A LEACHATE CONTROL PROGRAM FOR SACO, MAINE

By
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Introduction

Groundwater contamination can be a serious long-term result of the improper disposal of solid waste on land. In recent years the Environmental Protection Agency (EPA) has been actively studying the environmental effect of leachate resulting from solid waste disposal, especially from hazardous waste migration. Yet many municipal officials remain unaware of this problem, which may already be affecting the ground and surface water quality in their communities.

For many towns and cities, leachate prevention or correction programs are spurred only after a pollution problem has already been observed in a nearby well, lake or stream. This case study for the city of Saco, Maine, was prompted when a property owner adjacent to a city dump reported a deterioration in the quality of water in a small spring feeding a pond on his land. Based on the results of engineering studies, the city had already committed itself to closing the disposal area and was developing final designs for a new sanitary landfill when the water quality problem was found at the site.

Six months after the pollution problem was discovered near the disposal area, the site was abandoned. A location plan of the site and adjacent area is shown in Figure 1.

The abandoned disposal area was in rolling terrain and had been used primarily for agricultural purposes before it become a dump in the late 1950's. The material deposited at the dump during its 15-year operation consisted of residential and commercial solid wastes from the city of Saco, as well as industrial solid wastes primarily from a large tannery, an ordnance and automotive parts manufacturer, and a shoe shop.

As the disposal operation moved toward the easterly corner of the site, a high groundwater table was encountered and refuse was often placed in direct contact with groundwater. Without an operating plan, cover was provided only on an intermittent basis using highly permeable soils. The principal purpose of the cover material was to control blowing papers and to allow vehicle access; it did not prevent surface water percolation. This disposal area was not developed or operated as a sanitary landfill, as defined by the American Society of Civil Engineers or by the Maine Department of Environmental Protection.

The problem became aggravated in 1973, when a primary wastewater treatment plant was placed in operation, serving a large tannery in Saco. The plant produced 4 to 5 tons per day of sludge (dry basis) which was transported to the site for disposal. The solids content in the sludge was generally

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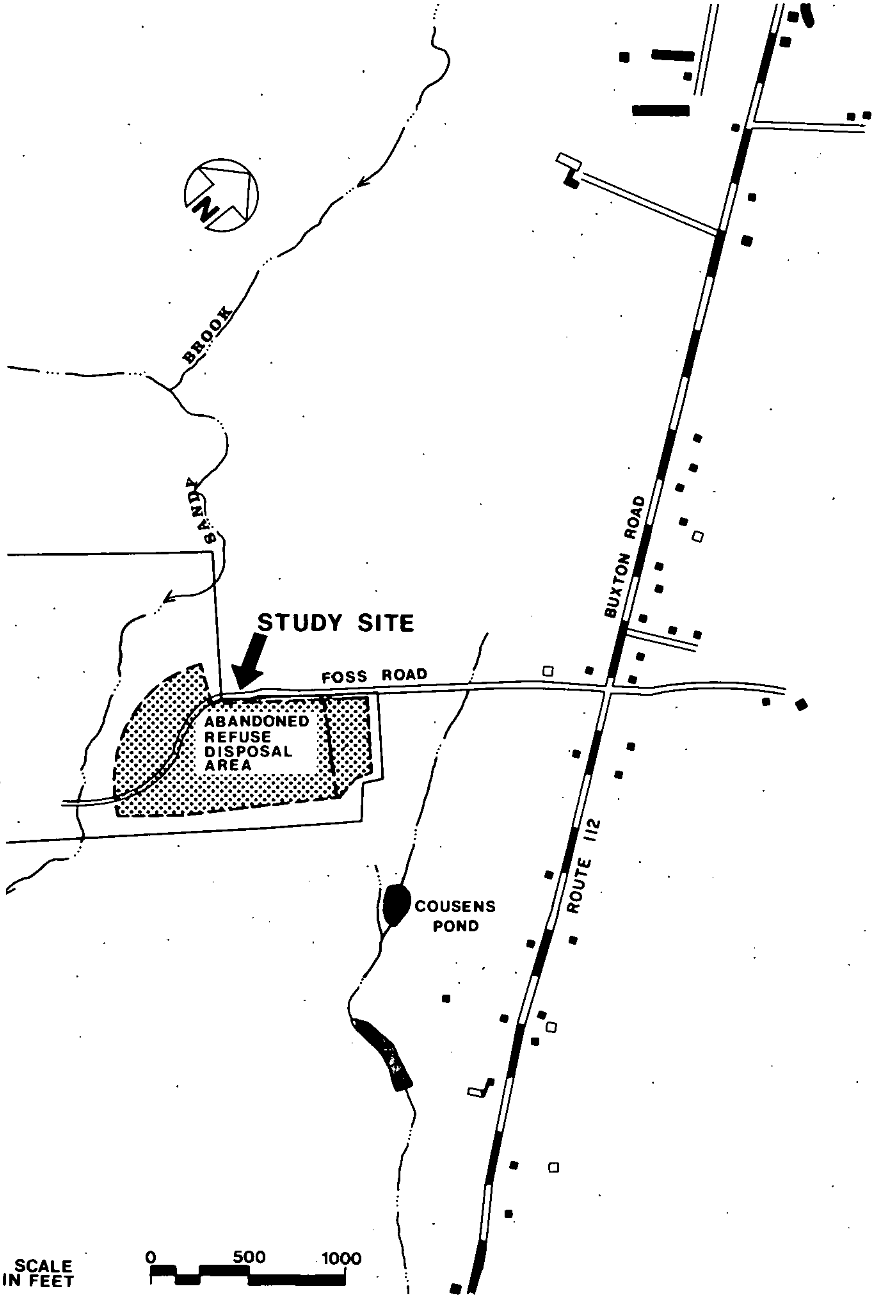

