new home construction,

increased industrial activity, shortage of disposal sites, and a significant increase in the production of refuse resulting from modern packaging and consumer consumption.

Population increases have resulted in refuse problems in communities where previously no service was provided and where there has been little or no recognition of municipal responsibility. Municipalities with established refuse collection and disposal services have found that community development means new problems. As growth presses to a municipality's borders and vacant land is developed, adequate refuse disposal sites become less readily available. Frequently, existing methods must be improved or an entirely new system adopted.

Refuse operations overlap in built-up areas, and municipalities are becoming involved with neighboring communities. The cost and complexity of disposal methods raise the question of municipal cooperation in order to achieve economies. Development of common disposal sites is often indicated as a matter of mutual benefit.

State health authorities have recently established standards for refuse disposal areas. This added dimension of official state interest is having an impact on prevailing methods of disposal and will affect the decisions of local officials with regard to pending and future policies for refuse collection and disposal.

DEVELOPMENT OF MASTER PLAN

It goes without saying that the master refuse plan of a community must be coordinated with other parts of the total urban planning program: such as education, parks and recreation, public health, air pollution control, water pollution control, transportation, etc. Of prime economic importance, for example, is the proper location of disposal facilities in relation to future population concentrations. Sites for these facilities must be designated and acquired either through zoning, leasing, purchase, or condemnation to avoid future hostile public reaction as well as to avoid expensive future acquisition costs.

The first step in the initiation of a refuse collection and disposal program would be to consult with public health officials for advice on rules and regulations, applicable standards, and suggested procedures. Health departments, local, state, or federal, will give as much assistance as they can and welcome inquiries from local officials. With competent staff and many years of experience, these departments can counsel on technical and procedural matters and help local officials avoid pitfalls and simplify their task.

Financial aid is available from several sources. There are existing

programs under which advances and grants for municipal public works planning are available.

The planning and design of refuse collection services and disposal facilities require highly specialized engineering competence, and most municipalities are not staffed to do this work. As a rule, therefore, a consulting engineer is selected. Selection should be based on professional competence and ability to carry out the work within the time limits prescribed.

The value and economy of a comprehensive study and report cannot be over-emphasized. A comprehensive study should consider all technical aspects of the work, including alternative solutions, the recommended approach, estimates of capital costs, and annual costs for fixed charges and operation, and methods of financing services and facilities.

The consummation of a well-planned project progresses naturally through the phases of the work. Properly conceived, designed, and constructed, the completed refuse collection and disposal system will be readily operated and maintained, and will meet the standards of the Departments of Health.

REFUSE DISPOSAL BY SANITARY LANDFILL

The term "sanitary landfill" is too often used to refer to a refuse disposal operation that is little better than an open dump. Actually, sanitary landfill means an installation where a satisfactory, nuisance-free refuse disposal operation is being carried out in accordance with recognized standard procedures. The operation of a sanitary landfill requires skill and knowledge. It is a scientific method and should be treated as such. Engineering and planning are needed to operate a satisfactory landfill.

Site Selection

Selection of a sanitary landfill site depends upon evaluation of the site itself and upon community acceptance of the site for refuse disposal purposes.

Ordinarily, selection of a site starts with a search for conveniently located waste land or low value land. Refuse disposal sites in the state now include borrow pits, ravines, areas adjacent to water courses, and low-lying swampy land. Advantages are relative ease of acquisition and isolation from built-up areas.

Actually, it is possible to use practically any site for a sanitary landfill, although submarginal rather than potentially valuable land would ordinarily be selected. Land costs, moreover, are *not* necessarily the controlling factor. The low first costs of waste land may be offset

by developmental costs in making the disposal site suitable for landfill operation and in procuring necessary cover material from another location. Long hauls to a sanitary landfill may, upon analysis, prove more economical than short hauls to an expensive disposal facility. For the larger cities, more than one site may be needed for the most economical operation. Counties may operate sanitary landfills at sites that can be utilized by several communities.

Site Capacity

Useful life of the sanitary landfill site is a major consideration. One of the common difficulties experienced by municipalities in the state is the early exhaustion of disposal sites and the absence of ready alternatives of additional land for refuse disposal. The useful life of a site comes down to the question of sound planning and good operation, which in combination allow full development of site capacity.

Capacity of a sanitary landfill site is usually expressed on an area basis—so many acres per contributory population per year. This approach can be misleading. Actual capacity is determined by the usable disposal *volume* that can be developed at the site. Fig. 1 shows volume required as measured by production and density of fill.

As noted, landfills are frequently located in abandoned gravel pits, quarries, and ravines as well as on relatively level land. Consequently, the depth available for fill is as important as the surface area of the site in measuring capacity. Detailed planning will make it possible to use the total volume of space available.

