U.S. Environmental Protection Agency
Hazardous Waste Ground-Water Task Force

Information and Documents for Compliance Assessment of the Bob's Home Service Wright City, Missouri Facility

Volume 7
Technical Reports and Plans -- General Technical Reports and Plans

October, 1985

PRC Environmental Management, Inc.

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Volume 7

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PRMT SECTION

BOB'S HOME SERVICE

DOCUMENT/SUBJECT CROSS-REFERENCE CHART

VOLUME 7

TECHNICAL REPORTS AND PLANS --

GENERAL TECHNICAL REPORTS AND PLANS

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		T013-P09-603-005	T013-P09-603-006	T013-P09-603-007	T013-P02-603-008	T013-P02-603-009	T013-P09-603-010	T013-P02-603-011	T013-P02-603-012										
NUMBER OF PAGES		2	2	2	54	14	2	350	17										
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PART A APPLICATION/INTERIM STATUS																			
COMPLIANCE ENFORCEMENT																			
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CORRESPONDENCE																			
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MAPS, DRAWINGS AND PHOTOGRAPHS																			
CONFIDENTIAL INFORMATION																			
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T013-P09-603-005	11-18-81	Soil Boring Log Description (2 Pages) o Hole Number: K1 - 80
T013-P09-603-006	11-19-81	Soil Boring Log Description (2 Pages) o Hole Number: K2 - 80
T013-P09-603-007	11-19-81	Soil Boring Log Description (2 Pages) o Hole Number: K3 - 80
T013-P02-603-008	10-12-83	Letter Report To: David A. Wagoner, Air and Waste Management Division, U.S. EPA Region 7 From: Michael D. Gill, Vice President of Operations, Bob's Home Service Re: Response to U.S. EPA's Region 7 letter of September 8, 1983 regarding denial of B.H.S., Inc. (54 Pages) o Monitoring Waiver Demonstration o Response to Deficiencies in Ertec Atlantic, Inc. Report - Horizontal gradient - Surface water balance - Saturated conditions and porosity o Enclosure I - Field Permeability Tests, Bob's Home Service

TECHNICAL REPORTS AND PLANS -- GENERAL TECHNICAL REPORTS AND PLANS

DOCUMENT	DATE	DESCRIPTION
T013-P02-603-008	(continued)	o Enclosure II - Laboratory Permeability/Compactability Test, Bob's Home Service o Enclosure III - Water Quality Evaluation, Bob's Home Service
T013-P02-603-009	02-12-84	Letter Report To: Jane Ratcliffe, Program Manager, U.S. EPA Region 7 From: Josepy M. Sorge, Associate of the Earth Technology Corporation Re: Response to applicant's comment dated October 12, 1983, Bob's Home Service (14 Pages) o Ground-Water Quality o Oxidized-Unoxidized Zones o Horizontal Gradient o Saturated Thickness o Water Balance o Saturated Conditions and Porosity

TECHNICAL REPORTS AND PLANS -- GENERAL TECHNICAL REPORTS AND PLANS

DOCUMENT	DATE	DESCRIPTION
T013-P09-603-010	08-10-84	Soil Boring Test (2 Pages) o B.H.S. Area I - Elevation 740 - Horizontal Sample
T013-P02-603-011	08-08-85	Potential for Public Exposure to Hazardous Waste (350 Pages) o Legislative Requirements o Transportation o Exposure Potential of the Unit o Appendices - Woodward-Clyde Environmental Assessment - Environmental Risk Assessment for 1980 & 1983 - Ten Largest Generators
T013-P02-603-012	08-23-85	Appendix D- Justification for the TOT Criteria Based on Risk Analysis o Facility Description

T013- P09 - 603-005

Site BHS County Warren

Location ___ ¼, ___ ¼, ___ ¼, Sec. ___, T. ___, R. ___, Quad. ___

Other location as grid coord. ___ Hole # K1 - 80'

Logged by Jim Williams

Dates 18 November 1981

Hole purpose: Exploration ___ Piezometer ___

Monitoring ___ Other Permeability

Drilling equipment ___

chem water sample ___ or dating sample ___

water first encountered ___ after Water @ 45'10" beginning of test hs.

DESCRIPTION

Water at:	Drill Proc.	Description	Depth	Thickness
72 hrs. ▽	ss fa	For abbreviations of drill procedures, how about flt. auger fa, air a, water w, roller bit rb, shelby tube st, split spoon ss, water sample for chemical tests ws, for dating ds, for water first encountered ▽ , after ___ hs, ▲ A circle around a sample would mean we collected a sample. For soil description, I suggest the following procedures: "clay, silty, brown, platy, firm, moist, root holes, CL" In other words, matrix first, other constituents second, then color, structure, strength, moisture, pecularities, and then engineering properties. Keep it brief and simple.	25-30	5.0'

Site_____ Hole #_____ County_____ K-1 80'

Location____¼,____¼,____¼, Sec.____,T.____,R.____,Quad_____

DESCRIPTION

Water at:	Drill Proc.	Description	Depth	Thickness
		1st test @ 15psi - no water loss into piezometer noted held 15 min approx. Increased to 20 psi for 15 min approx - took approx. 1 gal. total Increased to 28 psi for 10 min approx - took approx. 1 gal. total Increased to 52 psi - to this point total take of water about 8 gal. At the 52 psi for 5 min, took ½ gal. Continued total 10 minutes. Total test approx. 50 min. total take about 9 gal.		

T013-P09-603-006

Site BHS County Warren

Location ___ ¼, ___ ¼, ___ ¼, Sec. ___, T. ___, R. ___, Quad. ___

Other location as grid coord. ___ Hole # K-2 80'

Logged by Jim Williams

Dates 19 November 1981

Hole purpose: Exploration ___ Piezometer ___

Monitoring ___ Other Field permeability test

Drilling equipment ___

chem water sample ___ or dating sample ___

water first encountered ___ after ___ hs.

DESCRIPTION

Water at:	Drill Proc.	Description	Depth	Thickness
72 hrs.	ss	For abbreviations of drill procedures, how about flt. auger fa, air a, water w, roller bit rb, shelby tube st, split spoon ss, water sample for chemical tests ws, for dating ds, for water first encountered ▽ , after ___ hs, ▲ A circle around a sample would mean we collected a sample. For soil description, I suggest the following procedures: "clay, silty, brown, platy, firm, moist, root holes, CL"	25-30	5.0'
▽	fa	In other words, matrix first, other constituents second, then color, structure, strength, moisture, pecularities, and then engineering properties. Keep it brief and simple.		

,ite_____ Hole #_____ County_____

Location____¼,____¼,____¼, Sec.____,T.____,R.____,Quad_____

K-2 80'

DESCRIPTION

Water at:	Drill Proc.	Description	Depth	Thick-ness
		18 psi - taking slightly less than 0.1 gpm - 25 minutes		
		40 psi - took 0.4 gal. per 5 minute, reduced to 0.3 gal. per 5 minute, perhaps due to densification or possibly filling clay fractures for 30 minutes		
		61 psi took 2 gal. per 5 minutes for 30 minutes. The seal blew or ejected water up hole between grout and surrounding soil.		

T013-P02-603-007

Site BHS County Warren

Location ___¼, ___¼, ___¼, Sec. ___, T. ___, R. ___, Quad. ___

Other location as grid coord. ___ Hole # K-3 80'

Logged by Jim Williams

Dates 19 November 1981

Hole purpose: Exploration ___ Piezometer ___

Monitoring ___ Other Permeability test

Drilling equipment ___

chem water sample ___ or dating sample ___

water first encountered ___ after ___ hs.

DESCRIPTION

Water at:	Drill Proc.	Description	Depth	Thickness
72 hrs. ▽	ss fa	For abbreviations of drill procedures, how about flt. auger fa, air a, water w, roller bit rb, shelby tube st, split spoon ss, water sample for chemical tests ws, for dating ds, for water first encountered ▽ , after ___ hs, ▲ A circle around a sample would mean we collected a sample. For soil description, I suggest the following procedures: "clay, silty, brown, platy, firm, moist, root holes, CL" In other words, matrix first, other constituents second, then color, structure, strength, moisture, pecularities, and then engineering properties. Keep it brief and simple.	25-30	5.0'

Hole # _____ County _____

Location ____ ¼, ____ ¼, ____ ¼, Sec. ____, T. ____, R. ____, Quad _____

SCRIPTION

Water at:	Drill Proc.	Description	Depth	Thick-ness
		12 psi for 25 minutes 0.2 gal/5 minutes 28 psi for 25 minutes 0.6 to 0.5 gal/5 minutes increased to 50 psi Blew seal or ejected water up hole between grout and dirt.		

T013-P002-603-008

Sent to Shosky 5/31/85 LA

B.H.S., inc.

INDUSTRIAL WASTE
LANDFILL
Route 1, Box 116F
Wright City, Mo. 63390
314-745-3371

October 12, 1983

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OCT 19 1983
AIR AND WASTE COMPLIANC
BRANCH

David A. Wagoner
Air and Waste Management Division
USEPA, Region VII
324 East Eleventh Street
Kansas City, Missouri 64106

RE: Monitoring Waiver
Demonstration

Dear Mr. Wagoner:

This letter is in response to your letter of September 8, 1983 regarding the agency's denial of the BHS, Inc. groundwater monitoring waiver request. It is our understanding that the decision to deny the groundwater monitoring waiver at the BHS facility was primarily based on the report by Ertec Atlantic, Inc. included with your letter. It is further our understanding that the Waste Management Branch does not have a staff geotechnical engineer or hydrogeologist, thus, a detailed technical review of the Ertec report from that perspective has not been made.

At my request technical consultants to BHS have reviewed the Ertec report. Their comments indicate errors of procedure and assumption which would significantly impact the conclusions of the report. Furthermore, additional studies have been conducted in conjunction with the state permitting procedure which have direct bearing on the monitoring issue.

Don Sandifer was contacted by telephone on October 5, 1983 and a meeting was requested to address and resolve the preceeding issues. Mr. Sandifer agreed that a meeting was in order but requested that BHS first submit additional relevent information and a letter commenting on the Ertec report. The following general comments address the Ertec report and are numbered to correspond to report section numbers. Enclosures 1, 2 and 3 are copies of reports prepared by Woodward-Clyde Consultants and relate to field permeability, leachate/liner compatibility and water quality respectively. We are prepared to submit additional comments and information as determined appropriate at or subsequent to the meeting.

COMMENTS ON THE ERTEC REPORT

Section 2.1

The water quality data in Appendix J does not indicate similarity between the various water bearing units. Other monitoring data generated since 1977 and the supplemental information contained in Enclosure 3 also refute the Ertec position.

Section 2.2

Data included in the waiver demonstration indicate that the oxidized zone is not saturated thus the unsaturated zone would be greater than 15 feet thick in the subject area. The Ertec report indicates no data which refute this.

Section 2.3

The horizontal gradient is estimated by Ertec to be .3333. No data presented in the waiver demonstration would lead to a calculated gradient within the oxidized zone of 33 feet per 100 feet. This number (.3333) is an order of magnitude greater than the gradient indicated by the waiver demonstration data. Using the gradient indicated by this data would increase the Ertec calculation for lateral travel time by a factor of 10 Also, the results of additional field permeability tests in this zone have a bearing on the calculated rate indicated in the Ertec report. Utilizing the new data would result in a lower flow rate estimate.

Section 2.4

We have the same comment regarding the horizontal gradient and permeability as that for section 2.3 and further note that the assumption of a saturated thickness of 1 to 5 feet contradicts the previous statement regarding the unsaturated zone made in Section 2.2

Section 2.5

Comments made in this section apparently assume the method described in the referenced EPA report (SW-168) is the only apropriate procedure to follow when preparing a surface water balance and that DEK appendix L was prepared using this document. Neither assumption is correct. It has been determined that the

water balance presented in Appendix A of the Ertec report was not performed properly with respect to the SW-168 procedure and has resulted in incorrect conclusions. Without discussing specific errors at this time, it is noted that the annual values presented in the Ertec water balance do not balance. A water balance has been prepared following the SW-168 procedure accurately and the resultant calculated value for percolation remains zero as originally reported.

Section 2.6

We do not have access to the HELP program at this time and, consequently, have not conducted an evaluation of the landfill design with this system. It is pointed out, however, that the DEK report did not contain all "values" necessary to run a program of this type and that certain parameters would have to be calculated or assumed from information presented. Mr. Sandifer indicated that he would attempt to obtain specific values for the HELP program input paraments used by Ertec and the rational for their selection. We reserve further comment until such time as those values are available.

Section 2.7

We disagree with the Ertec assumption of saturated conditions and the value assumed for porosity. Our determination of percent saturation and porosity are derived from, "results of laboratory tests....as well as personal observation" as indicated in the Ertec report. We believe actual conditions should take precedent over assumptions made in contradition to observed conditions.

Chapter 3

This chapter contains numerous assumptions which have no factual basis. Obviously, we disagree with conclusions derived from such assumptions. We reserve further comment at this time.

Chapters 4 & 5

We see no reason to comment specifically on these chapters at this time beyond noting a general disagreement with conclusions drawn from erroneous assumptions and calculations.

I request an opportunity to discuss these issues in a meeting in Kansas City between appropriate members of your staff and BHS consultants. I further suggest that members of the Missouri Department of Natural Resources be present since the state monitoring program has a direct effect on this issue. Please coordinate the date & time with Ben Moore. He can be reached by telephone at 314-875-4618.

It is a policy of BHS,Inc. to cooperate fully with all regulatory agencys when their recommendations or decisions have a sound basis. It should also be pointed out that BHS has installed the monitoring system indicated in the state permit application. We cannot however agree, without comment, to any decision to alter the monitoring system based on information as unreliable as that contained in the subject report.

I look forward to an appropriate resolution of this matter. Please contact me or Mr. Moore if you have any questions

Sincerely,

Michael D Gill

Michael D. Gill
Vice President
of Operations

cc. Mr. John Doyle (MDNR)

ENCLOSURE 1

David A. Wagoner

October 12, 1983

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OCT 19 1983

AIR AND WASTE COMPLIANCE
BRANCH

BHS Exhibit 35
9-29-83, MCL

FIELD PERMEABILITY TESTS

BOB'S HOME SERVICE

INTRODUCTION AND BACKGROUND

Three field permeability tests and three laboratory permeability tests were performed by Woodward-Clyde Consultants (WCC) during the period between August 30, 1983 and September 26, 1983 at the request of Love, Lacks, McMahon & Paule.

Two types of field permeability tests were conducted in the monitoring wells at Bob's Home Service (BHS). A non-intrusive slug test was performed in monitoring well K2(OX) (see Figure 1). Well inflow tests were conducted in monitoring wells K3(80) and K4(80). The coefficient of permeability was also calculated for wells K2(OX) and K5(80) from well recovery data contained in Appendix F of the permit application.

The WCC laboratory permeability tests were performed on samples of the unoxidized glacial till to obtain more accurate values of the coefficients of permeability. The WCC laboratory permeability tests were performed in triaxial compression devices with backpressure saturation, which is the most accurate laboratory method to evaluate the coefficient of permeability (Zimmie et al 1981). The results of the permeability tests are summarized on Table 1.

The purpose of the field permeability tests was to evaluate the coefficient of permeability (hydraulic conductivity) of the oxidized glacial till and the unoxidized glacial till at the BHS site. A typical generalized geologic cross section of the BHS site is shown in Figure 2. A

zone of perched water, which varies in thickness from 5 to about 20 feet, is located at the interface between the oxidized and unoxidized glacial tills. Well K2(OX) is screened in the interface zone. Wells K3(80), K4(80), and K5(80) are screened in the unoxidized glacial till below the oxidized glacial till and above the sand aquifer. The sand filter pack for monitoring well K5(80) may extend into the oxidized zone so the coefficient of permeability measured in a field permeability test may be an average value of both the oxidized and unoxidized glacial tills.

Previous field permeability tests were performed in both the oxidized and unoxidized glacial tills by Dan E. Klockow & Associates (DEK). The horizontal field coefficient of permeability was measured in wells K1(OX), K1(80), K2(80), K3(80), and K1(SA) using a pressure test method. Due to the high pressures which were used, it is likely that the values of the coefficient of permeability which were calculated from the tests were higher than the in-situ coefficient of permeability. The results of the pressure tests are summarized in Table 1.

Laboratory permeability tests were performed on soil samples from both the oxidized and unoxidized glacial tills. The Missouri Department of Natural Resources (MDNR) performed falling head permeability tests on four samples. Coefficient of permeability values were also calculated from consolidation tests performed by DEK. The values of coefficient of permeability determined by the laboratory tests are summarized in Table 1.

METHODOLOGY

Slug Test

A non-intrusive slug test was performed in well K2(OX) using a down-hole head measurement device (DHHMD) developed by WCC in accordance with the procedure outlined in Bower and Rice (1976). A schematic of the DHHMD is shown in Figure 3.

The slug test was performed by lowering a sensitive differential pressure transducer to a specified depth in the water column of a well. The height of water in the well was then raised suddenly by submerging a "slug" or cylinder of known volume into the well. The change in height ~~in volts~~ was recorded at incremental times of 0.1, 0.5, 1.0, 2.0, 5.0, 8.0, 15, 30, 60, 140 and 880 minutes from the output of the digital volt meter. A continuous readout of the test was provided by the strip-chart recorder. However, the resolution of the strip-chart recorder was much less than the resolution of the output from the digital volt meter.

Well Inflow Test

The well inflow tests were performed and analyzed following the methodology outlined in Hvorslev (1951). Well inflow tests were performed in monitoring wells K3(80) and K4(80), which were completed in the unoxidized glacial till. These two wells contained no free water at the time of the test.

The wells were filled with potable water from the Wright City water supply to a height approximately 5 to 15 feet above the bottom of the well. The change in height of the water levels in the wells was measured at

elapsed times of approximately 10, 20 and 30 minutes and then daily for about two weeks using a Soil Test water level indicator.

Well Outflow Test

The well outflow evaluation was performed using well recovery data contained in the permit application. The data were analyzed using the methodology outlined in Hvorslev (1951) for well inflow and well outflow tests. After the installation of wells K2(OX) and K5(80), the water level in the wells slowly rose to an equilibrium position. The depth to water in each of the wells was measured two to three times per week for the six to eight week period until the equilibrium water level was reached. The change in water level with time resulting from the installation of the well is very similar to a well outflow test in which water is removed from a well and the recovery in water level in the well is measured as a function of time. The data from the well recovery after installation were treated as a well outflow test.

RESULTS

Slug Tests

The data from the slug test performed in monitoring well K2(OX) was analyzed using the procedure presented in Bower and Rice (1976). The theory and equations were developed based on a modified form of the Thiem equation:

$$Q = 2 \quad KL\left[\frac{y}{Ln\ (Re/r_w)}\right]$$

where Q is the flow rate (length^3/time), K is the hydraulic conductivity (length/time), L is the length of the well screen, y is the vertical

distance between the equilibrium water level and the water level in the well at a given time after the slug has been placed in the well, Re is the effective radius over which the changes in head is dissipated, and r_w is the radius of the well boring.

The results of the calculations from the slug test data for well K2(OX) indicates that the coefficient of permeability varies between about 5×10^{-8} and 2×10^{-7} cm/sec.

Inflow and Outflow Tests

The inflow and outflow test data from wells K3(80), K4(80), K5(80), and K2(OX) were analyzed using the equation for flow through a uniform soil presented in Hvorslev (1951). For the condition of variable head (rising or falling), the hydraulic conductivity may be calculated using the following equation:

$$K = \left[\frac{d^2 \, Ln\left(\frac{2mL}{D}\right)}{8L(t_2-t)}\right] Ln\left(\frac{H_1}{H_2}\right) \quad \text{for} \quad \frac{mL}{D} > 4$$

where K is the hydraulic conductivity (length/time), d is the diameter of the well riser pipe, m is the square root of the ratio of the horizontal to vertical hydraulic conductivity, L is the length of the well screen, D is the diameter of the well screen, H_1 is the height of the water column at time t, and H_2 is the height of the water column at time t_2.

Since the soil surrounding wells K3(80) and K4(80) was unsaturated prior to performing the test, the coefficient of permeability has been calculated using the Hvorslev equation to give an estimate of the order of magnitude of the in-situ hydraulic conductivity.

The range of values of hydraulic conductivity calculated using the Hvorslev equation are summarized in Table 2.

CONCLUSIONS

Based on a review of the field permeability data, the methodology of the field permeability tests, and the laboratory test data from MDNR and DEK, the primary conclusions are as follow:

1. Based on the slug test and well outflow test data, the coefficient of horizontal permeability of the oxidized zone appears to be in the range of approximately 1×10^{-8} to 2×10^{-7}.
2. Based on laboratory and field permeability tests, the coefficient of permeability of the unoxidized zone varies from approximately 5×10^{-9} to 5×10^{-8} cm/sec.
3. Although the pressure tests conducted by DEK were performed using a recognized procedure, the measured values of the coefficient of permeability were higher than exists in situ due to the high pressures which were used. The high pressure may have induced leakage around the seal and may have hydraulically fractured the soil or opened existing joints or cracks, thus, giving high values of the coefficient of permeability.
4. There is generally good agreement between data from the unoxidized till obtained using all of the test methods. The slug tests and inflow and outflow tests yield results which are about

equal to the falling head permeability tests and are between the values obtained from the consolidation tests and the field pressure tests.

REFERENCES

Bower, H. and R. C. Rice. (1976) "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells," Water Resources Research, Vol. 12, No. 3.

Hvorslev, M. J. (1951). "Time Lag and Soil Permeability in Ground Water Measurements," Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, Bulletin 36, 50 pp.

TABLE 1
HYDRAULIC CONDUCTIVITY CALCULATED FROM
PREVIOUS PERMEABILITY TEST DATA

Test Performed By	Sample Number	Test Type	Sample Location	Oxidized Coefficient of Permeability (cm/sec)	Unoxidized Coefficient of Permeability (cm/sec)
MDNR	BHS I	Lab, F. H.[1]	Test Pit	1.6×10^{-8}	
MDNR	BHS II	Lab, F. H.	Test Pit	1.1×10^{-8}	
MDNR	BHS III	Lab, F. H.	Test Pit	8.4×10^{-6}	
MDNR	K6	Lab, F. H.	Well K6		4.9×10^{-8}
DEK	1	Consol[2]	Well K1	4×10^{-9} to 2×10^{-8}	
DEK	K1	Consol	Well K1		1.1 to 1.4×10^{-8}
DEK	K2	Consol	Well K2		4×10^{-9} to 6×10^{-8}
DEK	K3	Consol	Well K3	4×10^{-9} to 2×10^{-8}	
DEK	K3	Consol	Well K3		9×10^{-9} to 2×10^{-8}
DEK	K4	Consol	Well K4		3×10^{-9} to 5×10^{-9}
DEK	K5	Consol	Well K5		5×10^{-9} to 1×10^{-8}
DEK	-	Pressure Test[3]	K1(OX)	2×10^{-6} to 1×10^{-5}	
DEK		Pressure Test	K1(80)		3×10^{-7} to 9×10^{-7}
DEK		Pressure Test	K2(80)		9×10^{-7} to 3×10^{-6}
DEK		Pressure Test	K3(80)		1×10^{-6}

[1] - Laboratory Falling Head Permeability Test
[2] - Laboratory Consolidation Test
[3] - Field Pressure Test

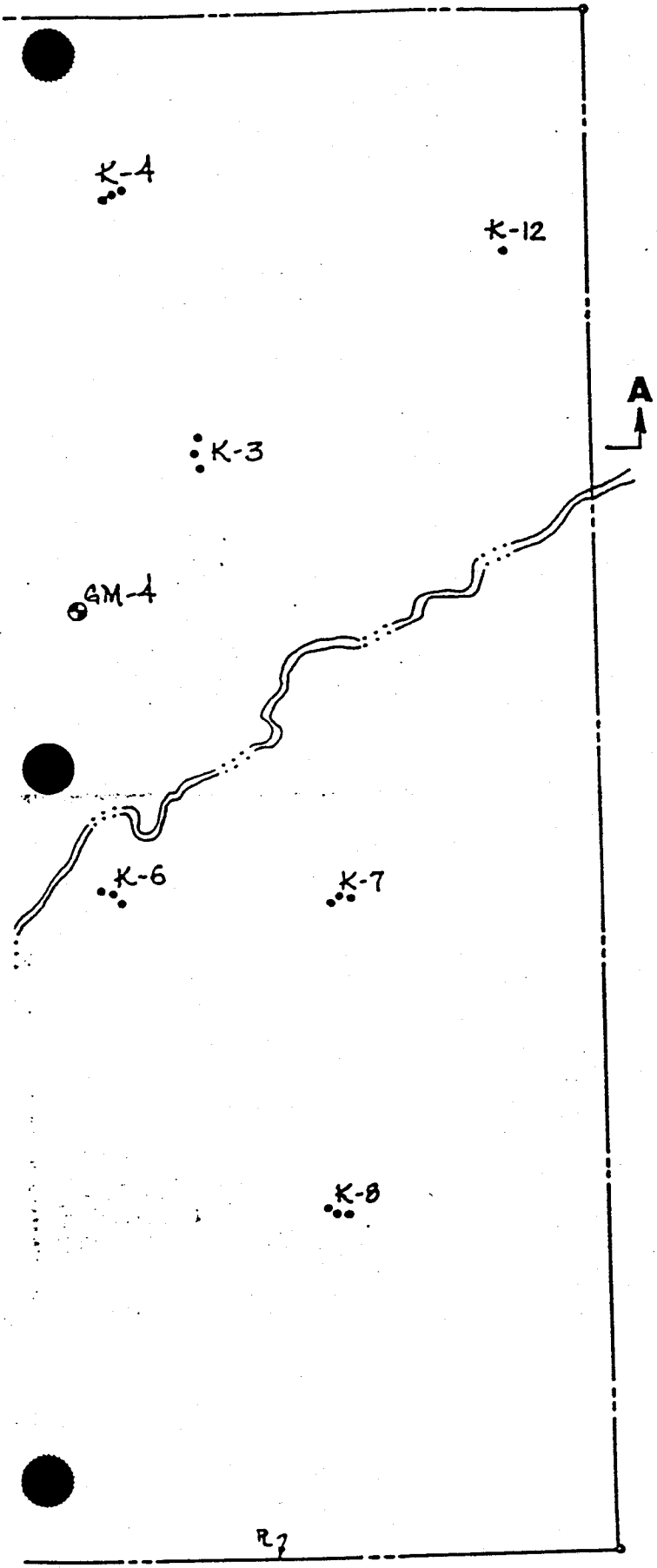
Woodward-Clyde Consultants

TABLE 2

HYDRAULIC CONDUCTIVITY BY
FIELD PERMEABILITY TESTS

Well Number	Type of Test	Hydraulic Conductivity (cm/sec)
K2(OX)	Slug	5×10^{-8} to 2×10^{-7}
K2(OX)	Well Outflow	1 to 2×10^{-8}
K3(80)	Well Inflow *	1 to 2×10^{-8}
K4(80)	Well Inflow *	5 to 8×10^{-9}
K5(80)	Well Outflow	1 to 5×10^{-8}

*Note: Tests performed in partially saturated soil.



GM-1 - MONITORING WELL LOCATION & NUMBER

K-1 - PIEZOMETER LOCATION & NUMBER

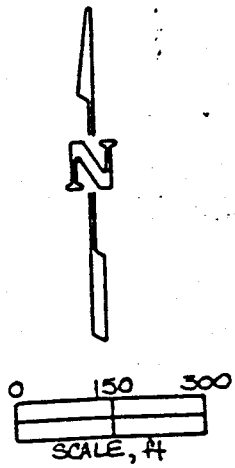
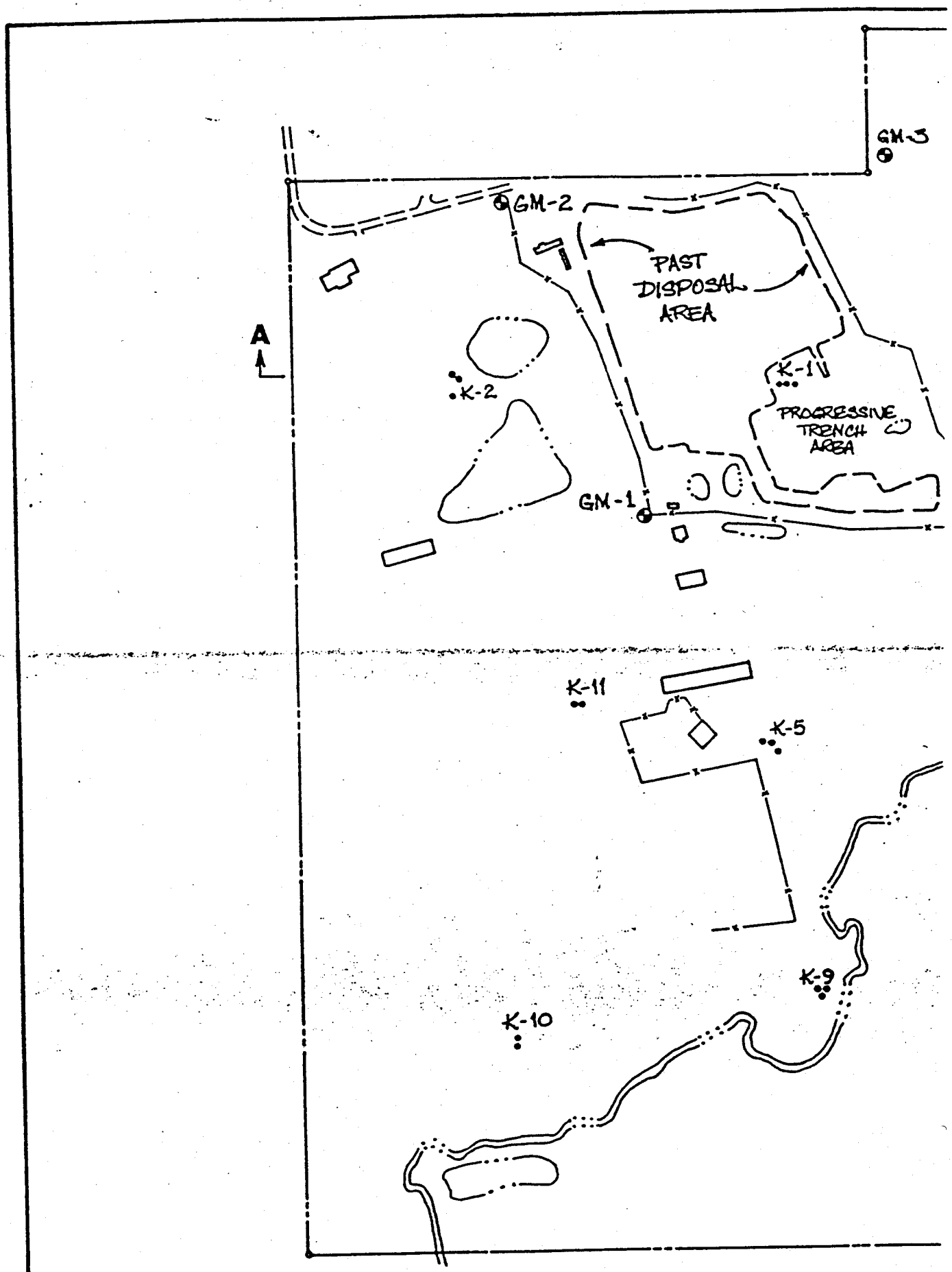
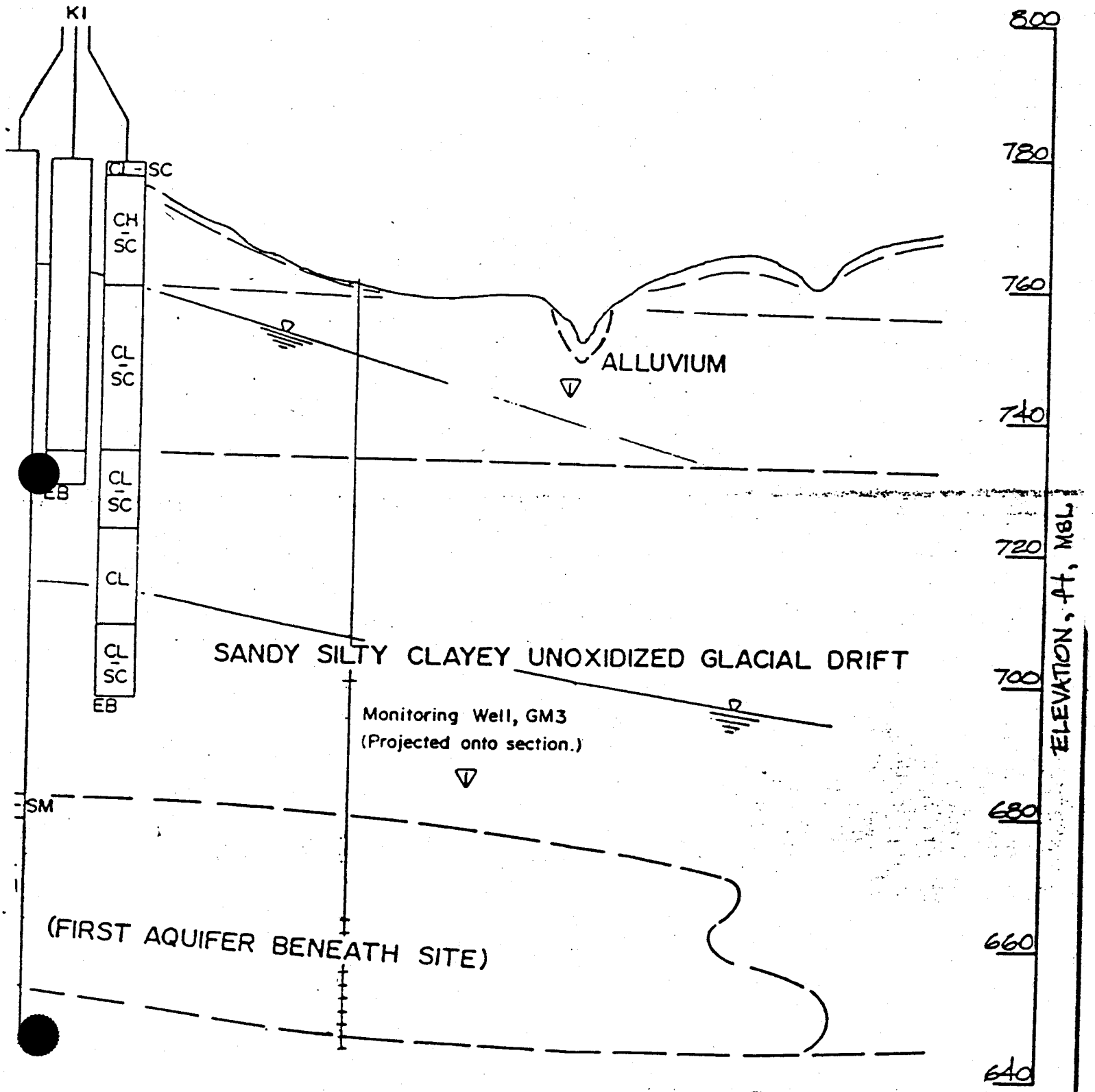


FIGURE 1



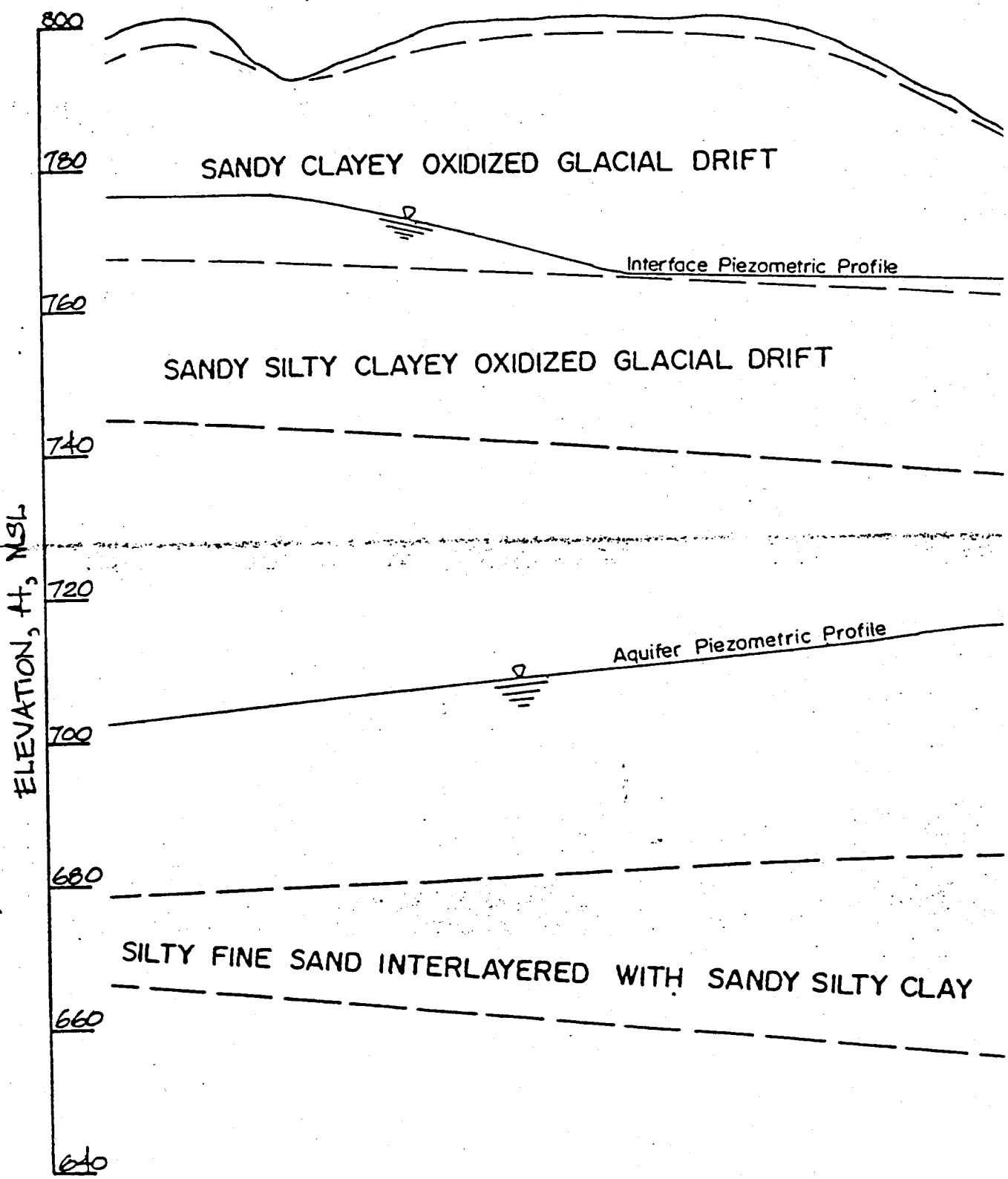
WCC 13C051
27 SEPT 83 KM



CTION A-A'