Figure 1: Location of abandoned refuse disposal area Saco, Maine

no more than 5 to 10 percent. The sludge was handled separately from other solid wastes, and was placed directly on the ground or in shallow trenches, occasionally in contact with groundwater. Cover was provided only intermittently.

The complaint of the neighboring property owner about water quality, in April 1974, prompted surface water tests and analyses by the city's engineer and by the Maine Department of Environmental Protection (DEP). This initial study confirmed that leachate was contaminating surface water in the vicinity. In order to arrive at means for correcting the problem that would be most acceptable, environmentally and economically, the city of Saco undertook a program designed to trace the path of the contamination migrating from the disposal area, to characterize the nature of the contaminants, and to develop alternative solutions to the problem. The Edward C. Jordan Company of Portland, Maine, was selected to provide consulting engineering services to the city, as well as testing and laboratory services in conjunction with the Maine DEP.

The city's program was undertaken in two phases:

Phase 1. Hydrogeological investigation.

Phase 2. Evaluation of alternate corrective measures.

The objective of the hydrogeological investigation, Phase 1, was to identify subsurface soils conditions and groundwater levels, and to install groundwater monitoring wells. The wells permitted the measurement of groundwater levels and the sampling of groundwater. In Phase 2 alternative corrective measures were identified and evaluated.

Hydrogeological Investigation and Groundwater Monitoring Program

A subsurface investigation and groundwater monitoring program was designed and initiated by the Jordan Company with approval of the Maine DEP. Thirteen soil borings were made, and monitoring wells installed in eleven of these holes at locations shown in Figure 2. These holes were placed to ring the site as well as to cover the interior of the dump area. In addition, a study was made of the groundwater and surface water hydrology of the area.

A marine clay is found beneath the abandoned disposal area at a depth of approximately 25 feet below ground surface. The clay is overlain by a fine permeable sand. The groundwater level varies seasonally at depths of 5 to 15 feet. Refuse depth averages 10 feet. In several areas refuse was found to be in the groundwater. Where this occurred, the submergence did not exceed 5 feet. The volume of refuse in the dump is estimated at 200,000 cubic yards. During periods of high groundwater, it is estimated that no more than 10,000 cubic yards of refuse are in direct contact with water.