Assuming a refuse production of 1500 pounds per capita per year (Fig. 2) delivered to the site, with a compaction of 700 to 750 pounds per cubic yard, annual volume required at a landfill site would be approximately 2,000 cubic yards per 1,000 population. Additional capacity of some 15 to 25 percent would have to be provided for cover material if brought from off the site. Sites should be located and acquired that will provide capacity for 20 to 25 years in the future.

Cover Material

An ideal soil for sanitary landfill is a combination of approximately 50 percent clay-silt and 50 percent sand, which is porous, compacts well, and is not subject to cracking upon drying. Clay, when it becomes dry, will crack, giving rodents and insects an access to the covered refuse. In addition, when clay becomes wet it is difficult to handle.

Water Pollution

A further consideration is pollution of ground or surface water by leaching through the landfill. The pollution hazard is increased when

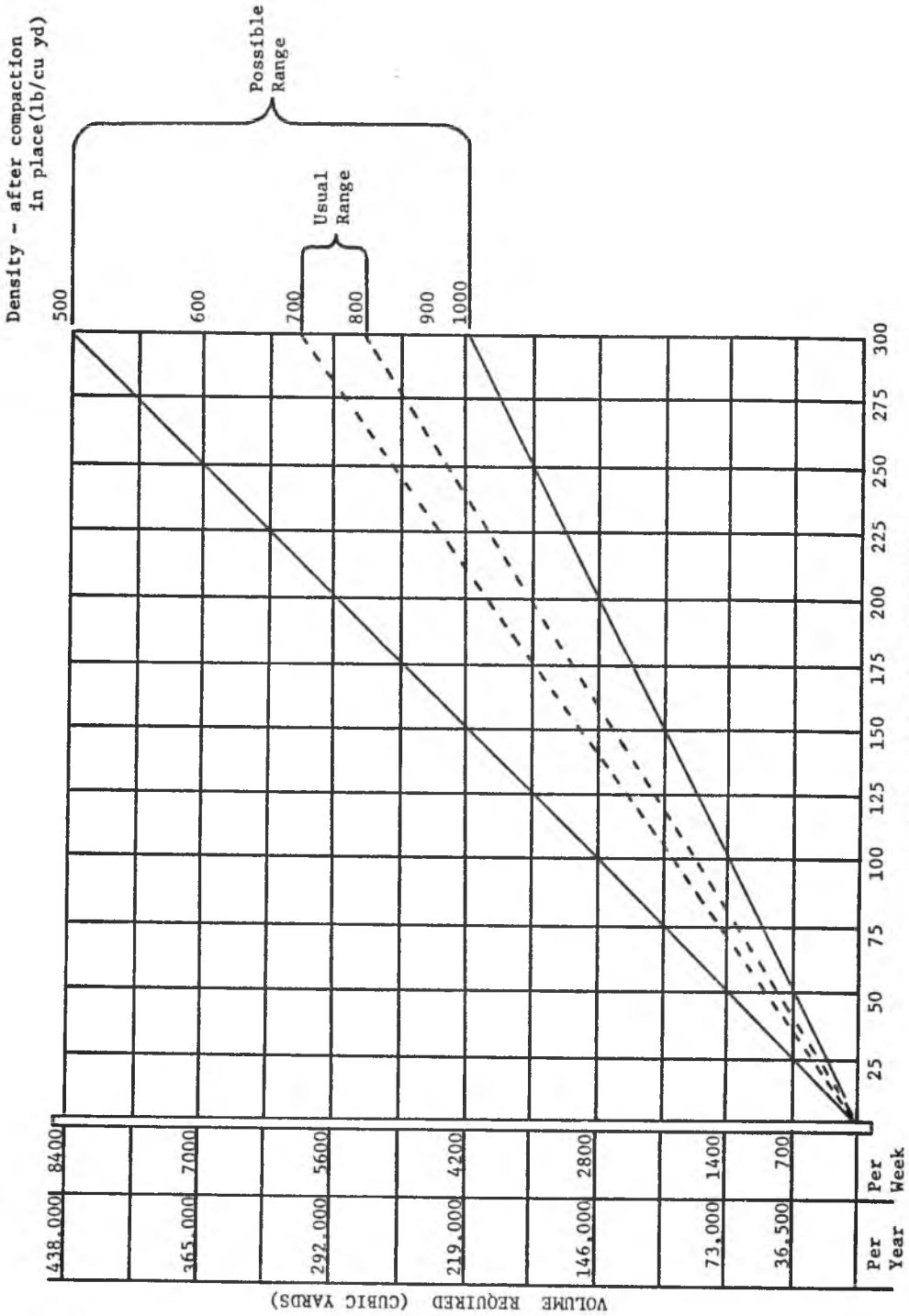


Fig. 1. Sanitary Landfill Volume Requirement.

