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SOLID-WASTE DISPOSAL SITES IN RELATION TO WATER RESOURCES IN THE SEATTLE-TACOMA URBAN COMPLEX AND VICINITY, WASHINGTON

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INTRODUCTION

Solid-waste deposits are adversely affecting the environment in the Puget Sound basin, especially water resources at and near disposal sites, and some adverse effects are likely to continue for the foreseeable future. The commonly held belief that "natural filtering" by the soil will prevent pollutants from damaging the quality of water resources and the environment is largely erroneous, as is the premise that new techniques in solid-waste disposal will quickly solve such problems. Although new disposal techniques will reduce the volume of the wastes and some of their undesirable effects, a residue of solid waste will still require disposal, presumably in the ground. Futhermore, if solid-waste production stopped tomorrow, the waste materials already in the ground would continue to decompose and to be a potential source of water pollution for considerable time.

An adequate evaluation of the environmental impact of solid-waste disposal in the Puget Sound basin requires reliable data on waste deposits and their environmental setting. As an aid to such evaluation, this report (1) presents an inventory of currently active, many former (inactive), and a few planned solid-waste disposal sites; (2) provides information about the active sites in relation to some features of the local environment (table 1); and (3) discusses relationships between solid-waste disposal and water quality in a rapidly urbanizing part of the Puget Sound region. Also presented (figure 1) is a graphic portrayal of some undesirable results of solid-waste disposal in areas of moderately permeable rock materials--examples of which exist at several solid-waste sites in the Puget Sound region.

The report is intended to serve as a foundation for future studies of water quality, land stability, and other considerations related to solid-waste disposal in this region. In addition, it may encourage more detailed consideration of geologic and hydrologic conditions in the selection of future sites--a key to effective waste-disposal management and control of adverse effects.

Sources of the data for active sites (see map) included field observations; public officials in health, planning, and engineering departments; landfills operators; and unpublished records and reports. The locations of the old inactive sites shown on the map were obtained from interviews with local officials (present and former), and bottle collectors. The number of old sites shown on this map is probably far less than the actual number of such sites in this area; presumably, each community had some type of solid-waste disposal site, many of which were not found during this study. More precise locations for all sites shown on the map, and other specific information on the active sites, are on file at the U.S. Geological Survey office in Tacoma, Wash.

The waste sites shown on the map are those receiving the types of waste most common to this region (general, demolition, wood, industrial, and sewage-sludge wastes). Deposits of other, special types, such as discarded household appliances or wastes from agriculture or mining, were not included on this map. However, they also could conceivably cause water-quality problems. Similarily, wastes requiring special care or handling, such as medical, radioactive, and pesticide wastes were not delineated. State law requires that hazardous wastes be "properly labelled and stored inaccessable to the public" (WAC-173-301-123). However, these hazardous materials are difficult to screen from other wastes, and substantial amounts reportedly end up in general disposal sites of this region.

TYPES OF SITES

The solid-waste disposal sites in the Puget Sound basin have been grouped into four categories for this inventory in accordance with nomenclature and usage of the main State regulatory agency, the Washington Department of Ecology. These categories are: open dumps, sanitary landfills, modified landfills, and promiscuous dumps.

An open dump is a land-disposal site where the waste materials are left uncovered, and are deposited with little or no regard for pollution controls or aesthetics. Usually there is no supervision, and some open dumps are not actually authorized, although they are customarily accepted as a necessary facility in the absence of authorized disposal sites. The open dumps of the Puget Sound basin are located mainly in sparsely populated areas. As populations become denser in urbanizing areas, the odors, blowing trash, and other undesirable aspects of open dumps generally cause rapid elimination of the dumps or their conversion to covered landfills. Almost any type of waste may be found at open dumps because of the common lack of supervision. Therefore, these sites are particularly important with regard to pollution hazards. Although open dumps vary in size and topographic setting, a significant number are on hillsides where the wastes are thrown onto the slopes; more often than not, there is a stream at the base of the slope. Burning is still practiced at some open dumps in this area.

A widely accepted definition of the sanitary landfill (Committee on Sanitary Landfill Practice, 1959; see "Selected References") may be paraphrased as a method of disposing of solid waste with a minimum of nuisance or hazards to public health or safety, by utilizing the principles of engineering to confine the solid waste to a relatively small area, compacting it to a small volume, and covering it with a layer of earth at the conclusion of each day's operation or more often. Weddle and Garland (1974, p. 21) go further in maintaining that "Disposal sites, no matter how well run, are not sanitary landfills unless detailed subsurface criteria were met in selecting the sites." However, the term "sanitary landfill" is often misapplied to any landfill where solid wastes are buried. During the period of this inventory, only site 40 (table 1) came close to meeting the strictest definition of a sanitary landfill.