The major groundwater recharge area in the vicinity of the disposal area is The Heath, a large, partly forested land area about 7,500 feet north of the site. From The Heath, groundwater moves outward in a radial pattern, both

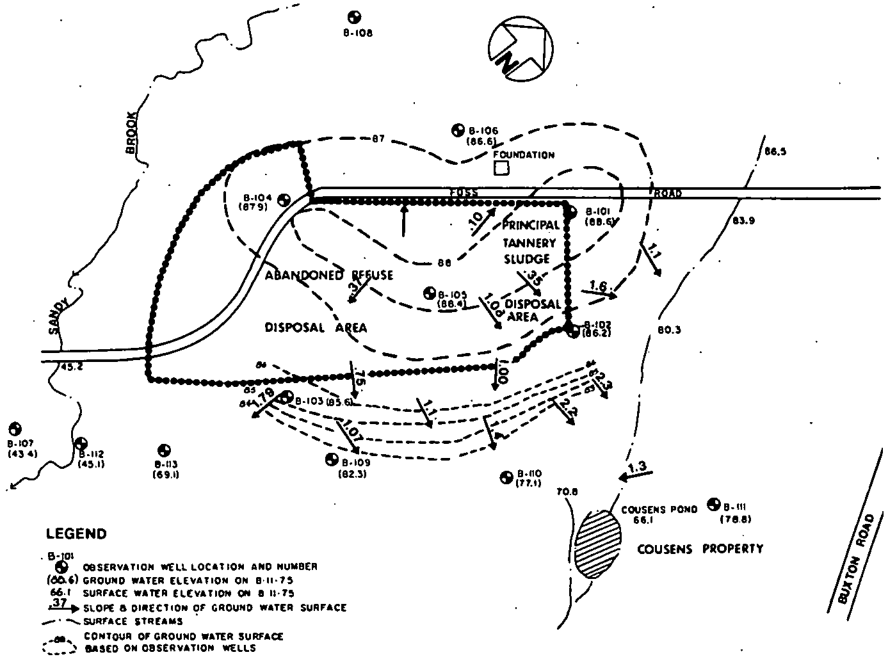

Figure 2: Hydrogeological profile at disposal site

underground and in several small surface streams, one of which is Sandy Brook. The difference in ground elevation between The Heath and the dump is approximately 10 feet.

Groundwater and surface water level measurements were taken to develop the groundwater contours shown in Figure 2. As is typical in most land disposal areas, a groundwater mound has developed beneath the fill area. It is assumed that the mounding results from surface water percolating from above and groundwater moving laterally through the refuse. This mound causes a hydrostatic pressure in all directions; however, the primary groundwater movement is in a southerly direction. The movement is confirmed by groundwater analyses which showed the greatest groundwater contamination to be in this direction. The primary area of leachate contamination lies south of the disposal area between Sandy Brook and the small stream feeding Cousens Pond.

Surface water samples taken over an 18-month period were supplemented by sampling at the new monitoring wells, as well as at several private wells in the vicinity. The wells used in this project did not permit samples to be taken at more than one depth at any point. Since the depth of the aquifer was small, this did not present a major restriction at this site. Samples were analyzed to identify the extent of groundwater contamination and the direction of its movement. The location of the borings and sampling wells is shown in Figure 3.