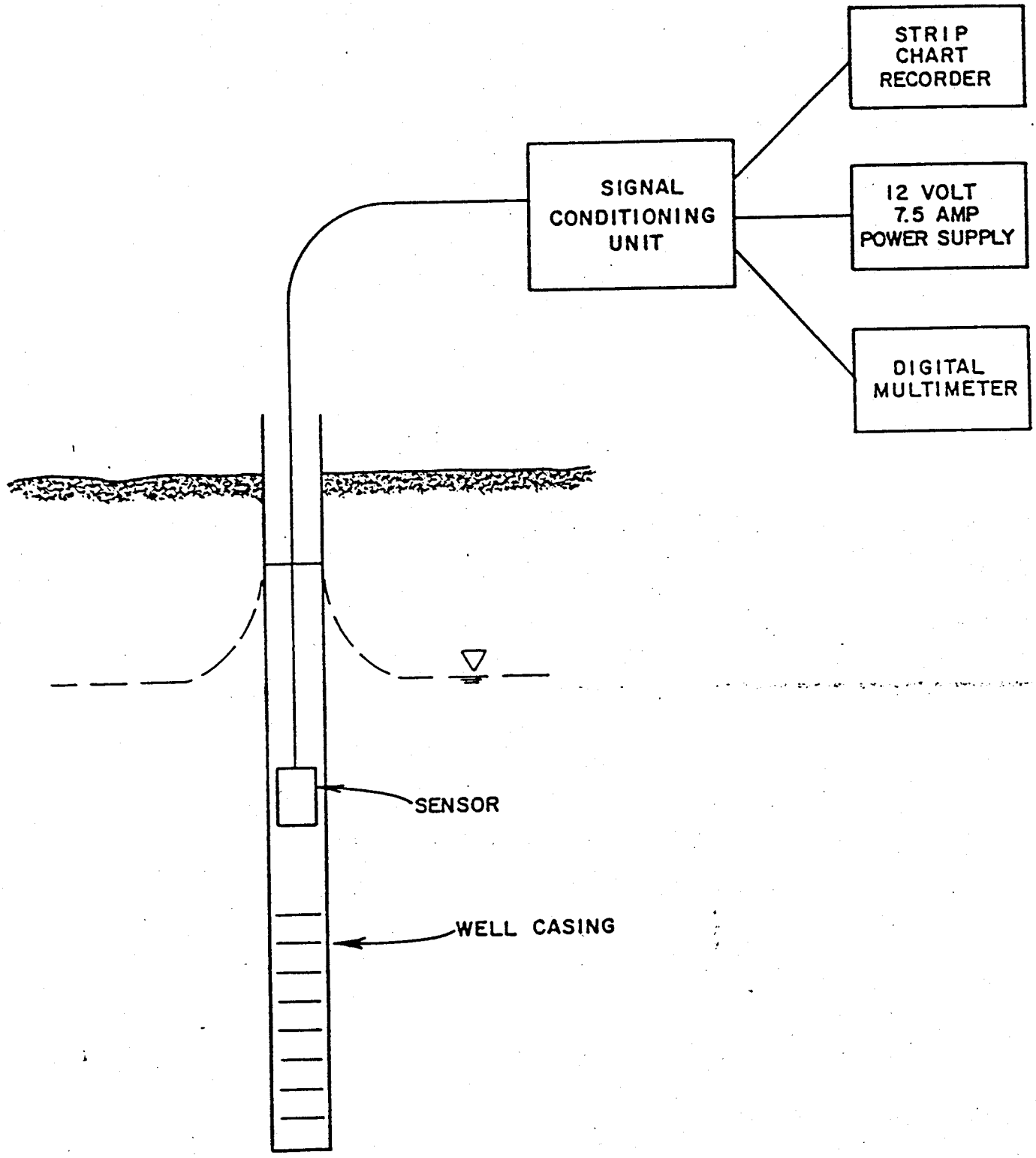
FIGURE 2

HORIZONTAL SCALE: 1" = 100'
VERTICAL SCALE: 1" = 20'



WCC 13C051
27 SEPT 83

GENERALIZED GEOLOGIC



DOWNHOLE HEAD MEASUREMENT DEVICE (DHHMD) SCHEMATIC

FIGURE 3

ENCLOSURE 2

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October 12, 1983

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AIR AND WASTE COMPLIANCE
BRANCH

BHS Exhibit 3
9-29-83, TL

LABORATORY PERMEABILITY/COMPATIBILITY TESTS
BOB'S HOME SERVICE

INTRODUCTION

Three permeability and two leachate/soil compatibility tests were performed on soil specimens from the unoxidized zone. The soil specimens were trimmed from Shelby-tube soil samples which were obtained from borings from the floor of the progressive trench area. The boring locations are shown in Figure 1.

The procedures used to perform the permeability tests were consistent with the methodology specified by the Army Corps of Engineers (1970), for "Permeability Tests with Back Pressure." The leachate/soil compatibility tests were performed in an identical manner to the permeability tests except that leachate from cell 1-N was substituted for ground water as the permeant in the test.

SOIL/LEACHATE COMPATIBILITY

All previous permeability tests, both in the laboratory and the field, were conducted either with ground water from the area, pore water (for the consolidation tests), or distilled water. The use of distilled water as a permeant has been shown by Olson and Daniel (1981) to give a ratio of measured K to Correct K of about 5/1000 to 1/10.

The effects of a leachate stream on soil will depend primarily on the types and concentrations of chemicals or compounds present in the leachate, the pore water chemistry, the type of soil, the pH, and the effective stress of the soil. Anderson and Green (1981), Anderson, Brown and Green

(1982), and Green, Lee and Jones (1981) performed experiments which show that certain organic and inorganic chemicals react with clay soils and may cause increases or decreases in the coefficient of permeability of the soil. The experiments were performed in fixed-ring permeameters, on unsaturated samples, with permeants at 100 percent concentrations.

The effect of a leachate on a given soil cannot be evaluated from existing data. The only way to evaluate the effect of a leachate on a given soil would be to conduct permeability tests using the leachate as the permeant in the test.

METHODOLOGY

Two Shelby-tube samples were obtained from borings in the floor of the progressive trench area at the locations shown in Figure 1. The floor of the progressive trench was approximately 5 to 10 feet below the interface between the oxidized and unoxidized glacial tills at the location where the samples were obtained.

Two borings were advanced to a depth of about 5 feet using 4-inch-diameter continuous-flight augers. One Shelby-tube sample was obtained at the bottom of each of the two borings. PVC caps (snug fitting) were placed on each end of the Shelby tube and the ends were wrapped with duct tape.

The Shelby tubes were then placed in plastic bags, placed in coolers, packaged in Styrofoam, and shipped to the Woodward-Clyde Consultants' (WCC) soils laboratory in Overland Park, Kansas.

Three permeability tests were performed on 2-inch-diameter by 2-inch-high soil specimens trimmed from the Shelby-tube samples from the unoxidized zone. The permeability tests were performed in triaxial compression devices with backpressure saturation. One permeability test was performed with ground water from the BHS site. The other two permeability tests were performed first with ground water from the BHS site and then with leachate from organic trench 1N.

The soil specimens were trimmed to size from soil extruded from the two Shelby tubes and placed in double latex membranes in the triaxial cells. Ground water was used as the cell fluid to decrease the potential for the creation of an osmotic gradient across the sample membrane.

The soil samples were then backpressure saturated and the samples consolidated to an effective stress of 40 psi. The samples were allowed to consolidate for twenty-four hours prior to beginning the permeability test.

The first permeability test was conducted using ground water from well GM1 as the permeant. The hydraulic gradient was increased in increments and the coefficient of permeability was measured twice at each gradient. Figure 2 shows the relationship between hydraulic gradient and coefficient of permeability for the soil specimen. The axial and total volumetric deformation were monitored during consolidation and the permeability tests. The results show that negligible consolidation occurred at gradients of 50, 100, or 200. To facilitate recovery of data, subsequent permeability tests were performed with a gradient of 500 and the axial and total volumetric deformations were monitored for evidence of consolidation.

The permeability tests on samples BHS 2 and BHS 3 were set up identically to the test for sample BHS 1. After the sample was saturated and consolidated, the hydraulic gradient was increased to 500 and a permeability test was conducted using ground water from well GM1 as a permeant. The permeability tests were performed for approximately twenty-four hours with a ground water permeant. No discernable axial or volumetric deformations occurred in the soil specimen. Leachate was then introduced into the inflow lines and used as the permeant.

RESULTS

The results of the permeability tests for ground water and leachate are given in Figures 2, 3 and 4 for samples BHS 1, 2 and 3, respectively. The coefficient of permeability values for ground water for the three samples ranged from 7×10^{-9} cm/sec to 5×10^{-8} cm/sec. The introduction of leachate as the permeant caused no change in the coefficient of permeability of the soil specimen. For sample BHS 2, the ground water coefficient of permeability ranged from 8×10^{-9} cm/sec to 1×10^{-8} cm/sec. The coefficient of permeability of sample BHS 2 using leachate as the permeant ranged from approximately 7×10^{-9} cm/sec to 9×10^{-9} cm/sec. For sample BHS 3, the ground water coefficient of permeability ranged from 7×10^{-9} to 1×10^{-8}. The coefficient of permeability for sample BHS 3 using leachate as a permeant ranged from approximately 7 to 8×10^{-9} cm/sec.

CONCLUSIONS

The primary conclusions based upon the laboratory permeability and compatibility tests performed herein are presented below:

1. The leachate permeant from organic trench 1-N does not increase or decrease the coefficient of permeability of the unoxidized glacial till.
2. The coefficient of permeability measured in the triaxial permeability test of the unoxidized glacial till is in the range of approximately 5×10^{-9} to 5×10^{-8} cm/sec.
3. The results of the permeability tests performed in the triaxial compression devices are in the same range as the coefficient of permeability values calculated from the well inflow and outflow tests for the unoxidized glacial till.
4. Permeability tests performed in triaxial compression devices with back-pressure saturation are more likely to give representative values of coefficient of permeability than other types of laboratory permeability tests.

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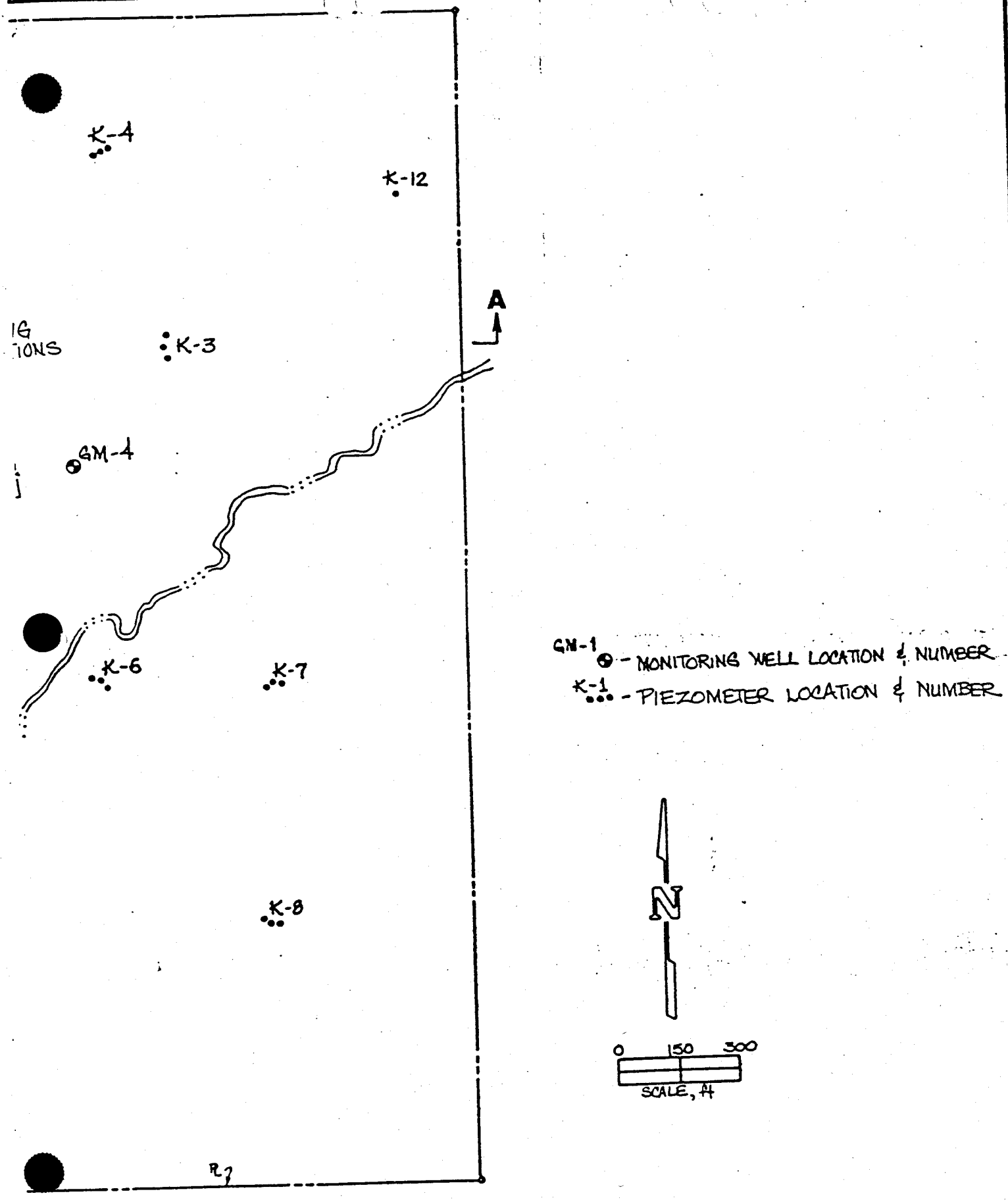
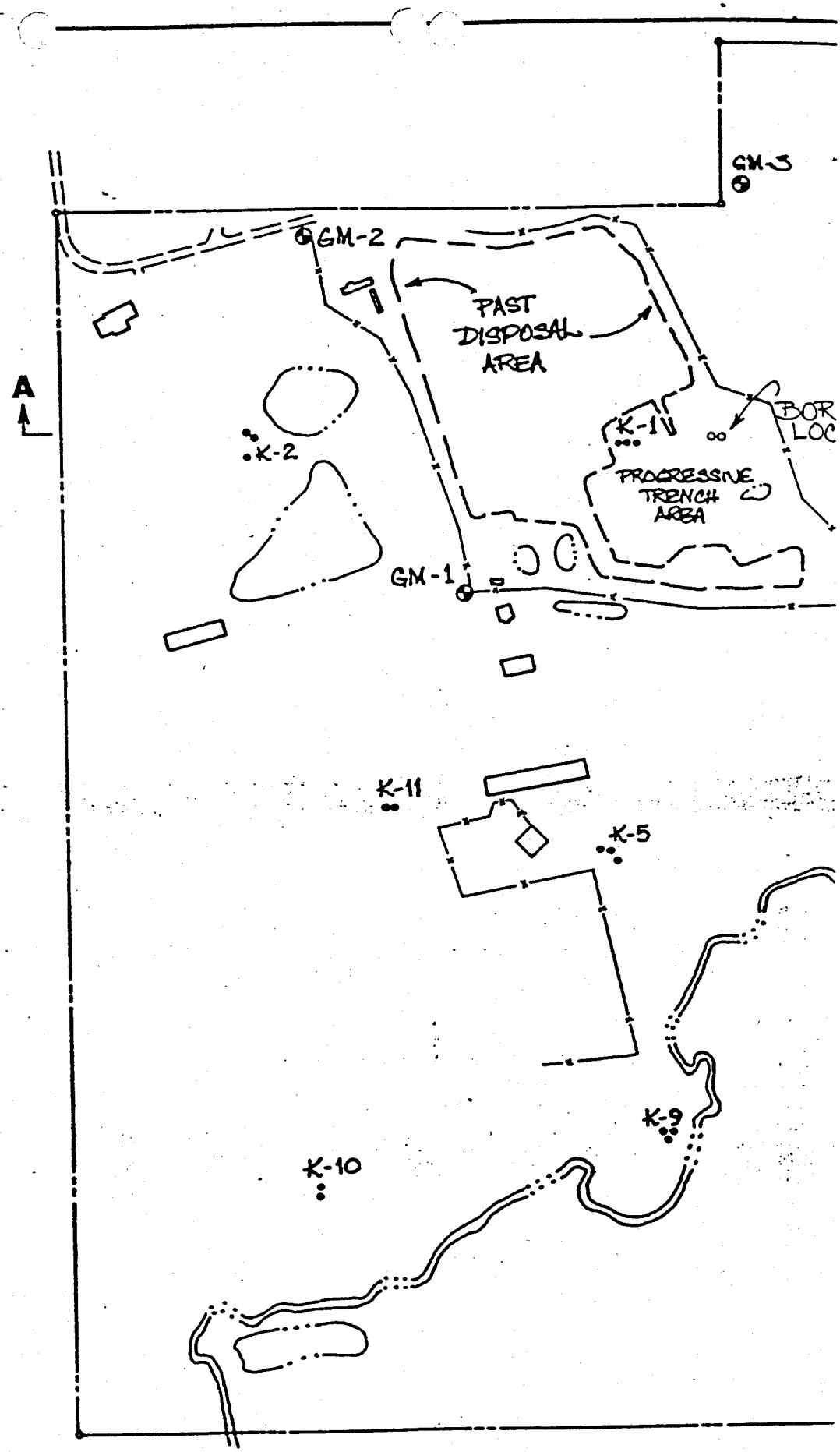

K-4
K-12
A
IG
IONS
K-3
GM-4
K-6
K-7
K-8
GM-1 - MONITORING WELL LOCATION & NUMBER
K-1 - PIEZOMETER LOCATION & NUMBER
N
0
150
300
SCALE, ft

FIGURE 1



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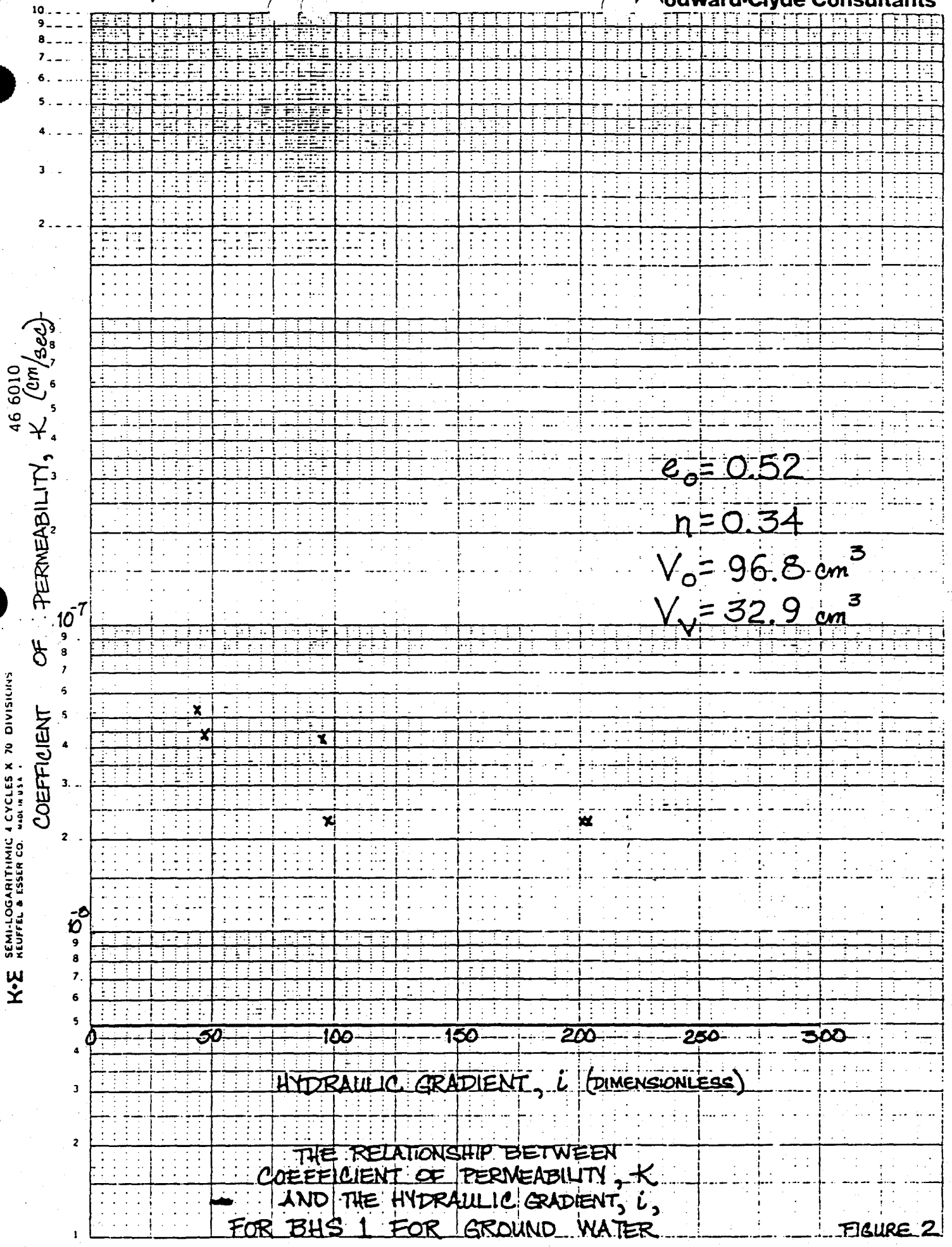
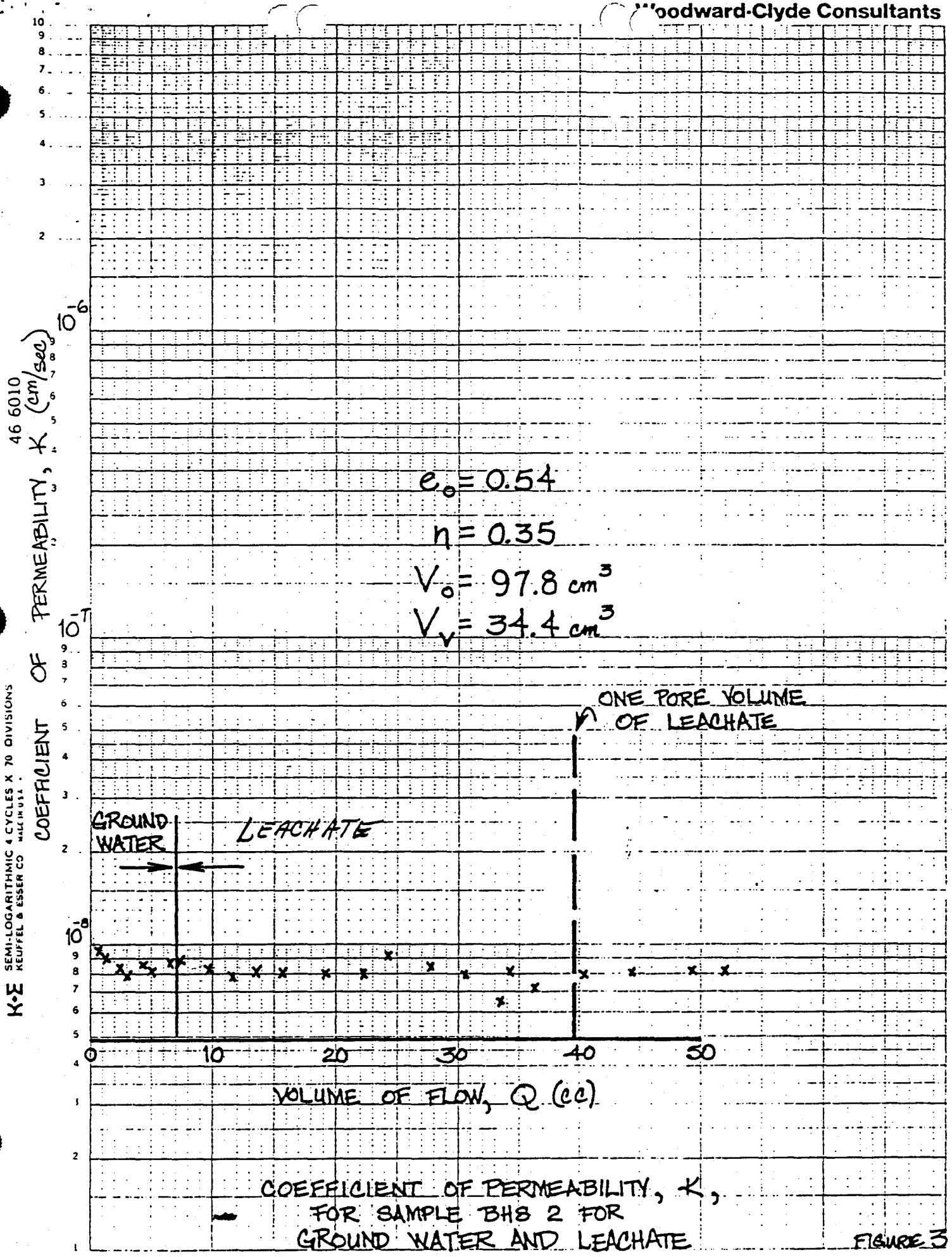
27 SEPT 83 KM



THE RELATIONSHIP BETWEEN COEFFICIENT OF PERMEABILITY, K AND THE HYDRAULIC GRADIENT, i, FOR BHS 1 FOR GROUND WATER

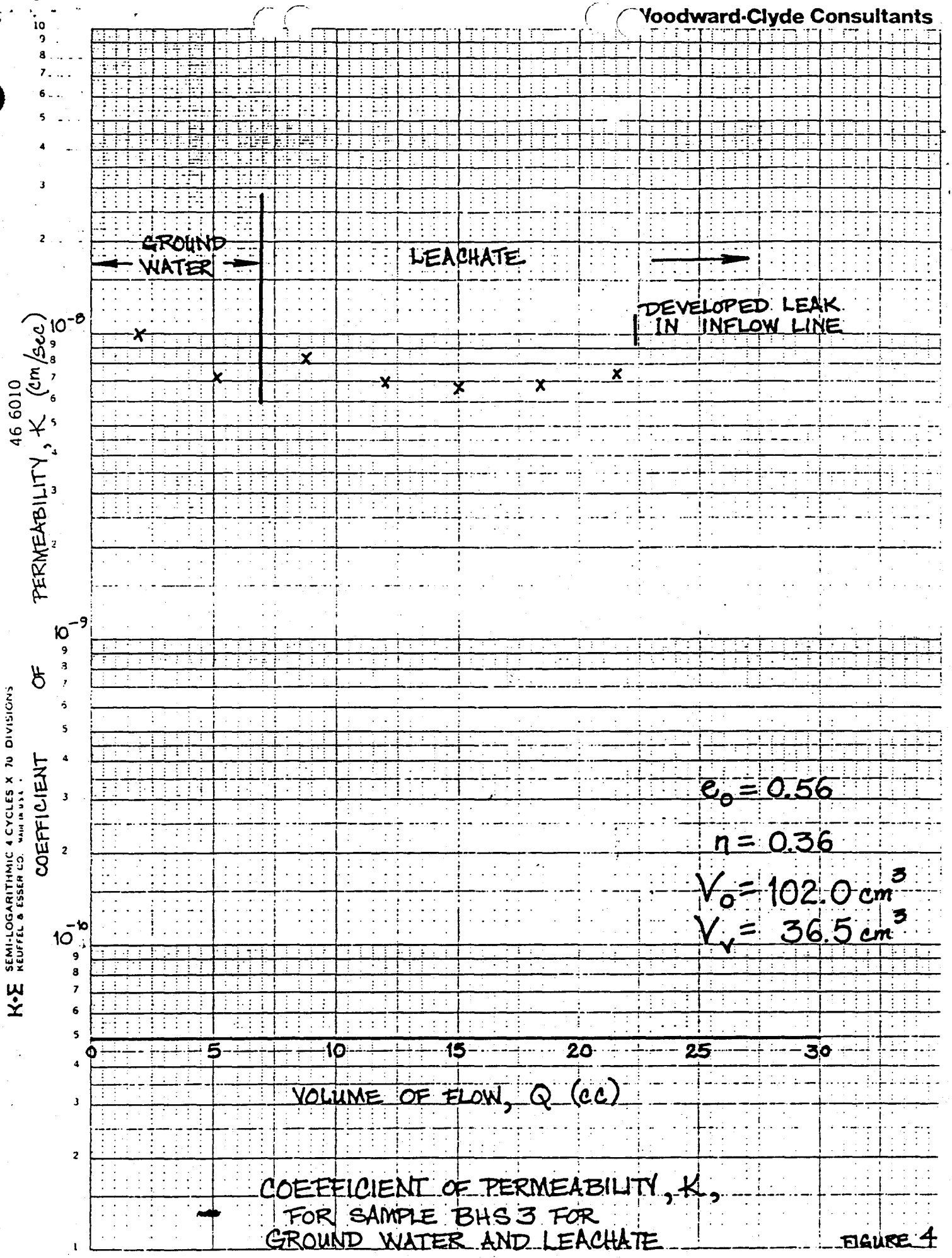
FIGURE 2



COEFFICIENT OF PERMEABILITY, K, FOR SAMPLE BH8 2 FOR GROUND WATER AND LEACHATE

FIGURE 3

K·E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS KEUFFEL & ESSER CO. MADE IN U.S.A. 46 6010



COEFFICIENT OF PERMEABILITY, K, FOR SAMPLE BHS 3 FOR GROUND WATER AND LEACHATE

FIGURE 4

ENCLOSURE 3

David A. Wagoner

October 12, 1983

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AIR AND WASTE COMPLIANCE
BRANCH

BHS Exhibit 37
4-29-83, TCA

WATER QUALITY EVALUATION

BOB'S HOME SERVICE

INTRODUCTION

Seven water samples were obtained from locations at the Bob's Home Service (BHS) site (see Figure 1). Two ground water samples were obtained from the interface zone, two from the sand aquifer, and surface water samples were taken from the stream, upstream and downstream of the facility, and the southern upgradient farm pond.

METHODOLOGY

The two ground water samples from the interface zone were obtained from monitoring wells K2(OX) and K5(OX). These wells were flushed by bailing them dry. The wells were sampled in accordance with the procedures outlined in the National Handbook of Recommended methods for Water-Data Acquisition (1977).

The ground water samples from the interface zone were obtained using a bailer which had previously been decontaminated. The bailers were decontaminated by first rinsing in acetone, followed by a thorough rinsing with distilled water. One bailer was dedicated to each well.

The day following flushing, a water sample was removed using the bailer. The first bailer of water was used to rinse the sample container and the plastic field test container. Subsequent bails of the ground water were used to fill the 1-liter sample container and the field test container.

Two ground water samples were obtained from the first sand aquifer from wells GM1 and GM4. These wells have permanent submersible pumps installed in them and had not been developed prior to flushing. The wells were flushed the day before sampling by engaging the submersible pump. Approximately one well volume of water was removed and the wells went dry. The pumps were again engaged after approximately 15 minutes but there was no water in the wells. The wells were sampled the following day by directly filling the 1-liter sample container and the field test container directly from the effluent port on the well casing.

The upstream water sample was obtained from a depression in the creek bed of the east stream approximately 150 to 200 yards upstream of the confluence of the east and west streams, which was upstream from all waste disposal areas. The downstream sample was obtained from a depression in the creek bed approximately 25 yards north of the south stream diversion structure. The containers were rinsed in the stream water and the upstream and downstream samples were obtained by direct immersion of the sample container and field test container.

A water sample was also obtained from the east bank of the south farm pond, just west of the landfill. The water sample was obtained using a clean plastic (distilled water) container. The water from the container was used to rinse and fill the 1-liter sample container and the remaining water was used for the field tests.

The pH of the sample was measured in the field using a Cole-Palmer Digi-sense pH meter. The pH meter was calibrated prior to each measurement using a pH 7 buffer solution. The drift of the meter was checked after

each sample measurement by again submersing the probe in the pH 7 buffer solution and recording the measured pH.

The temperature and specific conductance of each sample were measured using a Yellow Springs Instrument Model 33 SCT meter which was calibrated prior to use on the project. The pH, temperature, specific conductance, and physical description of all of the samples are summarized in Table 1.

RESULTS

Each of the seven water samples were analyzed for the cations Calcium (Ca), Magnesium (Mg), Sodium (Na) and Potassium (K) and for the anions Bicarbonate (HCO_3), Carbonate (CO_3), Sulfate (SO_4) and Chloride (Cl). The results of the laboratory analyses are summarized in Figures 2 through 8.

The anion and cation concentrations in mg/l were converted to meq/l and plotted on Stiff (Freeze and Cherry, 1979) and Piper Diagrams (Piper, 1944); see Figures 2 through 8. The charge balance and Total Dissolved Solids were calculated for each sample and are summarized in Table 2.

CONCLUSIONS

The charge imbalances for the water samples preclude a quantitative analysis of water quality. However, the primary qualitative conclusions are as follow:

1. The ground water in the interface zone does not appear to be the primary source of recharge to the sand aquifer. Based on a review of the water quality data, there does not appear to be a

direct hydraulic connection between water in the interface zone and water in the sand aquifer.

2. The upstream, downstream, and pond water samples have similar characteristics.
3. There is not any appreciable difference in the water quality in the upstream and downstream water samples.
4. The anion and cation concentrations in the sand aquifer are about an order of magnitude lower than the concentrations in the interface zone.