At a modified landfill, the solid waste is placed in the ground in some orderly fashion, generally with some degree of compaction, and with earth cover applied, but not necessarily on a regular basis. Most modified landfills in the Puget Sound basin have supervision, and the waste is compacted and covered about 3 or 4 times a week. Of the general-waste sites (see map explanation), the modified landfill is the most common type of waste-disposal facility in the Puget Sound basin.

The term promiscuous dump is used to indicate unauthorized disposal sites where solid wastes have been dumped on the land in a casual or arbitrary manner. These sites vary greatly in size and types of wastes they receive, and they grow very rapidly. Roadsides near authorized landfills are common areas of unauthorized dumping, two possible explanations being:

(1) the price for authorized disposal is considered too high, or (2) the authorized facility was closed at the time of the dumping. Other common places for unauthorized dumping include dead-end roads, roads along power-transmission lines, railroad rights-of-way, and the vicinities of solid-waste transfer stations and drop boxes (defined in "Outlooks and Trends"). Promiscuous dumps may contain especially troublesome or hazardous types of waste that are unacceptable at a supervised disposal site. Therefore, they could potentially cause serious water-quality problems, even though they usually are small. The inset map shows the abundance of unauthorized dumping sites in a typical developing suburban area near Olympia, Wash. The 4.3-square-mile area of that map has a total of 32 unauthorized sites in addition to two active authorized sites for disposal of demolition wastes (numbers 52 and 53).

Most active general-waste sites (see map explanation) in the Puget Sound basin are for general-purpose waste disposal. That is, they receive a wide variety of solid-waste materials, with the possible exception of unusually hazardous wastes such as radioactive wastes. Most of the other sites shown on the map receive mainly only one or two types of wastes, such as wood debris or scrap plasterboard, although lack of supervision at a disposal site apparently encourages the dumping of almost any kind of material.

WATER QUALITY AND LEACHATE

The greatest threat to water quality from the solid wastes is leachate--a generally noxious liquid produced by water moving through the waste deposits.

Leachate commonly contains dissolved and finely suspended solid matter and microbial products derived from the wastes (Brunner and Keller, 1972). The quality of the leachate is determined largely by the composition and amount of refuse, the sorting and degree of compaction, and amount of water in contact with and passing through the waste.

In the moist Puget Sound region, leachate is derived mostly from the direct infiltration of precipitation; however, the greatest opportunity for leachate production may occur where garbage is subject to frequent inundation by surface water or is in direct contact with ground water. (See right side of fig. 1.) Other contributions to the leachate include the liquid content of the waste itself or water produced in decomposition reactions. The infiltration of precipitation is especially significant here for two reasons: First, the study area receives moderate to large amounts of precipitation (from 30 to 100 inches per year), the amount increasing with altitude. Second, although the precipitation tends to be of low intensity, it is frequent. Thus, more precipitation soaks into the ground than would be the case if the same annual precipitation came in fewer, more intense storms (Foxworthy and Richardson, 1973). Open dumps with no soil cover, of course, allow the maximum infiltration of precipitation and rapid percolation of water through the wastes. Compaction and dense cover material tend to reduce infiltration and rates of percolation, but wastes deposited during the wet season in this region invariably receive abundant additional water from precipitation. For these reasons, land disposal of solid wastes in the Puget Sound region can be expected to produce significant amounts of leachate regardless of the type of disposal site and method of disposal.