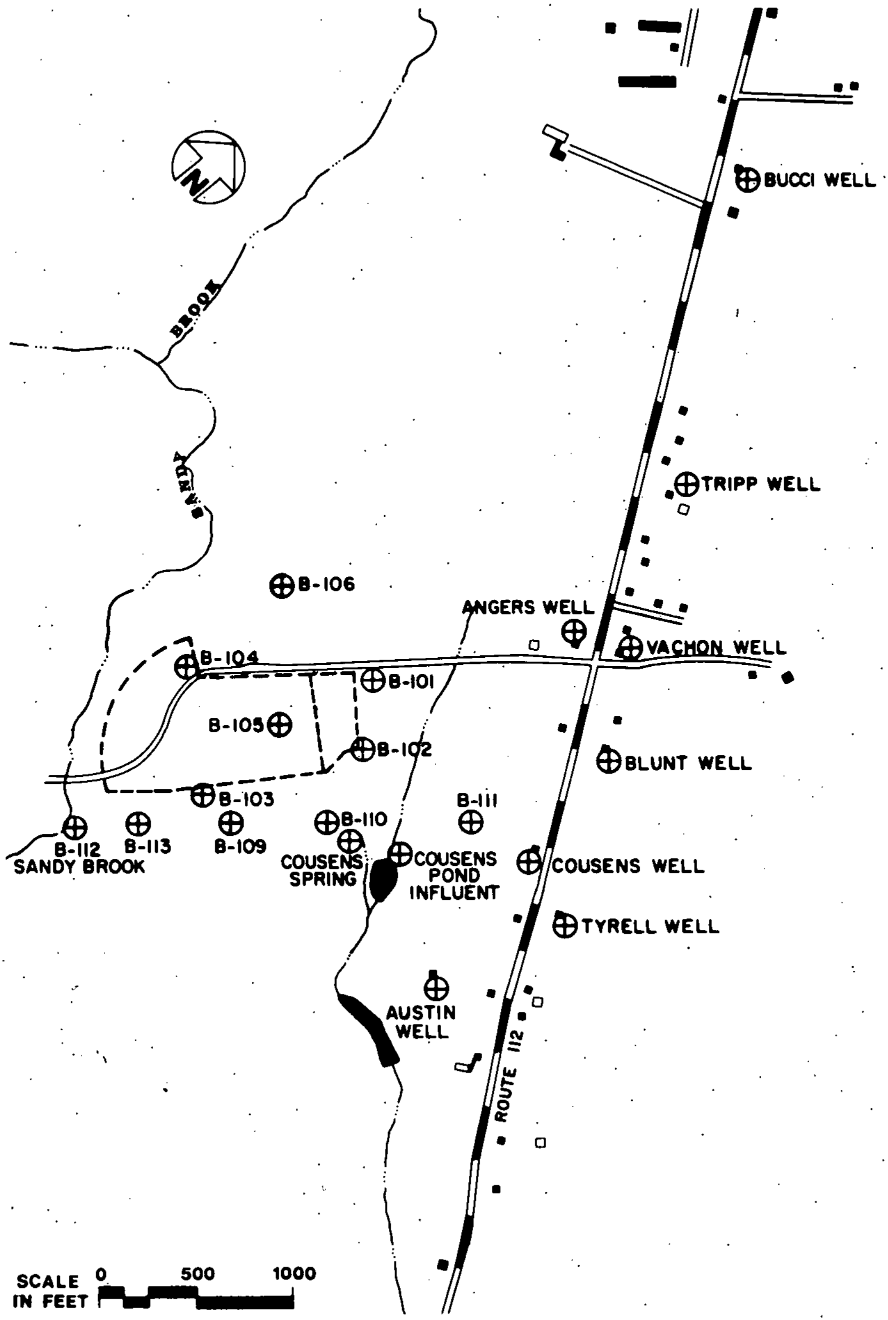

Figure 3: Monitoring points

TABLE I
WATER QUALITY MONITORING DATA*

	Chromium (mg/l)	Iron (mg/l)	Manganese (mg/l)	Zinc (mg/l)	Ammonia (mg/l-N)	Nitrate (mg/l-N)	Conductivity (hos/cm)
Bucci Well	.25	.04	.01	2.63	.03	.11	348.
Tripp Well	.01	.25	.01	.02	.01	2.1	112.
Angers Well	.01	.05	.01	—	.01	9.4	160.
Blunt Well	.025	.05	.025	.71	.02	.7	59.
Tyrell Well	.025	.025	.025	.08	.1	.24	44.
Austin Well	.025	.025	.025	.01	.04	.36	780.
Vachon Well	.025	.025	.025	1.13	.05	2.6	75.
Cousens Well	.025	.24	.04	.01	.01	.29	76.
Cousens Pond Inlet	.025	.23	.03	.6	.26	1.7	130.
Cousens Spring	.04	80.	31.	.17	11.	.77	1,530.
B-101	.27	106.	41.	.92	5.3	.29	750.
B-102	.29	442.	149.	1.6	187.	1.1	4,650.
B-103	.25	817.	28.	1.16	141.	.55	5,760.
B-104	.32	432.	32.	5.1	2.5	.9	1,010.
B-105	.17	323.	32.	1.4	24.	.3	2,630.
B-106	.04	50.	1.3	.89	.52	.7	73.
B-109	.26	642.	129.	.32	.38	.74	5,220.
B-110	.12	139.	2.7	.96	.28	1.8	67.
B-111	.04	19.	.67	1.1	.24	3.7	123.
B-113	.19	123.	6.8	1.6	.24	.7	91.

*Data for each monitoring point have been averaged over the sampling period.