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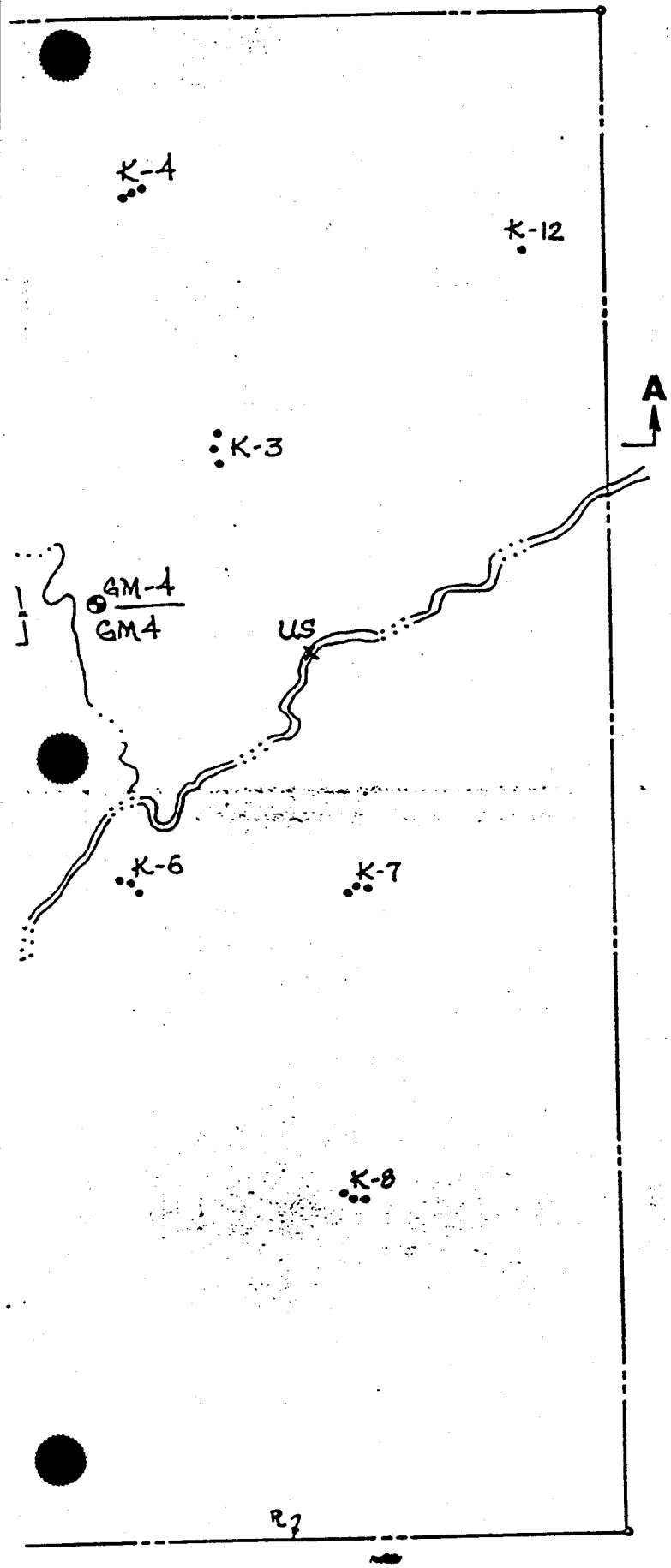

DS × - WATER SAMPLE LOCATION & DESIGNATION

GM-1 ⊖ - MONITORING WELL LOCATION & NUMBER

K-1 ••• - PIEZOMETER LOCATION & NUMBER

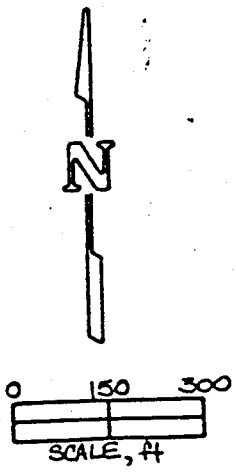

FIGURE 1

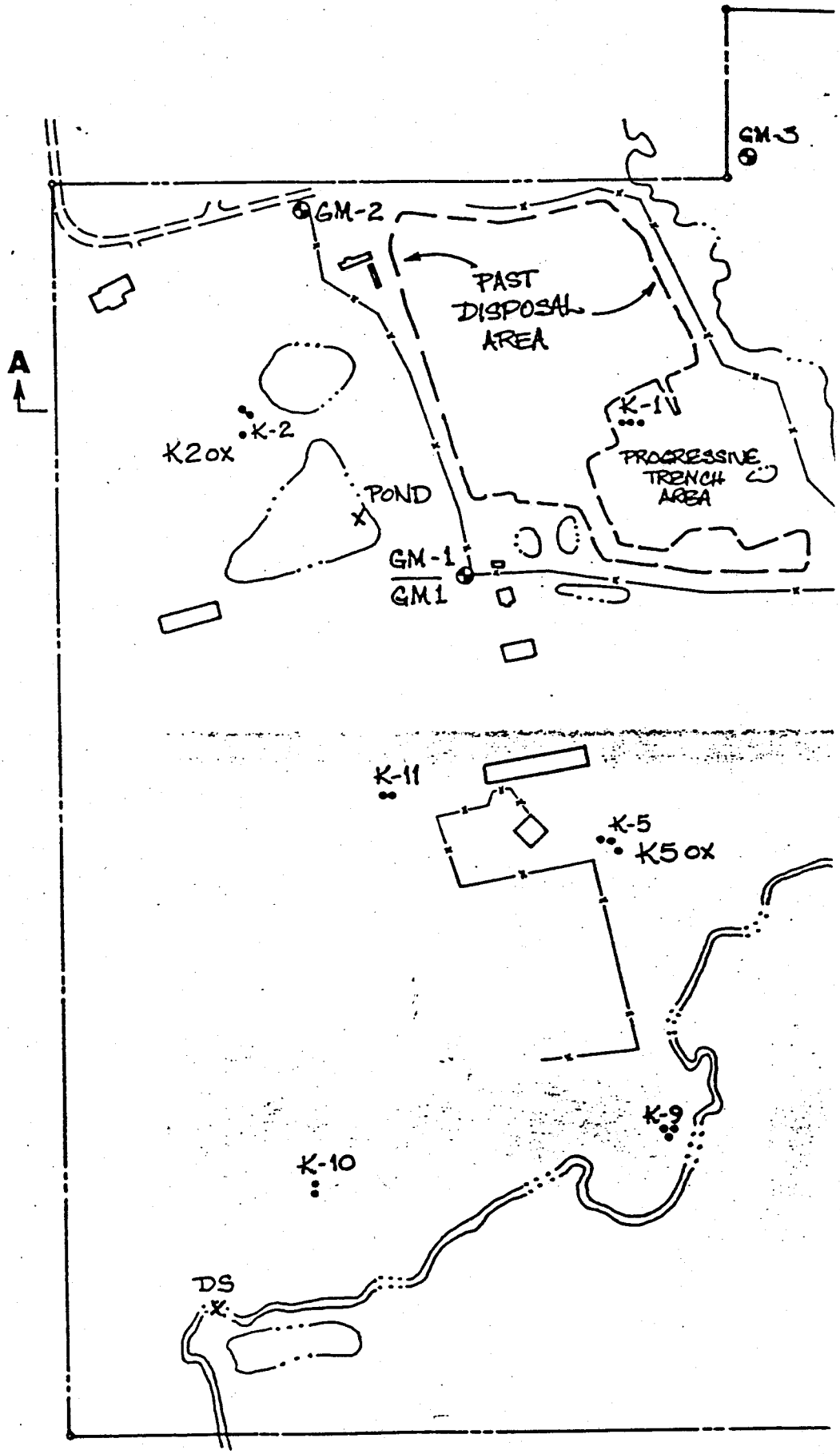

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FIGURE 2
STIFF AND PIPER DIAGRAMS

Project Name Bob's Home Service

Project Number 13C051

Sample Number K20X

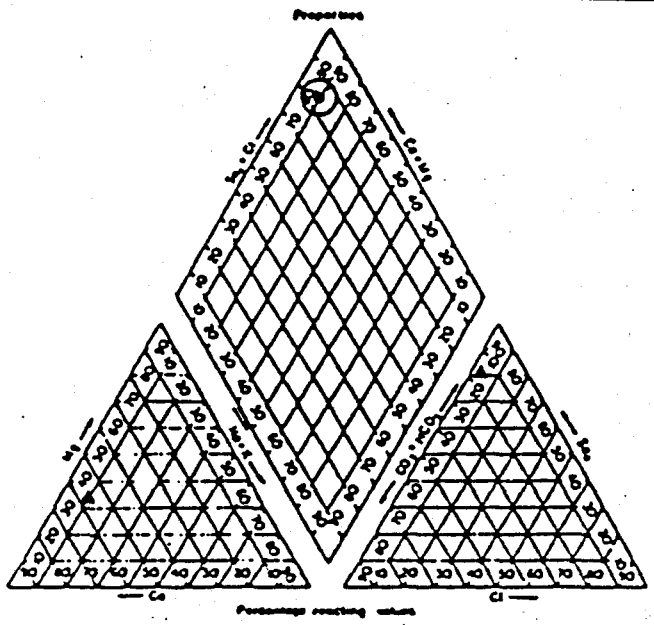
Location Well K2(OX)

Date Taken 9/1/83

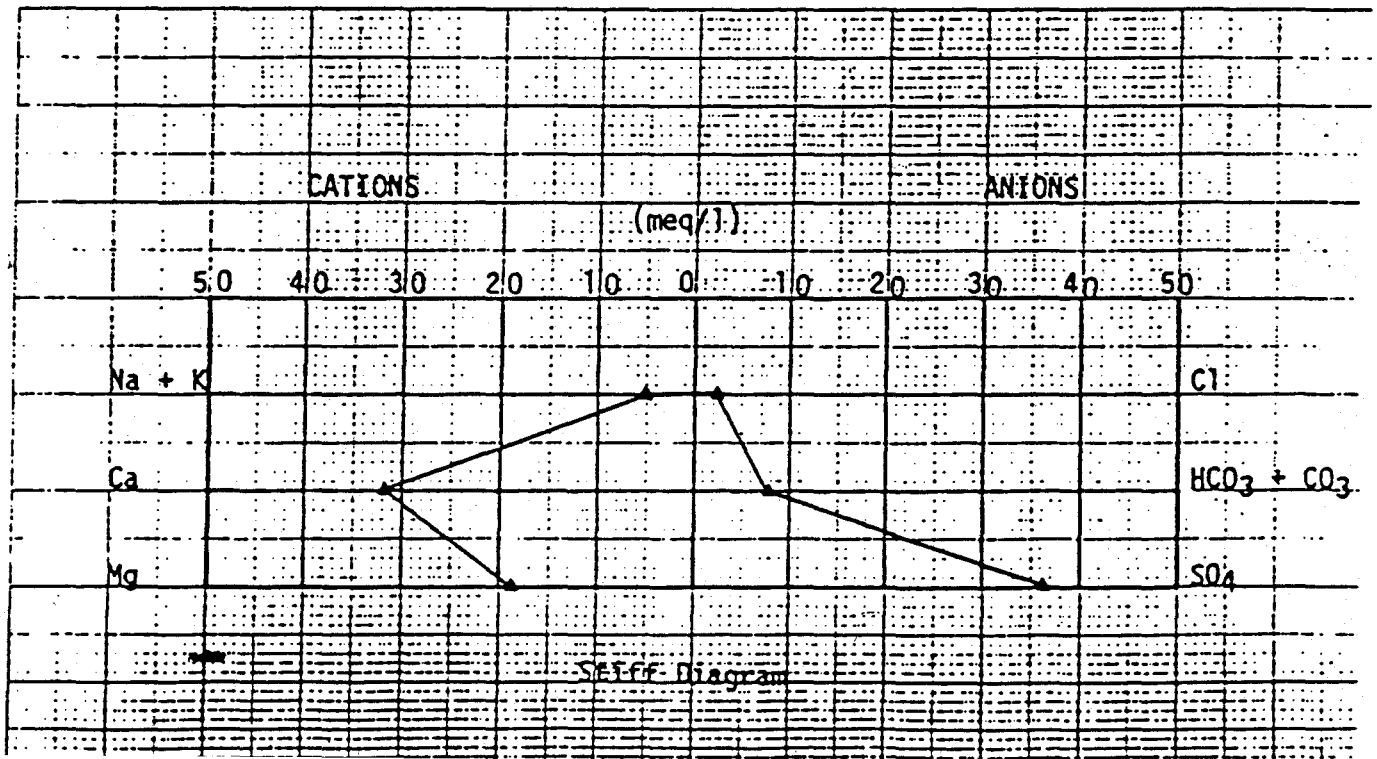
Comp. by Neil D. Williams
Date 9/19/83
Checked by PJK
Date 9/27/83

CATIONS	mg/l	meq/l	%
Ca	650	32.44	58
Mg	220	18.10	32
Na	115	5.00	9
K	8.3	0.21	1
Total		55.75	100

ANIONS	mg/l	meq/l	%
HCO_3	441	7.23	16
CO_3	0	0.0	0
SO_4	1740	36.23	80
Cl	74	2.09	4
Total		45.55	100



Piper Trilinear Diagram (After Piper, 1944)



Stiff Diagram

FIGURE 3
STIFF AND PIPER DIAGRAMS

Project Name: Bob's Home Service

Project Number: 13C051

Sample Number: K50X

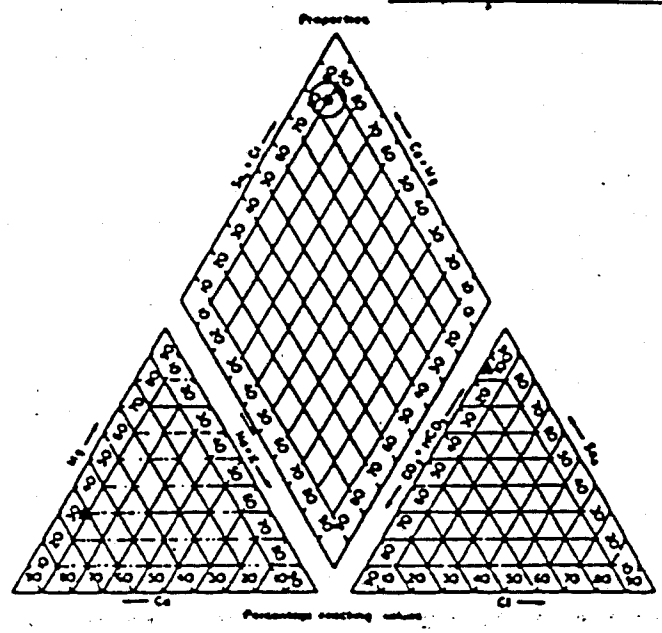
Location: Well K5(0X)

Date Taken: 9/1/83

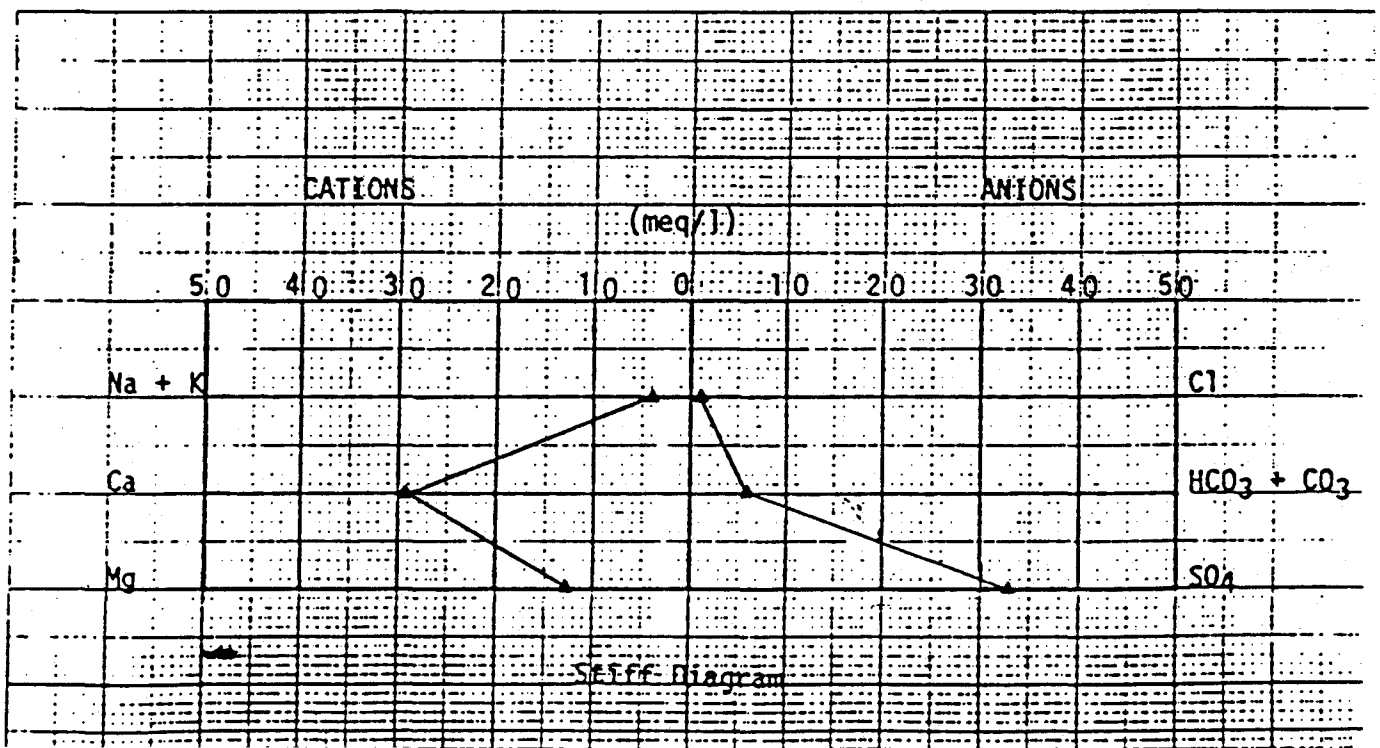
Comp. by: Neil D. Williams
Date: 9/19/83
Checked by: RJK
Date: 9/27/83

CATIONS	mg/l	meq/l	%
Ca	500	24.95	60
Mg	152	12.50	29
Na	93	4.05	10
K	6.6	0.17	1
Total		41.67	100

ANIONS	mg/l	meq/l	%
HCO_3	369	6.05	15
CO_3	0	0.0	0
SO_4	1580	32.90	83
Cl	22	0.62	2
Total		39.57	100



Piper Trilinear Diagram (After Piper, 1944)



Stiff Diagram

FIGURE 4
STIFF AND PIPER DIAGRAMS

Project Name: Bob's Home Service

Project Number: 13C051

Sample Number: GM1

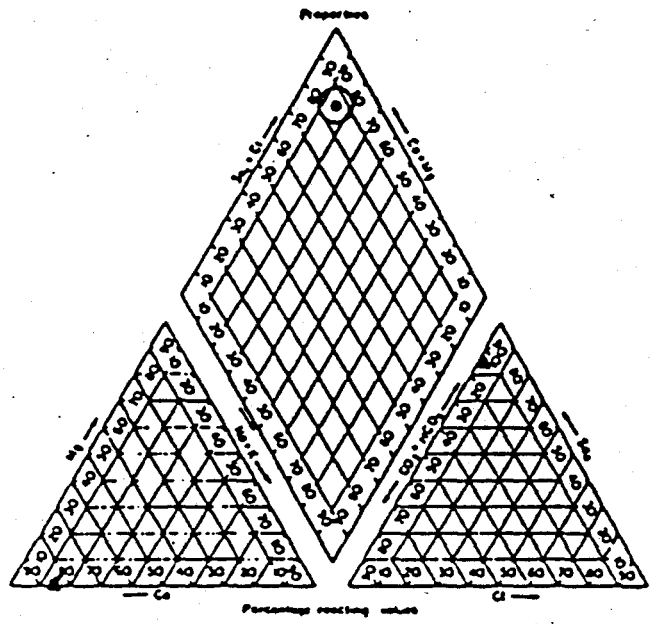
Location: Well GM1

Date Taken: 9/1/83

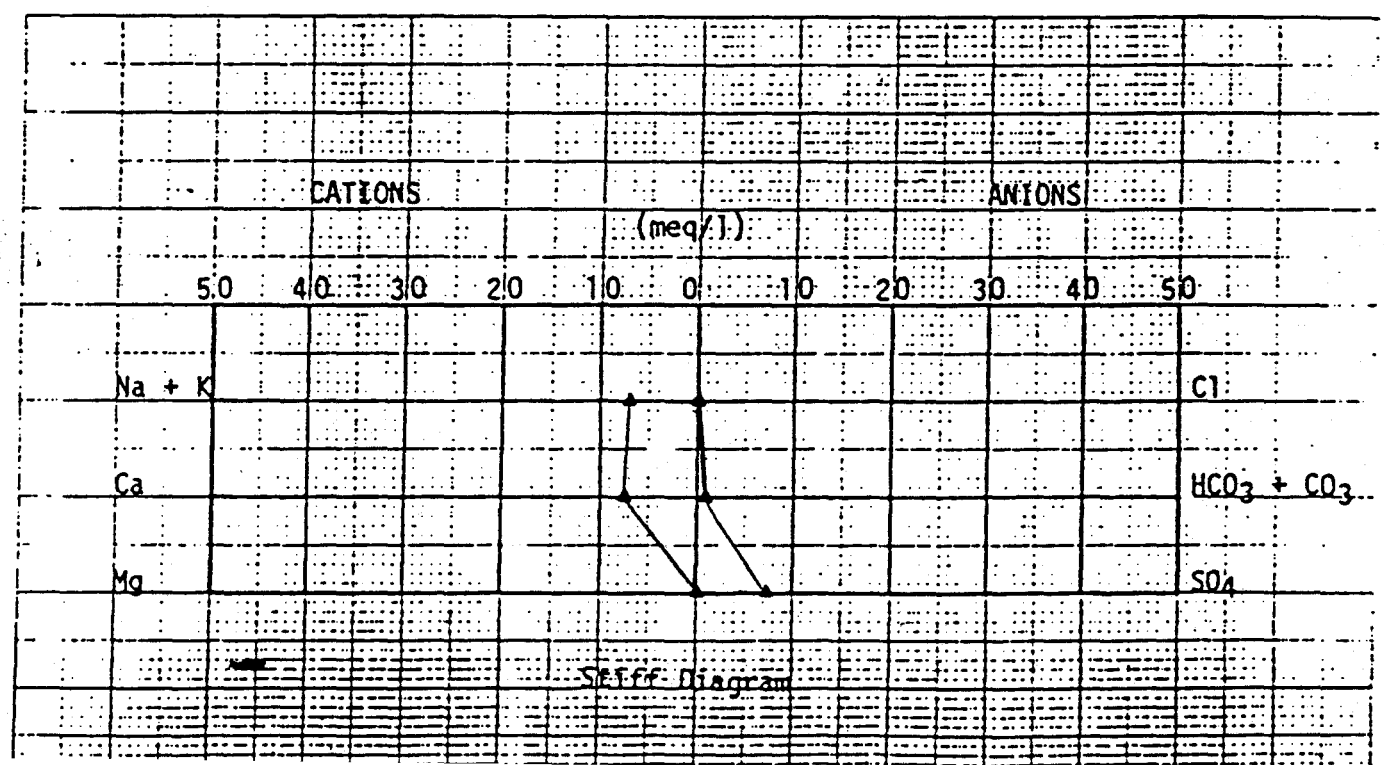
Comp. by: Neil D. Williams
Date: 9/19/83
Checked by: PJK
Date: 9/27/83

CATIONS	mg/l	meq/l	%
Ca	160	7.9840	53
Mg	2.3	0.1892	1
Na	108	4.6978	31
K	88	2.2505	15
Total		15.1215	100

ANIONS	mg/l	meq/l	%
HCO_3	0	0.0	0
CO_3	48	1.5997	17
SO_4	372	7.7450	82
Cl	5	0.1410	1
Total		9.4857	100



Piper Trilinear Diagram (After Piper, 1944)



Stiff Diagram

FIGURE 5
STIFF AND PIPER DIAGRAMS

Project Name Bob's Home Service

Project Number 13C051

Sample Number GM4

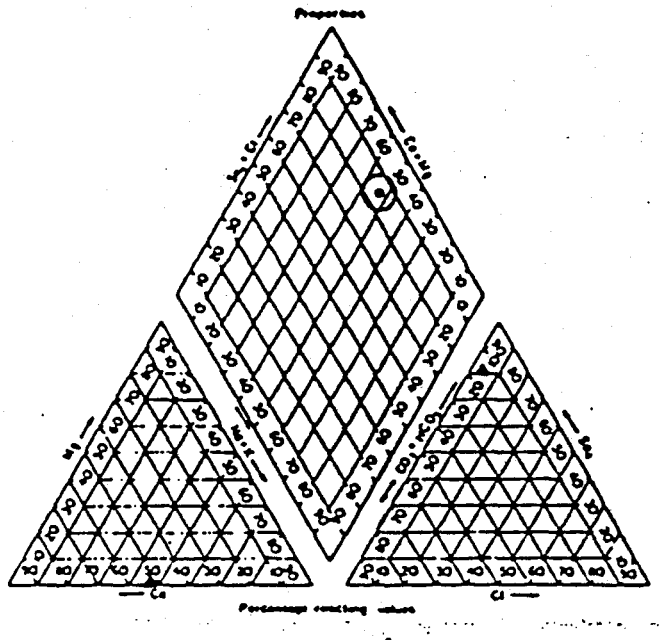
Location Well GM4

Date Taken 9/1/83

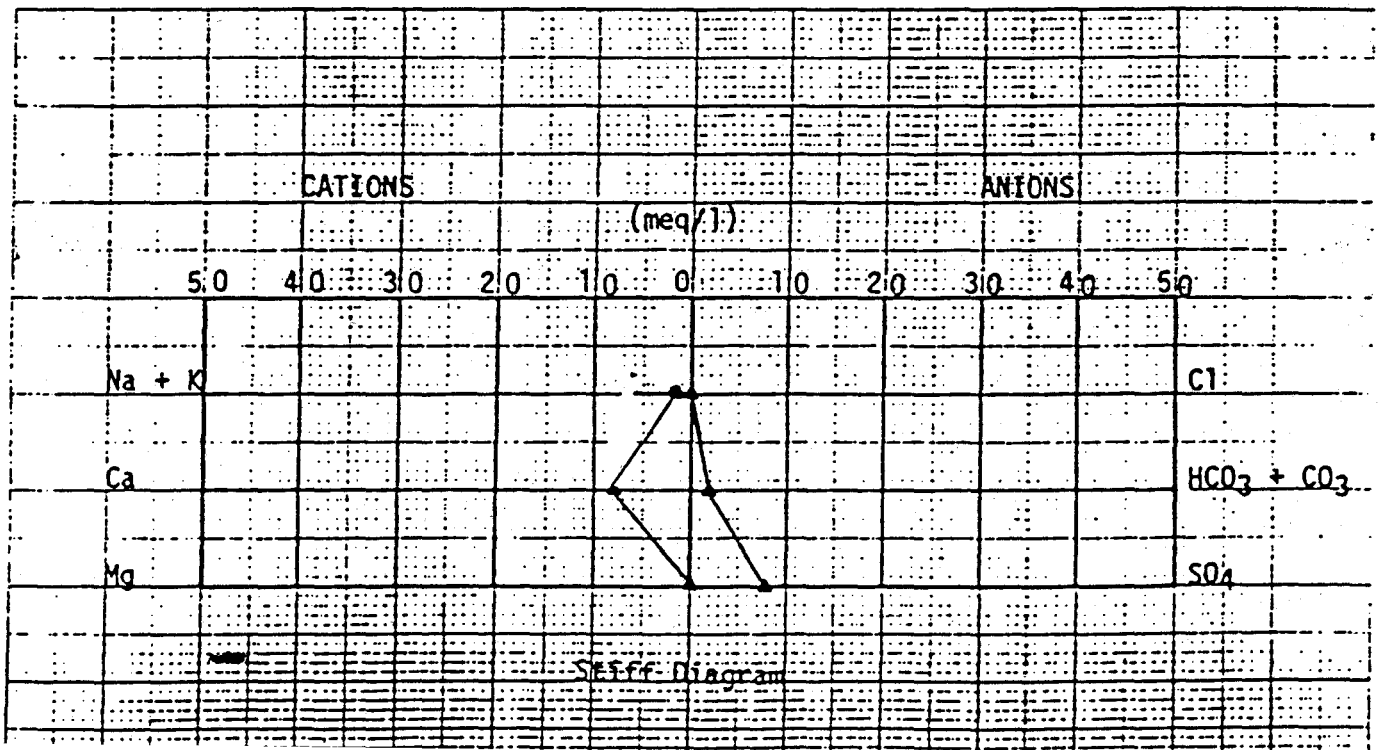
Comp. by Neil D. Williams
Date 9/19/83
Checked by PJK
Date 9/27/83

CATIONS	mg/l	meq/l	%
Ca	144	7.1856	86
Mg	0.4	0.0329	< 1
Na	18	0.7830	9
K	11.9	0.3043	4
Total		8.3058	100

ANIONS	mg/l	meq/l	%
HCO_3	0	0.0	0
CO_3	24	0.7999	13
SO_4	246	5.1217	86
Cl	2	0.0564	1
Total		5.9780	100



Piper Trilinear Diagram (After Piper, 1944)



Stiff Diagram

Woodward-Clyde Consultants

Page _____ of _____

FIGURE 6

STIFF AND PIPER DIAGRAMS

Project Name Bob's Home Service

Project Number 13C051

Sample Number US

Location Upstream Sample

Date Taken 9/1/83

Comp. by Neil D. Williams

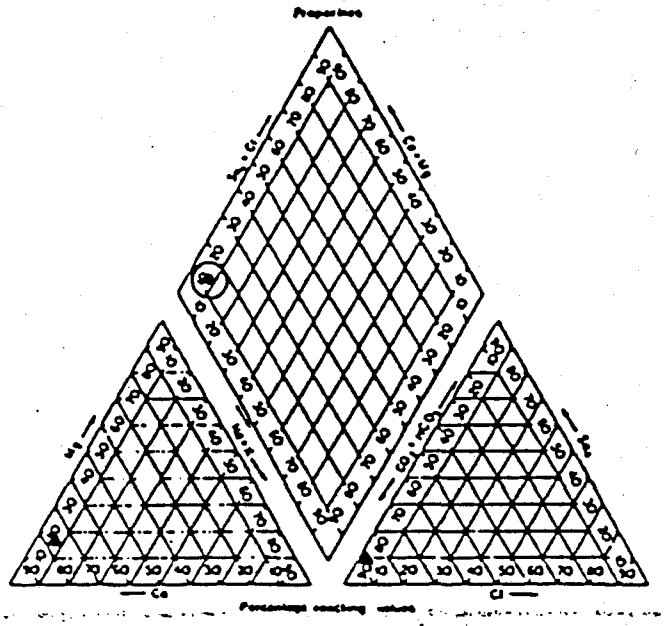
Date 9/19/83

Checked by PJK

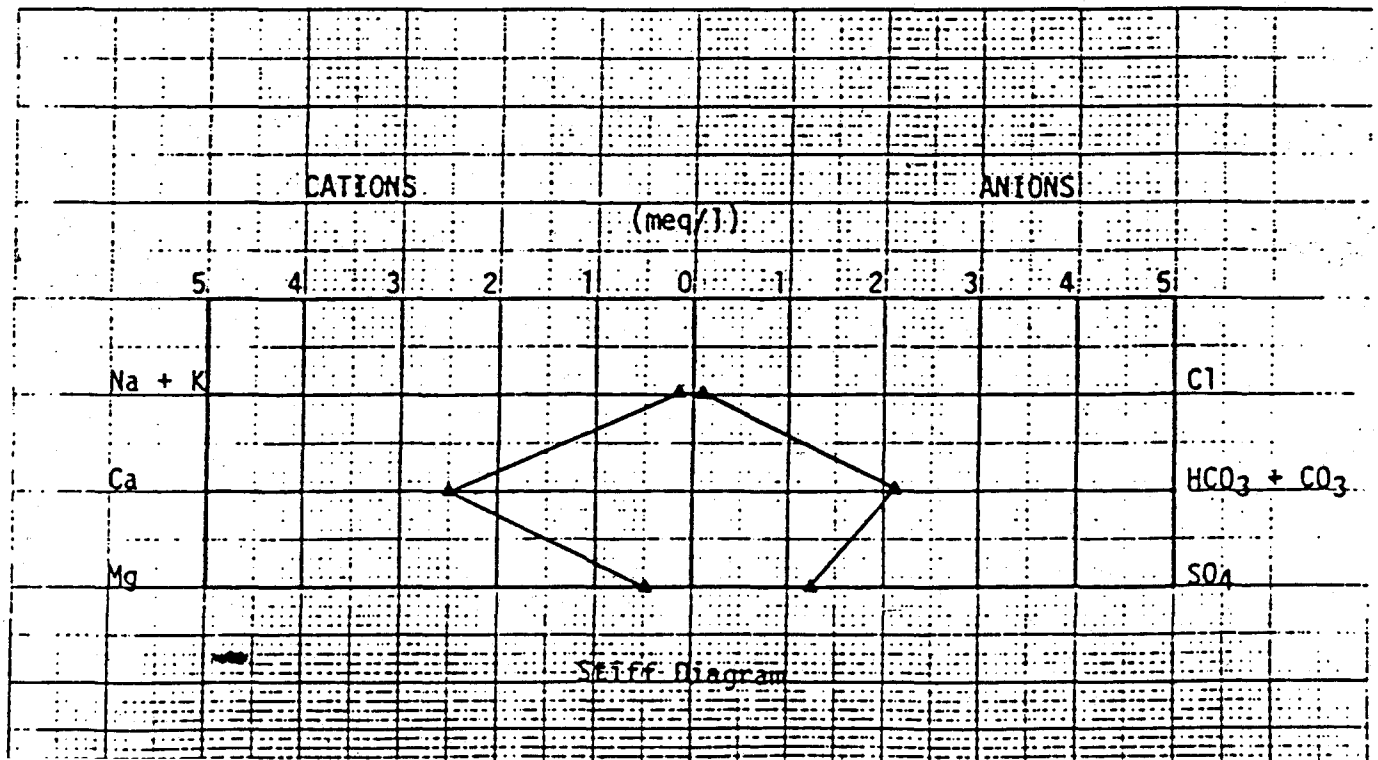
Date 9/27/83

CATIONS	mg/l	meq/l	%
Ca	50	2.4950	78
Mg	6	0.4936	16
Na	2	0.0870	3
K	4.2	0.1074	3
Total		3.1830	100

ANIONS	mg/l	meq/l	%
HCO_3	128	2.0978	87
CO_3	0	0.0	0
SO_4	12	0.2498	10
Cl	2	0.0564	3
Total		2.4040	100



Piper Trilinear Diagram (After Piper, 1944)



Stiff Diagram

FIGURE 7
STIFF AND PIPER DIAGRAMS

Project Name Bob's Home Service

Project Number 13C051

Sample Number DS

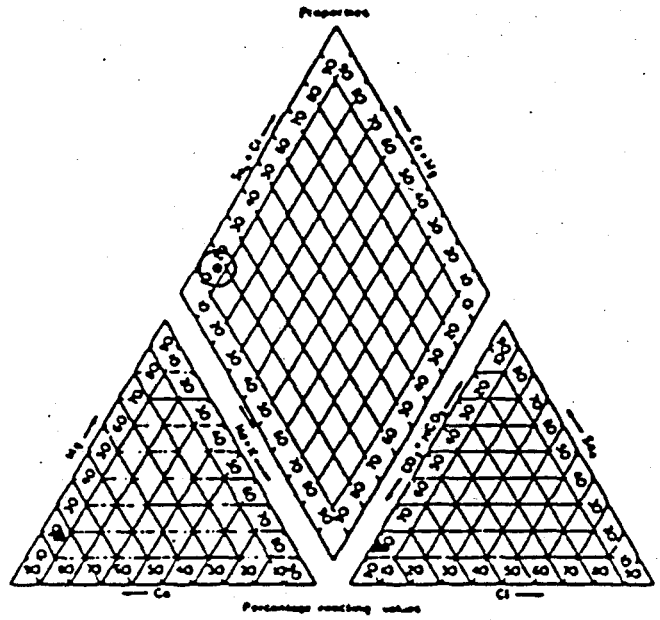
Location Downstream Sample

Date Taken 9/1/83

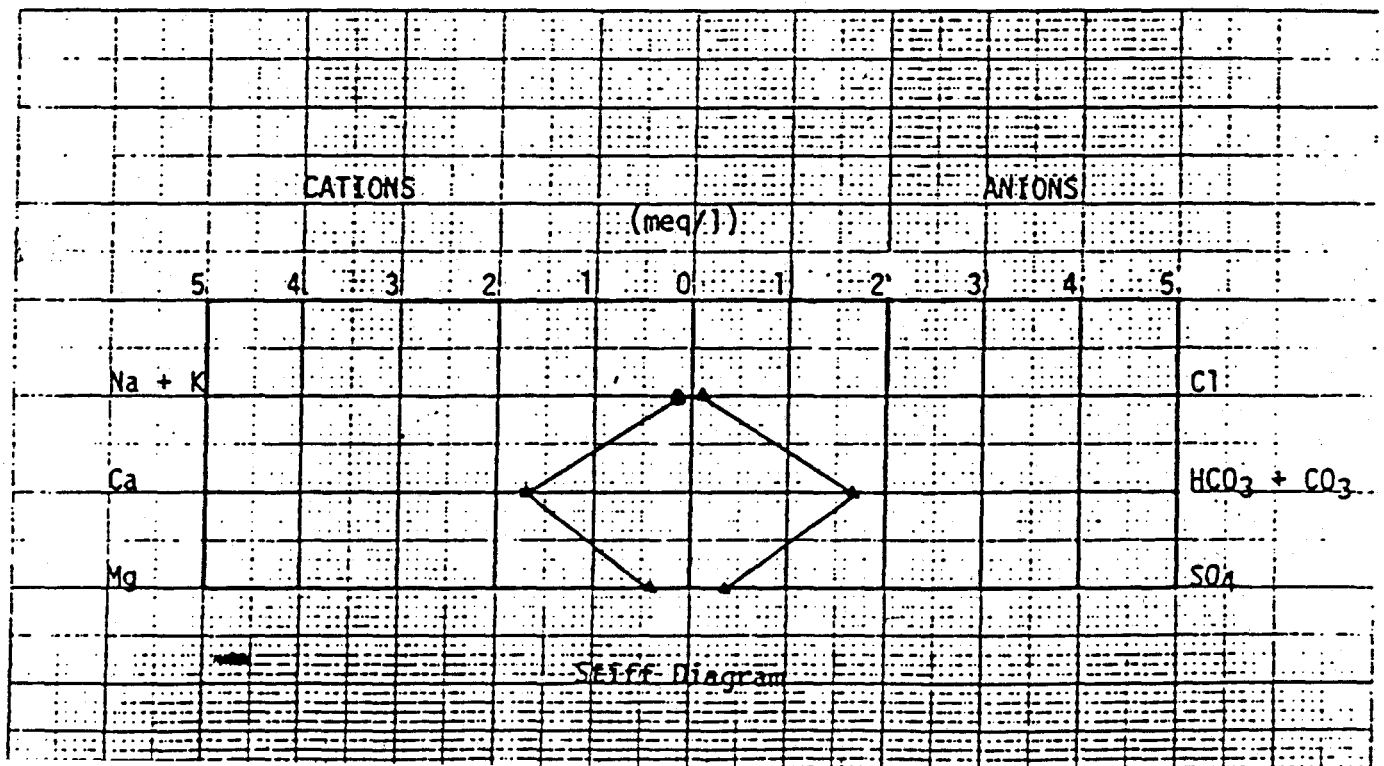
Comp. by Neil D. Williams
Date 9/19/83
Checked by PJK
Date 9/27/83