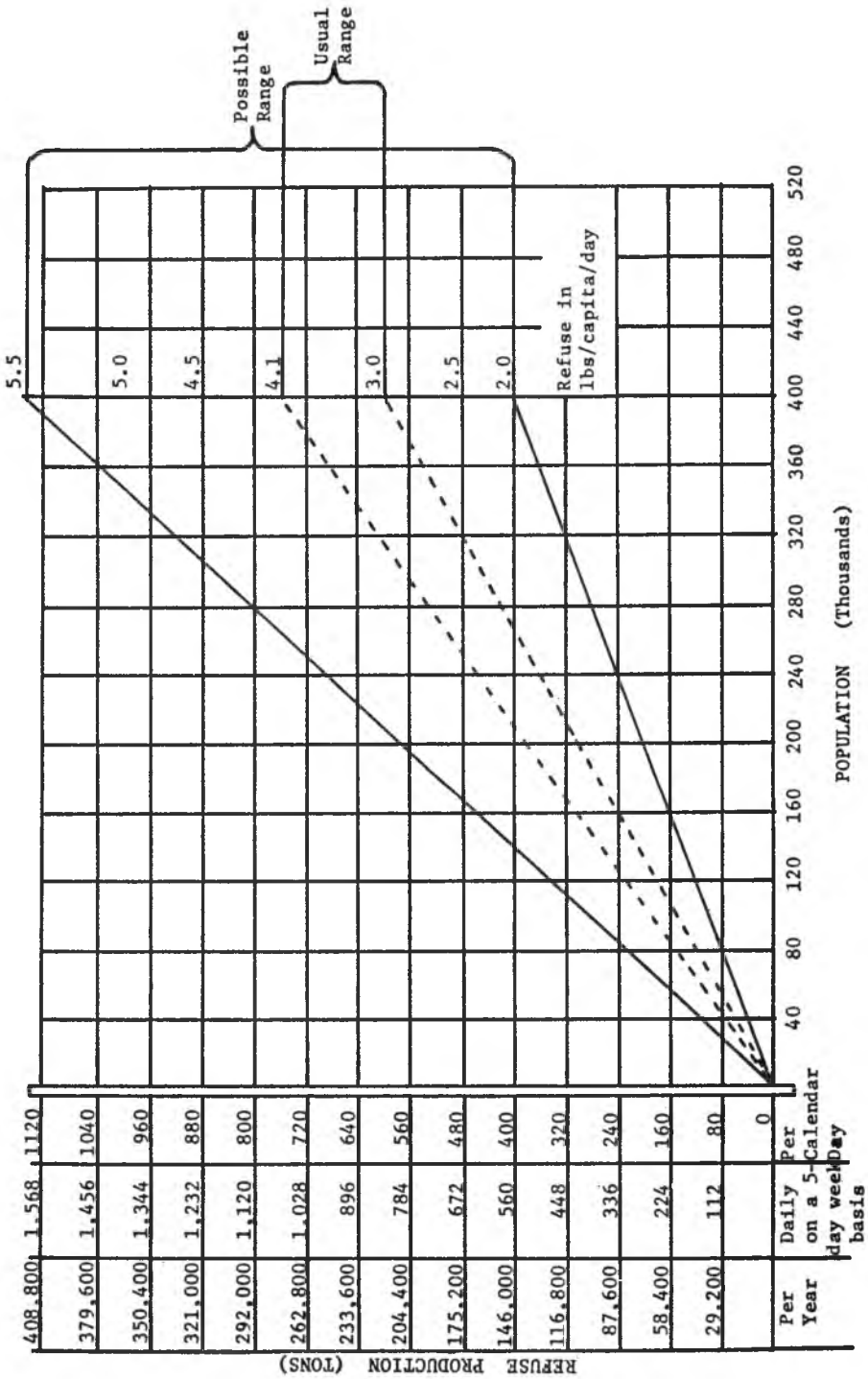


Fig. 2. Refuse Production at Various Per Capita Values.

disposal is in sand or gravel soil, where the ground water is penetrated, and where wells are located nearby. Therefore, water use in the immediately adjacent areas should be examined, even though it will not be the controlling factor under ordinary circumstances.

Low marshy land adjacent to rivers has been developed as landfills in which the material is actually deposited in the water in isolated cells. Although this method of site development for landfill operation has not resulted in serious water quality problems, experience in Indiana has been limited.

In any case, the possibility of water pollution should be thoroughly investigated when selecting and developing a site.

The disposal of certain kinds of industrial wastes in the landfill requires special safeguards and procedures, since they present a real possibility of serious and persistent water quality deterioration.