Analytical Methods

Groundwater samples were obtained, for analysis, from private water supplies as well as the monitoring wells. A manually operated pump was utilized to flush each monitoring well and to collect the samples. Private water supplies were collected from house taps. The water was permitted to run for approximately 5 minutes before the sample was collected. Samples were placed in clean containers, preserved if necessary, and transported to the laboratory for analysis. Metal concentrations were determined through the use of atomic absorption.

As shown in Tables I and II, samples taken within the dump and adjacent to it show contamination. This is indicated by higher conductivity and increased concentrations of iron, manganese, chromium, and ammonia. There is some upstream dispersion because of the mounding effect; however, the highest levels of contamination occur south of the site. Based on the groundwater level readings, the topography of the area, and the surface drainage patterns, it is believed that the dump and the immediate vicinity are the major groundwater recharge sources for the area contaminated by the leachate.

TABLE II
WATER QUALITY SUMMARY

	Iron (mg/l)	Manganese (mg/l)	Total Chromium (mg/l)	Ammonia (mg/l-N)	Conductance (hos)
PHS Drinking Water Standards	0.3	0.05	0.05*	—	—
Uncontaminated Groundwater	0.1	0.025	.01	.1-.2	60-80
Contaminated Surface Water	50-75	1-25	0-.05	5-10	1400+
Groundwater Beneath Disposal Area	300-1500	20-300	0.1-2	50-100	1200-7900
Groundwater South of Disposal Area	200-1900	6-100	.1-.3	1-25	100-5000

*Hexavalent

Chromium, believed to be from the tannery sludge, occurred at a peak concentration of approximately 2.0 mg/1 in samples taken within or directly south of the area. The high concentrations of iron and manganese do not necessarily indicate that inordinate amounts of these elements were disposed of at the dump site. What they may indicate is that the soil is being affected by the leachate plume. The plume produces low pH levels (5.6-6.7) and reducing conditions in the natural soils. These conditions cause release of iron and manganese from the soil which is then detected in the samples, thus indicating the plume's presence. Laboratory analyses of groundwater samples from the leachate plume show increases in ammonia and zinc, as well as increased conductivity.

Typical seasonal fluctuations in selected water quality parameters for a typical well (B-109) are compared to background data in Figure 4. These data show that the water quality has been severely affected within the leachate plume. Sufficient long-term data have not been developed to allow definitive conclusions to be drawn relative to seasonal variations.

Typical levels of contamination within leachate plumes have been developed by the Environmental Protection Agency and others. The levels of contamination vary considerably depending upon recent rainfall, runoff, and groundwater levels with respect to refuse. The data presented here are within the range of values contained in the literature.

Alternative Corrective Measures

Having determined that leachate from the abandoned Saco disposal area was degrading local water quality, alternative measures for the prevention of further contamination were studied. Two basic approaches were evaluated: (1) leachate collection and treatment; and (2) prevention of refuse-water contact.

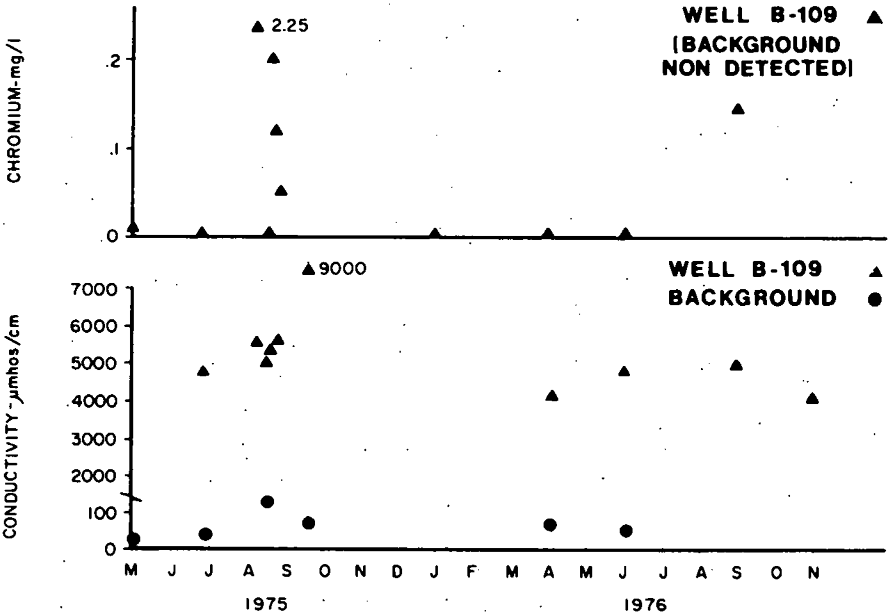

Figure 4: Representative monitoring well test results for chromium and conductivity