CATIONS	mg/l	meq/l	%
Ca	34	1.6966	75
Mg	5.3	0.4360	19
Na	0	0.0	0
K	5.3	0.1355	6
Total		2.2681	100

ANIONS	mg/l	meq/l	%
HCO_3	102	1.6717	83
CO_3	0	0.0	0
SO_4	14	0.2915	14
Cl	2	0.0564	3
Total		2.0196	100



Piper Trilinear Diagram (After Piper, 1944)



Stiff Diagram

FIGURE 8
STIFF AND PIPER DIAGRAMS

Project Name Bob's Home Service

Project Number 13C051

Sample Number POND

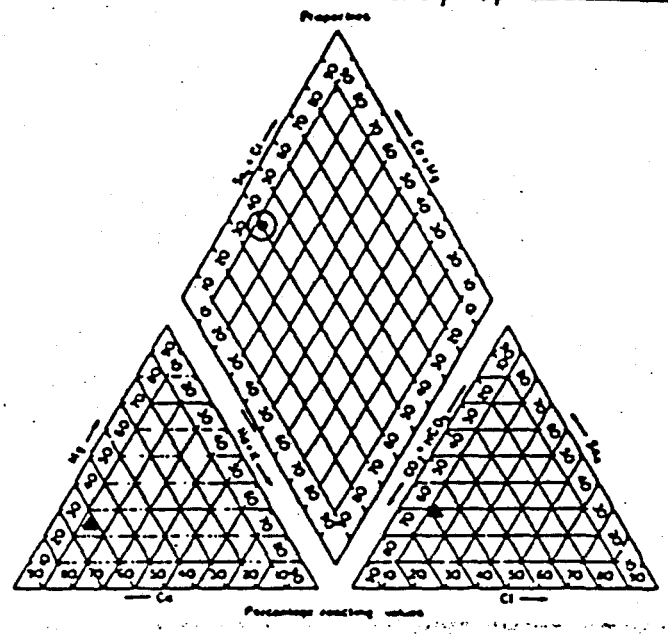
Location Upgradient Pond

Date Taken 9/1/83

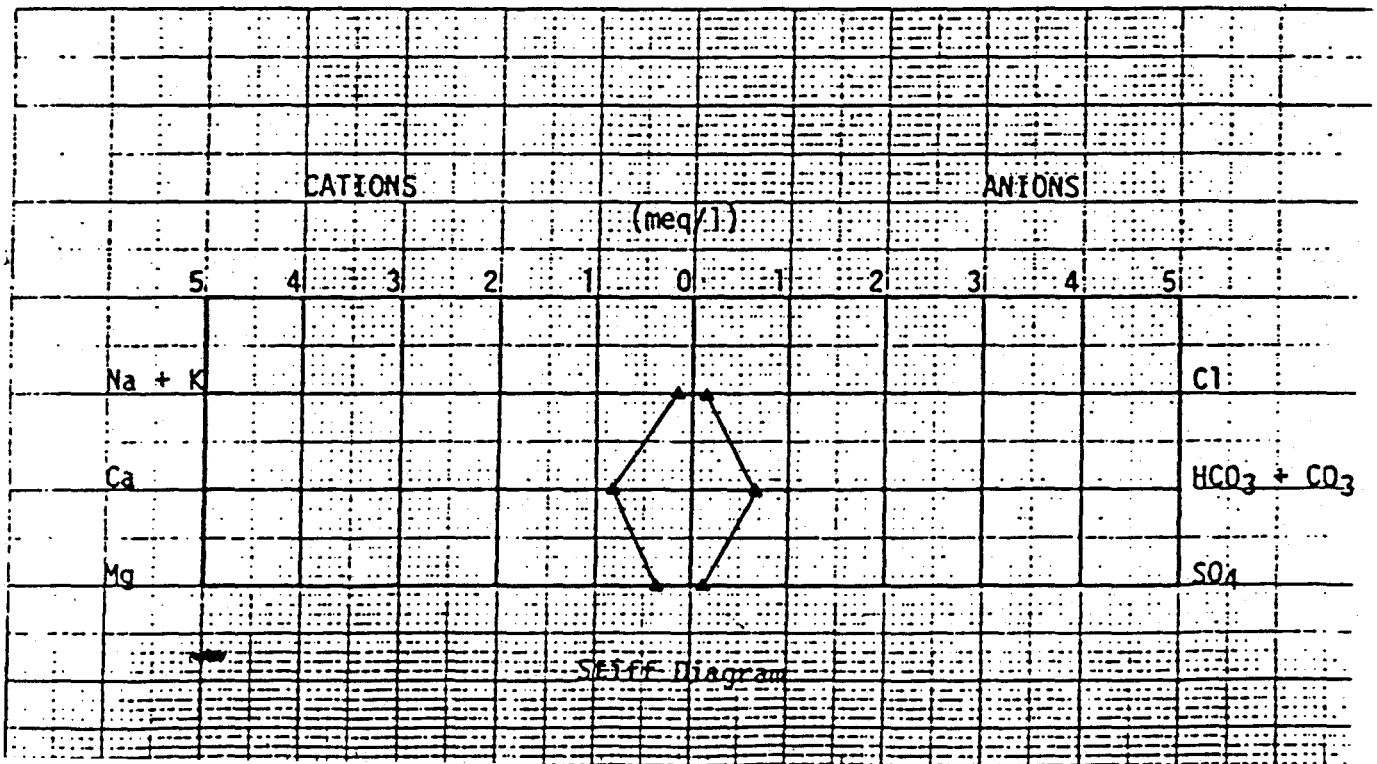
Comp. by Neil D. Williams
Date 9/19/83
Checked by PJK
Date 9/27/83

CATIONS	mg/l	meq/l	%
Ca	16.4	0.8184	62
Mg	4.1	0.3373	26
Na	2.0	0.0870	7
K	3.1	0.0793	5
Total		1.3220	100

ANIONS	mg/l	meq/l	%
HCO_3	38	0.6228	60
CO_3	0	0.0	0
SO_4	14	0.2915	28
Cl	4	0.1182	12
Total		1.0325	100



Piper Trilinear Diagram (After Piper, 1944)



STIFF Diagram

TABLE 1

SUMMARY OF FIELD ANALYSES *

Sample Location	Time	Method of Recovery	Temperature (°C)	pH	Conductance (μmhos/cm)	Color	Appearance
K2(OX)	8:40 am	Bailer	16	6.6	2,890	Light Brown	Slightly Cloudy
K5(OX)	9:15 am	Bailer	14.2	6.5	2,430	None	Clear
GM1	11:05 am	Pump	17.9	11.5	1,480	Light Brown	Slightly Cloudy
GM4	10:15 am	Pump	14.7	9.8	580	None	Slightly Cloudy
Upstream (US)	12:35 pm	Direct Immersion	23.3	6.4	230	Light Brown	Cloudy
Downstream (DS)	9:45 am	Direct Immersion	19.8	6.1	202	Light Brown	Cloudy
Pond	9:55 am	Plastic Container	25	6.3	133	None	Slightly Cloudy

* All samples taken on September 1, 1983

TABLE 2

CHARGE BALANCE SUMMARY

Sample Number	Charge Balance* (%)	pH Lab	pH Field	Calculated TDS (mg/l)	Water Type
Pond	+12.3	7.7	6.3	82	$CaHCO_3$
DS (Downstream)	+5.8	7.2	6.1	162	$CaHCO_3$
US (Upstream)	+13.9	7.7	6.4	204	$CaHCO_3$
GM1	+22.9	11.4	11.5	783	$CaSO_4$ (some Na)
GM4	+16.3	10.5	9.8	446	$CaSO_4$ (some Na)
K5(OX)	+8.2	6.8	6.5	2,723	$CaSO_4$ (some Mg)
K2(OX)	+10.1	6.7	6.6	3,248	$CaSO_4$ (some Mg)

* Charge Balance (percent): $\frac{\Sigma \text{cations} - \Sigma \text{anions}}{\Sigma \text{cations} + \Sigma \text{anions}} \times 100$ (after Hem, 1970)

APPENDIX

WATER QUALITY DATA

RECEIVED SEP 15 1983

WILSON LABORATORIES

528 NORTH NINTH STREET - P.O. BOX 1858 - SALINA, KANSAS 67402-1858 - (913)825-7186

LABORATORY REPORT

CLIENT: WCC (13C051)
ATTN: NEIL WILLIAMS
5055 ANTIOCH ROAD
OVERLAND PARK, KS 66203

DATE RPTD: 09/13/83
DATE RCVD: 09/02/83
PURCHASE AUTH:
FILE NO.: 83-9516
ORDER NO.: 5042

LAB NUMBER: 83090052
SAMPLE DESCRIPTION: K20X

DATE SAMPLED: 09/01/83
TIME SAMPLED: 840

ANALYSIS	CONCENTRATION	UNITS	BOOK-PAGE
ALKALINITY, PARTIAL	0.	MG/L AS CACO3	142-71
ALKALINITY, TOTAL	441.	MG/L AS CACO3	142-72
BICARBONATE	441.	MG/L AS CACO3	142-72
CARBONATE	0.	MG/L AS CACO3	142-72
CHLORIDE	74.	MG/L	197-45
PH	6.7	STANDARD UNITS	166-65
SULFATE	1740.	MG/L	196-23
CALCIUM BY AA	650.	MG/L	252-78
MAGNESIUM	220.	MG/L	252-78
POTASSIUM	8.3	MG/L	252-71
SODIUM	115.	MG/L	252-71

--CONCLUSION--LAB NUMBER: 83090052 K20X

LAB NUMBER: 83090053
SAMPLE DESCRIPTION: K50X

DATE SAMPLED: 09/01/83
TIME SAMPLED: 920

ANALYSIS	CONCENTRATION	UNITS	BOOK-PAGE
ALKALINITY, PARTIAL	0.	MG/L AS CACO3	142-71
ALKALINITY, TOTAL	369.	MG/L AS CACO3	142-72
BICARBONATE	369.	MG/L AS CACO3	142-72
CARBONATE	0.	MG/L AS CACO3	142-72
CHLORIDE	22.	MG/L	197-45
PH	6.8	STANDARD UNITS	166-65
SULFATE	1580.	MG/L	196-23
CALCIUM BY AA	500.	MG/L	252-78
MAGNESIUM	152.	MG/L	252-78
POTASSIUM	6.6	MG/L	252-71
SODIUM	93.	MG/L	252-71

--CONCLUSION--LAB NUMBER: 83090053 K50X

WILSON LABORATORIES

LABORATORY REPORT

CLIENT: WCC (13C051)

FILE NO.: 83-9516
ORDER NO.: 5042

LAB NUMBER: 83090054
SAMPLE DESCRIPTION: U S

DATE SAMPLED: 09/01/83
TIME SAMPLED: 1235

ANALYSIS	CONCENTRATION	UNITS	BOOK-PAG
ALKALINITY, PARTIAL	0.	MG/L AS CACO3	142-71
ALKALINITY, TOTAL	128.	MG/L AS CACO3	142-72
BICARBONATE	128.	MG/L AS CACO3	142-72
CARBONATE	0.	MG/L AS CACO3	142-72
CHLORIDE	2.	MG/L	197-45
PH	7.7	STANDARD UNITS	166-65
SULFATE	12.	MG/L	196-23
CALCIUM BY AA	50.	MG/L	252-78
MAGNESIUM	6.	MG/L	252-78
POTASSIUM	4.2	MG/L	252-71
SODIUM	2.	MG/L	252-71

--CONCLUSION--LAB NUMBER: 83090054 U S

LAB NUMBER: 83090055
SAMPLE DESCRIPTION: D S

DATE SAMPLED: 09/01/83
TIME SAMPLED: 945

ANALYSIS	CONCENTRATION	UNITS	BOOK-PAG
ALKALINITY, PARTIAL	0.	MG/L AS CACO3	142-71
ALKALINITY, TOTAL	102.	MG/L AS CACO3	142-72
BICARBONATE	102.	MG/L AS CACO3	142-72
CARBONATE	0.	MG/L AS CACO3	142-72
CHLORIDE	2.	MG/L	197-45
PH	7.2	STANDARD UNITS	166-65
SULFATE	14.	MG/L	196-23
CALCIUM BY AA	34.	MG/L	252-78
MAGNESIUM	5.3	MG/L	252-78
POTASSIUM	5.3	MG/L	252-71
SODIUM	ND(1)	MG/L	252-71

--CONCLUSION--LAB NUMBER: 83090055 D S

LAB NUMBER: 83090056
SAMPLE DESCRIPTION: POND

DATE SAMPLED: 09/01/83
TIME SAMPLED: 955

ANALYSIS	CONCENTRATION	UNITS	BOOK-PA
ALKALINITY, PARTIAL	0.	MG/L AS CACO3	142-71

WILSON LABORATORIES

LABORATORY REPORT

CLIENT: WCC (13C051)

FILE NO.: 83-9516
ORDER NO.: 5042

LAB NUMBER: 83090056 (CONT.)

ANALYSIS	CONCENTRATION	UNITS	BOOK/PAGE
ALKALINITY, TOTAL	38.	MG/L AS CACO3	142-72
BICARBONATE	38.	MG/L AS CACO3	142-72
CARBONATE	0.	MG/L AS CACO3	142-72
CHLORIDE	4.	MG/L	197-45
PH	7.7	STANDARD UNITS	166-65
SULFATE	14.	MG/L	196-23
CALCIUM BY AA	16.4	MG/L	252-78
MAGNESIUM	4.1	MG/L	252-78
POTASSIUM	3.1	MG/L	252-71
SODIUM	2.	MG/L	252-71

--CONCLUSION--LAB NUMBER: 83090056 POND

LAB NUMBER: 83090057
SAMPLE DESCRIPTION: GM 1

DATE SAMPLED: 09/01/83
TIME SAMPLED: 1105

ANALYSIS	CONCENTRATION	UNITS	BOOK-PAG
ALKALINITY, PARTIAL	192.	MG/L AS CACO3	142-71
ALKALINITY, TOTAL	216.	MG/L AS CACO3	142-72
BICARBONATE	0.	MG/L AS CACO3	142-72
CARBONATE	48.	MG/L AS CACO3	142-72
CHLORIDE	5.	MG/L	197-45
PH	11.4	STANDARD UNITS	166-65
SULFATE	372.	MG/L	196-23
CALCIUM BY AA	160.	MG/L	252-78
MAGNESIUM	2.3	MG/L	252-78
POTASSIUM	88.	MG/L	252-71
SODIUM	108.	MG/L	252-71

--CONCLUSION--LAB NUMBER: 83090057 GM 1

LAB NUMBER: 83090058
SAMPLE DESCRIPTION: GM 4

DATE SAMPLED: 09/01/83
TIME SAMPLED: 1015

ANALYSIS	CONCENTRATION	UNITS	BOOK-PAG
ALKALINITY, PARTIAL	21.	MG/L AS CACO3	142-71
ALKALINITY, TOTAL	33.	MG/L AS CACO3	142-72
BICARBONATE	0.	MG/L AS CACO3	142-72

LABORATORY REPORT

CLIENT: WCC (13C051)

FILE NO.: 83-9516
ORDER NO.: 5042

LAB NUMBER: 83090058 (CONT.)

ANALYSIS	CONCENTRATION	UNITS	BOOK/PAGE
CARBONATE	24.	MG/L AS CACO3	142-72
CHLORIDE	2.	MG/L	197-45
PH	10.5	STANDARD UNITS	166-65
SULFATE	246.	MG/L	196-23
CALCIUM BY AA	144.	MG/L	252-78
MAGNESIUM	0.4	MG/L	252-78
POTASSIUM	11.9	MG/L	252-71
SODIUM	18.	MG/L	252-71

--CONCLUSION--LAB NUMBER: 83090058 GM 4

NO(), WHERE NOTED, INDICATES NONE DETECTED WITH THE DETECTION LIMIT IN PARENTHESES.

ANALYSES WERE PERFORMED ON SAMPLES AS RECEIVED BY WILSON LABS UTILIZING APPROVED PROCEDURES PUBLISHED IN THE FEDERAL REGISTER, VOL. 44, NO. 233, DEC. 3, 1979 (69563-69575) AND AS AMENDED IN THE FED. REG., VOL. 44, NO. 244, DEC. 18, 1979.

WILSON LABORATORIES

Robert P. Selm

ROBERT P. SELM
PARTNER

T013-P02-603-009

115

The Earth Technology Corporation

500 Elizabeth Avenue, Suite 100, Somerset, New Jersey 08873
Telephone: (201) 560-1650

12 February 1984

Ms. Jane Ratcliffe, Program Manager
U.S. Environmental Protection Agency
Region VII
State and Local Assistance Work Unit
324 East 11th Street
Kansas City, Missouri 64106

Dear Ms. Ratcliffe:

I have attached the Earth Technology Corporation's final report on our review of the comments recieved from Bob's Home Service. The report was prepared by Mr. Dean Gregg after his discussion with Mr. Sandefur regarding our preliminary report. Following your evaluation of our report please contact us regarding the need for a further meeting between Mr. Gregg and your staff.

Thank you for the opportunity afforded to the Corporation through this assignment. Should you have any questions please contact Mr. Gregg or myself.

Yours truly,

Joseph M Sorge

Josepy M. Sorge
Associate

JMS/smf

cc: Dean Gregg (ETW)
Mr. Sandefur (EPA)

EPA-ARCWL
FEB 13 1984
Region VII, Kansas City, Missouri 64106

RESPONSE TO APPLICANT'S COMMENTS
DATED OCTOBER 12, 1983 --
BOB'S HOME SERVICE

The review of the data and reports prepared for Bob's Home Service is complicated by inconsistent labeling of wells and piezometers. Further compounding the problem is the lack of precise geohydrologic definition of the site and the quality of the supporting data. Finally, the required information and data are scattered through several reports further complicating the task of interpreting the site information provided.

Section 2.1

October 12, 1983 comment indicates disagreement with Ertec's position that the water quality data indicates similar ground-water quality from saturated glacial drift and from limestone bedrock aquifers. From the data in Appendix J of the DEK report and from data presented in Enclosure 3 of the October 12, 1983 both positions can be weakly argued.

The ground-water quality for all units is generally of the calcium-sulfate type. Concentrations of mean values of constituents in ground water from monitoring well MW, tapping materials at the glacial drift and bedrock contact is quite similar to mean concentration values from ground water from the P-series of piezometers tapping the oxidized-unoxidized contact zone of the glacial drift (FIT Project Report, May 8, 1981, p. 4-10). An average of the mean values of chemical constituents in ground water from the P-series piezometers are as follows: specific conductance,

1870 umhos; hardness, 1376 mg/l; and chlorides 20.3 mg/l. This compares for ground-water concentrations from well MW as follows: specific conductance, 1920 umhos; hardness, 1473 mg/l; and chlorides 32.5 mg/l. The Wash Well and the Zykon well tap bedrock; and ground-water samples collected on 11/20/81 had specific conductances of 1640 and 500 umhos; hardnesses of 1215 mg/l and 274 mg/l; and chlorides of 9 mg/l and about 0., respectively (DEK, March 6, 1983, Appendix J.) From these data and comparisons it can be argued that ground water contained in the oxidized-unoxidized contact zone, the glacial drift-bedrock contact materials, and the bedrock is similar in quality.

From data presented in Enclosure 3 of BHS response of October 12, 1983, a different interpretation is possible. Samples of ground water were collected September 1, 1983 from K2(OX), K5(OX), GM1, and GM4 for analyses. The results indicate that the waters are of the calcium-sulfate type. Water from K2(OX) and K5(OX), both tapping the shallow oxidized-unoxidized contact zone, contains much higher concentrations of dissolved solids (as indicated by the specific conductance) than does ground water from GM1 and GM4 both tapping the upper sand unit. The following table is used for comparison:

	pH	SC	HCO^3 mg/l	Cl mg/l	SO^4 mg/l	Ca mg/l	Mg mg/l	K mg/l	Na mg/l
K2(OX)	6.7	2890	441	74	1740	650	220	8.3	115
K5(OX)	6.8	2430	369	22	1580	500	152	6.2	93
GM1	11.4	1480	0	5	372	160	2.3	88	108
GM4	10.5	580	0	2	246	144	.4	11.9	18
K11*	7.2	600	288**	2	120	96	2.8	--	70

(*DEK Report, Appendix J, Nov. 20, 1981 sample from well K11. Based on the static water level of 46.2 feet, the water level elevation is about 713 feet. This then corresponds to well K11(SA).)
(** calculated)

There is a substantial difference in concentration of almost all constituents with the ground water from the oxidized-unoxidized contact zone being much more concentrated than the ground water from the upper sand unit. The ground water from the oxidized-unoxidized contact zone from wells K2(OX) and K5(OX) has a higher SC value (2660 umhos(mean) versus 1870 umhos) and chlorides (48 mg/l (mean) versus 20.3 mg/l) when compared with ground water for the P-series piezometer also tapping the oxidized-unoxidized contact zone (5-13) as stated in FIT Report (May 8, 1981, p. 4-10). This may indicate that the ground water from the oxidized-unoxidized contact zone sampled September 1, 1983 from wells K2(OX) and K5(OX) is atypical. Further the water samples from GM1 and GM4 are believed to be unrepresentative of water in the first sand unit because the wells were probably not developed. Enclosure 3, October 12, 1983, p. 2 states the following:

> "Two ground water samples were obtained from the first sand aquifer from wells GM1 and GM4. These wells have permanent submersible pumps installed in them and had not been developed prior to flushing. The wells were flushed the day before sampling by engaging the submersible pumps. Approximately one well volume of water was removed and the wells went dry. The pumps were again engaged after approximately 15 minutes but there was no water in the wells. The wells were sampled the following day by directly filling the 1-liter sample container and the field test container directly from the effluent port in the well casing."

From an assessment of that statement and the water quality analyses it is concluded that the water samples from GM1 and GM4 with a pH of 11.4 and 10.5, respectively, were probably not pure ground-water samples but were likely contaminated with residual water

from cementing the wells during construction. It should be noted that a potassium concentration of 88 mg/l for GM1 is a spurious value also.

Ground water from well K-11(SA) tapping the upper sand unit is dissimilar to water from the P-series piezometers tapping the oxidized-unoxidized contact zone in the glacial drift or the MW or Zykon wells tapping the drift-bedrock contact or bedrock. Unfortunately, the water sample from K-11(SA) was not analyzed for bicarbonate; however, by calculating the cation milliequivalents, the anion milliequivalents can be determined and the missing bicarbonate milliequivalents can be approximated. This resulted in a calculated bicarbonate concentration of 288 mg/l. The ground water from K-11(SA) is of the calcium-sodium-bicarbonate-sulfate type. This water type may appear to be erroneous; however, K-11(SA) is located in a stream drainage, the water-level elevation is shallow and at a ground-water high, and the ground water had a high COD concentration. It is believed that the sand unit is being recharged in the area near K-11(SA). Typically, ground water in recharge areas tend to be of the sodium-bicarbonate type which transitions to a sodium-calcium-bicarbonate-sulfate type to a calcium-sulfate type water with distance from a recharge area. However, even though ground water from piezometer K-11(SA) appears to be representative of ground water in the sand unit in the recharge area, it may not be representative of ground water further down gradient in the upper sand unit.

There is a lack of reliable and complete water quality data to permit an accurate characterization of the ground water from the

oxidized-unoxidized contact zone, the first sand unit, and from the drift-bedrock contact. The existing ground-water quality data from the oxidized-unoxidized contact zone and the glacial drift-bedrock contact are incomplete as they typically do not include analyses of basic water quality constituents (calcium, magnesium, sodium, potassium, sulfates and bicarbonates). Thus, it is very difficult to reach a definitive conclusion other than there are similarities in the ground-water quality from the different hydrogeologic units. The data, however, do not conclusively support the Applicant's contention that the water quality data do not indicate similarity between the various water-bearing units.

Section 2.2

The October 12, 1983 comment states that the Wavier Demonstration indicates that the oxidized zone is not saturated thus the unsaturated zone would be greater than 15 feet thick in the subject area. The Ertec report indicates no data which refutes this.

The Ertec report (August 1983, p.3) states that ". . . the available data indicate that only the upper 10 to 15 feet in the vicinity of the Area 1 facility consists of unsaturated soils (loess or drift materials)."

The monitoring records for the P-series piezometers, which tap ground water in the oxidized-unoxidized contact zone show ground-water levels varying from less than 10 to about 40 feet below top of casing. Assuming the casings stick up an average of 2 feet above land surface, the depth of water ranges from less than 8 to about 38 feet below land surface. Using the May 4, 1982

water-level data (DEK Report, Appendix J) the average depth to water below top of casing is 24.2 feet or 22.2 feet below land surface. The depth to water in the K(OX) piezometers ranges from only a few feet in K11(OX) to dry conditions elsewhere (DEK Report, Appendix F). The water levels in the P-series piezometers, because of their locations, are probably more representative of water levels in the oxidized-unoxidized contact zone beneath the disposal site than those from the K(OX) series. Some of the deeper ground-water levels in the P-series piezometers are caused by a suspected discharge from the oxidized-unoxidized contact zone to alluvium along the central stream. It is concluded that within the subject area, the oxidized glacial drift is partially saturated. The thickness of its unsaturated zone ranges from less than 8 to about 38 feet and averages about 22 feet. The Ertec-reported range (August 1983, p.3) of 10 to 15 feet is somewhat narrower than the P-series piezometer data would indicate.

Section 2.3

The comment questions the horizontal gradient of 0.3333 used by Ertec for the oxidized zone. The comment says that value is an order of magnitude higher than what is indicated by the Waiver Demonstration data. The comment also indicates that additional field permeability test data are lower than those used by Ertec.

Ertec used water levels measured in P-series piezometer monitoring data from November 19, 1981 (DEK Report, Appendix J) and constructed a potentiometric map for the oxidized zone. In the vicinity of piezometer P-8, the constructed contours indicate a very steep gradient, about 0.444. Near P-9 the gradient is about

0.19 and near P-7 it is about 0.20. The statement of an average permeability of 0.3333 is within reason. It could be argued that the water level elevation in P-8 is abnormally low (although the condition persisted) and that it erroneously controls the configuration of the contours -- hence gradient. Certainly there could be other equally valid interpretations of the data. However, the gradient is high. For example if the ground-water elevation of P-9 and P-10 and taken from November 19, 1981 at 735 feet and 757 feet, respectively (DEK Report, Appendix J), the gradient is 22/415 or 0.155 (about half of the value stated by Ertec). Using the DEK potentiometric map 16 of 27, the gradients of ground water in the oxidized-unoxidized contact zone determined normal to the piezometer location, range from 0.143 at P-3 to 0.080 at MW and average 0.115. The comment that 0.3333 is magnitude of order higher than the gradient indicated by the Wavier Demonstration data is unsupported by those data. The DEK Report, Appendix J and the DEK map 16 of 27 presents data indicating gradients of 0.155 and 0.115 (average), respectively.

The results of field permeability tests performed by Woodward-Clyde Consultants (WCC) during the period between August 30, 1983 and September 26, 1983 were considerably lower than the 1×10^{-5} cps value used by Ertec for a horizontal permeability (hydraulic conductivity) value of the oxidized-unoxidized contact zone. WCC used K2(OX) for their tests of that zone.

The K borings were constructed with 1 1/2 inch ID PVC pipe and screen. The placement of sand and/or gravel around the screen was largely by dumping from the top. The deeper piezometers used

natural sand materials. A grout was placed above the sand as a surface seal. With the small diameter casing and the use of an auger drilling rig through plastic soils (in part) there is a concern as to how well the piezometer could be developed. The auger rig tends to smear the boring with any plastic clay materials sealing off fractures and more permeable sand or gravel lenses. If the piezometer was not developed thoroughly and if the clay coating was not removed from the boring walls then there would not be good hydraulic communication between the piezometer and the undisturbed soils. This would result in abnormally low hydraulic conductivities from in-situ testing.

Most of the P-series piezometers tapping the oxidized-unoxidized contact zone are sampled and their ground-water levels measured on a frequent basis. Appendix J of the DEK Report gives the resultant monitoring data. An analyses of those data were performed to determine hydraulic conductivities of the materials using the Cooper-Jacobs straight line method. Although neither the data nor the method represents a rigorous analyses, the results are useful for comparison. Several assumptions were necessary to perform the analyses: 1 - the rate of withdrawal of water was 1 bail per 2 minutes; 2 - the water level was measured 1 minute after bailing ceased; and 3 - the average screen length was 20 feet. The following table gives the approximate results.

APPROXIMATIONS OF HYDRAULIC CONDUCTIVITIES

Well No	Date of Bailing	Rate of Bailing (gpm)	T (gpd/ft)	K (cps)
P-3	9-01-81	0.37	27	6.5×10^{-5}
P-S	9-01-81	0.37	9.9	2.3×10^{-5}
	5-03-82	0.37	7.7	1.8×10^{-5}
P-7	9-01-81	0.37	14.2	3.3×10^{-5}
P-10	9-01-81	0.37	9.8	2.3×10^{-5}
	11-19-81	0.37	5.8	1.4×10^{-5}
	5-03-82	0.37	5.1	1.2×10^{-5}
P-11	9-01-81	0.37	9.9	2.3×10^{-5}
K11(SA)	11-19-81	0.09	1.9	3.9×10^{-6}

It is concluded that the P-series piezometers, because of their larger diameter casings (3 inches) and history of sampling are likely to be better developed and have better hydraulic connection with the natural soil than does the K-series piezometers. Further, that the higher hydraulic conductivity values from the P-series piezometers are more representative of the oxidized-unoxidized contact zone than are values from the K-series. Because of the heterogeneity of the material and the secondary fracture permeability which has been developed, in-situ testing of properly developed piezometers will likely produce more representative hydraulic conductivity values than laboratory testing of soil samples.

From these data and analyses, it is concluded that it was not unreasonable for Ertec to use a hydraulic conductivity value of 1×10^{-5} cps to represent the oxidized-unoxidized contact zone.

Section 2.4

The comment was made that Ertec assumed a saturated thickness of 1 to 5 feet which would contradict their previous statement regarding the unsaturated zone in Section 2.2.

The assumed thickness of the saturated zone of 1 to 5 feet was used to calculate the inflow into the landfill trenches and near the trenches. It is proper to assume that near the trenches, where the gradient is steep, that the unsaturated thickness increases and the saturated thickness decreases. The value of 1 to 5 feet of saturation is reasonable near the trenches. Further west of the landfill trenches, the saturated thickness would be substantially greater. Thus, because of the location and how the information is used, the different Ertec statements regarding thickness of saturated or unsaturated materials are not contradictory.

Section 2.5

The comment states that the Applicant reestimated the water balance using SW-168 procedure and the result was 0 percolation as originally calculated using some other (undefined) procedure. Further, that Ertec, following the SW-168 procedure, did not perform the proper analyses and resulted in incorrect conclusions.

Neither the Applicant nor Ertec had the correct water balance. The only water balance presented by the Applicant available for review was contained in the DEK Report, Appendix L. That balance did not take into account the effect of soil moisture and soil moisture difficiencies on the actual/potential evapotranspiration. Ertec performed the water balance calculation properly throughout the procedure except for the final calculation for percolation. Ertec mistakenly assumed that monthly positive values of I-PET or I-AET would be equivalent to percolation values for those months. Ertec neglected to consider moisture return to soil storage during months where I is greater than PET or AET. The corrected values

for percolation (in inches of water by month are as follows:

	Nov	Dec	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sept	Oct	Tot
PERC	0.00	0.00	0.00	0.00	0.57	0.35	0.03	0.00	0.00	0.00	0.00	0.00	0.95

Thus, the correct calculated value using SW-168 for percolation is about 1 inch per year and not zero as claimed by the Applicant nor 4.27 inches per year as originally calculated by Ertec. Ertec also calculated 2.5 inches per year percolation using the HELP model. Because this is a different procedure from that described in SW-168 and the merits of the two methodologies cannot be readily assessed, the percolation rate should be considered in a range from about 1 to about 2.5 inches per year.

Section 2.6

No response necessary to this comment.

Section 2.7

Comment made that Applicant disagrees with Ertec's assumption of saturated conditions and porosity and prefer their values from laboratory tests and observations.

The value of effective porosity of 0.01 to 0.10 is reasonable and in agreement to literature and general practice. This value is not to be confused with the larger value of porosity.

With regards to the assumption that the unoxidized zone is saturated, it is very clear that it is an assumption for a conservative case calculation. More importantly, the effect of the "observed" vertical joints in the unoxidized drift (Ertec, August 1983, p. 7) has not been defined by the Applicant. These joints could be rather effective conduits to convey fluids from the landfill to the upper sand unit.

Section 3

No response necessary to this comment.

Section 4 and 5

No response necessary to this comment.

After reviewing the information, several unanswered questions arise concerning the hydrogeologic regime which have not been addressed in any of the Applicant's submittals.

The upper sand unit appears to be receiving recharge near the area between K11 and K10. There that unit is near land surface and may even be intersected by the contact between the oxidized-unoxidized zone. This then, could provide additional short circuits to introduce contaminates to the upper sand unit. The flow in the upper sand unit is in three separate outwash lobes: one to the west northwest (by piezometer K2); the second to the northeast (near well GM4, and boring TH40), and the third to the north northeast (near piezometer K4). The flows are generally towards areas of higher topographic elevation then that of the recharge area. What then is the fate of ground water contained in the upper sand unit? Does it eventually daylight as spring or surface water discharge on the other side of the ridge? Or does it leak downward to recharge the bedrock aquifers?

There is also a question about the steepening of water-level contours for ground water contained in the oxidized-unoxidized contact zone near the central stream. Is the ground-water discharging from that zone into alluvium beneath the drainage? There is no information on this possible subdischarge nor the fate of ground water in the oxidized-unoxidized contact zone.

In summary, it is Ertec's impression that, from a hydrogeologic viewpoint, there is a potential for contamination of the upper sand unit and to a lesser extent, the deeper bedrock aquifers. It has not been adequately demonstrated that there is a low potential for contamination of useable water supplies or the surface water environment from the hazardous waste disposal facility.

This document "Response to Applicant's Comments, Dated October 12, 1983 -- Bob's Home Service" was prepared by the Earth Technology Corporation by Dean O. Gregg, Senior Hydrogeologist (Professional Engineer, State of Georgia No. 5357 and Professional Geologist, State of Georgia No. 234).

For The Earth Technology Corporation
by Dean O. Gregg, P.E, P.G.

Date: February 12, 1984

PROJECT: BHS - Area I

LOCATION: Elev 740' between joints oxidized

BORING NO.: Horizontal SAMPLE NO:

DEPTH: SURF ELEV:

PERMEAMETER NO. 457 E & 550 N

DATE SAMPLE: 10-11-83(?) BY Williams, Jim

DATE TESTED: Nov - June BY St. Ivany

DATE COMPUTED: 8-10-84 BY Williams, Charles

DATE CHECKED: BY

DATE PLOTTED: BY

RUN NO.	WATER TEMP. °C	SAMPLE LENGTH CM L	INITIAL HEAD CM H_1	FINAL HEAD CM H_2	TEST TIME SEC. t	$\log_e \frac{H_1}{H_2}$	$\frac{aL}{At}$	K CM/SEC.	TEMP. CORR.
18-1		6.77	66.36	34.92	5,702,400	.6426	5.009×10^{-5}	3.216×10^{-5}	
18-2		6.77	86.36	28.45	7,603,200	1.110	3.756×10^{-5}	4.170×10^{-5}	
18-3		6.77	86.36	44.45	4,260,800	.6842	7.034×10^{-5}	4.672×10^{-5}	

T013-P09-6B-010

a - STAND PIPE AREA = 1.75 CM^2

A - SAMPLE AREA = 41.48 CM^2

$K = \frac{aL}{At} \log_e \frac{H_1}{H_2}$ = {PERMEABILITY IN CM/SEC.