Land Reclamation

Part of effective planning and operation is the eventual use of the finished fill. This should be determined before the operation commences. It will give aim and direction to the whole operation. While land reclamation is one of the advantages of a sanitary landfill, the main object of such an installation is effective refuse disposal.

LANDFILL OPERATION

Detailed engineering planning and control, both prior to and during operation, are necessary to insure efficient operation and maximum site utilization. Careful planning and control will pay dividends in economy, trouble-free operation, and full capacity utilization of the landfill site.

There are two methods of operating a sanitary landfill, area and depression. These methods are shown in Figs. 3 and 4, respectively. The method selected will depend upon subsurface conditions, drainage, and topography of the land. If the land is relatively level the area method (also called the trench method) should be used. With hilly or rolling terrain, the depression method or a combination of the two may prove more desirable.

Area Landfills

One of three methods of operation is usually used for area landfills; namely, progressive excavation, cut and cover, or imported cover. These methods (particularly the first two) often are called the trench method of landfilling.

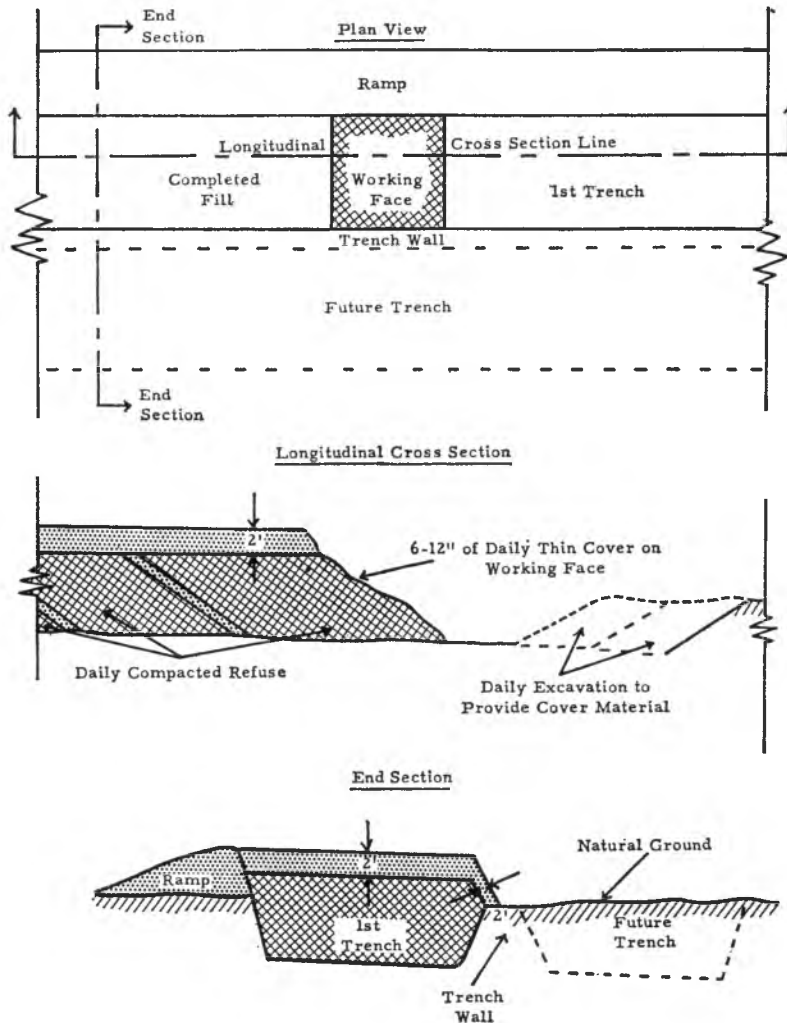


Fig. 3. Trench Method of Sanitary Landfill—cover obtained in operating trench.

Progressive Excavation: The distinguishing feature of this method is its continuity. Cover material is excavated from the area directly in front of the working face of the landfill and is put over the previously compacted refuse behind. The cover is excavated as required and the process goes on almost continuously.