The effective use of a leachate collection and treatment system is dependent upon the character of the site. Normally, this alternative is very difficult and expensive to implement once a problem has developed. Prevention of refuse-water contact requires that both surface and groundwaters be controlled. This is a major goal in the design of all sanitary landfills. When no refuse-water contact occurs, leachate will not be a problem. Alternative corrective measures considered for the Saco site are discussed below.

Collection and Treatment

Leachate collection can best be accomplished by installing an underdrain system and associated works surrounding the site, in conjunction with the proper closing and capping of the area. In Saco this system would involve installation of underdrains in the area defined by wells B-101, 102, 103 and 104. During and immediately following installation, while groundwater levels are being lowered, a large quantity of contaminated water would be collected and would require treatment before discharge to Sandy Brook. The leachate collected initially would have been in contact with the refuse for varying periods of time. In addition to the iron, manganese and chrome, the leachate might contain a wide range of complex organic compounds resulting from the decomposition of materials placed in the landfill. Although temporary treatment would be required during this initial leachate collection period, treatment could be discontinued when the system reached a steady state. Steady state conditions would occur when groundwater levels are lowered, so that no water remains in contact with refuse. When that condition is reached, no more contaminated water would be collected.

To treat a temporary flow of leachate economically over a period of perhaps several months, capital expenditure should be minimized. To meet this objective, a treatment system consisting of two holding ponds in series separated by a dike of graded filter and was initially considered. However, systems of this type are still being tested and evaluated. Initial analyses showed that such a system would have difficulty achieving sufficient treatment before discharge to Sandy Brook.

Because of the short-term use of the treatment system, chemical and/or biological treatment processes were not considered economically feasible. In addition, no suitable receiving water was located nearby. Thus collection and treatment was not given further consideration as an overall solution to the leachate problem.

Prevention of Refuse-Water Contact

Leachate formation may be controlled by preventing water from coming in contact with refuse. Water may reach the refuse by percolating through the surface or by lateral movement of groundwater. Both of these sources of water must be controlled to eliminate the formation of leachate. The percolation of surface water into the buried refuse can be controlled by properly grading the surface of the landfill and covering with an impervious layer. The lateral movement of groundwater through the refuse and the movement of leachate away from the landfill may be controlled by constructing a vertical barrier to prevent such movements. These objectives can be met by any of several alternative methods.

Prevention of surface water percolation involves the placement of an impervious cover. Placement of the cover involves several steps: (1) site grading; (2) placement of soil to cover the refuse; (3) placement of an impervious layer (see below); and (4) placement of protective soil if necessary, and topsoil, fertilizer, and seed. The area to be covered at the Saco dump is about 9 acres (42,500 square yards) and is shown in Figure 5. Several alternative surface sealing systems were studied. Since each of these systems is capable of effectively restricting percolation of water into the refuse, cost is the major factor in selection. Cost data are presented following a brief description of alternative systems.

Synthetic Liners. Synthetic materials such as Hypalon and EPDM (Ethylene Propylene Diene Monomer) have been used to contain water in lagoons and holding ponds. These materials would also be effective in providing a watertight seal for surface application. The installation of the liner would have to be handled with care to ensure that no breaks occur.