$e = \frac{SAL - W_s}{W_s}$ = VOID RATIO

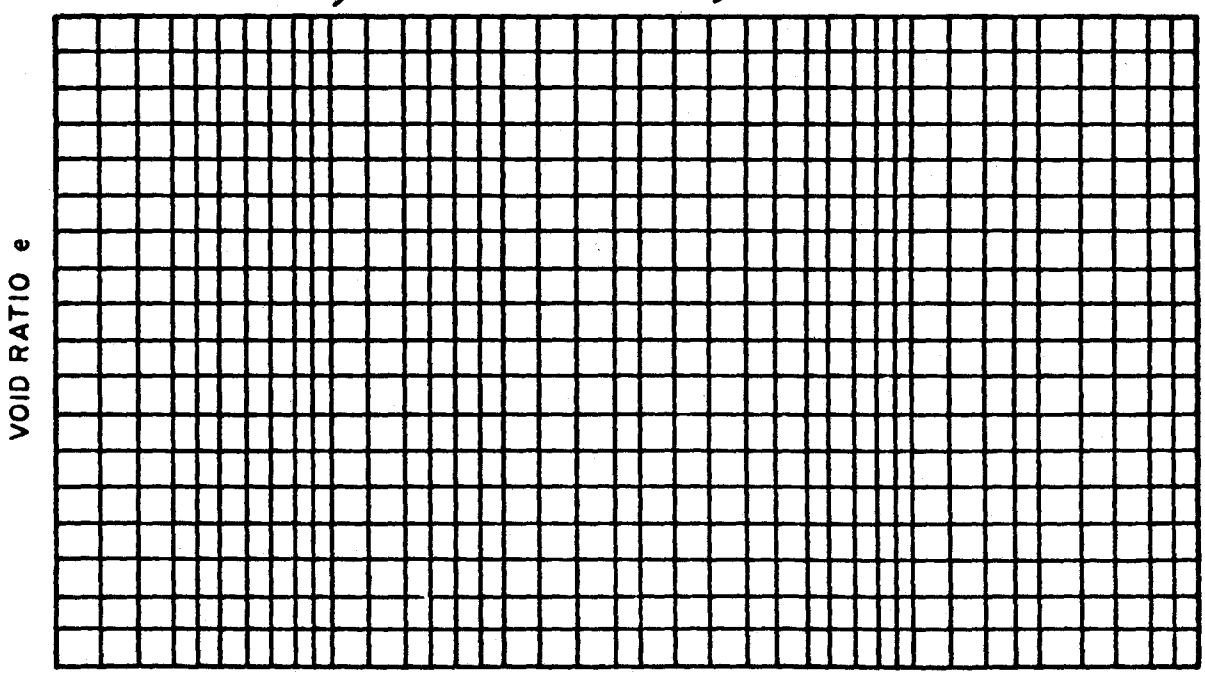
S = SPECIFIC GRAVITY

W_s = WT. OF DRY SOIL IN GMS.

SUMMARY

TEST	WT. DRY SOIL	e	K $\frac{CM}{SEC.}$

This was a long term test where the oxygen was driven out creating a reducing environment. The joints & cracks swelled



PERMEABILITY TEST

Warren County

PROJECT: BHS - Area I	DATE SAMPLE: 10-11-83 (?) BY Williams, J.M
LOCATION: SE-NE-NE-SW-32	DATE TESTED: NOV - JUN BY ST IUANI
BORING NO.: SAMPLE NO:	DATE COMPUTED: Aug 10, 84 BY Williams, Charles
DEPTH: SURF ELEV: 726'	DATE CHECKED: BY
PERMEAMETER NO. 660 E + 520 N	DATE PLOTTED: BY

RUN NO	WATER TEMP. °C	SAMPLE LENGTH CM L	INITIAL HEAD CM H_1	FINAL HEAD CM H_2	TEST TIME SEC. t	$LOG_e \frac{H_1}{H_2}$	$\frac{aL}{At}$	K CM/SEC.	TEMP. CORR.
15-1		6.76	71.76	50.16	5,702,400	.3581	5.024×10^{-3}	1.501×10^{-8}	
15-2		6.76	86.36	53.42	7,603,200	.3909	5.772×10^{-3}	1.474×10^{-8}	
15-3		6.76	86.36	62.86	4,262,800	.3176	7.062×10^{-3}	2.243×10^{-8}	

a - STAND PIPE AREA = 1.75 CM^2

A - SAMPLE AREA = 41.25 CM^2

$K = \left(\frac{aL}{At}\right) LOG_e \frac{H_1}{H_2}$ = {PERMEABILITY IN CM/SEC.

$e = \frac{SAL - W_s}{W_s}$ = VOID RATIO

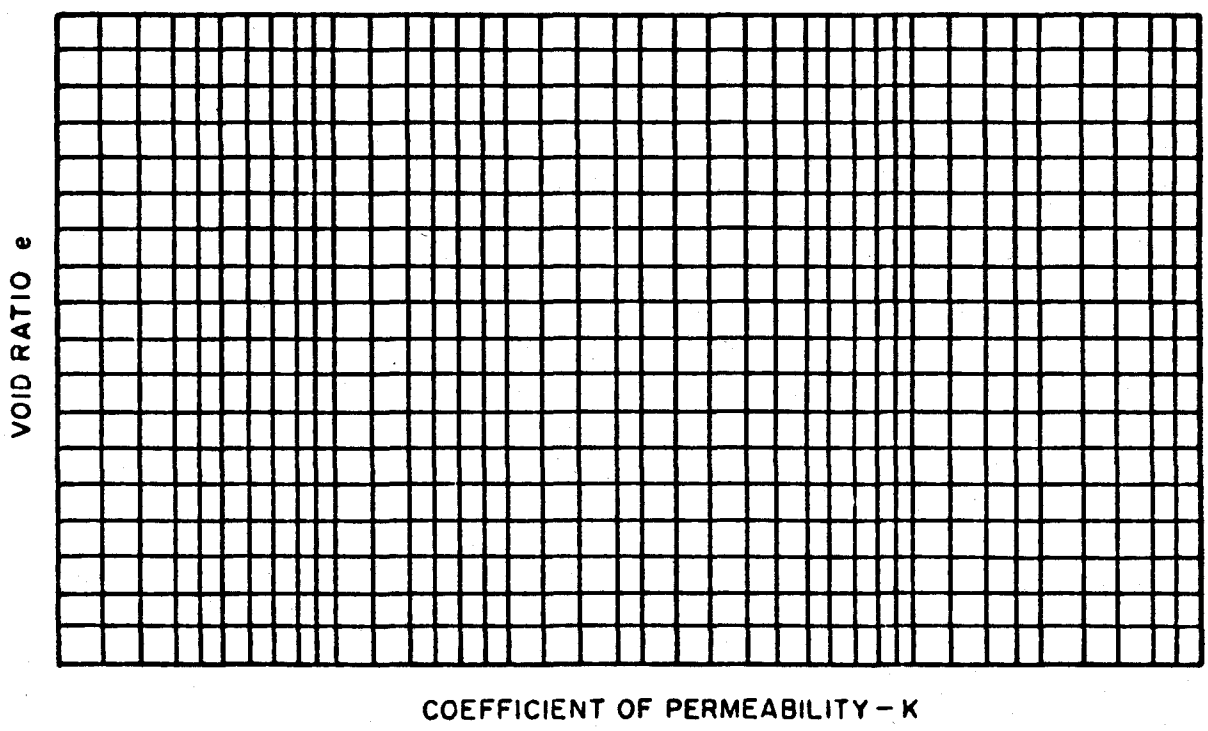
S = SPECIFIC GRAVITY

W_s = WT. OF DRY SOIL IN GMS.

SUMMARY

TEST	WT. DRY SOIL	e	K $\frac{CM}{SEC.}$

unoxidized glacial till



T013-P02-603-011

POTENTIAL FOR
HUMAN EXPOSURE
AT THE
B.H.S., inc.
WRIGHT CITY FACILITY
08/08/85

RECEIVED

AUG 1 9 1985

PRMT SECTION

B.H.S.
Incorporated

Route 1, Box 116F
Wright City, Mo. 63390
Phone 314-745-3371
St. Louis 314-946-4782

INDUSTRIAL WASTE DISPOSAL FACILITY

August 8, 1985

Mr. Michael J. Sanderson
Chief, RCRA Branch
Waste Management Division
U. S. E.P.A. Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Dear Mr. Sanderson:

As per your request B.H.S., Inc. has prepared a report on "Potential for Public Exposure to Hazardous Waste" for this facility.

If you have any questions, please give me a call.

Sincerely,

Michael D. Gill

Michael D. Gill
Vice President
Operations

MDG/ph

cc Copy of Report to MDNR

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APPENDICES

Appendix A	Woodward Clyde Environmental Assessment
Appendix B	Woodward Clyde Groundwater Monitoring Evaluation
Appendix C	Environmental Risk Assessments 1980 & 1983
Appendix D	System Management Assoc. Health Profile
Appendix E	Transportation Waste Spill Emergency Response
Appendix F	Leachate Analysis
Appendix G	Ten Largest Generators
Appendix H	Checklist

MAPS

Three Mile Radius Map
Warren County Master Plan
Aerial Photo of Section 32 Township 47 Range 1W

1.0 INTRODUCTION

1.1 Legislative Requirement

Section 3019 of the 1984 Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act (RCRA) mandated that all facilities submitting Part "B" of a RCRA Application must also provide information on the potential for public exposure to hazardous waste arising from the subsequent permitting of the facility.

On July 3, 1985 the Environmental Protection Agency (EPA) finalized the "Permit Applicants' Guidance Manual for Exposure Information Requirements under RCRA Section 3019". Utilizing this document B.H.S., Inc. provides the following information as required under Section 3019.

1.2 History of Facility

To fully explain potential exposures at B.H.S., Inc. a brief history of the Wright City Facility and controlling State and Federal regulations must be presented.

In 1971 Mr. James Zykan Sr. opened a sanitary landfill located approximately in the center of a 158 Acre farm. The farm is situated three miles southwest of Wright City, Missouri. The sanitary landfill comprising 7+ acres was operated under a county permit and a Missouri Division of Health permit until permit number 121901 was issued by the newly organized Missouri Department of Natural Resources (MDNR) in 1976. In 1977 the sanitary landfill was closed. The 158 acre farm was permitted as a "Special Industrial Facility" (Permit #721901) with 12 acres due North of the old sanitary landfill designated for landfilling. In September 1980 B.H.S., Inc. timely submitted Part "A" of a RCRA Application (MOD068521228). In December 1982 the State of Missouri issued a Treatment, Storage and Disposal permit (TSD122282-001) to B.H.S., Inc. to cover the remaining life of the original 12 acre landfill area. In August of 1983 B.H.S., Inc. submitted Part "B" of a RCRA application with a subsequent revision submitted in April 1984. At present, B.H.S., Inc. is still waiting comments from the EPA covering the 1984 submittal.

1.3 Permit Conditions

The 1977 and 1982 permits from MDNR had special conditions attached which directly impacted the operations at B.H.S., Inc. Each individual waste stream from individual generators had to be separately permitted through MDNR prior to disposal at B.H.S., Inc. This provided a good check and balance system that in the long run has been beneficial to B.H.S., Inc. Through this control B.H.S., Inc. has not been allowed to dispose of bulk liquids, high concentrations of organic solvents, large volumes of ignitable or reactive wastes nor highly volatile wastes. This restriction was promulgated as a regulation in Missouri's 1980 Hazardous Waste Regulations. B.H.S., Inc. has operated under these restrictions since 1977. The following may not be disposed of at B.H.S., inc:

A. Ignitable or reactive waste;

B. Volatile waste;

C. Liquid wastes; nor

D. Sludges that contain liquids which drain freely fromn the sludge by gravity, are free flowing sludges, or contain more than five percent (5%) Organic liquid by weight.

The EPA has been mandated to place further restrictions on the landfilling of hazardous waste. It is expected that these regulations should be in place by 1990.

The 1977 permit required monitoring of the 12 acre landfill area. This consisted of 16 shallow (approximately 40 foot deep) wells, three deep wells and one creek monitoring lacation. These locations were monitored quarterly until January 1984 when they were replaced by one upgradient and four down gradient deep (approximately 100 feet) wells, two interceptor trenches (35 feet deep) and two upgradient and three down gradient creek monitoring locations.

1.4 Legislative Restrictions

Missouri's 1980 regulations required the usage of a 200 foot buffer zone which was expanded to 300 feet in October 1980 by legislation. MDNR inspected the facility on a monthly basis until 1981 when legislation required the interval to be decreased to weekly.

1.5 Wastes Handled

B.H.S., Inc. disposes of non-hazardous State controlled hazardous and Federally controlled hazardous industrial wastes. These wastes can be categorized as follows:

A. Waste Water Treatment Sludges (less than 1% hazardous constituent)

B. Paint Waste

(a) Trash contaminated with paint
(b) Paint sludges (<5% hazardous constituent)

C. Pesticide Wastes (<10% hazardous constituent)

(a) Waste water treatment sludges
(b) Product production biproducts
(c) Dust collector dusts
(d) Trash contaminated with pesticides

D. Clean-ups (<5% hazardous constituent)

(a) Soil
(b) Equipment
(c) Lagoons

E. Non hazardous waste

The category listed as clean-up comprises most of the waste disposed of, on a volume basis, at B.H.S., Inc. This category is comprised of one time only large volume (500-5000 cu. yds.) permits. It is estimated that this category comprises from 33 to 50 per cent of the waste handled at B.H.S., Inc.

The remaining four categories evenly comprise the unallocated monthly to yearly waste capacity disposed of at this facility.

Ninety percent of the waste is disposed of in bulk form. Containerization of the waste (ie. drums, bulk bags) is strictly viewed by B.H.S., Inc. as a materials handling and transportation requirement. After the waste is placed in the landfill the natural and synthetic liner system must provide the needed protection.

2.0 Pathway Information

2.1 General Information

Appendices A, C, D, E provide copies of all health profiles, risk assessments and protential pathway assessments prepared for the B.H.S., Inc. facility. All reports conclude that B.H.S., Inc. poses a low risk to human health and the environment. There have been no insurance claims or settlements for transportation or site liability.

The cover insert contains a map labeled as Warren County Master Plan map. The land use area within three miles of the facility has been transposed onto figure 1.

An aerial photo of the facility is provided in the cover insert.

Appendix P of the Operations Manual submitted April, 1984 comprising a section of the Part "B" application gives specific information on federally regulated hazardous waste disposed of at this facility. Appendix F of this report provides a chemical analysis of leachate generated since 1980 at this facility.

Appendix G gives information on the 10 largest generators utilizing the B.H.S., Inc. facility.

In 1981 there were 4,080 cu. yds. of federally regulated hazardous waste disposed of at this facility. In 1982 this volume expanded to 11,136 cu. yds. In 1983 the economy was in the throes of a recession and the federally regulated volume fell to 6,033 cu. yds. In 1984 a large volume of clean-ups raised the regulated total to 23,309 cu. yards. B.H.S., Inc. utilized no pretreatment other than chemical stabilization of small amounts of free liquids found in drummed material.

The E.P.A. inspected the facility in early 1981, late 1982 and late 1984. MDNR inspects the facility on a weekly basis. Inspection reports are kept by B.H.S., Inc. and MDNR. Division of Health has just completed an inspection and report on this facility. At this time copies of the report were not available.

2.2 Management Practices

In July of 1980 B.H.S., Inc. started the practice of providing yearly physicals for all of its employees. Results of each employee past and present physicals are maintained in the company files. To date there has been no accident or illness attributable to the handling of hazardous waste.

Although no hazardous waste related cases have been noted at

claims filed. One of the drivers while descending from the cab of his truck twisted a knee which required surgery. Another driver while ascending his vehicle slipped and sprained his back. A site operator while helping the mechanic replace a truck leaf spring sprained his back when the jack slipped.

The absence of hazardous waste related incidents can be attributed to the awareness and respect for waste that is instilled into the workers by an effective training and retraining program.

2.3 Ground Water

Existing ground water withdrawal wells located within a three-mile radius of the facility are plotted on Figure 1. A total of 80 wells have been identified. Also shown on Figure 1 are the locations of Wells 8, 16, 26, 27, 28, 31, 42 and 46, the licensed drinking water wells that have been identified.

The primary aquifers utilized in the region are comprised of the limestones, dolomites and sandstones of the Ordovician System. Units which are know to yield potable water include the Plattin, Joachim, St. Peter, Roubidoux and Gasconade Formations. These units are typically located from 300 to 1000 feet below ground surface.

Limited information is available concerning the depths and usage of water supply wells within three miles of the facility. Two of the closest wells (located within 1/4 mile of the site) are reported to be approximately 380 and 400 feet deep and cased in approximately the upper 200 and 220 feet, respectively. It is anticipated that other water supply wells would be installed using a similar design, which is typical of wells that utilize the bedrock aquifers in the area.

Based on available information, it appears unlikely that any wells utilize the perched water zone as a water supply source.

Typical usages of ground water from bedrock aquifers are for domestic purposes (including individual residence drinking water supply), livestock watering, and irrigation. It is anticipated that ground water from bedrock aquifers may be used for crop irrigation. The extent of usage is not known at this time. There are no known commercial food preparation industries or high-volume pumping wells located within the three-mile radius.

Regional studies of ground water discharge and recharge areas are not available. Based on review of available site ground water monitoring data, Woodward-Clyde (WCC) presented an evalauation of the local ground water systems (Appendix B). Included in the WCC report were assessments of ground water recharge and discharge which are summarized below.

The bedrock aquifer is recharged in an area south of the site possibly from the channel of an intermittent stream that flows from northeast to southwest. Local vertical recharge is apparently limited by a low permeability layer of glacial deposits that overlie bedrock.

The perched groundwater table (above the low-permeability deposits) is probably recharged by infiltration from the surface (during precipitation) and from the farm ponds located west of the landfill. This ground water discharges to the stream at seeps on the valley sides.

The net precipitation value for the area is approximately 7.3 inches. This value was derived by subtracting the average annual evapotranspiration (about 30 inches) from the mean annual rainfall amount (about 37.3 inches). The references used to obtain these data are: 1) "Soil Survey of Montgomery and Warren Counties," USDA Soil Conservation Service, 1978; and 2) "Water Atlas of the United States," Water Information Center, Inc. 1973.

The 7.3-inch net precipitation value has not been adjusted to account for the net runoff, which must be subtracted to yield the net infiltration (percolation) which can be expected. Appendix L to the "Engineering Design Manual", Part "B" Permit contained in the August 3, 1983 application submittal an evaluation of the water balance at the site. According to this evaluation there is no net percolation of surface water into the subsurface (e.g., the net percolation value is 0.0).

2.4 Surface Water

The locations of surface water bodies within a three-mile radius of the facility are shown on Figure 1. There are no known drinking water, industrial or commercial intakes within the specified area. The primary use of surface water in the area is expected to be for livestock watering. A recreational lake, located about one-half mile southwest of the site, receives surface water discharge from the intermittent stream that drains the southern part of the site. No other surface water bodies are known to receive surface runoff from the site.

The intermittent stream previously described is the only stream on, or within 1000 feet of the site which contains appreciable flow. However, the flow is not readily measurable except during periods of high surface runoff (ie., storms). No flow velocity measurements are available.

Three surface impoundments are used to manage surface water runoff at the site. The water is not discharged to the stream,

analyses of the water indicate that any contaminants present are below NPDWR Standards.

The intermittent stream does receive occasional discharge pumped from the shallow ground water interceptor trenches if the ground water is shown to contain no contaminants at levels in excess of NPDWR.

Water quality sampling is performed at locations upstream and downstream of the facility. Available data indicate that surface water quality has not been adversely affected by the facility. Available analytical data for samples obtained from the stream in 1984 are summarized in Appendix B.

2.5 Air

The principal wind direction in summer is from the South-Southwest and in winter is from the Northwest.

Missouri hazardous waste regulations prohibit the disposal of wastes with a true vapor pressure greater than 75 MM of pressure at 25 degrees Centigrade. All waste streams must first be permitted through MDNR and wastes are inspected for atypical odors. In conjunction with these restrictions wastes posing an air-borne hazard are required to be containerized. B.H.S., Inc. is also required to cover all waste which might constitute an air borne hazard with a minimum of one foot of cover om a daily basis. B.H.S., Inc. has no air monitoring system around the unit.

B.H.S., Inc. has experienced odor complaints in the past. On one occasion soil contaminated with less then 5% orthochlorphenol (Sturgeon Missouri Spill 1981) was disposed of at this facility. Due to the extremely low odor threshold for that chemical, complaints were received while the waste was handled. Once the cleanup was completed, this problem was alleviated.

Another instance for an odor complaint is when freshly pumped leachate is pumped to the surface impoundment. Fresh leachate is in an anaerobic state which lends to the generation of a septic odor. During the time period it takes for the aeration system to convert the leachate to an aerobic state an odor may be present. The extent of the odor is normally limited to the immediate area surrounding the lagoon. Inspection by MDNR immediate to or the day after an odor complaint has never resulted in a violation of Missouri's air regulations.

Wright City lies three miles to the Northeast of the facility. Its' population totals approximately 1900 people. Due to the remaining area being rural or weekend only residents, the estimated permanent population within four miles of the facility is three thousand.

2.6 Soil

In 1980 soil samples were taken from three locations across the facility. One sample was taken from the field on the West Side of the 158 acres farm. A second sample came from the middle of the old sanitary landfill. The third sample was taken from the field bordering on the East property line. A test for Arsenic was performed on all three samples.

	Ug As/g
East field	13.8
Old landfill	28.7
West field	
South of Barn	37.5

All samples indicated arsenic present at the same level of magnitude. Publications indicate that arsenic is a naturally occuring element in the earths crust at this level of magnitude.

Any other tests that have been performed are directly related to the hydrogeological soil testing. Results of these tests are found in the Engineering Section of the Part "B" application.

2.7 Transportation

There are three directions from which waste can be transported to B.H.S., Inc. Waste coming from West of the facility would travel on Interstate 70 to the Wright City Exit then proceed west on the South Outer road for approximately 500 feet to county road H. H is then taken South for apporoximately three miles to county road M. M is then taken East for approximately three quarters of a mile to Muenz Road. Muenz Road is followed South for 3/4 of a mile to the facility gate.

Waste coming from the East would take Interstate 70 to the Wright City exit. Then West on the North outer road to the West overpass. Once the truck crosses over I70 to the South Outer road it proceeds along the aforementioned route.

Waste coming from the Southwest would exit off of Interstate 44 at the Missouri Highway 47 north exit. Highway 47 would be followed north until county road O was encountered. The truck would proceed north on O until it junctions with county road M. M would be followed North then West to Muenz Road. The driver would then turn South on Muenz to the facility.

Trucks that enter the facility stop at the office and present their manifest. Once the manifest is approved the truck proceeds to the laboratory where the waste is inspected. Containerized

waste would be stored in the storage warehouse for future disposal. Bulk waste would be taken to the trench area for offloading.

Once the truck is offloaded the truck would proceed to the truck wash area for cleaning if the need arises.

In addition to the routine training for all employees the B.H.S., Inc. drivers are trained for emergency in route spill response procedures, see Appendix E.

In addition to the manifest B.H.S., Inc. drivers carry waste specific information including copies of MDNR applications, waste analysis and safety data sheets. Drivers are responsible for inspection of roll-off boxes and dump trailers both at the time they are delivered to the generator and when the boxes are picked up. This guarantees that damages which might result in over the road waste loss are removed.

B.H.S., Inc. staffs on-site mechanics for routine maintenance and repairs.

B.H.S., Inc. drivers are also required to inspect generator supplied containers for road worthy condition.

Another driver function is to inspect the waste at the generators facility to catch obvious discrepancies (ie. free liquids, solvents or other non conforming characteristics). B.H.S., Inc. drivers have the authority to deny acceptance of a generators waste if in their opinion the waste does not meet the basic description as permitted.

Part of the B.H.S., Inc. on-site spill response includes the emergency clean-up of materials deposited on the off site access roads. The B.H.S., Inc. daily inspection routine is for spills on the site access roads, staging and storage areas. Employees are required to notify the office upon observing any spill materials outside of the active trench berm area.

2.8 Subsurface Gas

Although prior to 1977 B.H.S., Inc. did operate a sanitary landfill on part of the 158 acre facility, that area has remained separate from the hazardous waste operations. At no time after the 1977 issuance of the Special Industrial Waste Permit has sanitary waste been disposed of on site. The material disposed of on site which would closest resemble sanitary waste would be the Times Beach Flood debris. This material had a higher concentration of furniture and solid material than normal trash.

The amount of organic residue contained in a waste varies but does seem to have general characteristics for specific types of waste.

	Water	Organic Solids	Inorganic Solids
WWTS	50-75%	5-20%	5-45%
Paint sludge	25-35%	25-35%	30-50%
Pesticide sludge	50-25%	10-35%	40-85%
Paint/ Pesticide Trash	0-20%	10-50%	50-90%
Contaminated Dirt	5-20%	5-10%	70-90%

From this estimate the total amount of organic material present for subsequent decomposition into methane gas is low compared to what is found in sanitary waste.

It should also be noted that the leachate collection system that surrounds the waste will act as a venting system which would relieve pressure buildup.

2.9 Known Release Information

There have been no known releases from the B.H.S., inc. facility other than that describe in the report submitted under the Continuing Release provision of Section 3004(u). In that report the leachate outbreak eminating from the old sanitary landfill was described along with the corrective action employed.

In Nov. 1982 during the clean-up of a coal-tar pit in Alton Illinois an outside transporter experienced trouble with his tailgate latch. Solid chunks of coal tar sludge were dropped on the transportation route from approximately the Missouri river bridge in St. Charles to the office of B.H.S.,inc. The spillage was noticed shortly after the drivers arrival by B.H.S., inc. personnel. The party in charge of the clean-up was notified along with the transporters dispatcher. Those two organizations dispatched a clean-up crew who removed waste from the bridge to the Interstate 70 exit at Foristell. MDNR was notified of the nature of the spill and the extent. An emergency response crew comprised of B.H.S., inc personnel was dispatched from this office and worked its way back along the route until it met the other crew at the Foristell exit. The spillage was first noticed

MDNR inspected the spill route the following day to confirm that the spill was cleaned properly.

3.0 Exposure Potential of the Unit

3.1 Potential for Human Exposure Via the Ground Water Pathway

The primary potential pathway for human exposure to potentially contaminated ground water would be through domestic or agricultural use. As discussed previously, it is expected that any such usage would involve the deep bedrock aquifers. It is anticipated that the section of glaciofluvial deposits which overlie bedrock will effectively inhibit vertical migration of contaminants to the bedrock aquifers.

The landfill design incorporates a leachate collection system consisting of a blanket drain, collection trench and sump which is expected to intercept potentially contaminated leachate that may be generated. Details of the design are described in Chapter 4 of the "Engineering Design Manual," presented in the Part "B" Permit Application.

Monitoring of groundwater quality in interceptor trenches and monitoring wells has shown that no releases of contaminants to the ground water have occurred to date.

Based on this information, the potential for the facility to contribute to human exposure of food chain contamination through the ground water and the likely magnitude of such affects are expected to be low.

3.2 Potential For Human Exposure To Surface Water

Surface water runoff at the site is managed by the use of diversion structures and collection impoundments. The details of the runoff management system are described in Chapter 4 of the "Engineering Design Manual" presented in the Part "B" Permit Application and summarized below.

Surface water which falls outside the landfill trench is diverted around the excavation. Precipitation falling within the landfill trench is handled either as leachate, as potentially contaminated runoff, or as uncontaminated runoff. Details of leachate treatment are described in Chapter 3 of the "Engineering Design Manual." Potentially contaminated runoff is segregated by placement of temporary berms, then pumped into SI1, and sampled and analyzed. If determined to be non-hazardous, the water is pumped to impoundment SI3. If hazardous constituents are present, the water is treated as described in Chapter 3 of the "Engineering Design Manual." Uncontaminated runoff is pumped directly to SI3. No runoff is discharged directly to the intermittent stream.

The surface water management system is designated to control the

The presence of the recreational lake (Lake Lucern) downstream from the site presents a possible exposure pathway should contaminated runoff discharge to the intermittent stream which passes through the site and subsequently enters the lake. However, the potential for human exposure or food-chain contamination are expected to be low because of the existence of the surface water management system. Monitoring of the surface water in the stream has indicated that to-date no deterioration of surface water quality has occurred downstream of the facility.

3.3 Potential For Human Exposure From Subsurface Gas Releases.

As described previously B.H.S., inc does not co-dispose of sanitary trash with the hazardous waste. This plus the fact that the nature of the material disposed of lends itself to a low concentration of organic matter the potential to produce significant quantities of subsurface gases is minimal.

If gases should accumulate the leachate collection system which surrounds the cell would act as a conduit for gaseous escape before significant pressures of gas could develop.

The double synthetic membrane tied into the final cap would preclude subsurface gases from migrating along underground passageways (e.g. water and sewer lines).

The number of households withing a quarter of a mile of the facility is less than ten with the majority of those on the outskirts of the quarter mile limit. Missouri law requires a 300 foot buffer zone to surround the disposal portion of the facility. This would allow dispersion of any subsurface gases that would be emitted from the leachate collection system.

Because of the aforementioned factors I would estimate the potential for human exposure from subsurface gas releases to be low.

3.4 Potential For Human Exposure Via The Air Pathway

The total number of households within a half-mile of the disposal facility is less than twenty with the majority of these lying to the North of the facility. The principle wind direction in the summer is from the South Southwest toward the North northwest. In the Winter the principle wind direction is from the Northwest toward the Southwest. Therefore the wind direction is normally not in a direct path to the limited permanently occupied dwellings.

B.H.S., inc is located near the top of a ridge separating two water sheds. The presence of an extended lowlying area affording a conduit for gas migration is limited. This area is

not known for extended periods of air inversions but lends itself to rapid dispersion. This can be exemplified by only a limited number of odor complaints with no subsequent violation of the Clean Air Laws.

Missouri law and regulations restrict the nature of the waste that can be accepted for landfilling. Those waste with a high potential for rapid air hazards (e.g. volatile or ignitable organic liquids or reactive wastes) are not allowed to be landfilled. Each waste stream must be individually permitted through MDNR. Special permit conditions require that wastes associated with airborne hazards (e.g. asbestos) must be covered the same day as disposal. Any wastes which exhibit an airborne hazard must be containerized in D.O.T. approved packaging.

The visual and chemical inspection performed prior to a wastes acceptance will limit the potential for acceptance of nonconforming wastes. The training and safety data sheets will allow for the proper handling of this particular type of waste by site personnel. Incompatible wastes are identified along with segregation techniques to be employed.

As described above the possibility of subsurface gas buildup is extremely remote.

Testing of raw leachate indicates that there is only trace levels of organics present in the leachate. The location of the leachate holding lagoon is approximately 800 feet from the facility boundary. This is the only material that is bulk evaporated at this facility.

The potential for human exposure due to an air pathway is low.

3.5 Potential for Human Exposure From Release by Transportation

B.H.S., inc maintains its transportation equipment on site. Drivers are trained and responsible for inspecting their equipment to guarantee roadworthyness. The drivers duty at the generators is to perform the initial inspection of the waste and to examine the containers for potential leaks.

Drivers are fully knowledgable of emergency spill proceedures and have immediate access to emergency response numbers and carry waste identification literature in excess of that required by RCRA.

By thoroughly training its drivers and endeavoring to instill a sense of responsibilty into its personnel, B.H.S., inc. has achieved a fine road record to date.

The routes of transportation into the facility are designed to

inc. makes it a practice to limit the transportation of waste to this facility during extreme weather conditions. It is common practice to call generators and reschedule pickup dates due to inclement weather. B.H.S., inc maintains Muenz road by removing snow in the winter and provided the funds for its paving.

Again the low degree of toxicity of the waste landfilled at this facility and the required packaging lowers the potential for human exposure.

As described in the Potential Release information in chapter 2 B.H.S., inc. has a reliable emergency spill response program that is utilized even if B.H.S., inc. vehicles are not involved.

There is also decontamination equipment and a truck wash facility onsite for the cleaning of trucks which may have waste on the vehicle.

The potential for human exposure due to transportation into and out of the facility is low.

3.6 Potential for Human Exposure From Releases to Soil

The potential for soil contamination due to air, surface water and transportation have been described above.

B.H.S., inc. limits the exposure of its earth moving equipment to contact with waste. Those units which operate in the active trench area are thoroughly cleaned by site personnel prior to their leaving the active area.

Site personnel are trained to be conscientious of their hygienic exposure to the waste.

This facility has good site security eliminating the unknown entry of offsite personnel or livestock. Public access is not only limited by a chain link fence surrounding the disposal area but a gate, which is controlled at the office, prohibits unknown road traffic from entering the property.

Food crops are grown on and adjacent to the property but again with an extremely limited air pathway contamination potential the possibility of food chain contamination is low.

The overall potential for soil migration of contaminants offsite is low.

3.7 Potential for Human Exposure From Worker-Management Practices

The health data described in Chapter 2 covering worker physicals and Workman Compensation claims exemplifies the concerted effort

its employees. By means of an initial and ongoing training programs employees are conscious of the need for proper handling of the hazardous waste disposed of onsite.

The initial training program begins with a review of the possible modes of entry of contaminants into the human body. Then safety measures and equipment are identified to control the entry modes.

A four part safety film is shown to the employee with tests administered at the end of each presentation.

A monthly safety newsletter is utilized for ongoing training of personnel as well as the usage of individual safety data sheets for each waste indicating proper safety equipment and procedures

Emergency response and contingency plans have been developed. All employees are given their own operations manual prior to working with hazardous waste. This manual has all the safety information previously described to the employee as well as thier duties in case of an emergency.

As evidence by the good safety track record at this facility the potential for worker-management exposure is low. The motto here is "If a worker has a question he is to keeping asking until that question has been fully answered".

APPENDIX A

5055 Antioch Road
Overland Park, Kansas 66203
913-432-4242

Woodward-Clyde Consultants

March 27, 1985
WCC Project W4C7729-1

FEDERAL EXPRESS

Mr. Mike Gill, Vice President of Operations
BHS, Inc.
Route 1, Box 116-F
Wright City, Missouri 63390

ENVIRONMENTAL ASSESSMENT REPORT
BHS, INC., WRIGHT CITY, MISSOURI

Dear Mike:

Enclosed is the Environmental Assessment Report for the BHS, Inc. landfill near Wright City, Missouri.

If you have any questions or comments, please contact us.

Very truly yours,

Thierry R. Sanglerat
Assistant Project Engineer

Michael M. Katzman
Senior Project Geologist

bf

enc.

ENVIRONMENTAL ASSESSMENT REPORT

Prepared for

BHS, Incorporated
Wright City, Missouri

WOODWARD-CLYDE CONSULTANTS
5055 Antioch Road
Overland Park, Kansas 66203
March 27, 1985
WCC Project W4C7729-1

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ENVIRONMENTAL ASSESSMENT REPORT
BHS, INCORPORATED
WRIGHT CITY, MISSOURI

EXECUTIVE SUMMARY

This report presents a preliminary assessment of the potential for environmental impairment associated with the continued operation of the BHS, Inc. industrial waste management facility near Wright City, Missouri. This environmental impairment assessment is based upon a review of documents provided by BHS, Inc. and data contained in our files. The facility has been operated by BHS, Inc. since 1971. Prior to 1977 and for an indeterminate period of time, a portion of the property was operated as a sanitary landfill. This sanitary landfill has been closed and provided with a cover. Adjacent to the closed landfill, BHS is currently accepting and landfilling hazardous and non-hazardous solid wastes from a broad group of generators that includes industries, hospitals, and public agencies.

Five areas relating to the potential for gradual environmental impairment have been identified and are described below:

1. Wastes Received and Disposed at the Site. The wastes pose an inherent potential for environmental impairment. The wastes are mainly solids having low contaminant levels and include soils, expended safety equipment, off-spec pesticides, paint sludges, sludges from industrial wastewater processes, and wastes with maximum organic liquid content of 5 percent by weight. The hazardous contaminant levels in the disposed wastes are such that the potential impairment associated with these wastes is classified as moderate.

2. Environmental Pathways. Humans, animals, and vegetation are exposed to chemical substances via environmental pathways that include air, soil, ground water, and surface water. At the BHS site, the primary pathways appear to be ground water and surface water. The National Interim Primary Drinking Water Regulations (NIPDWR) standards were not exceeded in any ground or surface water samples collected in 1984.

The potential impairment associated with these pathways is classified as low. This classification assumes that if ground water contamination is detected, the interceptor trenches can be operated in a manner which will limit the off-site migration of contaminants. The potential impact of flooding at the site has not been addressed in this assessment but has been addressed in the Part B application filed by BHS.

3. Population at Risk. The term population at risk refers to potential receptors and includes humans, animals, and vegetation. The site is located in a rural area and surrounding land use is primarily agricultural. The closest town is Wright City, population 1200, approximately 3 miles to the northeast. This municipality is hydrogeologically down gradient and employs the deep aquifer as a source for drinking water supply. A recreational lake near the facility is partially fed by an intermittent stream that crosses the BHS property and constitutes a potential receptor. The potential impairment associated with population receptors is classified as low.

4. Management Practices. It appears that the plant is operating in general conformance with the requirements established by regulatory agencies. BHS management has responded to comments and concerns from regulatory agencies in a timely fashion and management appears responsive to the need for environmental protection. Waste handling procedures have been for the most part conducted in an appropriate and responsible manner. Pollution related complaints concerning the landfilling operation appear to be limited only to four odor complaints in the past seven years. Based on these observations, the potential impairment associated with management of the facility has been classified as low.

5. The potential impact of outside environmental factors on the site has been classified as low.

In the opinion of Woodward-Clyde Consultants, continued operation of this facility poses a low potential for gradual environmental impairment. The removal of the two farm ponds and the construction of the storage pond covers will further decrease the potential for environmental impairment.

1.0 INTRODUCTION

1.1 Authorization

In accordance with Addendum 1 dated January 25, 1985 to the Agreement between BHS, Inc. (BHS) and Woodward-Clyde Consultants (WCC), WCC has prepared the following assessment of the potential for gradual (non-sudden) and/or abrupt environmental impairment at the BHS facility near Wright City, Missouri.

1.2 Purpose and Scope of Assessment

This report was prepared for the purpose of assisting BHS, Inc. in completing the required documentation for their Environmental Impairment Liability (EIL) insurance. Such insurance would typically cover claims that arise from gradual environmental impairment resulting from the operation of the hazardous waste landfill. This environmental impairment report may also serve to address portions of the environmental requirements of the 1984 RCRA Amendments.