Cut and Cover: A cut and cover landfill is one in which trench-type excavations are made on the site to hold the refuse and get cover material. The trenches are usually parallel to each other in

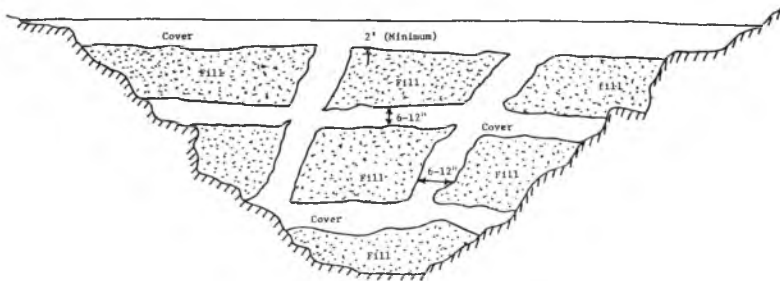


Fig. 4. Depression Method of Sanitary Landfill.

order to use the site efficiently. The trenches should be as near as possible perpendicular to the prevailing winds to minimize the scattering of loose refuse. The width of the trench should be approximately twice the width of the tractor used in order to obtain maximum compaction of the material. Unlike the progressive excavation method, refuse at a cut and cover fill is usually discharged at the top of the working face, although in some cases it may be desirable to discharge it at the bottom.

Imported Cover: The imported cover method of operating a landfill is not a single method but rather several, and is used when cover material is obtained from a source outside the site.

Depression Landfills

Depression fills are those that use natural or man-made irregularities or depressions in topography. These types of fills include canyons, ravines, pits, or quarries.

Usually the total depth of the refuse in a depression site is greater than the depth in an area fill. The fill is constructed by dumping refuse in sloping layers and compacting it. Each stratum thus formed has a total depth of from 4 to 20 feet. Each layer must be well covered with compacted, inert cover material; and it is good practice to cover the sloped working face at the end of each work period.

In any of the methods just described, the stability of exposed fill slopes must be considered. Experience indicates that slopes of 1:2 (one vertical to two horizontal) are acceptable and only those approaching 1:1 need to be subjected to rigorous analysis.

Access Roads

Access roads to the landfill should be regularly maintained under all weather conditions to permit a smooth flow of traffic. The entrance to the access road should be provided with a gate and lock so that the

site may be closed at the end of the day. There should be signs showing hours of operation and directing traffic to the designated dumping areas from the access road to the operating face of the landfill.

Operation Face

The operating face in the fill area should be limited to a length which can be easily controlled and worked by the equipment operator. The smaller the face, the less likelihood of difficulties. This requires strict control by personnel at the landfill site over all incoming vehicles.

Compaction and Cover

As refuse is deposited in the fill area, it should be spread out in thin layers and compacted. After the refuse is thoroughly compacted, cover material is placed over the refuse and compacted. Refuse should not be left exposed at the end of the day's operation. The final refuse layer at the end of each day is covered with approximately six inches of compacted fill material in order to prevent fires and keep odors, flies, and rodents under control.

Compaction and cover give stability to the filled areas and facilitate the fullest utilization of the site. When a section is completed, a minimum final cover of two feet of earth should be placed over the fill. Ultimate use of the site may require a covering soil layer of greater depth.

Drainage

The surface of the fill should be carefully graded to permit drainage and prevent ponding of surface water. This may require regrading if uneven settlement of the fill occurs. Re-grading is most important when the final cover of two feet is placed over the filled area and during the succeeding six months to one year.

Fire Prevention

A water supply should be available at the landfill site at all times to prevent and extinguish fires. The water supply may be in the form of a piped supply, tank trucks, well, or auxiliary pumps if the landfill site is located near a source of surface water.

Screening

Where natural screening is not afforded by trees or topography, a permanent perimeter fence and plantings are desirable. This is a must if the useful life of the site is expected to extend over a period of time—more than five years, for instance.

Fencing

Confinement of blowing papers and light refuse materials to the landfill site is best accomplished by use of light, movable fences, such as snow fences. Fencing is located around the landfill operation to protect surrounding areas. The fence should be regularly cleaned of litter to prevent unsightliness. Effective continuous operation will minimize the problem.

Winter Operation

Certain facilities and procedures are necessary for a successful landfill operation during the winter. These include:

- (1) Keeping the access road passable for collection vehicles.
- (2) Providing a heated garage for the motor equipment to facilitate starting in cold weather.
- (3) Providing shelter for the operator in cold weather.
- (4) Providing a heated cab on equipment for the operator.
- (5) Keeping the operating face and surrounding area of the landfill free of snow for equipment mobility.
- (6) Stockpiling cover material.

Some landfills might need to use separate winter areas which are more readily accessible from the access road.

LANDFILL REGULATION

Burning

No burning of refuse should be practiced at a landfill. It involves the same problems as open-burning anywhere, creates the additional hazard of igniting the fill, and causes air pollution.

Operating Hours

The hours during which the landfill is open for collection vehicles should be closely phased with the refuse collection schedule. Since it is necessary to allow time for the equipment operator to compact and cover the final loads of refuse, the site should be closed at an hour which enables the operator to finish his daily work.

In scheduling the hours during which the site is open, consideration must also be given to individual residents if they are allowed to dump at the site. A good practice is to place detached containers at the gate for use by individuals, and this has been done successfully at some sanitary landfills. Wherever possible, actual dumping by individuals at the site should be prohibited.