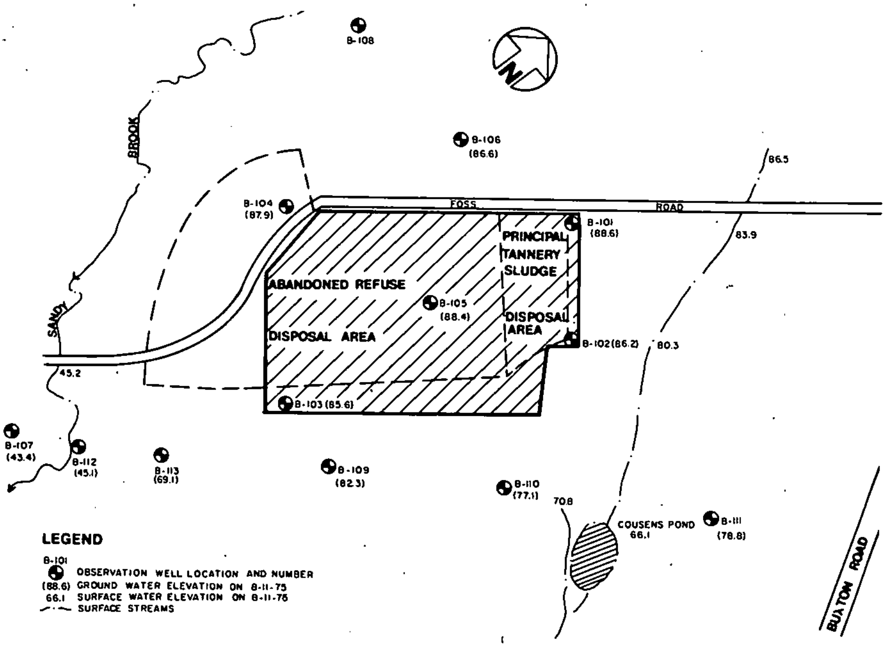

Figure 5: Surface area to be covered

Soil-Bentonite Mixture. Bentonite clay can be used as an additive to native soils to form an impervious barrier. Bentonite is an imported naturally occurring clay which swells enormously when placed in contact with water. When it swells, it fills voids in the soil and reduces permeability. This material has also been used extensively in the construction of ponds and lagoons. When used as a seal over a disposal area, the bentonite is spread over the prepared site, using conventional farm machinery, at an application rate of 1.0 to 4.0 pounds per square foot. The material is mixed with the soil to a predetermined depth (2 to 6 inches), then rolled and covered.

Soil-Cement Mixture. A soil-cement seal would be similar to the soil-bentonite system described above; however, portland cement would be used as the admixture rather than clay (bentonite). Liquid asphalt would be sprayed over the surface at one-quarter gallon per square yard to aid in the curing process.

Natural Clay. Natural marine clays or other impervious soils can be used to form a watertight course. There must be a source of this material within an acceptable haul distance to make this method feasible.

Many of the coastal areas of southern Maine are underlain by an impervious marine clay, and this is an inexpensive source of suitable sealing material, readily available to the city of Saco.

In Saco the use of natural clay would involve grading of the site, placement of 6 inches of soil, placement of a 1-foot layer of clay, and finally placement of a 6-inch soil layer suitable for supporting a grass crop. Minimum surface grade would be 2 percent to encourage efficient runoff. Once the impervious course were covered with topsoil, fertilizer and seed would be added.

In conjunction with each of the above surface sealing systems, provisions would have to be made to improve surface runoff and divert it from the vicinity of the former disposal area. The drainage system would consist of well-defined impervious drainage channels leading to major natural drainage areas in the vicinity. Improved surface runoff would reduce percolation and reduce recharge of the groundwater beneath the disposal area.

In addition to controlling percolation, a complete encapsulation system would include a vertical barrier to prevent lateral groundwater movement. The vertical barrier would extend from the ground surface to the impervious clay layer which lies beneath the disposal area at a depth of approximately 25 feet. Alternative types of vertical barrier are described below.

Slurry Trench. The slurry trench method involves the construction of an impervious bentonite clay wall around the abandoned disposal area. A trench is dug and a bentonite-water slurry is added to stabilize the trench. After the excavation has proceeded for a short distance (about 100 feet), the trench is backfilled with a soil-bentonite mix to form an impervious wall 18 to 24 inches thick. No site dewatering is required. Additives to the bentonite prevent its breakdown in the presence of leachate.

Grouting. A grout wall may be installed by pumping a grout compound into the soil through vertical pipes. As the grout fills the voids, pressure increases and the tubes are withdrawn. Since close spacing is required to form a tight barrier, the quantity of material and the long installation time makes this an expensive alternative.