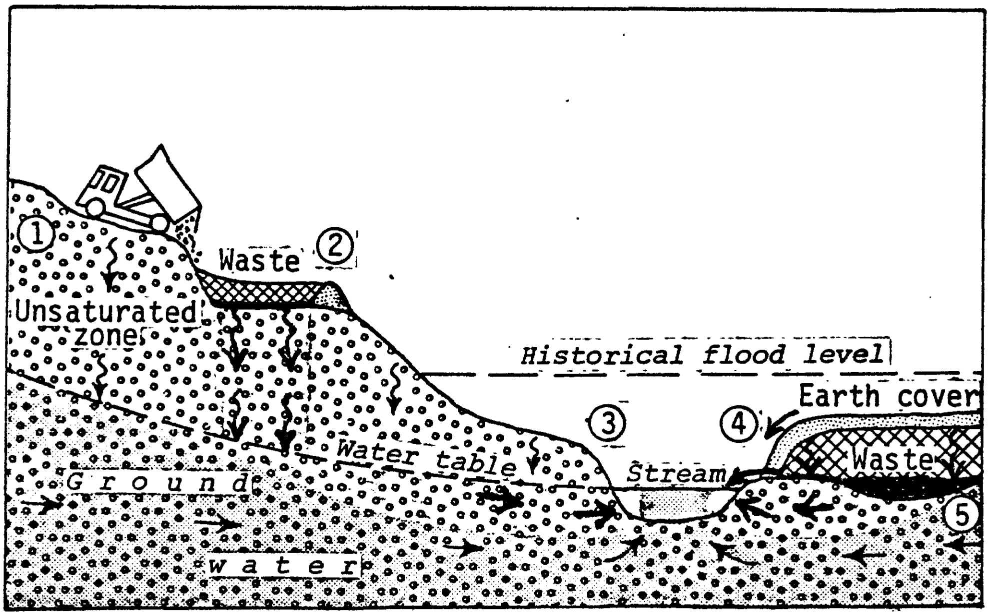

Figure 1.--Examples of undesirable results of solid-waste disposal in areas of moderately permeable rock materials. Colors show character of water: Red, contaminated; gray, uncontaminated. Arrows show general direction of water movement.

EXPLANATION FOR FIGURE 1

1. Water derived from infiltrating rain and snow percolates downward through the unsaturated zone, providing natural recharge to the ground water.

2. Wastes in dump are leached by water from precipitation, and the leachate percolates downward to contaminate the ground-water body. Overland runoff of leachate may be prevented by dike or berm.

3. Contaminants are carried by ground water to points of ground-water discharge, such as stream channels. Time of travel depends mostly on distance between source and discharge points, permeability of the rock materials, and hydraulic gradients.

4. Disposal on flood plain or marsh land near channel constricts flood flow of river and is subject to inundation and erosion during floods. Earth cover retards, but does not prevent, infiltration and percolation of water from precipitation. Runoff from fill area may carry sediment and contaminants to stream.

5. Disposal at or below the water level greatly increases the concentration of contaminants in the ground water and decreases the time of travel between source and discharge points.

The migration of the leachate to the streams and ground water depends mainly on the soil and rock materials beneath the site, the amount of leachate, the topography of the site, and the local hydrologic conditions. Generalized migration paths of leachate from the waste deposits to the ground and surface waters are depicted in figure 1. Movement of leachate in the unsaturated materials above the water table is generally downward (fig. 1, left side). However, a less permeable layer in the flow path, such as a clay layer in natural deposits beneath the wastes or a layer of compacted earth within the waste deposits themselves, can cause a perched zone of saturation that produces lateral migration of the leachate. This perching and lateral movement of the leachate, which are not shown in figure 1 for simplicity of presentation, is the situation that causes the very common emergence of leachate on slopes at or below solid-waste landfills. The pressure of gasses produced by decomposing wastes also may affect the movement of the percolating leachate.

Although most soils are fairly effective in filtering and attenuating suspended particles and microbes, the dissolved waste products, unless shunted laterally to the land surface or adsorbed on particles of soil or rock materials, will migrate eventually to the water table, resulting in water-quality reduction in the ground water and any streams fed by the ground water. The inevitability of this slow, downward migration to the ground water means that the only way to prevent leachate from degrading the water resources is by complete containment of the leachate and accompanying treatment that is effective in changing it to an acceptable condition before its ultimate disposal.

Where complete containment of leachate-producing solid wastes is not possible, adverse effects on water quality could be reduced by selecting the site and designing the disposal operation to be as compatible as possible with the local hydrologic conditions. An important consideration in this regard is that the soil or rock material underlying the waste-disposal site should be porous enough to carry large volumes of liquid, but not so permeable that leachate will percolate rapidly downward. Loose sand and gravel will accept the waste readily but are too permeable; conversely, clay has a large volume of pore space, but absorbs and transmits the liquid too slowly. Silt and some glacial deposits seem to be a good compromise in this regard; however, extensive uniform deposits of these materials are difficult to find in the Puget Sound basin. A long migration path, in terms of both distance and time, before the leachate reaches a body of surface or ground water, provides the greatest opportunity for filtration, degradation, and dilution of pollutants. Locating solid-waste disposal sites as high above the water table as feasible increases the time that leachate is exposed to aerobic reactions and the opportunity for adsorption on soil particles in the unsaturated zone. Because subsurface water movement is generally slow, years may pass before leachate reaches the ground water. However, once there, the effects on water quality can last for some time after the site is closed and covered (Hughes and others, 1971, p. 5; Weddle and Garland, 1974).