Supervision

Successful landfill operation depends upon adequate supervision. When such supervision is not provided, indiscriminate dumping is encouraged. The access gate should be locked unless the landfill is operating.

Salvaging

Salvaging slows down and interferes with the landfill operation.

FACILITIES AND EQUIPMENT

Equipment Needs

Basic equipment needs for successful landfill operation are a sufficiently large and rugged piece of equipment for use in compaction, excavation, covering, and grading. Larger volumes of refuse or special site conditions may require additional pieces of the same type of equipment or specialized equipment.

Each site must be studied before a determination can be made of the exact equipment required for preparation of the site, daily operation, and special situations. The terrain, for example, may require extensive provision for drainage, construction of dikes, the use of drag lines through muddy or marshy land, or extra rugged equipment for use in rocky, heavy, or gravelly soil.

Cover material at the site requires excavation, transportation, placing, and leveling. If cover material is brought from another location, equipment is required to load and transport such cover material from its source to the place of use and to handle it at the site.

Types of Equipment

The choice and range of equipment used in operating a landfill are fairly standard. Equipment adapted to landfill operation includes bulldozer, front-end loader, drag line, shovel, scraper, and backhoe. Differences in equipment relate to size, weight, horsepower, costs, and special use features, such as varying shapes of bulldozer blades, side dumping front-end loaders, split buckets, and other variations.

Fig. 5 shows various types of equipment used in operating a sanitary landfill.

Further equipment considerations are down-time for repairs and necessary stand-by equipment. Idle time becomes a cost factor where there is inadequate control over refuse collection and delivery to the disposal site.

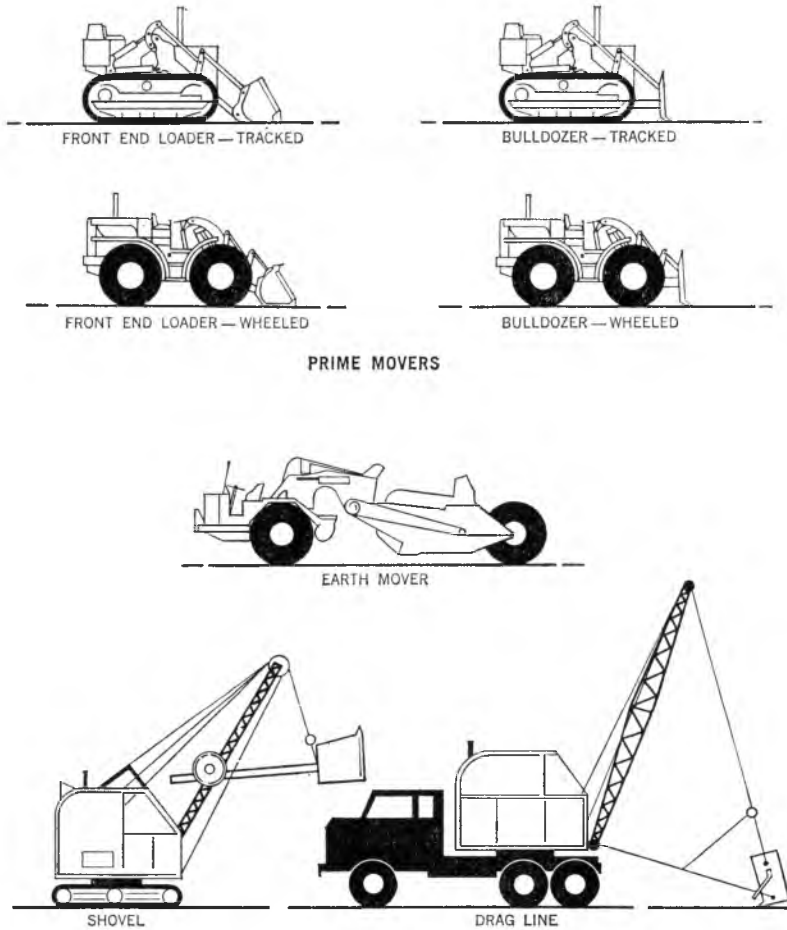


Fig. 5. Sanitary Landfill Equipment.

Current Experience

Experience among municipalities of the state indicates that landfills serving up to about 50,000 population can operate with a single piece of basic equipment in the \$20,000 price range and weighing about 12.5 tons, if there are no unusual site problems. In landfills serving in excess of 50,000 population or with special site conditions, additional equipment is needed.

A crawler type tractor appears to be the most satisfactory. The tractor should be fitted with a bucket attachment, bull-clam, or similar device to use in trenching, transporting earth short distances, and to cover the compacted refuse.