Imper-Wall. The Imper-Wall system is a proprietary grouting technique which increases the efficiency of grout injection. In this process, a special 24- to 48-inch steel I-beam with a grout pipe attached is driven by a vibrating hammer through the soil to the underlying clay layer. As the beam is driven into and then extracted from the soil, a grout of bentonite is pumped through the pipe into the soil. As the beam is removed, the void space is filled and the grout forms an impervious barrier. Subsequent sections overlap to form a continuous wall. The Imper-Wall method is faster than conventional grouting and requires less material, thereby reducing cost.

Steel Sheeting. Leachate movement may also be controlled by driving interlocking steel sheet piling around the abandoned disposal area and into the clay layer beneath the refuse. The cost of protecting the piles against corrosion and subsequent failure would make this alternate extremely expensive.

Concrete Wall. Construction of a concrete wall would be complicated by high groundwater and unstable soils and would require dewatering of the site. The dewatering process would require the pumping of contaminated water, thus this method would not be feasible even if the difficult excavation problems were solved.

Cost Comparison

Since the cost of the corrective system is a major factor in selection, preliminary cost estimates were developed for the various alternatives.

The capital costs associated with closing the abandoned dump area and placing an impervious cover vary from $152,000 to $231,000 (or from $0.40 to $0.60 per square foot.) These costs include site preparation and grading; soil cover, the impervious course with protection as required; fertilizer and seed; additional wells to monitor the effectiveness of the system; and contingencies and engineering. Most of these costs are the same for any system. The principal factor which leads to differences in cost is the impervious cover and associated protective material. This portion of the cost varies from $179,000 for a synthetic membrane to $100,000 for a natural clay system.

Cost estimates for the vertical barriers were developed from a review of recent contractors' bids for similar projects, and were compared on the basis of cost per square foot of wall. These costs, which include material and installation, are as follows:

Method	Unit Cost	Total Cost
Slurry Trench	$ 6.00/sq ft	$370,000
Imper-Wall	$ 4.00/sq ft	$240,000
Grouting	$15.00/sq ft	$900,000
Concrete Wall	$ 6.75/sq ft	$400,000

Conclusions

Based on a preliminary evaluation of the alternatives presented above, it was concluded that the use of a locally available clay for the surface cover would offer the city of Saco the most cost-effective means of preventing percolation of surface runoff into the refuse. The use of the Imper-Wall techniques with a bentonite barrier would offer the most cost-effective means of constructing a vertical barrier to restrict lateral groundwater movement and to encapsulate the buried refuse.

It was also concluded that phased implementation of a leachate correction program would be the most prudent path to follow. The first phase would include grading and covering the area, in conjunction with improving surface drainage. In addition to preventing percolation of water through the refuse, the impervious cover would reduce groundwater recharge. As a result, groundwater levels would be lowered, possibly enough to eliminate refuse-water contact. Groundwater quality and levels would be monitored to measure the effect of the cover system.

If groundwater contamination persisted, additional steps would be necessary beyond the phase one improvements described above. Because of the high cost of vertical barriers, second-phase implementation measures would include the placement of an underdrain system on the north side of the area to further lower groundwater levels.

Complete encapsulation of the buried refuse was not recommended at this time. The high cost, maintenance requirements, and potential long-term liability of such a system would preclude its implementation without additional evaluation.

Current Status

The engineering report prepared for the city of Saco was submitted to the Maine DEP in November 1975, with a recommendation that the abandoned disposal area be graded, covered with an impervious clay material, and seeded in conjunction with improved site drainage. The Maine Board of Environmental Protection approved this proposal.

The City Council placed a referendum before the residents of Saco requesting authorization to spend up to $147,000 to correct the leachate problem. Following approval of this referendum by a wide majority, the city awarded contracts for the grading of the site and the placement of the impervious cover material.

The initial portion of the project was completed in November 1976. The entire project area is scheduled for loaming and seeding as soon as conditions permit in the spring of 1977.

Additional groundwater monitoring wells will be installed during the winter of 1976/77. Groundwater levels and water quality will be monitored intensively for a period of 18 months to determine the effectiveness of the corrective measures in reducing the generation of leachate. At the end of the 18-month period, a summary report will be submitted to the DEP. Based on that report, the need for additional corrective measures, if any, will be determined.