Some aquifers yield less water, or yield water of poorer quality, than others. Placing disposal sites above the inferior aquifers could reduce the amount of leachate entering the more productive, high-quality ground-water sources.

Ground-water quality possibly could be protected by purposely siting landfills in areas of ground-water discharge. However, the areas of ground-water discharge commonly are at or near streams, lakes, or other surface-water bodies; therefore, waste disposal in such areas would enhance the migration of the contaminants into the surface waters (fig. 1, right side). This might be advantageous in cases where the receiving surface waters provide adequate dilution, but such a disposal scheme should allow for the possible inundation or erosion of the wastes by flooding streams and for the likelihood that the landfill would be a long-term source of contaminants. Furthermore, in any area of productive aquifers, the pattern of ground-water flow and of seepage to or from the surface water could always be altered by future pumping (Zanoni, 1972, p. 12).

EXAMPLE PROBLEMS IN THE PUGET SOUND BASIN

Of the many solid-waste disposal sites visited that are in areas of shallow ground water or near surface-water bodies (see table 1), several sites stood out as having obvious impacts on the water resources. Three major landfills are described briefly as examples of problems associated with solid-waste disposal in the Puget Sound basin; they were selected on the basis of field observations and also because of the availability of information in the public reports cited below.

One example of a site having obvious impact on nearby surface water is site 7 (table 1) located at the mouth of the Snohomish River, near Everett, Wash. Here, solid waste is transported by barge from Seattle and disposed of on the fill, the solid waste being in direct contact with, or just above, the surface water. A report of the U.S. Environmental Protection Agency (1973) relates local water pollution to the disposal operations, and includes a photograph reportedly showing leachate discharging from a side wall of the barge channel.

Another problem site located near surface water is site 29 on a hillside overlooking the Green River about 1 3/4 miles northwest of Kent, Wash. Springflow entering the upper part of the site reportedly is contributing to the production of leachate in the landfill. A major problem addressed in a proposal to alleviate the pollution of nearby streams (Stevens, Thompson, & Runyan, Inc., 1973) is the effective collection and treatment of the leachate before it enters the Green River.

An example of a site having impact on both surface and ground water is site 26 about 7 miles east of Renton, Wash. This site receives about 55 inches of annual precipitation, is 920 acres in area, and the fill is on moderately permeable sand and gravel that overlies glacial-till deposits. Leachate is visible in surface water near the site and reportedly is also entering the ground water (Moore, Wallace, & Kennedy Inc., 1973).

The leachate produced by the numerous wood-waste sites in the Puget Sound basin is causing significant water-quality problems and is currently under study. The Snohomish County Environmental Health Department, in cooperation with the Washington Department of Ecology and the University of Washington, is conducting research to determine the general composition of wood-waste leachate and its effects on surface and ground water (Byron Robertson, Snohomish County, written commun., 1974). Preliminary studies reportedly show that wood-waste deposits in direct contact with water produced, in 3 to

6 months, visible leachate of high acidity and biochemical oxygen demand (BOD), with associated problems including discoloration, offensive odors, slime production, and slight changes in water temperature. For one large deposit of cedar wood waste, the production of leachate reportedly has continued for at least 4 years since deposit of the waste began.

OUTLOOKS AND TRENDS

In response to restrictive legislation and rising costs, the trend in solid-waste disposal in this region is toward greater efficiency and consolidation of operations, and recycling or other utilization of waste materials. Most of the counties and some major cities are actively seeking practical methods to salvage or otherwise utilize the solid waste, and to reduce its bulk so as to extend the life of available landfill sites. One or a few large sanitary landfills are either in operation or planned for each county. The plans call for transfer stations (facilities where individuals and route-collection vehicles can transfer waste into a larger vehicle for transport to the disposal site) to be strategically placed throughout the counties, mostly near urban areas. Drop boxes (self-service containers requiring special equipment to transport them to disposal sites) are to be located in or near rural communities. The consolidation of landfill operations is expected to eliminate most or all of the open dumps and greatly reduce promiscuous dumping by making disposal sites readily accessible to as many people as possible in the Puget Sound basin.

For planned additional sites, the only specific information available was from Snohomish County; the location of one of the county's two proposed sanitary landfills is shown on the map. Transfer stations will be located near or in Everett, and drop boxes will be placed at or near locations of old open dumps, mostly in the rural areas. Other counties either plan to expand current facilities to handle the expected volumes of solid waste or declined to divulge future locations that are under consideration as possible sanitary landfill sites (to avoid possible land speculation in those areas). In other cases, decisions on future solid-waste sites or plans for locations had not been made at the time of this inventory.