Capacity Requirements for Crawler Type Tractors

| Population Served | Suggested Loader Capacity (cubic yards) | Tractor (HP) |
|-------------------|---|--------------|
| 6,000 — 10,000 | $\frac{3}{4}$ | 30 |
| 10,000 — 20,000 | 1 | 45 |
| 20,000 — 50,000 | $1\frac{3}{4}$ | 45 — 65 |

For large cities the use of a dragline for trenching may provide more economical use than the bulldozer.

Municipal officials will want to make thorough investigations and compare costs prior to procurement and to examine the choice between tracked and wheeled units. Adaptability of the basic equipment to other public works uses is a consideration in the case of small landfill operations.

SUPPORTING FACILITIES AND PERSONNEL

Supporting facilities are required for efficient landfill operation, including (1) a heated garage to simplify maintenance, allow easy starting in winter, and extend the useful life of the equipment, (2) shelter for employees to change clothes, keep records, have meals, and secure protection during extreme weather conditions, and (3) toilet facilities, shower, wash basin at the weigh station, and a portable latrine at the site.

Other operating facilities, already mentioned, including fencing for litter control and water supply for fire fighting purposes.

Platform scales to record weight of material delivered to the site are desirable in larger installations. These assist in scheduling operations and recording changes in the amount of material received. Scales facilitate control of the operation and may be used in establishing and collecting dumping fees.

Minimum personnel needs are a full-time employee to operate the main piece of equipment and supervise the fill. Depending on the scale of operation, additional personnel may be needed to run equipment, control truck traffic, and otherwise assist in operations.

SUMMARY

The role of the health officer has become more complex in the past 25 years, but so too has the role of the elected official. People are more sophisticated about politics, more demanding, less willing to pay for services, and more likely to turn the office holder out unless he pays attention to them as citizens. It is the American heritage that we enjoy

the free political system. But so long as the responsibility of refuse collection and disposal lies within the political schedule we shall experience the tendency to "duck" an unsavory issue if it means a loss of votes to this elected official. It is imperative, therefore, that public understanding and support be fostered at every opportunity.

The conveyance of solid waste from collection to disposal involves people and machinery. It is not like the conveyance of water and sewage, and therefore needs *planning*. There is a need for imaginative thinking on the tangled problems of where our cities are headed, where they ought to be a decade or generation from now, and how to get there. As engineers, public health officials, or just plain citizens, we should insist that all engineering projects be referred to the *urban master plan* and when such a plan does not exist, to insist on knowing why it doesn't, and when there will be one.

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ADDENDUM
MODEL ORDINANCE ON SANITARY LANDFILLS;
SUGGESTED BY NEW JERSEY STATE
HEALTH DEPARTMENT

The New Jersey State Health Department has recommended that all municipalities in the state require licensing and bonding for sanitary landfill. It is believed that this will make available "effective controls" on landfill operations which if not properly carried out could result in "smelly, smoky, vermin infested eyesores which give a black eye to the municipality and the state."

Under the proposed ordinance, "poor performance on the part of the landfill operator could result in forfeiture of his bond and provide officials with just cause to revoke or to refuse to renew the license."

The following are the key sections of the model ordinance in abbreviated form:

License Required

It shall be unlawful to maintain or operate a sanitary landfill, or any place for the disposal of refuse, anywhere within this municipality without first having secured a license. It shall be unlawful to maintain, operate or permit the maintenance or operation of such premises in violation of any portion of this ordinance.

The original fee for such license may be renewed annually upon payment of a renewal fee. No such license shall be issued except on direction by a governing body.

Bond

No license shall be issued, or effective, unless there is on file a cash bond or a bond with a corporate surety to assure that:

(a) the licensee, his agents and servants, will comply with all of the terms, conditions, provision requirements, and specifications contained in this ordinance.

(b) the licensee, his agents and servants, will faithfully operate the sanitary landfill for which the license is issued in accordance with the provisions of this ordinance.

(c) the licensee, his agents and servants, will save harmless this municipality from any expense incurred through the failure to operate and maintain the sanitary landfill as required by this ordinance, including any expense this municipality may be put to for correcting any condition or violation of this ordinance by the municipality's own labor and equipment, whenever the Board of Health determines it is

necessary to correct any condition in violation of this ordinance, or from any damages growing out of the negligence of the licensee or his agents or servants.

(d) before acceptance, all bonds shall be approved by the governing body of this municipality. If a corporate bond is offered, it shall be executed by a company authorized to transact business in the state as a surety. If a cash bond is offered, it shall be deposited with the treasurer of the municipality, who shall give his official receipt.