This assessment is based upon a review of documents made available to us by the BHS management, interviews with Mr. Michael D. Gill, BHS Vice President, and a one-day site inspection. This assessment is, therefore, inherently general and preliminary. The primary objectives of this report are to: (1) present the format and components of a typical environmental impairment assessment, (2) present our best estimate of potential impairment for each factor addressed based upon the information made available to us, (3) identify those factors and areas for which more information is required to improve the estimation of the potential impairment, and (4) recommend means for acquiring the additional information.

1.3 Approach

1.3.1 Site Inspection

A site inspection was made on March 5, 1985, by WCC personnel Philip J. Knotts (hydrologist) and Thierry-R. Sanglerat (geotechnical engineer). The WCC inspection personnel met with BHS representatives, Mike Gill and Ben Moore, who described the general landfill operations and management activities, provided background information, and conducted a tour of the site facilities.

1.3.2 Data Acquisition and Review

The data provided by BHS management and reviewed as part of this assessment are listed in Table 1. Additional data were obtained from WCC files and published literature.

1.3.3 Assessed Potential Classification

The approach to assessing the potential of environmental impairment involves consideration of a number of factors in each of the following five areas:

- The inherent hazard potential of the wastes received, handled, processed, stored and disposed at the site;
- The potential environmental pathways through which humans, animals or vegetation could be exposed to chemical substances originating from the site;
- The nature of the biological populations that are at risk due to potential exposure to the chemical substances originating from the site; and

- The facility's management practices and other activities and procedures that may affect the potential exposures.

- The potential impact of outside environmental forces or factors acting upon the site.

Each of these areas is evaluated separately on a potential classification scale ranging from least hazardous (very low risk) to most hazardous (very high risk). The qualitative scale of potential used in this report is: very low = well below average; low = below average; moderate = average; high = above average; and very high = well above average. The classification is subjective and reflects the degree of perceived hazard. An overall classification for the facilities is then estimated by combining the separate classifications for the four major areas. The four areas, as they relate to the potential for gradual environmental impairment, are discussed in Sections 3, 4, 5 and 6 of this report; the overall facility classification is presented in Section 7.

1.4 Limitations

The preparation and use of this report are subject to the provisions of the Agreement between BHS and WCC dated January 18, 1985. The purpose of this report is to assist BHS in completing the necessary documents for obtaining Environmental Impairment Liability insurance. The report also addresses some of the environmental assessment requirements of the 1984 RCRA Amendments.

The objective of this report is to identify conditions that could lead to long-term environmental impairment. The objective is limited to those conditions that can be identified through visual site inspection and through review of data made available to WCC. This report does not provide a complete evaluation of the environmental risk arising from operation of the subject facility, nor does it provide a guarantee of the facility's future performance or environmental risk. The verification of information

provided by BHS employees and its consultants and of detailed investigations, testing, and analytical evaluations are beyond the scope of this assessment. However, this report is intended in part to identify the need for additional studies.

2.0 DESCRIPTION OF FACILITIES

2.1 Landfill and Installations

The BHS, Inc. industrial waste management facility is located in Warren County, Missouri, approximately three miles southwest of Wright City, as shown in Figure 1. The BHS property covers approximately 158 acres. The general site soil stratification consists of, in descending order, loess and modified loess, glacial drift, glaciofluvial silts and sands with some clay interlayering, glacial till, and a residual gravelly clay immediately overlying the rock/refusal surface (D. E. Klockow & Associates, April, 1984).

The waste handling operation consists of receiving, checking, and landfill disposal of hazardous and non-hazardous waste materials. The facility has been operated by BHS, Inc. since 1971. The present staff consists of about 15 people. Prior to 1977, and for an unknown period of time, a portion of the property was operated as a sanitary landfill. This area and the past hazardous waste disposal area have been closed and provided with a cover.

The facilities at the site are shown in Figure 2 and include:

- Offices, laboratory, and septic tank
- Parking area
- Heavy equipment and equipment storage
- Maintenance and garage area
- Various storage warehouses
- Covered truck-wash storage pads
- Former covered sanitary landfill
- Past disposal area
- Covered and uncovered surface impoundments

- Borrow material area
- Active disposal area
- Interceptor trenches
- Leachate sumps
- Monitoring wells and piezometers

Four surface impoundments (SI-1, SI-2, SI-3 and SI-4) exist at the site (see Figure 2). The SI-1, SI-2 and SI-4 impoundments are lined and have leachate collection systems. The surface impoundments have been used to manage surface runoff and liquid hazardous wastes from leachate collection systems generated from site operations.

Figure 2 shows the location of the past landfilling area and the currently operating landfill designated as Area 1. The cell in Area 1 has been designed so that a minimum of 30 feet of soil remain in place between the first aquifer and the bottom of the cell. Area 1 has been constructed with a leachate collection system that consists of a blanket drain, collection trenches, and sumps.

To the east and south of the landfill area are three interceptor trenches designated I-1, I-2 and I-3 (see Figure 2). The trenches are designed to intercept ground-water flowing from Area 1 toward an intermittent stream located to the east and south of the landfill. Trench I-1 consists of a compacted clay barrier with a sand drain on the up-gradient side. Trenches I-1 and I-2 drain to a common collection location. Trenches I-2 and I-3 consist of sand drains without the clay barrier.

To the east of the landfill, at the surface water sampling locations shown in Figure 3, BHS has constructed subsurface compacted clay barriers across the alluvium of the intermittent stream. These barriers are intended to divert ground water within the alluvium to the surface to facilitate sampling during dry seasons.

According to BHS management, the accumulated quantity of waste landfilled between 1977 and 1984 is estimated to be approximately 150,000 cubic yards. The projected rate of disposal is estimated to vary between 30,000 to 60,000 cubic yards per year.

2.2 Permits

Permits which are applicable to this landfill operation pertain to solid waste management activities and have been issued by the Missouri Division of Health and the Missouri Department of Natural Resources.

2.2.1 Air Pollution Control Requirements

BHS personnel indicated that no air monitoring is done on the site. It appears that the State of Missouri does not consider the facility a source of air pollution and, thus, does not require it to have a permit.

2.2.2 Water Pollution Control Requirements

The BHS facility currently has no applicable National Pollution Discharge Elimination System (NPDES) permit. According to BHS, all recovered water is solidified or spray irrigated for evaporation.

Occasionally the interceptor trenches are pumped directly into the intermittent stream that flows across the property adjacent to the landfill. Prior to pumping, laboratory analyses are performed on water samples obtained from the interceptor trenches; only if contaminant levels are found to be below NIPDWR standards, will pumping take place.

2.2.3 Solid Waste Management Requirements

BHS obtained approval to operate a 120-acre "Refuse Disposal Area" from the Missouri Division of Health (MDOH) on November 16, 1971. The MDOH approved site includes the area occupied by the current operating facilities. A variety of waste materials were landfilled under MDOH regulations and on

November 1, 1974, approval to operate was also obtained from the Missouri Department of Natural Resources (MDNR). A permitting program was subsequently developed by MDNR and on August 1, 1976, Solid Waste Disposal Area Operating Permit No. 121901 was issued by the MDNR. Special Solid Waste Disposal Area Operating Permit No. 721901 was issued on May 25, 1977 and allowed BHS to landfill special industrial waste materials in the current operating area. This area is now referred to as Area 1, as shown on Figure 2.

Subsequent to enactment of the Missouri Hazardous Waste Management Statute, implementing rules and regulations were developed by MDNR. BHS currently holds MDNR Hazardous Waste Facility Permit No. TSD 122282 001 for its present operation.

BHS submitted Notification of Hazardous Waste Activity to the United States Environmental Protection Agency (EPA) on July 30, 1980. Part A of the federal permit application was submitted to EPA on September 19, 1980. Interim status was achieved and the facility is currently operated under the applicable requirements of 40 CFR Part 265. In April of 1984 BHS filed the proper notification and Part B permit application to conform to USEPA requirements. Review of the RCRA Part B application is in progress. BHS also submitted an application for above-ground waste disposal.

Performance of a RCRA audit on this facility was not within the scope of this study and a compliance audit of the administrative and technical RCRA requirements has not been made.

2.3 Operations and Procedures

Before any hazardous waste from a generator can be accepted at BHS (other than permitted emergencies, exempt persons, or multiple collections of less than 220 pounds), the generator must supply all the information which must be known to treat, store or dispose of the waste in accordance with the

current regulations. However, the following types of wastes are not accepted by BHS:

- Ignitable waste as defined in 10 CSR 25-4.010(2) RSMo and 40 CFR 261.21(a)
- Reactive waste as defined in 10 CSR 25-4.010(4) RSMo and 40 CFR 261.23(a) unless cyanide and sulfide concentrations are less than 500 ppm
- Volatile waste having a true vapor pressure greater than 78 mm Hg at 25° Centigrade
- Bulk liquids
- Free-flowing sludges or free liquids which will drain from the sludge by gravity. No sludge may be landfilled which contains more than 5 percent by weight organic liquids. Exception to this rule is allowable only with prior approval by MDNR.

Once the waste information has been received, BHS completes a "Missouri Department of Natural Resources Hazardous Waste Disposal Request" form for each waste material to be landfilled. This form is then submitted to MDNR for disposal approval prior to accepting the wastes.

Upon arrival at the site, BHS inspects all waste materials and analyzes selected samples prior to disposal. The following analyses are performed on the randomly collected samples:

- pH
- Specific gravity
- Percent volatiles at 100° Centigrade
- Percent volatiles at 600° Centigrade

Containers are opened for inspection, free liquids are mixed with solid waste or cement kiln dust and void spaces greater than 10 percent of drum capacity are filled with sand or soil or the drum is crushed.

Once the waste is found to be acceptable, it is then unloaded in the active zones of the landfill. The drum disposal areas are segregated from the bulk waste disposal trenches.

A soil cover is placed over the waste on a weekly basis. If there is an odor problem or a wind dispersal problem associated with the waste, the waste is then covered with sufficient soil to control the problem. When the trench has been filled to within 2 feet of the original ground level with waste, the trench is closed and provided with intermediate cover. Leachate and contaminated water that accumulate in the active area of the trench are segregated and pumped to surface impoundment SI-2. Ground water monitoring is performed on a regular basis.

2.4 Wastes

Materials landfilled at the BHS facility are both hazardous and non-hazardous waste from a broad group of generators that include industries, small businesses, private citizens, hospitals and public agencies. Examples of the types of wastes disposed at the facility are the following:

- Paint sludge containing heavy metals such as cadmium, chromium, nickel, lead, mercury, and traces of solvents such as toluene, benzene, etc.
- Heavy metal contaminated waste (less than 1 percent by weight)
- Pesticides (less than 10 percent by weight)
- Dust collector dust
- Spill clean-up materials
- Expended safety equipment
- Contaminated soils from lagoon removal

- Wastes contaminated with chemicals such as creosote, orthochlorophenol, pentachlorophenol, etc.
- Sludges from industrial wastewater processes
- Wastes with maximum organic content of 5 percent by weight
- Non-hazardous wastes

The landfilled solid wastes are either containerized in drums or disposed in a bulk form.

3.0 INHERENT HAZARD POTENTIAL OF WASTES

The potential for hazardous waste constituents to adversely affect the terrestrial and aquatic environments depends upon a number of circumstances and conditions. These include concentration of the compound in the waste, mobility of the hazardous constituent in various environmental media, toxicity of the compound in the terrestrial and aquatic ecosystems, and persistence of the compound in the environment.

The wastes disposed at BHS that pose the greatest potential risk to terrestrial and aquatic environments are: pesticides, wastes containing solvents, wastes containing heavy metals, and wastes contaminated with, for example, creosote and ortho- and pentachlorophenol. Other disposed wastes may pose equal or greater risk to the environment than these. It is difficult to assign an inherent hazard potential without knowing the concentration and chemical form of the hazardous constituents within the disposed materials.

In the opinion of Woodward-Clyde Consultants, the inherent hazard potential of the wastes present at the site should be classified as moderate. This classification is based solely on the toxicity of the various hazardous compounds being handled by the BHS facility.

4.0 ENVIRONMENTAL PATHWAYS

The media and means through which humans, animals and vegetation are exposed to chemical substances are termed environmental pathways. The identified potential exposure pathways of the site are: air, ground water, surface water, and access haul roads.

4.1 Airborne Emissions

The principal wind direction in summer is from the south-southwest and in winter is from the northwest. No air monitoring is done either on site or off site.

The standard BHS practice for handling wastes that might have a wind dispersal problem is to cover them with soil as soon as possible after disposal. As long as this handling practice is followed, there should be no particulate emission problem.

In early 1981 the U. S. Environmental Protection Agency (EPA) obtained some surface soil samples off site. The EPA report and data were not made available to the inspection team, but it is believed that no noticeable level of contamination was detected off site. This would indicate that particulate emissions are not a problem at the facility.

During the site inspection and the discussions with the BHS staff, there was no indication of problems from fugitive gaseous emissions from the landfill. However, there have been four odor complaints over the past few years. Although these complaints occurred about the time a particularly odorous waste was being disposed, they may indicate that a potential gas generation problem exists that would need to be addressed in the near future.

In the opinion of Woodward-Clyde Consultants, insufficient quantitative information exists to classify potential impairment from air emissions. However, based on (1) site visit observations, (2) the fact that BHS does

not handle particularly volatile wastes, and (3) the fact that air emissions are generally not a significant problem at similarly operated hazardous waste landfills, a classification rating of low for the facility would be reasonable.

4.2 Ground Water

The WCC ground-water monitoring report dated March 7, 1985 provides the following conclusions about ground-water conditions at the site:

1. Based on 1984 water levels and previous monitoring data from the GM wells, ground water movement in the aquifer is generally from south to north at the site with an estimated ground-water gradient ranging from 0.03 to 0.07 ft/ft.

2. Vertical recharge to the aquifer is apparently limited by an overlying deposit of low permeability soil which creates a perched ground-water layer above the identified aquifer. The direction of flow in the perched layer is radially away from the impoundments toward topographically lower areas but the perched water is also moving slowly downward to the underlying aquifer.

3. Ground-water recharge to the aquifer is occurring to the south of the site and the recharge source is the intermittent stream that flows from northeast to southwest across the southern portion of the site.

4. There appear to be no cyclic or seasonal trends in ground-water elevations although ground-water levels may generally decrease during periods of drought.

5. National Interim Primary Drinking Water Regulations (NIPDWR) standards were not exceeded in any water samples collected in 1984 at BHS.

6. Methylene chloride, hexachlorobutadiene, and bis(2-ethylhexyl)phthalate were the only priority pollutants detected at the site in 1984. Hexachlorobutadiene and bis(2-ethylhexyl)phthalate were detected in GM-1R during the third quarter at 78 ug/l and 47 ug/l, respectively, but were not detected in the fourth quarter samples and were not detected in the leachate sample. Retesting for methylene chloride indicated concentrations were below the method detection limit.

7. Distinct cyclic, seasonal or other trends in the ground-water quality were not discernable and, in general, the water quality in the GM wells, the interceptor trenches, and the stream was very similar. Elevated pH values observed in wells GM-1, GM-1R, and GM-4 appear to be related to grout within or near to the screened zone of these wells.

Site investigations have indicated the presence of selenite crystals in the oxidized glacial till joints. The potential for dissolution of the selenite crystals by landfill leachate could not be assessed.

On the basis of WCC's assessment of ground-water conditions, the current potential of impairment from ground-water contamination at the site is low.

4.3 Surface Water

The site is located on the uplands of the Missouri River, a region that typically consists of rolling hills and gently sloping valleys. The topography at the site varies from 810 feet MSL in the northwestern corner to 724 feet MSL at the southwestern corner. As shown in Figure 1, an unnamed, intermittent stream with several small tributaries drains the site and immediate vicinity. This stream feeds a recreational lake one-half mile southwest of the facility.

The covered SI-2 impoundment is the only impoundment presently used for the storage of potentially hazardous liquids generated from on-site operations. Wastewater from SI-2 evaporates or is treated with cement kiln dust and the

resulting solids disposed in the hazardous waste trenches. SI-1, SI-3 and SI-4 are used to manage surface runoff that has not been in contact with the waste. The runoff waters that have been in contact with the waste on site are pumped into pond SI-1 where water samples are then obtained and tested. If the contaminant levels in SI-1 are found to be below NIPDWR standards, the water is discharged into the unlined SI-3 pond. The water in pond SI-3 is used for irrigation during summer.

With the exception of occasional pumping from the interceptor trenches, water is not discharged into the intermittent stream adjacent to the landfill. The interceptor trenches are pumped to the stream only after chemical analyses show that contamination levels are below the NIPDWR standards. The water quality of the intermittent stream at the downstream sampling station is similar to that of the upstream sampling station, indicating that the facility is not adversely affecting the surface water quality of the area.

On the basis of water quality data and site observations, WCC concludes that the potential of impairment from surface water contamination at the site is low.

4.4 Access Roads

As described in the report prepared by D. E. Klockow & Associates, the recommended access route to the facility from the west is to exit U. S. Interstate 70 (I-70) at Warren County Route H, south on Route H to a "T" intersection with Warren County Route M, east on Route M approximately one-half mile to Muenz Road, then south on Muenz approximately one-half mile to the facility. The recommended access route from the east is to exit I-70 at Warren County Route F, then proceed west on the north outer road to Warren County Route H, then south on Route H following the directions previously given. The recommended access route from the south is to follow Missouri Highway 47 north to Warren County Route O, east on Route O to Warren County Route M, west on Route M to Muenz Road, then south on Muenz to the facility.

All road surfaces to the front gate are paved and those on the site are gravelled. The conditions and load limits of bridges along the paved routes were not evaluated. The traffic on these local access roads through this lightly populated area is minimal. Because the probability of an accident resulting in a spill is low, WCC concludes that the potential of environmental impairment from local access road contamination is also low.

4.5 Overall Environmental Pathway Classification

In the opinion of WCC, the combined potential for gradual environmental impairment from the four pathways described above should be classified as low. This classification assumes that if ground-water contamination is detected, the interceptor trenches will be operated in a manner that will limit the off-site migration of contaminants.

5.0 POPULATION AT RISK

This section identifies population receptors that are at risk from potential exposure to hazardous substances originating from the site. The receptors include land use activities, human population, and animal and plant populations. An overall potential impairment rating for the population receptors has been assigned in Subsection 5.4.

5.1 Land Use in Site Vicinity

The site is located in a rural area in Warren County, Missouri, approximately 3 miles southwest of Wright City, as shown in Figure 1. Land use surrounding the site is mostly agricultural, and most of the agricultural land is cropped with the rest being devoted to raising livestock. The other major land use in the area is recreational. There is a recreational lake one-half mile southwest of the site that has several lake home subdivisions around it.

5.2 Human Population

The population of Wright City is approximately 1200 people. The area around the BHS facility is a thinly populated agricultural area with few farms and recreational subdivisions in the vicinity. Some rural water supplies are obtained from bedrock wells about 200 feet deep; a few shallow wells of unknown depth are known to exist.

5.3 Animals and Plant Population

Animals in the area around the BHS facility consist of those indigenous to the eastern part of Missouri and agricultural livestock. There is no evidence that the area around the facility is a habitat for any rare or endangered species. Deer tracks observed at the site indicate that wildlife does traverse the area.

The area is classified as grassland and deciduous forest. Plant life around the BHS facility consists of indigenous eastern Missouri flora or commercial crops such as corn, wheat, soybean, sorghum and hay. There is no evidence of the area around the facility being a habitat for any rare or endangered plant species.

5.4 Impairment Associated with Populations at Risk

Based upon the low population density and the low classification rating assigned to environmental pathways, WCC concludes that the potential for gradual environmental impairment associated with surrounding populations should be classified as low.

6.0 MANAGEMENT PRACTICES

The BHS facility's management procedures and other activities and procedures that may affect potential environmental impairment constitute the management practices aspect of the environmental impairment assessment.

6.1 Compliance with Regulations and Standards

The BHS facility is currently operating under Federal RCRA Interim Status and has a Missouri State landfill permit to treat, store and dispose hazardous waste. Discussions with BHS management and review of the available files indicated no major instances of non-compliance with regulations. The USEPA inspects the facility once a year while MDNR inspects the site weekly and generates a quarterly report. It appears that BHS response to past instances of regulatory non-compliance and to EPA and MDNR requests has been timely and appropriate. It also appears that BHS's management of solid wastes is being performed in conformance with current requirements of the regulatory agencies.

Because of insufficient information, an evaluation could not be made as to whether BHS is meeting all state administrative and technical solid waste requirements.

6.2 Management Attitude

Based on the site visit and review of selected BHS files, it appears that the attitude of BHS management is one of cooperation with the spirit and letter of applicable regulations. The management also appears committed to making their best efforts to conform with all environmental regulations as well as any requirements regarding employee health and safety. Correspondence with regulatory agencies appears timely and responsive.

6.3 Employee Training and Safety Procedures

BHS management has stated that there is an employee training program and safety procedures are available. However, at the time of the site visit, the employees were not seen wearing any kind of special safety equipment.

6.4 Waste Handling and Treatment Procedures

The waste handling and treatment procedures, for the most part, are apparently being conducted in an appropriate manner.

6.5 Emergency Plans and Site Security

In case of an emergency, BHS has a contingency plan which contains a formal written response procedures and emergency equipment is readily available on site. The main entrance to the site is the only vehicular access to the active area from a public road. The site and the inner active area are both partially fenced.

6.6 Past Incidents

BHS management has indicated that there have been no past incidents that have resulted in the release of hazardous constituents to the environment. During the summer of 1981, leachate was noticed leaking through the sanitary landfill berm. The berm was subsequently reinforced and no further leaking was apparent. On September 10, 1984, a non-hazardous waste spill occurred on site. The spill was due to an accident involving a truck containing brine.

6.7 Impairment Associated with Management Practices

On the basis of the site visit and review of some BHS files, WCC concludes that the potential of gradual environmental impairment from current management practices should be classified as low.

7.0 OUTSIDE ENVIRONMENTAL FACTORS

Outside environmental factors result from potential impact on the site from sources beyond the control of site operations. Although the site occurs in earthquake Zone I, ground failure and subsequent waste emissions due to earthquakes is considered low. Additionally, catastrophic failure of a

small dam upstream of the site is a potential hazard but the risk to the site from such a failure is also considered low. The site is well marked and partially fenced. Potential incidents related to trespass are considered low.

8.0 CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the potential environmental impairments at the site and presents recommendations for additional information.

8.1 Summary of Present Potential of Environmental Impairment

The present assessment of the potential of gradual environmental impairment for the four areas discussed in this report is summarized below.

Area	Assessed Potential Classification
Inherent Hazard Potential of Materials	Moderate
Environmental Pathways	Low
Population at Risk	Low
Management Practices	Low
Outside Environmental Factors	Low

Based upon these preliminary assessments, WCC concludes that the present information would support a low overall potential of gradual environmental impairment classification for this facility.

8.2 Recommendations for Additional Information

WCC recommends that additional information be obtained or remedial actions be taken in the following areas:

1. Implementation of the removal plan for the two farm ponds. These two farm ponds are located outside the fenced area and at a higher elevation than some of the adjacent landfill area.

2. Obtain water level measurements in all wells and piezometers to provide a better definition of the direction of ground-water movement and possible fluctuations in ground-water levels. These measurements can be easily and inexpensively obtained.

3. Additional sampling of piezometers installed in the aquifer monitored by the GM wells may confirm the possibility of grout contamination of specific GM wells. If grout contamination is confirmed and pH values do not return to values representative of the aquifer, replacement of the contaminated wells may be necessary to comply with monitoring requirements.

4. To evaluate and establish the reliability of the analytical results, it is recommended that a minimum 10 percent QA/QC program be implemented. The program would include the submittal of blind duplicates, spikes, splits, standards and blanks to the laboratory on a regular basis. The results of all QA/QC analyses should be reported with each set of sample analyses.

5. Consider the installation of gas vents in the closed landfill areas to allow generated gases to be vented to the atmosphere and protect the integrity of the cap.

6. Restrict wild animal access to the property.

APPENDIX B

EVALUATION OF 1984 GROUND WATER MONITORING DATA
BHS, INC.
WRIGHT CITY, MISSOURI

WOODWARD-CLYDE CONSULTANTS
5055 Antioch Road
Overland Park, Kansas 66203
March 15, 1985
WCC Project W4C7729-2

EVALUATION OF 1984 GROUND WATER MONITORING DATA
BHS, INC.
WRIGHT CITY, MISSOURI

INTRODUCTION

This report presents an evaluation of the 1984 ground-water monitoring data obtained at the BHS, Inc. site near Wright City, Missouri. The evaluation was requested by BHS, Inc. for presentation to the Missouri Department of Natural Resources (MDNR) and was performed in accordance with Addendum 2 to our agreement for services with BHS, Inc. Although the report is to be submitted to MDNR, it is not intended to substitute for the 1984 Annual RCRA Ground Water Monitoring Report.

SITE DESCRIPTION

The BHS, Inc. industrial waste management site is located 3 miles southwest of Wright City in Warren County, Missouri, as shown in Figure 1. Located on the uplands of the Missouri River, the region typically consists of rolling hills and gently sloping valleys. The topography at the site varies from about 810 feet MSL in the northwestern corner to about 724 feet MSL at the southwestern corner. As shown in Figure 1, an intermittent stream with several small tributaries drains the site and immediate vicinity. A geologic description of the site is presented in Appendix A.

A brief description of the waste management facilities at the site is presented below.

Surface Impoundments

Four surface impoundments (SI-1, SI-2, SI-3 and SI-4)exist at the site (see Figure 2). The surface impoundments have been used to manage

non-contact surface runoff and liquid wastes generated from site operations.

SI-2 is the only impoundment presently used for the storage of potentially hazardous liquids generated from on-site operations. SI-1, SI-3 and SI-4 are used to manage non-contact surface runoff.

Landfills

Figure 2 shows the location of the past landfilling area and the currently operating landfill, Area 1. The cell in Area 1 has been designed so that a minimum of 30 feet of soil remain in place between the first aquifer and the bottom of the cell. Area 1 has been designed with a leachate collection system consisting of a blanket drain, collection trenches, and sumps for the final collection of leachate.

Auxiliary Structures

To the east and south of the landfill area are three interceptor trenches designated I-1, I-2 and I-3 (see Figure 2). The trenches are designed to intercept ground-water flow from Area 1 toward the intermittent stream to the east and south of the landfill. Trench I-1 consists of a compacted clay barrier with a sand drain on the up-gradient side. Trenches I-1 and I-2 drain to a common collection location. Trenches I-2 and I-3 consist of sand drains without the clay barrier.

BHS has also constructed subsurface compacted clay barriers across the alluvium of the stream at the surface water sampling locations shown in Figure 3. The barriers are intended to divert ground water within the alluvium to the surface for sampling during dry seasons.

Berms designed to divert surface runoff resulting from a 24-hour, 25-year storm event have been constructed around the Area 1 landfill.

SAMPLE COLLECTION AND ANALYSES

During 1984, monthly water samples were obtained for chemical analyses from six ground-water monitoring wells, five surface water sampling stations and two interceptor trench sumps at the BHS site. The six ground-water monitoring wells were designed to monitor the ground-water quality in the uppermost aquifer at the site as described in Appendix A. The locations of the wells and the other sampling stations are shown in Figure 3. The samples were obtained and analyzed by MMTL Analytical Services in Columbia, Missouri, and the results are presented in Appendix B. Concentrations of selected chemicals during 1984 are presented as time-concentration plots in Appendix C.

Generally the ground-water levels were measured prior to flushing the wells in preparation for sampling. The water level data are presented in Table 1. Water level fluctuations during 1984 and the daily precipitation as recorded at Hermann, Missouri are presented in Figure 4. Potentiometric contour maps, interpreted from the observed water levels, are presented in Appendix D.

Well GM-1R was added to the monitoring network in July 1984 to replace well GM-1. EPA Region VII requested this change because GM-1 was apparently located too near the waste management facilities and might be influenced by the facilities. Well GM-5 was also added to the monitoring program in July of 1984.

DIRECTION AND RATE OF GROUND-WATER MOVEMENT

The direction of ground-water movement based on the water levels in the ground-water monitoring (GM) wells is from south to north (or southeast

to northwest). This direction of flow is generally consistent with the direction of flow interpreted from ground-water levels measured previously in piezometers installed at the site, (Appendix A).

The potentiometric contours indicate recharge of the aquifer monitored by the GM wells is occurring to the south of the site. Seepage from the intermittant stream, which flows from northeast to southwest across the southern portion of the site, appears to be the most probable source of recharge. The site geology, as described in Appendix A, indicates that the aquifer monitored by the GM wells may be incised by the stream or interface with the stream alluvium along at least a portion of this drainage way.

Precipitation runoff and perched ground water that discharges to the stream are sources of water which may seep into the aquifer along the stream. Nested piezometers installed at the site indicate the presence of a perched ground-water zone above the unoxidized glacial drift (see Appendix A) which apparently acts as an aquitard limiting the downward migration of the water into the underlying aquifer. The potentiometric contours from nested piezometers installed in this perched zone indicate that ground-water recharge to the perched zone originates from the farm ponds located west of the landfill (see Figure 3).

Because the ponds are a relatively constant source of recharge, flow in the stream resulting from ground water is expected to be less variable than flow resulting from surface runoff. During periods with little or no rainfall, ground water that discharges to the stream may comprise the majority of the flow. The specific conductance of the stream is expected to increase during the summer since the ground water generally has higher

concentrations of dissolved solids. However, no surface water samples were collected in June, July and August of 1984 because the streams were dry.

Lack of precipitation is expected to result in a decline of perched ground water elevations. Water levels may decline below the elevation of the ground surface so that no surface discharge occurs along the stream; however, subsurface discharge to the alluvium may continue.

The ground-water observations in the GM wells generally indicate a decline in the water levels during June, July and August of 1984, indicating a lack of recharge. The large decline of water levels observed in wells GM-3 and GM-4 is reported to be due to additional pumping conducted between sampling periods. The additional pumping was apparently conducted in an effort to ensure that these wells were sufficiently developed. The observed increase in water level in well GM-2 during September of 1984 may be due to an erroneous measurement. As shown in Figure 4, there does not appear to be a direct correlation between precipitation and fluctuations in ground-water levels except for the decreasing levels generally observed during June, July and August when little precipitation occurred.

The ground-water gradients estimated from the monthly water level data and the interpreted potentiometric contours for the GM wells varied from 0.03 to 0.07 ft/ft in May 1984 and November 1984, respectively, and are consistent with gradients previously estimated by others (see Appendix A). Based on the values for field permeability (1×10^{-5} cm/sec) and porosity (0.33) presented in Appendix A, the average linear velocity of ground-water flow would be less than 3 feet per year.

WATER QUALITY DATA

Water samples were analyzed monthly for selected water quality indicator parameters and the heavy metals and pesticide fractions of the National Interim Primary Drinking Water Regulations (NIPDWR) standards. Additional samples from the GM wells and interceptor trenches were analyzed quarterly for an additional 112 priority pollutants, total coliform, Gross Alpha, Gross Beta, and total radium. The results of these analyses are presented in Appendix B and discussed below.

NIPDWR

The results indicate that the concentrations of heavy metals and pesticides were all less than the NIPDWR standards. The reported levels of coliform bacteria and radiochemical activity were occasionally greater than the NIPDWR maximum levels as presented in Appendix B. The aquifer monitored by the GM wells is not reported to be a drinking water supply (Appendix A).

Priority Pollutants

Priority pollutants were not detected in any samples at concentrations above the method detection limit, with the following exceptions:

Well GM-1R. Hexachlorobutadiene and Bis(2-Ethylhexyl)phthalate were detected in the third quarter sample at concentrations of 78 ug/l and 44 ug/l, respectively. Well GM-1R replaced well GM-1 in July of 1984 so that the third quarter analysis was the first priority pollutant analysis from well GM-1R. Only Methylene Chloride at 160 ug/l was detected in the fourth quarter sample from well GM-1R. Methylene Chloride is a glass-cleaning solvent commonly used by laboraties to clean bottles. Retesting of the water from GM-1R indicated less than the method detection

limit (10 ug/l) of Methylene Chloride. The analytical results from a leachate sample obtained at the site are presented in Appendix E. The results indicate Hexachlorobutadiene and Bis(2-Ethylhexyl)phthalate at concentrations below the method detection limit (10 ug/l).

GM-4. Methylene Chloride was detected in the fourth quarter sample at a concentration of 33 ug/l. Retesting of the water from GM-4 indicated a Methylene Chloride concentration below the method detection limit (BMDL).

GM-5. Methylene Chloride was detected in the third quarter sample at a concentration of 12 ug/l. No priority pollutants were detected at concentrations above the method detection limit in the fourth quarter samples from well GM-5.

Interceptor Trench 3. Methylene Chloride was detected in the fourth quarter sample at a concentration of 570 ug/l. A sample from this trench was retested with the concentration of Methylene Chloride reported at BMDL.

General Water Quality Parameters

The general water quality parameters, including chloride, sulfate, magnesium, sodium, specific conductance, TOC, TOX and pH, indicate the water quality in the stream, the interceptor trenches and the GM wells is very similar with the following exceptions:

Specific Conductance. Specific conductance is a measure of the total dissolved solids. The specific conductance measured in samples obtained from the wells and trenches is slightly higher than samples obtained from the stream. Specific conductance is expected to be higher in the ground water and trenches because of the longer contact time between the soil and the water. The increase in specific conducance, sodium and chloride in the stream during September is the result of a brine spill reported to have

occurred near Area 1 prior to the date of the in September sampling. By December, specific conductance, sodium and chloride had nearly returned to the pre-spill concentrations.

Magnesium. The concentrations of magnesium are highest in the interceptor trenches, lower in the ground water and lowest in the stream. As with the specific conductance, the magnesium content may also be related to the contact time between the soil and ground water and a difference in water quality between the perched ground water and the aquifer.

pH. The pH values of the stream and interceptor trenches is generally in the range of 7.0 to 8.0±. The pH of the ground-water samples obtained from the GM wells is also in this range with the exception of wells GM-1, GM-4 and the first three samples obtained from well GM-1R. The pH values for GM-1, GM-1R and GM-4 range from about 9.0 to 11.0±, although the values for GM-1R in recent months has approached the range of 7.0 to 8.0. With the exception of these wells, ground-water samples obtained at other on-site locations and depths (see Appendix E) have indicated pH values between 6.0 and 8.0±, possibly indicating the water quality in wells GM-1, GM-1R, and GM-4 is being impacted by cement grout in or near the well screen. Problems with installing the GM wells were reported and, in the case of GM-4, the grout was found to have dropped 15 to 20 feet after placement. To evaluate the potential impact of the grout on the water quality, a grout mix similar to that used to install the GM wells was prepared. Water which was exposed to the grout was sampled and analyzed for selected parameters including pH. The results which are presented in Table 2 indicate a pH of between 10 and 11.

Sulfate. The concentration of sulfate was lowest in the stream, higher in the trenches, and highest in the GM wells, although concentrations in the GM wells were widely varied. The highest concentrations (1000 to 2000 mg/l) were detected in wells GM-3, GM-1R, and GM-5. Sulfate concentrations in wells GM-1, GM-2 and GM-4 were initially between 200 to 500 mg/l. Sulfate concentrations increased in wells GM-2 and GM-4 during the summer months and returned to lower concentrations in the fall. The results of the grout/water analyses presented in Table 2 do not indicate significant contributions of sulfate from the grout. Previous analyses of samples obtained from piezometers installed at the oxidized/unoxidized interface indicate higher concentrations of sulfates in the perched water (1580 to 1740 mg/l in K5(ox) and K2(ox)) than in the aquifer (246 to 372 mg/l in GM-4 and GM-1) (WCC report dated November 21, 1983).

Miscellaneous

Other observations include:

1. The water quality in Trenches I-1, I-2 and I-3 is very similar and relatively stable.

2. Although the concentrations of some parameters increase slightly in the stream as it flows through the site, the concentrations at the downstream sampling station are very similar to the concentrations at the upstream sampling stations. The concentrations at the downstream location increased following the brine spill in September; however, by December of 1984 the concentrations were generally similar to the up-gradient concentrations.

3. Based upon the available data, there does not appear to be any distinct trend in concentrations with time, precipitation, water levels, or location at this site. The mean values and the standard deviations for pH, TOC, TOX and specific conductance for the 1984 samples are presented in Appendix E.

CONCLUSIONS

Based upon our review of the 1984 ground-water monitoring data and the reports of previous hydrogeologic investigations by others at the site, we present the following conclusions for your consideration:

1. The potentiometric contours interpreted from the 1984 water levels reported in the GM wells indicate ground water movement in the aquifer is approximately from south to north at the site. The estimated ground-water gradient varied between approximately 0.03 to 0.07 ft/ft during 1984. The direction of flow and estimated gradients are consistent with the interpretations of previous monitoring data.

2. Vertical recharge to the aquifer is apparently limited by an overlying deposit of low permeable soil. Nested piezometers installed at the site indicate a perched ground-water layer above the identified aquifer. The direction of flow in the perched layer is radially away from the impoundments, toward topographically lower areas. Water levels in the nested piezometers indicate a downward vertical gradient at the site.

3. Ground-water recharge to the aquifer monitored by the GM wells is occurring to the south of the site as indicated by the potentiometric contours. The source of the water recharging the aquifer appears to be the

intermittent stream which flows from northeast to southwest across the southern portion of the site.

4. No cyclic or seasonal trends in ground-water elevations are apparent from the existing water level data. It appears that the ground-water levels may generally decrease in response to a lack of precipitation.