The obvious and potential problems at many of the sites included in this inventory show the need for careful consideration of hydrologic and geologic conditions in the selection of future solid-waste disposal as an important safeguard for minimizing long-range undesirable effects upon the environment. However, many other factors are also considered in the selection of future solid-waste disposal sites. Some of these factors are: (1) land costs of future sites; (2) transportation and operation costs; and (3) adverse public reaction to disposal sites, including fears of aesthetic and health problems and of possible reduction in real-estate values. Whether or not too much importance has been placed on the nonenvironmental factors in the past is a debatable point; however, the geologic and hydrologic considerations certainly have been slighted in selection and use of some of the sites, with obvious harmful results. Much valuable information on the geology and hydrology of the region is available to guide selection and design of future sites (see Selected References). This general information does not, however, minimize the need for detailed on-site studies. With new information, the abundant examples of problems identified with sites in the region, and the continually improving understanding of leachate generation and control, site selection and management of future solid-waste landfills can be greatly improved.

Discontinued former sites, as well as active sites, will continue to be sources of pollution in the future. The full impact of the present sites (both active and inactive) on the water resources probably cannot be fully evaluated; however, their great number (see map), the close proximity of many to surface water and shallow ground water, and the obvious leachate discharges from some of the sites indicate the need for effective monitoring of streams and ground water near the larger solid-waste disposal sites, which have the potential to generate large amounts of leachate and be especially troublesome polluters of the water resources.

SELECTED REFERENCES

Brunner, D.R., Hubbard, S.J., Keller, D.J., and Newton, J.L., 1971, Closing open dumps: U.S. Environmental Protection Agency rept. SW-61ts, 19 p., 6 figs.

Brunner, Dirk R., and Keller, Daniel J., 1972, Sanitary landfill design and operation: U.S. Environmental Protection Agency rept. SW-65ts 59 p., 27 figs.

Committee on Sanitary Landfill Practice, 1959, Sanitary landfill: American Society of Civil Engineers-Manuals of Engineering Practice No. 39., New York, 61 p.

Foxworthy, B.L., and Richardson, Donald, 1973, Climatic factors related to land-use planning in the Puget Sound basin, Washington: U.S. Geol. Survey Misc. Geol. Inv. Map I-851-A (map with text).

Hughes, G.M., Landon, R.A., and Farvolden, R.N., 1971, Hydrogeology of solid waste disposal sites in northeastern Illinois: U.S. Environmental Protection Agency rept. SW-12d, 154 p., 33 figs.

Liesch, B.A., Price, C.E., and Walters, K.L., 1963, Geology and ground-water resources of northwestern King County, Washington: Washington Div. Water Resources Water Supply Bull. 20, 241 p.

Luzier, J.E., 1969, Geology and ground-water resources of southwestern King County, Washington: Washington Dept. Water Resources Water-Supply Bull. 28, 260 p.

Moore, Wallace, & Kennedy, Inc., 1973, Preliminary report on sewage disposal, leachate collection, leachate disposal, for Cedar Hills facilities: Consultant rept. for King County, 113 p., 13 figs.

Newcomb, R.C., 1952, Ground-water resources of Snohomish County, Washington: U.S. Geol. Survey Water-Supply Paper 1135, 133 p.

Noble, J.B., and Wallace, E.F., 1966, Geology and ground-water resources of Thurston County, Washington: Washington Div. Water Resources Water Supply Bull. 10, 254 p.

Schneider, W.J., 1970, Hydrologic implications of solid-waste disposal: U.S. Geol. Survey Circ. 601-F, 10 p.

Stevens, Thompson, & Runyan, 1973, Drainage and pollution control plan for the Kent-Highlands Sanitary Landfill: Consultant rept. for City of Seattle, 45 p., 13 figs.

U.S. Environmental Protection Agency, 1973, Report to the Tulalip Indian Tribe-Evaluation of the Ebey Slough landfill operation: Solid Waste Management Branch working paper no. 87, 23 p., 8 figs. (with app.).

U.S. Soil Conservation Service, 1965, Mean annual precipitation 1930-1957, State of Washington: U.S. Soil Conserv. Map M-4430.

Walters, K.L., and Kimmel, G.E., 1968, Ground-water occurrence and stratigraphy of unconsolidated deposits, central Pierce County, Washington: Washington Dept. Water Resources Water Supply Bull. 22, 428 p.

Weddle, Bruce R., and Garland, George A., 1974, Dumps: a potential threat to our ground water supplies: Nation's Cities, v. 12. no. 10, 6 p.

Zanoni, A.E., 1972, Ground-water pollution and sanitary landfills--a critical review: Ground Water, v. 10, no. 1, p. 3-16.