Application—Investigation

Applications for licenses shall be filed with the municipal clerk and shall contain a description of:

- a. the plot of land on which the disposal of refuse is proposed, including soil conditions
- b. the sequence and plan of operation
- c. the source of water supply and the nature of equipment to be used for its distribution on the landfill
- d. type and capacity of equipment to be used for operations
- e. fire prevention and control plans
- f. nuisance and vermin control program
- g. existing and proposed roadways and easements
- h. existing topography and water courses with a diagram and written statement explaining proposed location and extent of earth work and fill operations
- i. profiles indicating final depth of the fill
- j. estimated daily or weekly volume of refuse
- k. successive layers of fill and earth cover to arrive at final grade
- l. drainage plan for finished area
- m. number of yards of cover material to be maintained on the landfill site for a one week supply
- n. title to or other legal indices of authorization to operate and maintain the proposed landfill site
- o. such other information as may be required by the governing body of this municipality
- p. name of engineer who planned the sanitary landfill.

Copies of the application shall be forwarded by the municipal clerk to the Board of Health and the Zoning Board for their study and recommendations.

The health officer shall examine the premises and coordinate his investigation with the staff of the Department of Health to determine whether the granting of the license to the applicant would or would not

violate statutes relating to public health or local ordinances or would, in any way, create a hazard or menace to the public health.

Regulations

In the operation or maintenance of any place for the disposal of refuse in the municipality, (certain regulations - - - of the State Sanitary Code) as well as all of the following rules and regulations, shall be complied with:

- (a) all refuse shall be thoroughly compacted by equipment of sufficient weight and capacity to carry out all necessary operations to the satisfaction of the Board of Health. Sufficient auxiliary equipment shall be maintained on the site or otherwise available to permit operation in case of breakdown.
- (b) refuse material shall be spread out on the working surface area of the landfill so that the depth does not exceed a maximum of 10 feet above the working surface.
- (c) the area shall be supervised to prevent fire and the blowing of papers and, where required by the State Sanitary Code, shall be covered at the end of each day's operation.
- (d) cover material will consist of earth and/or other inert materials such as ashes, cinders, or gravel. A minimum depth of 6 inches of compacted cover shall be kept on all active faces of the landfill at all times. The active faces of the landfill shall be sloped downward and covered at the end of each day's operation with at least 6 inches of compacted cover material where required by the State Sanitary Code.

A minimum of one week's supply of cover material shall be maintained on the site of the landfill at all times.

Materials requiring no special handling may be stockpiled for use in road building on the disposal site.

- (e) explosive and highly flammable materials, as well as chemicals of known or unknown origin, shall be excluded from the working face of the landfill. Such materials may be disposed of on landfill site only under the direction and supervision of a representative of the individual or agency producing such wastes. Such materials shall be disposed of in accordance with incineration methods as described in item (h).

All bulky combustible wastes may be disposed of by incineration methods as described in item (h).

- (f) all uncovered refuse material existing on the site at the time the license is issued, either in the form of an open dump or any other

form, shall be covered with cover material at least 6 inches in depth and compacted.

- (g) the licensee or operator shall erect temporary or permanent fences or take other measures as may be necessary to control blowing of paper and other materials from the landfill and prevent unauthorized entry and indiscriminate dumping.
- (h) materials deposited on a landfill site as referred to in item (e) may be burned through use of any device, system or construction operated in such a manner to comply with the requirements of the State Air Pollution Control Code, but only during the hours of 9 a.m. to 4:30 p.m.
- (i) adequate firefighting equipment, as approved by the municipal fire department, shall be available at all times on the site.
- (j) the license holder shall take precautions to eliminate excess dust in dry weather during operation of the landfill.
- (k) insect and rodent prevention and extermination programs shall be conducted on the landfill site as directed by the health officer.

Insurance

The licensee shall obtain insurance coverage of his operations against claims for personal injuries in the amount of \$100,000 per individual claim and \$300,000 for claims of more than one individual and additional insurance coverage against property damage claims in an amount not less than \$10,000 and submit proof of compliance with this regulation to the municipal clerk.

Enforcement

The Board of Health of this municipality is hereby empowered to take such action as may be necessary to secure compliance with this ordinance including the making of any inspection to that end and the closure of any landfill area pending a hearing for revocation of license before the governing body.

Revocation of License

Any license issued under the provisions of this ordinance may be revoked by the governing body of this municipality for any violation of any law or ordinance pertaining to the operation or maintenance of such establishment.

Penalty

Any person, firm, or corporation who shall violate any of the provisions of this ordinance shall, upon conviction, be punished by a fine

of not to exceed \$200 or by imprisonment in the county jail for a period of not to exceed 90 days, or both such fine and imprisonment, and each violation of any of the provisions of this ordinance, and each day the same is violated shall be deemed and taken to be a separate and distinct offense.