5. National Interim Drinking Water Regulations (NIPDWR) standards were not exceeded in any water samples collected in 1984 at BHS.

6. With the exception of Methylene Chloride, Hexachlorobutadiene and Bis(2-Ethylhexyl)phthalate, no Priority Pollutants were detected at the site in 1984. Hexachlorobutadiene and Bis(2-Ethylhexyl)phthalate were detected in GM-1R during the third quarter at 78 ug/l and 47 ug/l, respectively, but were not detected in the fourth quarter samples and were not detected in the leachate sample. Retesting for Methylene Chloride indicated concentrations were below the method detection limit.

7. In general, the water quality in the stream, interceptor trenches and GM wells was very similar. With the exception of the brine spill impact, the surface water quality at the downstream sampling station was similar to the water quality at the upstream sampling stations.

8. Distinct cyclic, seasonal or other trends in the water quality were not discernable.

9. The elevated pH values observed in wells GM-1, GM-1R, and GM-4 appear to be related to grout within or near to the screened zone of these wells.

RECOMMENDATIONS

Based upon our review of the data and our experience at similar sites, we present the following recommendations for your consideration.

1. Water level measurements in all wells and piezometers are relatively inexpensive to obtain and may provide for better evaluations, at least initially, of the direction of ground water movement and fluctuations in ground-water levels.

2. Additional sampling of piezometers installed in the aquifer monitored by the GM wells may confirm the possibility of grout contamination of specific GM wells. If grout contamination is confirmed and pH values do not return to values representative of the aquifer, replacement of the contaminated wells may be necessary to comply with monitoring requirements.

3. To evaluate and establish the reliability of the analytical results, it is recommended that a minimum 10 percent QA/QC program be implemented which would include the submittal of blind duplicates, spikes, splits, standards and blanks to the laboratory on a regular basis. The results of all QA/QC analyses should be reported with each set of sample analyses.

LIMITATIONS

The GM-series wells were installed by others to monitor ground-water conditions in what is identified as the uppermost aquifer, although an overlying perched ground-water layer has been identified at the site. This evaluation of the 1984 ground-water monitoring data is based on the assumption that the GM wells are installed in a single, continuous, water-bearing

stratum and that the wells were constructed to monitor ground-water conditions only in this aquifer. That is, the wells are not screened through more than one aquifer or water-bearing strata and are constructed to limit the vertical migration of water between aquifers or water-bearing strata.

TABLE 1

GROUND WATER ELEVATION DATA
BHS, INC.

Well No.	Surface Elevation (ft, MSL)	Screened Zone (ft, MSL)	1983 Dec	1984 Jan	1984 Feb	1984 Mar	1984 Apr	1984 May	1984 Jun	1984 Jul	1984 Aug	1984 Sep	1984 Oct	1984 Nov	1984 Dec
GM-1	796.3	700.8 - 670.3	702.5	702.0	-	702.3	703.3	699.8	698.3	-	-	-	-	-	-
GM-1R	765.3	728.0 - 705.0	-	-	-	-	-	-	-	749.3	740.3	737.8	740.3	740.3	
GM-2	812.3	665.0 - 636.5	668.4	667.3	-	-	667.3	664.3	662.3	667.3	666.7	718.3*	666.7	663.3	
GM-3	772.8	675.0 - 647.0	691.0	688.1	-	685.8	687.8	682.8	660.8	660.8	683.8	674.3	692.8	657.8	
GM-4	758.0	682.3 - 653.0	727.9	709.2	-	-	731.0	693.0	688.0	688.0	700.0	686.0	698.0	703.5	
GM-5	777.6	686.4 - 631.4	-	-	-	-	-	-	-	666.6	682.0	682.6	678.6	676.6	

March 1, 1985
WCC Project WAC7729-2

Woodward-Clyde Consultants

TABLE 2

GROUT/WATER ANALYSES
BHS, INC.

Analysis	Concentration	Units
Total Organic Halogen	100.	UG/L as CL
Chloride	52.	MG/L
Sulfate	143.	MG/L
Total Organic Carbon (Sparged)	4.	MG/L
Magnesium	10.8	MG/L
Sodium	166.	MG/L

Notes: Analyses were performed on samples as received by Wilson Labs utilizing approved procedures published in the Federal Register, Vol. 49, No. 209, October 26, 1984.

Samples analyzed February 18, 1985.

APPENDIX C

REPORT ON

BOB'S HOME SERVICE, INC.

AND

J & Z DISPOSAL, INC.

WRIGHT CITY, MISSOURI

NOVEMBER 5, 1980

ENVIRONMENTAL RISK ASSESSMENT SERVICE (USA)

60 BATTERYMARCH STREET, BOSTON, MASSACHUSETTS 02110
(617) 426-6780

REPORT ON

BOB'S HOME SERVICE, INC.

AND

J & Z DISPOSAL, INC.

WRIGHT CITY, MISSOURI

NOVEMBER 5, 1980

1. INTRODUCTION

Bob's Home Service, Inc. (BHS, Inc.) is a solid waste management firm operating two geographically separate landfill disposal facilities in the Wright City, Missouri, area. One of these, the subject of this report, is a chemical landfill. The other, several miles away, is a sanitary landfill. Wright City is approximately 35 miles west of St. Louis on I 70. (Please see Figure I in the Appendix.)

BHS, Inc. desires to obtain Environmental Impairment Liability ("EIL") insurance for its chemical landfill operations only on behalf of itself and three other named insureds including J & Z Waste Disposal, Inc., as this coverage is defined in Form EIL (USA) - 1276. Environmental Risk Assessment Service (USA) ("ERAS") has been retained to survey BHS, Inc.'s activities at the site and furnish a report assessing the liability risks as a prerequisite to acceptance of the risk by the underwriters of EIL insurance.

The risk assessment given by ERAS in this and similar reports is based on the following factors:

1. The nature and quantities of the materials handled, in particular the potential for damage to health (of human, animal, or plant life) or property if releases to the environment were to occur.
2. The degree of control exercised on materials processing, handling, and storage.
3. The adequacy of controls on the treatment of waste streams released to the environment.
4. The amount of management attention given to matters of environmental concern.
5. The location of the insured's operations relative to possible damage targets.

The evaluation is largely qualitative and is given on a verbal scale from very high to very low risks.

2. DISCLAIMER

The material that follows is furnished pursuant to an express agreement that the ERAS study and report are made for the benefit of both BHS, Inc. and the potential insurers and that ERAS is free to inform the potential insurers of any if information relevant to the

evaluation of the potential risk coming to its attention in the course of the survey or preparation for it. It is further understood that ERAS accepts no liability to the potential insured, insurers, reinsurers or others arising out of any negligence, lack of diligence, or failure to furnish services of a professional quality on the part of ERAS's employees or agents in its preparation, nor for any losses sustained by BHS, Inc. as a result of any denial of insurance based on the survey or report.

Factual information has been obtained from BHS, Inc.'s personnel and has been assumed to be correct and complete by ERAS. A draft of this report has been reviewed by BHS, Inc.

3. RISK ASSESSMENT

As a class, hazardous waste disposal is assigned a risk rating that is very high compared with the average rating for industrial and commercial activities as a whole. Compared to other hazardous waste disposal sites, BHS, Inc. is assigned a rating that is low compared to the median for such sites.

This favorable rating is assigned by ERAS subject to the recommendation that the following qualification be included in any coverage that is provided to BHS, Inc.

- BHS, Inc. adopt a system of chemical testing sufficient to establish that the initial load of each waste stream from each new customer and new waste streams from existing customers conform to the shipping manifests or other advance indications of waste composition supplied by the waste generators. The present screening procedures may continue for homogeneous waste streams once their identities are established.

4. OPERATIONS

A. General

The original owner of BHS, Inc., Mr. James Zykan, initially became involved in solid waste management as a municipal refuse hauler and then sanitary landfill owner and operator. When the need became apparent, Mr. Zykan established a hazardous solid waste disposal operation at his facility in Hickory Grove, Warren County, Missouri. A three-year industrial solid waste disposal permit was obtained from the Missouri Department of Natural Resources on May 25, 1977. BHS,Inc. began accepting industrial (hazardous) waste

at the time on 15 acres out of the site total 150. It is estimated that if all permittable acreage on the present site were to be utilized, a total disposal capacity of 1,000,000 cubic yards would be available. Permits for an additional 23 acres have been applied for with the expectation of further applications in future.

Subsequent to issuance of the May 25, 1977, permit, Missouri developed a specific hazardous waste management program with associated rules and regulations. These became effective on July 1, 1980, and required BHS, Inc. to apply for a new five-year disposal permit. The new permit has not as yet been issued but a variance (i.e. an extension) to the original permit has been granted. New permits have become political footballs in this election year so some further delay in issuance is to be expected.

The landfill has acquired considerable unwanted notoriety as it is now the only permitted solid waste disposal facility in Missouri although B.F.I. operates a hazardous liquid waste disposal facility near Kansas City. A number of other landfills were closed as a result of the July 1 regulations. BHS, Inc.'s principal motive for acquiring non-sudden environmental impairment liability insurance at this time appears to be the company's desire to demonstrate good faith compliance with all reasonable present and potential regulatory requirements.

The facility does not accept liquid or radioactive wastes. Mr. Zykan is now deceased and ownership has passed to his widow. Actual day-to-day operation (including acceptance or rejection of specific wastes considered for disposal) is under the direction of Mr. Michael Gill. Mr. Gill possesses a B. S. in Chemistry and an M.B.A. The facility employs seven individuals in additional to Mr. Gill: three drivers, one mechanic, two laborers and a secretary/bookeeper. BHS, Inc. is somewhat unique in that it is the transporter of approximately 90 percent of the waste disposed of at the site, both drums and bulk. Transporter bonding is not mandated by Missouri and none has been obtained.

The site was designed by an apparently competent engineering firm, Reitz and Jens, Inc. of St. Louis, at an appropriate fee ($60,000.) The site encompasses the disused 10-acre sanitary landfill that was Mr. Zykan's original disposal facility.

B. Site Description

The area surrounding the Bob's Home Service, Inc. landfill is basically rural. Land bordering the property is occupied by farmland and woods with Innsbrook (a part-time vacation home community on a man-made lake) lying approximately 1/2 mile southwest of the site. Location of Innsbrook relative to BHS, Inc. is shown on Figure II. There are four or five neighbors on the entry road, one of whom operates a hog farm. All of these residences are on wells. As shown in Figure II, little further development has taken place.

i. Geology

BHS, Inc. is in an area of Kansan glacial tills having thicknesses of at least 100 feet with limestone and shale bedrock below the till.

The bedrock formations in the region are Mississippian Age shales and limestone of the Burlington and Ferm Glen Formations plus the Chouteau and Sulphur Springs Group where the tills are thinner, and Ordovician (Kimmswick, Decorah or Plattin) where the tills are thicker. The large unconformity between formation of Ordovician and Mississippian Ages results from absence of Silurian and Devonian rocks in this part of Missouri.

A paleo-erosional surface is at the contact between the bedrock and the tills of the Pleistocene Age. A valley is indicated from the northwest to the southeast. This erosional valley was filled with massive, fine-grained till during the Pleistocene Age. Valleys of this type are common in northern Missouri although, at BHS, Inc., this deep erosional valley filled with massive, fine-grained, tight tills, while unusual, is quite favorable for this type disposal operation. The disposal facility is situated over or close to the center of this thick till valley. This valley condition indicates groundwater in the BHS, Inc. area will be contained and not migrate downward or disperse laterally.

In the larger valley with intermittent stream that runs through BHS, Inc. neither bedrock outcrops nor springs have been detected. Because of the absence of these two items, no rapid lateral movement of fluids can be expected. Further, no bedrock outcrops, sprin or sinkholes have been detected within one-fourth mile of the site. There are no established mineral reserves within one-fourth of the site.

Overlying the bedrock in this area is a thick (over 100 feet thick in this site) glacial till. The till, during test drilling, generally was tight and dry; a continuous flight auger was used to advance the hole. Where the test hole reached bedrock, water entered and rose in what previously was a dry hole indicating the tightness of the till and that it was an aquiclude. This tightness is equally effective whether the water tries to move upward or downward. This Pleistocene till from the Kansan glacier is of a CL soil known to be fairly still clays of uniform texture, pre-consolidated and effectively impervious to fluid flow. Overlying the till are Putnam or related soils of windblown origin. A shallow clay pan from the modified loess is above the bottom elevation of the waste disposal.

These shallow soils, along with the sloping, local, upland topography provide for most of the rainfall to flow laterally along the surface rather than infiltrate. This rolling topography is more desirable than a flat site because it reduces infiltration opportunity by increasing surface runoff and reducing surface detention storage.

ii. Subsurface Investigation

Tests have included 16 piezometer holes, one monitoring well and an initial test hole. The 16 piezometer holes were drilled 35 feet deep and a 3-inch diameter PVC pipe was installed with sand backfill in the annular space between the pipe and side of the hole. At a depth of 10 feet below ground surface, a bentonite seal was placed around the pipe and a local soil backfill placed above the bentonite seal up to ground surface in the annular space between the pipe and side of the test hole. During drilling of each of these piezometer holes, soil samples were recovered at each change in strata for purposes of visual classification of the soils. Also, soil smaples were kept stored in air-tight glass containers for laboratory testing of two samples from each hole.

Fourteen of the test holes were drilled dry, with a continuous flight auger powered by a truck-mounted coring rig. Two were drilled with a rotary coring rig known as an Ingersoll-Rand T-4. This rig utilizes compressed air with injected water as the drilling medium. None of the peizometer holes encountered any natural groundwater table nor did they encounter any perched water table. At the time of drilling, two holes were filled with water at the end of the

drilling and pipe installation sequence as a result of method of hole advance using compressed air with injected water.

A monitoring well was drilled in the southeast corner of the tract the lowest surface grade within the tract. Drilling for the deep monitoring well encountered a thin layer of topsoil at the surface and entered glacial till deposits. The overwhelming thickness of the tills drilled were clayey, either all fine materials or sand and/or gravels with clay binder. Isolated sand and/or gravel strata were found. This stratification is typical of glacial tills and extended to a depth of 168 feet at which limestone bedrock was encountered. The bedrock was penetrated for a depth of 6 feet with the roller cone bit used on the drill rig, to verify absence of voids in the surface of the bedrock. No voids were located.

The initial test hole drilled in August 1976 was drilled 129 feet or at least 10 feet below the elevation of the gravel pocket encountered in the monitoring well; however, no gravel or water was encountered. The gravel layer is not continuous. Three test holes were drilled in March 1980. These test borings were drilled dry with a 6-inch continuous flight auger powered by a truck-mounted core rig. The test holes were advanced to a total depth of 67 feet. Split-spoon or Shelby tube samples were taken every 5 feet. No water was encountered.

The soils information was obtained through extensive drilling and sampling. The tests confirm this site has a very dense, perconsolidated, impermeable, low plastic clay. (See Tables 1 and 2 for summary of soil tests.)

Samples from each hole were analyzed for their gradational characteristics and Atterberg Limits. Gradation was determined by hydrometer and sieving as outlined in ASTM D-422. Atterberg Limits were determined on that sample finer than No.40 fraction in accordance with ASTM D-423 and ASTM D-424. The percentage clay fraction on these samples together with the hydrometer analysis indicates these soils have clay sizes (minus .002mm) ranging from 18% to 42% and plasticity indices of 7 to 4

The grain size distribution covers of samples from the 16 piezometer holes and monitoring well have remarkably similar gradation curves. If overlaid or plotted on one sheet of paper, they would fall within a very narrow band. This indicates the uniformity laterally across the site which on an aggregate basis is expected

istic curve from the larger sizes down to the clay size fractions and smaller. This smooth, well-graded shape allows extremely dense packing without unusual difficulty which, in turn, can create a tight soil of low permeability without the need for the presence of large quantities of platelet-shaped particles (clay) to create low permeability.

It has been noted during tabulation of the percentage smaller than 2 microns that more clay size particles are evident in the deeper samples. This is fortuitious and assures greater resistance to water flow through the soil strata at the bottom of the disposal cells.

Permeabilities were calculated from consolidation tests of undisturbed samples. This deductive method of permeability determination had to be used due to the impossibility of using permeameter time-flow measurement. Results of these tests are listed in Table 3.

The soil tests confirm that the glacial tills are dense and impermeable. The glacial till that fills this deep V-shaped rock valley has favorable characteristics for minimizing any potential contamination of the ground or surface water in this area.

The magnitudes of the cation exchange of the 9 samples from various locations shown in Table 1 are low. These low magnitudes suggest rather stable (volumetrically) clay minerals such as kaolinites, chlorites and illites. The size of a clay particle can and will change with cations absorbed and availability of polar liquids. Low cation exchange indicates low potential change in clay particle size which in turn indicates the permeability of the soil zone from which the sample was taken will not be adversely affected (increased) by possible changes in dissolved salts.

iii. Hydrogeologic Information

1. An examination of the records of the wells drilled into the St. Peter Sandstone (the only substantial aquifer under the site) indicates the top of the St. Peters varies from elevation 439 to 462 at depths of 325 to 385 feet. Water elevations at the time of drilling and development were 654 to 686.

2. Insufficient data are available for development of meaningful water table contours.

3. Groundwater movement is to the east. The undoubtedly low rates of flow through the St. Peter Sandstone are not available.

4. The St. Peter Sandstone is a major source of groundwater through this whole area. It is of the Ordovician system of the

Mississippian Limestones and a surface thickness of at least 100 feet of dense, impermeable, unstratified, glacial tills. The area of the BHS, Inc. and its surroundings is not a recharge area.

5. Table 4 gives the analyses of water samples taken in April and June 1977 from: (1) "M", the monitoring well in the southeastern corner of the site; (2) "E", the open stream near southwest corner of the BHS, Inc. property; (3) "I", the "Old Well"; and (4) "Z", the Zykan residence well.

The April 11, 1977, samples for wells "O", "E" and "Z" all meet the Drinking Water Standards except for somewhat high phenol contents. Water from the monitoring well "M" exceeds the allowable drinking water standard for arsenic, barium, chromium, iron, lead, phenol, sulphate.

The June 16, 1977, samples were obtained from "M", "O" and "E". The iron content is above drinking water standards in all three wells, significantly high in "M" and "O". Phenols remain somewhat above the drinking water desirables. In all three wells the sulphates are high.

6. This site is in an area of Missouri glacial tills having thicknesses of at least 100 feet in depth with limestone bedrock below the till. Records indicate some areas have formations of Mississippian and others of the Ordovician System as shallowest bedrock. Characteristic of glacial till are denseness and impermeability when unstratified.

The current and projected regimen of surface water resources in the area is wet weather streams running from valley heads. No development of a connection between water which may seep into the landfill and natural groundwater is foreseen. The tills are effectively impermeable due to good gradational characteristics and high densities. Transmissibility is very low because of the thickness of the till and its relative impermeability which preclude contamination of groundwater used for domestic supplies pumped from the bedrock below the glacial tills.

The 150 acre property of BHS, Inc. is at the upper end of a watershed which starts about 2 1/2 miles southwest of Wright City

in Warren County, Missouri, and drains southwestwardly to Charette Creek which discharges into the Missouri River about 5 miles upstream of Washington, Missouri.

No precipitation record is available for Wright City but the National Weather Service reports the following annual average rainfalls in inches for the following stations:

Troy (11.5 miles north of Wright City)	37.51
Warrenton (7.0 miles west of Wright City)	37.15
Washington (19.0 miles south of Wright City)	38.02

Plate 1, "Gauging Stations, Average Annual Runoff, Soil Infiltration Values and Areas of Anomalous Runoff in Missouri," 1973, from Water Resources Report 28, "Flood-Volume Design Data for Missouri Streams" by John Skelton, U.S. Goelogical Survey, prepared in cooperation with Missouri Geological Survey and Water Resources (1974) indicates the average runoff at the location of the property of BHS, Inc. is 9.6 inches; and the average soil infiltration value is 2.6 inches. This map also shows the average soil infiltration increasing to 3.5 inches south of the BHS, Inc. property.

Average annual lake evaporation at St. Louis for the 50-year record 1911-1962 was 35.21 inches ("Lake Evaporation in Illinois" by W. J. Roberts and John B. Stall; Illinois State Water Survey Report in Investigation 57, Urbana, 1967.) Columbia, Missouri, for the period 1891-1940 with a mean annual percipitation of 38.09 inches had 40.69 inches of mean annual evaporation ("Evaporation From Lakes and Reservoirs: A Study Based on 50-Years' Weather Bureau Records," directed by Adolph F. Meyer; Minnesota Resources Commission, St. Paul, Minnesota; June 1942.) This same reference for the same 50 years 1891-1942 shows that St. Louis with a then mean annual precipitation of 36.57 inches had a 40.99 inches mean annual evaporation.

Evapotranspiration is substantially equivalent to total evaporation which "is the sum of water lost from a given land area during any specific time by transpiration from vegetation and building of plant tissue; by evaporation from water surfaces, moist soil and

snow; and by interception. The term is applied primarily to stream drainage basins for the period of the annual climatic cycle or subdivision of that period. Total evaporation is essentially precipitation upon the drainage basin minus runoff, corrected for change in storage volume within the basin and for subsurface leakage" (from Lee, C.H.; "Transpiration and Total Evaporation," Chap. 8 in O.E. Meinzer (ed): "Hydrology," Vol. IX of "Physics of the Earth," McGraw-Hill Co., Inc., New York, 1942.)

Using an average annual rainfall of 37.3 inches and an average annual runoff of 9.6 inches the total evaporation at the property of BHS, Inc. is 27.7 inches. The portion of this that is strictly "transpiration" depends upon the types of vegetation on the watershed; trees can use 10 to 40 inches annually; tall grasses 20 to 30 inches; crops 12 to 48 inches annually.

There are 333 acres of upper watershed that drain surface runoff onto BHS, Inc. property. Adding to this the 150 acre within BHS, Inc. property, the surface runoff from 483 acres leaves the property.

The tight impermeable soils of the BHS, Inc. site are deep enough to preclude any "in and out" underflow. The limited information about the principal aquifer under the site, the St. Peter Sandstone, shows the top of the aquifer falling toward the east and north. Wells 23214, 26843 and 26966 indicate top of the St. Peter at elevations 448, 462 and 441, respectively (23214 is about half-mile northwest of BHS, Inc.; 26843 is about a mile west and 26966 about a mile east of BHS, Inc.). Well 27016 with top of St. Peter at 439 ia about one-half mile southwest of the BHS, Inc. site.

The impact of the operations of BHS, Inc. site on the existing water balance as to quantities is not significant. Surface and groundwater quality as they may be affected by the BHS, Inc. operation should be unchanged under the procedures and monitoring precautions governing the operation.

The existing and proposed slopes of the site are of the order of 3% to 10% and consequently, surface runoff is and will be relativ rapid with poor detention of surface flows in the many small depressions which exist on all natural or man-made surfaces. The rapid

surface runoff together with the lesser depression storage results in smaller amounts of infiltration than would occur in flatter terrain.

C. Site Operations

BHS, Inc. may be considered typical of hazardous waste landfills insofar as the character of the wastes it accepts is concerned. The following list of accepted wastes excerpted from the daily log is representative.

Mobay-Elemental Sulfur Sludge
Ashland Chemical - Alkyd Resins
Monsanto - Arsenic Trisulfide
Western Environmental - Orthochlorophenol
Rohm & Haas - Kelthane Pesticide
PCB Sludge (Concentration below EPA approval threshold)
Petrolite - Acylated Polymers.

An excellent manifest system has been in operation since 1977. BHS, Inc. is actively seeking more wastes and expects to be in business at this site for another twenty to twenty-five years.

The facility disposes of both bulk and drums, dry residues and sludge. Sludge must be at least 25% solids. A sludge evaporation pad is not utilized. Bulk liquids are not accepted. BHS, Inc. requires that generators warrant their waste composition. For drummed wastes, three drums per load are inspected. A chemical screening test is employeed for bulk and drummed waste verification which utilizes the following parameters:

Visual Inspection
% Volitals @ 100C & 600C
pH
Specific Gravity

As far as incoming volume is concerned, HBS, Inc. may be considered a relatively small operation. Their volume history is shown below.

1978 - 16,000 Drums
1979 - 20,000 Drums; 6,200 cu. yds. Bulk
1980 (Feb. - Sept.) - 11,000 Drums; 8,000 cu. yds. Bulk

Present tipping fees are $21 per drum and $37.10/yd for bulk materials. Both of these fees are quite low by national standards.

A waste quantity report is submitted to the state monthly.

Waste disposition is currently taking place entirely within a 12-acre area surrounded by a chain link, three-strand barbed wire fence. An electrically controlled gate is utilized which is open only during entrance or exit of vehicles. A watchman for after-hours security is not employed, nor has a scale been installed. An adequate employee shed has been constructed with hot water showers. Water for this shower is obtained from one of the monitoring wells on-site.

BHS, Inc. utilizes the trench method for disposal. Drums are surrounded by limestone screenings or agricultural lime. Initially, a drilled cell method was tried in which holes 3-feet in diameter and 27-feet deep were drilled and filled with drums. This approach has since been abandoned.

Trenches are excavated and kept open for three different types of wastes; organic, alkaline and acidic. Trenches are about 30-feet deep leaving at least 65-feet of till underneath. A bio-farm is not employed. In the past, leachate collection was not attempted but a first trench taking this approach has just been constructed. If any leachate is produced, which is unlikely because of the 2-feet of effectively impermeable till placed over the underdrain system, it will be pumped to evaporation ponds on-site. Four concrete evaporation ponds for leachate and contaminated runoff have been proposed in the permit application. These will feature removable fiberglass covers. Two unlined lagoons are presently in use. Runoff is not now contained and erosion is a minor problem. An NPDES permit has not been obtained, although an application is said to be in process.

Materials handling at the site is good. An excellent safety data sheet is prepared for the site foreman and truck drivers in case a spill should occur. A concrete truck washing pad has been constructed so truck exteriors can be easily cleaned of hazardous materials. The road leading to the pad is ditched to the lagoons.

The site hydrologic monitoring system consists of 16 piezometer wells, and two conventional wells. One more conventional well is planned. Samples are taken every quarter and nine parameters are tested. In one quarter out of four, sixty-six (66) parameters are

Equipment at the site is standard. It includes; a backhoe, loader and medium dozer (D6) with sheepsfoot roller. A higlift with removable bucket is on order.

Intermediate and final cover plans are adequate. Each trench is filled to within two feet of the top. This is filled and compacted over this. A two foot minimum layer is then spread over the area by scraper adding further protection. One foot of top soil is then placed over this and planted with soil holder; usually grass. This provides a bare minumum of seven feet of cover over buried waste. In some instances where the grade is more severe, the cover can be as much as ten to twelve feet above the waste. Each trench is filled, 2 feet of the effectively impermeable till is used as cover material. A further 2 feet of cover will be placed over the site at closure with a maximum slope of 10%. Each trench is provided with a coordinating system, both vertically and horizontally, should deposited wastes need to be located in the future.

A closure trust fund has been provided with an initial deposit of $15,000. As more land is utilized, $3,300 per acre will be added to the fund. A post-closure fund has also been established in the amount of $2.50 per drum and $3.75 per cu. yd. These figures are based on estimates developed by Mr. Gill. They have not as yet been approved by the Missouri DNR or the EPA. The DNR should be the ultimate regulating agency as they are near primacy.

No significant pollution incidents have yet occurred at Bob's Home Service, Inc. hazardous waste landfill. All previous Missouri DNR Surveillance Reports were inspected. The site was closed momentarily by an overzealous DNR official reacting to an inaccurate report by a private citizen, but the event was of no significance.

Some discussion is warranted regarding the Innsbrook vacation home community. The community is represented by the Lake Lucerne Homeowners Association. This organization brought suit against BHS, Inc. during the early stages of the landfill's development. A countersuit was lodged by BHS, Inc. which was eventually with-

drawn when the initial suit was dropped because of lack of substance. Nevertheless, a $40,000 bond has been provided by BHS, Inc. to protect the lake.

A further noteworthy point concerns the former association between BHS, Inc. and Chem-Dyne of Hamilton, Ohio. Chem-Dyne and BHS, Inc. engaged in a joint venture for a period of one year in which Chem-Dyne contributed marketing efforts but were disposed of by BHS, Inc. All wastes furnished by Chem-Dyne were first approved by the Missouri DNR before acceptance by BHS, Inc. Because of the excellent hydrogeology at the site, limited time of association between Chem-Dyne and BHS, Inc., and specific state approval for each waste, the Chem-Dyne connection should not be of concern.

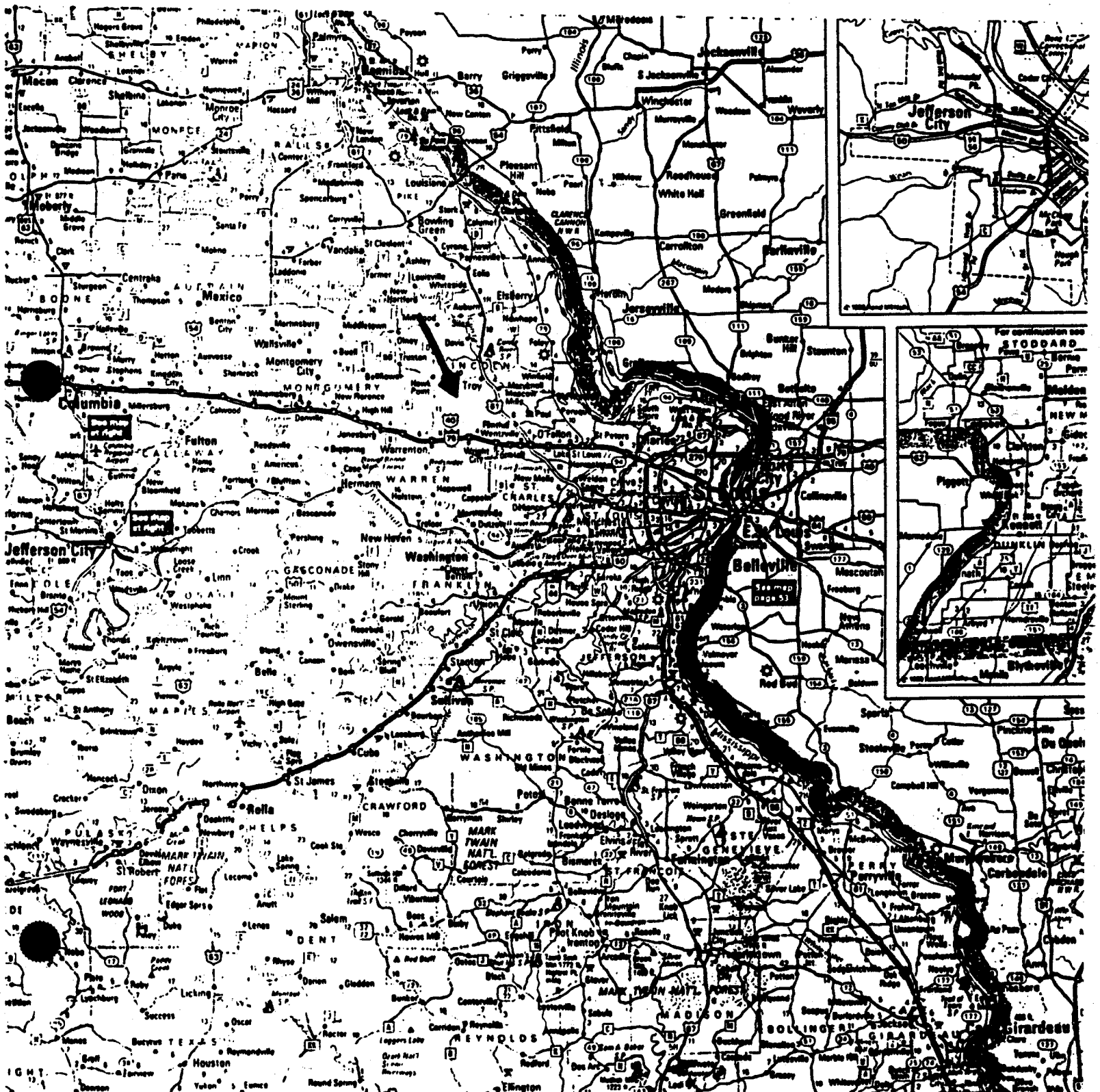
5. SURVEY CONTACTS

The survey was performed by Dr. Robert H. Smith, P.E. as a consultant to ERAS. Dr. Smith visited HBS, Inc. on October 7, 1980. The site operation was discussed with Mr. Michael Gill, facility manager who conducted Dr. Smith on a thorough inspection.

Mr. Denis Degner, of the EPA Region 7 (Kansas City)Notification Section was contacted regarding current compliance of BHS, Inc. with RCRA notification regulations. BHS, Inc. has notified and is in compliance.

Mr. Kevin Brown, regional inspector for the DNR in St. Louis was contacted for his opinion. Mr. Brown expressed satisfaction regarding the site, noting its thick strata of effectively impermeable clay and the many monitoring wells surrounding the facility.

FIGURE I - Wright City Area



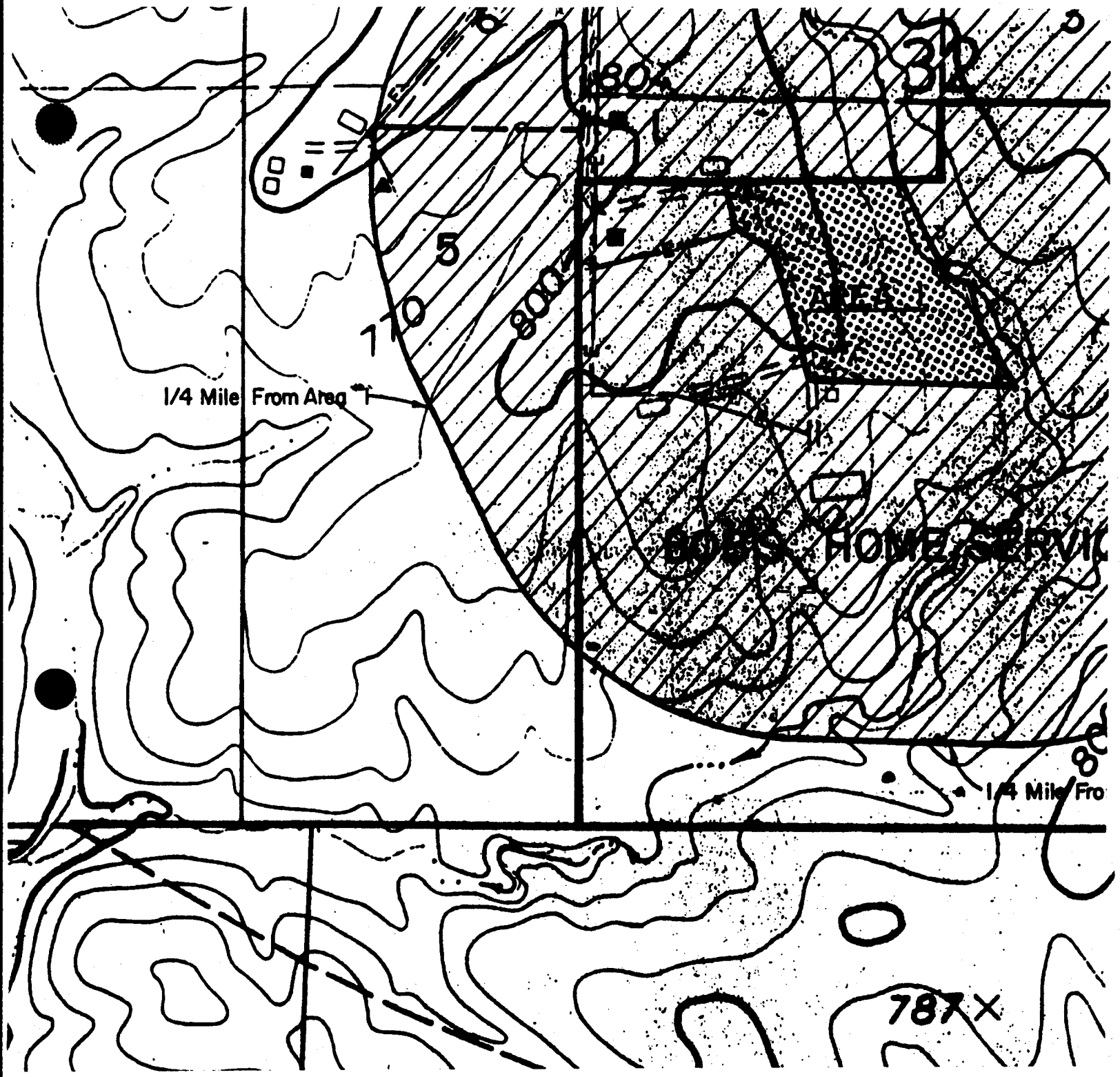

1/4 Mile From Area
1/4 Mile Fro
787

TABLE 1

Plasticity and Cation Exchange of Fine Soils

Test Hole	Depth	LL	PL	Soil Class	pH	Moisture	Air-Dried me/100gms	Oven-Dried me/100gms
23+00 0+20	35'	32	18	CL	7.8	1.5	13.5	13.7
23+00 0+20	50'	27	18	CL	8.0	0.6	9.0	9.1
23+00 0+20	65'	26	16	CL	8.0	0.5	7.9	7.9
21+45 N+70	35'	25	13	CL	8.0	0.7	8.9	9.0
21+45 N+70	50'	24	15	CL	8.1	0.5	8.4	8.4
21+45 N+70	65'	25	17	CL	8.1	0.6	7.4	7.4
20+20 N+80	45'	41	21	CL	7.6	0.8	10.9	11.0
20+20 N+80	50'	30	18	CL	7.9	0.7	9.8	9.9
20+20 N+80	65'	23	15	CL	7.9	0.5	7.7	7.7

TABLE 2

Shelby Tube Samples

Test Hole	Depth	Density lbs/cu.ft.	Moisture Content Percent
23+00 0+20	35-37'	119.9	14.8
23+00 0+20	45-47'	113.6	18.6
23+00 0+20	55-57'	120.0	15.6
21+45 N+70	35-37'	118.4	16.2
21+45 N+70	55-57'	121.5	15.9
20+20 N+80	35-37'	117.2	16.1
20+20 N+80	45-47'	101.8	24.9

TABLE 3 - PERMEABILITY

Test Hole	Depth	Permeability cm/sec.
21+45 N+70	55-57'	5.4×10^{-9}
21+45 N+70	55-57'	7.7×10^{-9}
20+20 N+80	45-47'	20.0×10^{-9}
29+10 I+80	65-67'	10.0×10^{-9}
29+10 I+80	65-67'	5.8×10^{-9}
29+10 I+80	65-67'	2.6×10^{-9}
16+35 E+55	35-37'	5.6×10^{-9}
10+65 Q+70	45-47'	13.0×10^{-9}
10+65 Q+70	45-47'	5.0×10^{-9}

TABLE 4 - WATER QUALITY BACKGROUND DATA

BHS, Inc. Site Water Quality Analyses Background Data

Test For	Unit	Well "M" 4/11/77	Well "M" 6/8/77	Well "O" 4/11/77	Well "O" 6/8/77	Sampling Pt. "E" 4/11/77	Sampling Pt. "E" 6/8/77	Well "Z" 4/11/77	EPA Drinking Water Stds. in ppm
Arsenic	ppb	216.	-	-	-	-	-	-	0.05
Barium	ppb	1120.	104.	62.2	52.9	89.0	114.	64.5	1.0
BOD, 5-day	ppm	7.08	55.3	1.43	9.64	3.06	4.19	1.19	
Cadmium	ppb	6.22	-	-	-	-	-	-	
Cobalt	ppb	126.	-	-	-	-	-	-	0.01
Chromium	ppb	70.1	7.34	-	-	-	-	-	0.05
COD	ppm	1.95	461.	2.34	40.3	290.	15.5	25.7	
Iron	ppb	620.	2330.	200.	1490.	190.	413.	160.	
Cyanide	ppm	0.0110	-	-	-	-	-	-	0.2
Nickel	ppb	298.	-	-	273.	-	-	-	
Lead	ppb	656.	-	26.1	-	8.25	-	-	0.05
Phenol	ppb	5.60	1.70	6.10	4.90	7.10	3.50	5.60	
Fluoride	ppm	0.461	0.292	0.469	0.262	0.566	0.195	0.620	1.4-2.4
pH	pH	7.20	7.20	7.20	7.00	7.80	7.00	7.60	
Sulfate	ppm	1110.	1220.	1110.	1120.	66.6	53.2	67.7	
Zinc	ppb	220.	222.	770.	1060.	-	-	230.	
Silver	ppb	-	-	-	-	-	-	-	0.05
Copper	ppb	-	-	-	-	-	-	-	
Mercury	ppb	-	-	-	-	-	-	-	0.002
Selenium	ppb	-	8.31	-	8.82	-	-	-	0.01
Tin	ppm	-	-	-	-	-	-	-	
Spec. Conduct.	mmpc	2.01	2.20	2.05	2.14	343.	0.371	501.	
Nitrate	ppm	-	0.330	-	0.270	-	0.310	-	10
ORGANO-PHOSPHATE									
Azinphos	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Diazinon	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Disulfoton	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Methyl Parathion	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Malathion	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Parathion	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Thiodan	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Ethion	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Trithion	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
PESTICIDES & PCB									
Lindane	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Heptachlor	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Aldrin	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Heptachlor Epoxide	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
DDT (total)	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Dieldrin	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Technical Chlordane	ppm	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Methoxychlor	ppb		<0.10		<0.10		<0.10		
Polychlorinated Biphenyls	ppm	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15		
Toxaphene	ppb		<0.10		<0.10		<0.10		
[illegible]	ppm	<0.02		<0.02		<0.02		<0.02	
[illegible]rin	ppm	<0.02		<0.02		<0.02		<0.02	

Well "M" is monitoring well at southeast corner of Area No. 1.
Well "O" is old well, 150 feet south of southwest corner of Area No. 1.
Well "Z" is well at Zykan residence, near northwest corner of Zykan Farm.
Sampling Point "E" is near the southwest corner of Zykan Farm where creek leaves property.

mmpc - Millimhos/centimeter at 25°C

#2282

TABLE 5 - QUARTERLY TEST PARAMETERS

MID-MISSOURI TESTING LABORATORY

DETERMINATIONS MADE IN ACCORDANCE WITH AWWA - WPCF - APHA STANDARD METHODS

606 NICHOLS COLUMBIA, MO 65201 314/442-0237

Date: September 18, 1980

Client: Bob's Home Service

Date Received: September 3, 1980

Sample Collected By: Mid-Missouri Testing Laboratory

Parameter	SAMPLE Well #3	Well #5	Well #6	Well #7	Well #8	Well #9	Date Analyzed
pH	6.8	6.7	6.5	6.6	6.6	6.5	9/4/80
Redox Potential Millivolts	434	404	414	414	424	414	9/4/80
Specific Conductivity µmhos	2950	1750	1600	1600	2550	2450	9/4/[illegible]
COD mg/l	10	≤4	≤4	6	13	≤4	9/5/80
Chloride mg/l	14.0	13.5	14.0	17.0	13.5	9.5	9/5/80
Total Hardness mg/l as $CaCO_3$	2200	1150	1030	1100	1840	1800	9/4/80
Total Iron mg/l	14.4	9.55	1.62	1.01	3.21	4.25	9/9/80
Total Arsenic µg/l	≤14	≤14	≤14	≤14	≤14	14	9/12/80
TOC mg/l	30.8	42.1	26.9	43.6	14.9	28.3	9/4/80

Approved [illegible]

MID-MISSOURI TESTING LABORATORY

DETERMINATIONS MADE IN ACCORDANCE WITH AWWA – WPCF – APHA STANDARD METHODS

600 NICHOLS COLUMBIA, MO 65201 314/442-0237

Date: July 9, 1980

Client: Reitz & Jens (Bob's Home Service)

Date Received: June 12, 1980

Sample Collected By: Mid-Missouri Testing Laboratory

SAMPLE

Parameter	Well #3	Well #5	Well #6	Well #7	Well #8	Well #9	Date Analyz
Nitrate (mg/l N)	3.2	0.3	0.6	0.3	0.2	0.4	7/2
Sulfate (mg/l)	2200	650	700	550	1225	1200	7/3
Fluoride (mg/l)	≤0.2	≤0.2	≤0.2	≤0.2	≤0.2	≤0.2	7/8
Cyanide (mg/l)	*	≤.002	≤.002	≤.002	≤.002	≤.002	7/9
Arsenic (mg/l)	0.177	≤.014	≤.014	≤.014	≤.014	≤.014	7/3
Barium (mg/l)	≤0.1	≤0.1	≤0.1	≤0.1	≤0.1	≤0.1	6/23
Cadmium (mg/l)	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	6/23
Chromium +6 (mg/l)	≤.002	≤.002	≤.002	≤.002	≤.002	≤.002	7/7
Total Chromium (mg/l)	≤.02	≤0.02	≤0.02	≤0.02	≤0.02	≤0.02	6/20
Copper (mg/l)	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	6/20
Lead (mg/l)	≤0.1	≤0.1	≤0.1	≤0.1	≤0.1	≤0.1	6/25
Manganese (mg/l)	0.16	0.88	1.09	0.33	0.10	0.72	7/2
Mercury (mg/l)	≤.001	.002	≤.001	≤.001	≤.001	≤.001	6/30
Nickel (mg/l)	≤0.02	≤0.02	≤0.02	≤0.02	≤0.02	≤0.02	6/23
Selenium (mg/l)	*	≤.002	≤.002	≤.002	≤.002	≤.002	7/7
Silver (mg/l)	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	6/23
Zinc (mg/l)	0.05	0.10	0.08	0.24	0.07	0.09	6/23

Comments:
1. ≤ means less than or equal to the lower detection limits of analytical equipment.
2. All metals are "total" concentrations.

* Quantity of sample insufficient to perform test.

Approved Gregory P. Mattil

MID-MISSOURI TESTING LABORATORY

DETERMINATIONS MADE IN ACCORDANCE WITH AWWA – WPCF – APHA STANDARD METHODS

BOB NICHOLS COLUMBIA, MO 65201 314/442-0237

Date: July 9, 1980

Client: Reitz & Jens (Bob's Home Service)

Date Received: June 12, 1980

Sample Collected By: Mid-Missouri Testing Laboratory

SAMPLE

Parameter	Well #5	Well #6	Well #7				Date Analyzed
BHC	<4.0	<4.0	<4.0				7/8
α BHC	<4.0	<4.0	<4.0				7/8
β BHC	<4.0	<4.0	<4.0				7/8
γ BHC	<4.0	<4.0	<4.0				7/8
δ BHC	<4.0	<4.0	<4.0				7/8
Chlordane	<9.0	<9.0	<9.0				7/8
Heptachlor	<4.0	<4.0	<4.0				7/8
Heptachlor Epoxide	<7.0	<7.0	<7.0				7/8
α Chlordane	<9.0	<9.0	<9.0				7/8
β Chlordane	<9.0	<9.0	<9.0				7/8
Tech Chlordane	<23	<23	<23				7/8
Dieldrin + Aldrin	<10	<10	<10				7/8
Aldrin	<5.0	<5.0	<5.0				7/8
Dieldrin	<10	<10	<10				7/8
DDT + Metabolites	<50	<50	<50				7/8
o,p'-DDE	<10	<10	<10				7/8

Comments:
1. Results are expressed as nanograms/liter.
2. < means lower than the lowest detection limit of analytical equipment.
3. Pesticide, chlorinated hydrocarbon, PCB analysis by ABC Laboratories, Inc. Columbia, Missouri.

Approved

MID-MISSOURI TESTING LABORATORY

DETERMINATIONS MADE IN ACCORDANCE WITH AWWA – WPCF – APHA STANDARD METHODS

506 NICHOLS COLUMBIA, MO 65201 314/442-0237

Date: July 9, 1980

Client: Reitz & Jens (Bob's Home Service)

Date Received: June 12, 1980

Sample Collected By: Mid-Missouri Testing Laboratory

SAMPLE

Parameter	Well #5	Well #6	Well #7				Date Analyze
p,p'-DDE	< 10	< 10	< 10				7/8
o,p'-DDT	< 50	< 50	< 50				7/8
p,p'-DDD	< 50	< 50	< 50				7/8
p,p'-DDT	< 50	< 50	< 50				7/8
Endrin	< 28	< 28	< 28				7/8
Heptachlor	< 4.0	< 4.0	< 4.0				7/8
Heptachlor Epoxide	< 7.0	< 7.0	< 7.0				7/8
Lindane	< 4.0	< 4.0	< 4.0				7/8
Methoxychlor	< 120	< 120	< 120				7/8
Toxaphene	< 300	< 300	< 300				7/8
PCB	< 240	< 240	< 240				7/8
Aroclor 1242	< 240	< 240	< 240				7/8
Aroclor 1016	< 240	< 240	< 240				7/8
Aroclor 1254	< 240	< 240	< 240				7/8
Aroclor 1260	< 240	< 240	< 240				7/8
HCB	< 4.0	< 4.0	< 4.0				7/8
Mirex	< 32	< 32	< 32				7/8

Comments:
1. Results are expressed as nanograms/liter.
2. < means lower than the lowest detection limit of analytical equipment.
3. Pesticide, chlorinated hydrocarbon, PCB analysis by ABC Laboratories, Inc. Columbia, Missouri.

NANO = .001 µ = .00001 mg/l
= 10^{-9}

Approved Gregory P. Mott

MID-MISSOURI TESTING LABORATORY

DETERMINATIONS MADE IN ACCORDANCE WITH AWWA – WPCF – APHA STANDARD METHODS

608 NICHOLS COLUMBIA, MO 65201 314/442-0237

Date: July 9, 1980

Client: Reitz & Jens (Bob's Home Service)

Date Received: July 12, 1980

Sample Collected By: Mid-Missouri Testing Laboratory

SAMPLE

Parameter	Well #3	Well #5	Well #6	Well #7	Well #8	Well #9	Date Analyze
pH	7.2	6.7	6.7	6.8	6.6	6.6	6/12
Redox Potential (millivolts)	409	409	414	404	389	384	7/3
Specific Conductivity (μmhos)	2200	1300	1450	1150	1900	1700	6/18
TOC (mg/l)	*	13.1	32.4	20.9	36.1	22.5	6/[illegible]
COD (mg/l)	36	16	14	18	≤4	10	6/[illegible]
Total Hardness (mg/l $CaCO_3$)	2020	1088	1176	931	2010	784	7/2
Chloride (mg/l)	25.0	13.5	12.0	20.5	13.5	7.0	6/18
Total Iron (mg/l)	2.[illegible]	3.20	1.80	1.00	≤.02	7.40	7/3
BOD_5 (mg/l)	*	2	1	2	1	2	6/12
Suspended Solids (m/gl)	*	184	81	202	277	935	7/1
TDS (mg/l)	*	1682	1746	1304	2831	2437	7/1
Turbidity (TU)	98	29	22	86	34	180	7/1
Extractable Oil (mg/l)	*	7.2	4.0	4.8	2.8	1.8	6/24
Fecal Coliform (#100 ml)	*	≤1	≤1	≤1	≤1	≤1	6/12
Alkalinity (mg/l) $CaCO_3$	356	389	407	406	412	395	6/24
Phenol (mg/l)	≤.001	≤.001	≤.001	≤.001	≤.001	≤.001	7/7

Comments:
1. ≤ means less than or equal to the lower detection limits of analytical equipment.
2. All metals are "total" concentrations.

* Quantity of sample insufficient to perform test.

Approved Gregory P. Matthews

SUPPLEMENTAL REPORT ON

BOB'S HOME SERVICE, INC.

MAY 5, 1983

ERAS

ENVIRONMENTAL RISK ASSESSMENT SERVICE (USA), LTD.

131 STATE STREET BOSTON, MASSACHUSETTS 02109 TELEPHONE: 617/720-1931 TELEX: 94-8202

SUPPLEMENTAL REPORT ON

BOB'S HOME SERVICE, INC.

MAY 5, 1983

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I. INTRODUCTION

Bob's Home Service, Inc. (BHS') is a solid waste management firm which operates a chemical landfill disposal facility in the Wright City, Missouri area. Wright City is approximately 35 miles west of St. Louis on Interstate 70.

BHS is seeking to obtain Environmental Impairment Liability insurance ("EIL") coverage for its chemical landfill operations. As a condition of granting such insurance, underwriters have required BHS to retain Environmental Risk Assessment Service (USA), Ltd. ("ERAS") to perform a survey of the operations and to prepare a report summarizing the risks of environmental liability assoicated with the activities. ERAS had surveyed this facility in October, 1980 and submitted a final report of the survey observations dated December 11, 1980. The survey had been performed in anticipation that BHS would obtain the EIL insurance at that time. This report is based in part upon information and observations contained in the previous ERAS report, and upon further data obtained from conversation with BHS representatives.

The risk rating given by ERAS in this and similar reports is based on the following factors:

A) The nature and quantities of the materials handled, in particular the potential for damage to health (of human, animal, or plant life) or property if releases to the environment were to occur.

B) The degree of control exercised in materials processing, handling, and storage.

C) The adequacy of controls on the treatment of waste streams released to the environment.

D) The amount of management attention given to matters of environmental concern.

E) The location of the insured's operations relative to possible damage targets.

The evaluation is largely qualitative and is given on a verbal scale from very high to very low risks.

2. DISCLAIMER

The material that follows is furnished pursuant to an express agreement that the ERAS study and report are made for the benefit of both BHS and the potential insurers and that ERAS is free to inform the potential insurers of any information relevant to the evaluation of the potential risk coming to its attention in the course of the survey or preparation for it. It is further understood and agreed that ERAS accepts no liability to the potential insured, insurers, reinsurers, or others for any losses sustained by BHS as a result of any denial of any insurance based on the survey or report.

Factual information has been obtained from BHS's personnel and has been assumed to be correct and complete by ERAS. A draft of this report has been reviewed by BHS.

3. RISK ASSESSMENT

The manufacture/operation of hazardous waste landfills, taken as a composite class, represents a risk of environmental impairment that is much greater (i.e. much more hazardous) than average, compared with all other commercial and industrial activities. Within this class of activities, BHS's operations represent a risk of environmental impairment that is below (that is less hazardous) then average compared with other similar operations.

Factors which affected this favorable risk rating are as follows:

A) The nature of the site's hydrogeology and its remote location;

B) the high level of environmental management and state-of-the-art technologies displayed by BHS;

C) site improvements being implemented in order to achieve authorization of BHS's new operating permit, and;

D) BHS is the transporter for 90 percent of the waste it landfills.

BHS was required by the State of Missouri to accept flood debris from Times Beach, MO, a town in which some areas are highly contaminated with dioxin. The flood debris itself is non-hazardous according to test results. Regardless, county residents, after losing an injunction to halt the disposal of Times Beach debris at BHS, are now seeking to withdraw BHS' operating permit. The risk of environmental

impairment or personal injury resulting from the disposal of these wastes appears low. However, the extent of negative publicity could result in EIL claims. For this reason, ERAS expresses a high degree of concern about the possibility of claims resulting from BHS' acceptance and disposal of the Times Beach, MO flood debris.

4. OPERATIONS

BHS lies in a basically rural area in Hickory Grove, Missouri. A part-time vacation home community with a man-made lake lies about 1/2 mile southwest of the site; four to five residences are located on the access road west of the site. Two small streams exist on site. As discussed in greater detail in the previous summary report, the site is located over a very dense, impermeable (permeability = 2-20 x 10^{-9} cm/sec) clay. The clay layer is in excess of 100 feet at this site. The St. Peter's aquifer, which is the only one of substantial size in the area, is encountered at depths of greater than 300 feet. BHS obtains water from this aquifer at a depth of 400 feet as do two other local residents. Other houses draw water from a depth of 250-300 feet.

Laverne Zykan owns the land and is the principle stockholder in BHS. The site occupies 158 acres on which 15 are permitted to receive hazardous wastes. Its EPA identification code is MAD068521228. As the 15 acres reach capacity, plant management hopes to expand its operations to utilize the remaining acreages for waste disposal. Three unlined lagoons exist on-site.

Mr. Michael Gill, BHS' facility manager, is responsible for environmental affairs. BHS has established a closure and post-closure trust fund for the site. The fund contains $230,000 dollars.

BHS is the only permitted hazardous waste landfill in Missouri. It accepts drummed and bulk dry residues and sludges. The sludges must be greater than 25 percent solids, and contain less than 5 percent organic liquids. No radioactive, bulk liquids, PCB (greater than 50 ppm), ignitable, reactive, or volatile wastes are accepted.

As a prerequisite of accepting the waste, BHS requires the waste generator to provide a one-time description of the waste stream. Information such as percent organic matter, pesticide analysis, and health-related data is required. The waste generator gives BHS a

copy of the registration filed with the State of Missouri; BHS also receives a permit to accept the waste from the state for every customer's individual waste stream.

Ninety percent of the waste disposed of at BHS is hauled by BHS employees. The remaining wastes are generally spill clean-up materials which are hauled by other contractors. BHS performs some standard analyses at the site (pH, percent volatiles) and visually inspects the waste. BHS' trucks are tractor trailer and roll-on box types. No tank trucks are used.

As indicated earlier, 15 acres of the site are permitted for hazardous and industrial waste disposed. About 1 to 2 acres remain unused, the estimated time to fill this remaining acreage is 2 years. BHS's trench system has been re-designed since the last survey in which it was observed that three trenches were excavated and kept open for receipt of organic, acidic and basic wastes respectively. Presently, a progressive trench system is used. Corrosive wastes are kept separated in the trench by cells constructed with a minimum of one foot of clay on the top and bottom, and three feet on the sides. The trenches are 37 feet deep at one end and 47 feet at the other; a gravel blanket drain and a 3 percent slope at the trench bottom facilitates collection of leachate. The leachate is pumped to an unlined holding lagoon. While not physically hazardous as determined by testing, the leachate, by regulatory definition must be handled as a hazardous waste. The leachate quality is periodically tested; BHS is required to submit data on leachate volumes collected and quality. Sawdust is mixed with the leachate from the lagoon and placed into the facility solid waste trenches. In 1980 about 50,000 gallons of leachate were collected.

BHS was issued a new operating/construction permit on December 22, 1982 (the State of Missouri #122282-001). Before BHS is authorized to operate under the new permit, it must complete a number of site improvements which it and the State agreed upon during the permit negotiations. During this period, BHS is operating under a variance granted by the State.

Among the items requested were improvements to the on-site surface impoundments, and installation of additional ground water monitoring

systems. With regard to monitoring, the previous ERAS report indicated that the monitoring system consisted of 16 piezometers and two conventional wells. In the proposed system, the piezometers will be eliminated. Groundwater monitoring will be accomplished by use of four 125-175 foot deep wells drilled to a sand seam. Surface water monitoring will occur at five locations including Lake Lucerne, a man made impoundment associated with a nearby vacation community. The firm currently samples groundwater quality parameters (chloride, iron, Mn, phenols, Na, and SO_4) annually and groundwater contamination parameters (pH, specific condustance, TOC, and total organic halogen) semi-annually. This frequency is in accordance with the RCRA regulations. BHS submitted its data for March, May, September, and December of 1982. The data appears consistent; levels for dissolved heavy metals in the piezometer wells are very low, generally less than 10 ppb. Individual pesticides and PCB concentrations were below detection limits, the highest of which was 15 ppb. BHS is completing sand filled monitoring trenches on the complete east side of the facility and on half of the south side. These trenches will be dug 2 feet deeper than the deepest point in the disposal trenches, and will be 30 inches wide. Collected groundwater will flow to a sump from where it will be pumped to the surface for testing and then to the leachate holding surface impoundment.

BHS keeps records of three-dimensional coordinates of waste placement within the disposal trenches. It uses an infrared computer in the field to determine the location coordinates. The state receives a copy of the waste inventory within each disposal cell.

Of the three on-site unlined surface impoundments, one is a holding lagoon for collected leachate; the leachate is mixed with sawdust and disposed of in the waste trenches. BHS submitted leachate quality monitoring data obtained in October, 1982. Nickel was present in the highest concentrations (0.2 ppm); all pesticide concentrations were below detection limits (10 ppm or less).

One impoundment receives wash water from truck washing operations and precipitation runoff which may have contacted waste materials. The wash water is tested for hazardousness; if it is non-hazardous it is released to holding lagoon #3. Its contents are spray irrigated on

site. BHS plans to handle this discharge in the future by releasing it to the metropolitan sewer system. BHS is not required to obtain an NPDES permit for current activities.

According to Mr. John Doyle of the State of Missouri Department of Natural Resources, BHS' new permit requires that the leachate and truck wash surface impoundments be upgraded as a condition of permit authorization. The old lagoons will be drained and filled in. The reconstructed lagoons are required to be equipped with a leachate collection system and a clay liner.

In December-January of this year, a flood in dioxin-contaminated Times Beach, Missouri caused the accumulation of large quantities of debris. At the order of the state, this material was sent to BHS (See Appendix A) for disposal. The State of Missouri agreed to accept any liability associated with disposal of the flood debris at BHS, and agreed to assume all debris excavation and removal costs, should any occur in the future.

As a result of the State Directive, the County of Warren and its citizens filed an injunction against BHS to prevent it from accepting the waste; the State intervened and became a co-defendent. The court required the county to post a $75,000 bond to halt the disposal; the county could not raise the money and the injunction was dropped. The debris analysis showed no detectable levels of dioxin. The citizens of the county have now filed an appeal to the court to have BHS' operation permit revoked.

5. SURVEY ACTIVITIES

Ms. Leslie Nelken of ERAS contacted Mr. Michael Gill, facility manager via telephone (314-745-3158) on February 9, 1983. Mr. Gill, who also provided input for the previous survey report, was well versed with the site's operations, environmental regulations, and the facility's current status with regard to permits and environmental projects. As indicated earlier, to Mr. Gill's knowledge there is no pending or current environmental litigation facing BHS; with the exception of the neighbors' appeal to revoke the site's operating permit. An injunction filed earlier has since been withdrawn (see Section 4).

Mr. John Doyle (314-751-3241) of the Missouri Department of Natural Resources, Waste Management Program, was contacted on February 16, 1983. Mr. Doyle indicated that the State issued BHS a new operating permit on December 22, 1982; however, prior to authorizing the permit, construction changes to the facility specified by the State must be completed, inspected and authorized. These changes include additions to the groundwater monitoring system and upgrading of two on-site surface impoundments. BHS has agreed to these improvements and is working toward their completion.

Mr. Doyle stated that BHS has submitted its groundwater monitoring data to the state in a timely manner. In two instances, arsenic and TOC levels in the groundwater were thought to be high; however, additional testing found these levels to be comparable to background levels.

Mr. Doyle rated BHS as a firm in which continued improvement of site operations, professional management, and state-of-the-art techniques is evident. The firm displays a cooperative attitude with the regulatory agency.

BOB'S HOME SERVICE, INC.

APPENDIX A

LETTER FROM STATE OF MISSOURI ORDERING
BHS TO ACCEPT TIMES BEACH, MO FLOOD DEBRIS

MISSOURI DEPARTMENT OF NATURAL RESOURCES
P.O. Box 176 Jefferson City, Missouri 65102 (314) 751-4422

January 5, 1983

Michael Gill
Site Manager
B.H.S. Inc.
Industrial Waste Landfill
Route 1, Box 116F
Wright City, MO 63390

Dear Mr. Gill:

This letter is to confirm the results of the discussion and the agreements which have been reached by my Department with you, as herein set forth.

Due to the flooding of Times Beach, Missouri, and the potential contamination caused by the 2-3-7-8 TCDD contaminated soil, a potential and major health hazard has arisen and the Governor by executive order number 82-24 has declared a state of emergency and has directed this Department to take appropriate action. Pursuant to the provisions of law due to the emergency and in accordance with the Governor's executive order, the Department is hereby requesting and directing B.H.S Inc. to dispose of various flood debris from the Times Beach area, excluding any 2-3-7-8 TCDD contaminated soil.

In this regard the State and this Department agree to the following terms:

1. The State of Missouri and the Department of Natural Resources represent that, to the best of their knowledge, information and belief, such flood debris and waste is non-hazardous, and not subject to regulation under the terms and implementing regulations of the Resource Conservation and Recovery Act of 1976, the Missouri Hazardous Waste Management Act, as amended, and the Toxic Substances Control Act. The State and the Department further represent that to the best of their knowledge, information and belief, the debris to be disposed hereunder is not contaminated with 2-3-7-8 TCDD to such an extent as to render the same a hazardous waste.

2. That with respect to the disposal and burial of the waste provided for herein B.H.S Inc. shall not be required to perform any test as to the composition or the nature of the debris and shall not be required to maintain any manifest with regard to the same as ordinarily provided under the Hazardous Waste Management Act and rules.

3. The State and the Department certify and represent to the best of their knowledge, information and belief that the disposal of such debris by B.H.S. Inc. at its hazardous waste site will not be in violation of any federal, state or local law.

4. Since the flood debris and waste is not classified as hazardous under the provisions of the Hazardous Waste Management Act, B.H.S. Inc. shall not be required to collect or pay to the State the 2 percent disposal landfill tax provided for by Section 260.390(8), RSMo, for accepting or disposing of this waste.

5. B.H.S. Inc. is authorized to bury and dispose of such waste and debris in progressive fill area number 5 or in such other fill area in the site as may hereafter be approved. B.H.S. Inc. will not be required to meet the daily soil requirement regulation with respect to this waste unless necessary to control odor or to control the blowing of debris.

6. B.H.S. Inc. shall segregate and not co-mingle or co-dispose this waste with any hazardous waste which may be accepted at the facility for a period of 6 months unless sooner authorized by the Department. B.H.S. Inc. shall maintain at all times records as to the location of the disposal of this waste and debris at the site and shall make those records available to the State and the Department promptly upon request.

7. The State and the Department agree to perform or cause to be performed without expense to B.H.S. Inc. all monitoring, testing, removal, abatement or other remedial action of whatever nature as may be directed, ordered or reasonably necessary in the event it is ever determined by any agency or court of competent jurisdiction that the disposal of such waste at the site constitutes a hazard or substantial threat to the health of humans or to the environment whether the same arises or is based upon any statute or common law, including but not limited to the Resource Conservation and Recovery Act, the Missouri Solid Waste Disposal Management Act, CERCLA (42 USC section 9607) and all common law theories of nuisance and strict liability. This provision shall not be applicable in the event there is a final adjudication that B.H.S. Inc. or its agents, officers, or employees were negligent, reckless or involved in intentional wrongdoing with respect to the receipt for disposal, and the disposal of the waste provided for herein and with respect to the operation of its facility with regard to this waste.

8. If B.H.S. Inc. or any of its agents, officers or employees are named as a defendant or respondent in judicial or administrative proceedings, instituted to hinder, prevent, or remove the disposal of this waste in B.H.S. Inc's site, or instituted to challenge the issuance of a permit to operate a hazardous waste facility by the Department of Natural Resources, the appropriate State agents and officers, if the State or its agents or officers have not been named in that suit, will request the State of Missouri to take all necessary steps to intervene in the suit. As a party or as an intervener, the State will assume the primary lead and responsibility for the defense of any such suit or suits, including any expenses or costs incurred but not including attorneys' fees. The State will do this to the extent allowed by the law and Rule 4 of the rules of the Missouri Supreme Court. Nothing herein shall be construed to prevent, however, the State or its agencies from taking whatever action it deems necessary to enforce applicable laws or the terms of the permit in the event it believes that such laws or terms have been violated by B.H.S. Inc., its agents, officers of employees. Furthermore, the State reserves the right to seek an adjudication of its rights and responsibilities under this agreement. Neither the State nor any of its agencies are promising to serve as the attorney or legal advocate for B.H.S. Inc. Consequently, nothing contained in this agreement is intended to impose or create any actionable duty or cause of action for money damages for negligence or malpractice in favor of B.H.S. Inc., its agents, officers or employees against the State's legal officers or employees who undertake to perform the legal duties and responsibilities provided for in this paragraph.

9. In addition to the consideration herein provided, the Department will compensate B.H.S. Inc. for accepting and disposing of the flood debris and waste as follows:

(a) a minimum charge of $45,000 which will include up to 1000 cubic yards of semi-compacted waste and,

(b) for each additional cubic yard, the rate of $40 per cubic yard and,

(c) cubic yardage shall be determined by the total volume of the waste and debris in place on the site including the 3 feet of final soil cover over this waste.

10. The consideration and compensation being paid is subject to and is conditioned upon the accuracy of the certifications and representations made herein.

Sincerely,

DEPARTMENT OF NATURAL RESOURCES

Fred A. Lafser
Director

FAL:pol

Attorney General John Ashcroft approves this agreement as to its legal form and effect and certifies that it binds the State of Missouri in its sovereign capacity.

John Ashcroft
Attorney General

APPENDIX D

SYSTEMS MANAGEMENT ASSOCIATES

5427 VALKEITH
HOUSTON, TX. 77096

HEALTH PROFILE: HAZARDOUS WASTE DISPOSAL FACILITY

Prepared for

B.H.S., Inc.

Wright City, MO 63390

In Accordance with

Missouri State Statute 260.395

24 March 1982

Jay H. Glasser, M.S., Ph.D.
Vito Logrillo, M.P.H.
Sam Milham, M.D.

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Final Report
Health Profile: Hazardous Waste Disposal Facility
Submitted by: Systems Management Associates
for: B.H.S., Inc.
Wright City, MO 63390

1. Introduction: As part of the permit issuance process for the operation of a hazardous waste site, the Annotated Missouri Statutes [Section 260.395], requires an operator to:

> (5) Submit with the application for a hazardous waste disposal or treatment facility a profile of the environmental and economic characteristics of the area as required by the commission, including the extent of air pollution and ground water contamination; and a profile of the health characteristics of the area which identifies all serious illness, the rate of which exceeds the state average for such illness, which might be attributable to environmental contamination.

This document accompanies the application of Bob's Home Service, Inc., [B.H.S.] for a permit to operate a hazardous waste disposal facility and is provided to meet the requirements for a health profile as proscribed by the law. This document:

- describes the nature and extent of the health profile for B.H.S. consistent with the intent and purpose of the Missouri Statutes
- outlines the technical and methodological back-up to support the health profile structure
- presents the complete health profile

While providing a complete general health profile as required, consideration was given to specific indices to monitor specific types of waste materials deposited by BHS. In addition, data aggregation and analysis must be, and is, specific for the distribution, number, and populations in the surrounding areas. Any profile, to satisfy the law, must be technically

responsive to these varying characteristics. The definition of areas, level of aggregation, and the analysis presented in this profile are responsive to the specific setting of BHS, its operations, and Section 260.395.

2. Purpose of the Health Profile

Section 260.395, containing the health profile requirement, presents the intent of the law; to provide a health profile suitable to monitoring serious illness which might be indicative of environmental hazards exposure to residents in or near a hazardous waste site operation. The section specifically cites the need for the profile to be sensitive to detecting rates of serious illness associated with environmental hazards health effects that exceed state averages.

There are no current State regulations available specifically describing the structure, content or analysis process required to meet the intent of the law. However, the State has issued summary guidelines (Appendix 1). This profile is consistent with these guidelines.

BHS is prepared to meet the full intent of the law, and as part of the application process wishes to provide complete explication of the structure and content of the required health profile. BHS does not presume to assume the form of any forthcoming State regulations. However, BHS consultants wish to document the profile development consistent with the State Statutes, the existing guidelines, and in accordance with currently recognized technical and scientific requisites for a community health profile of serious illness potentially related to hazardous waste disposal site operations.

Two basic technical requisites of the profile are:

- Provide a baseline to monitor serious illness conditions as required by the Missouri Statute on an ongoing and comparative basis

- Relate measures and data that are appropriate to monitor health effects to known or potentially hazardous substances that are disposed in the BHS waste landfill.

The profile is structured to meet the two requisites stated above. To accomplish these two purposes the profile will conform to the following technical characteristics:

- require objective and timely data of sufficient quality to meet the need for ongoing and comparative analysis for such serious illnesses.
- describe health effects to the known etiology and epidemiology of populations exposed to toxic or potentially hazardous compounds.
- provide a comparative framework to appropriately aid the identification of health effects reflected in general population trends and those indicative of potential or known hazards associated with landfill operations.
- provide measures of variability or sensitivity associated with indices, rates, and trends employed in the profile in order to produce valid and objective conclusions related to a health profile of areas surrounding BHS site operations.
- require an assay of multiple sources of data, information, and methods to select appropriate measures to reflect the technical requisites of providing a multi-dimensional view of selected environmental hazard-related serious illness explicit in the technical considerations cited above.

3. <u>Detection of Health Effects of Hazardous or Toxic Substances</u>

The development of the profile draws heavily on the known relationships of toxic effects. Sources are fully documented in the profile. For purposes of review these sources are summarized below:

- Health statistics and biostatistics provide the information base and the analytical techniques to collect, analyze, and assess data sources that are identified as pertinent to the hazardous waste site health profile. Statistical aspects include an assessment of reliability, validity, and time trends used to construct the base line profile.
- Medical Etiology and Epidemiology; the study of epidemiology and its relation of risk factors, disease distribution patterns, and multi causation of illness provide the knowledge base for selecting specific indicators of possible serious health effects related to environmental quality or hazardous substances.
- Toxicology and related studies provide the basis for compiling and defining risks related to specific substances that are disposed in BHS landfill operations.
- Engineering and related geophysical and environmental sciences contribute data that can be used to identify specific potentially toxic substances. In turn the identified substances can indicate health monitoring indices where the literature supports such linkage.
- Demography defines and measures characteristics of the community and state populations for comparative analysis, for specific monitoring of populations, and for information on population dynamics relevant to on-going monitoring of health effects.

4. <u>Sources of State Data for the Profile Construction</u>

The sources of data and information below are used consistent with the knowledge base described in the prior section. This section covers sources of data, and critically reviews the sources for inclusion in the profile. A

subsequent section describes the measures to be derived from these sources. Emphasis is placed on the use of on-going health information systems, consistent with the need for monitoring over time, on a practical, cost-effective basis as described in the section on the Purpose of the Profile.

4.1 Missouri Data and Health Statistics

The State of Missouri has ongoing health data sources that are consistent with the multiple requirements spelled out in previous sections. The basic data required for a serious illness profile will be drawn from the following subsets:

- Mortality Data - Missouri death certificates provide cause-specific death information on all deaths occurring within the state by place of residence and other descriptors. Mortality is an obvious major data base to study specific disease patterns. Death certificates and derived statistics provide a continuous source of data on mortality. This source of data is used in the profile.
- Natality Data - Natality data consist of information on births, fetal deaths, and the circumstances surrounding birth including related demographic and health descriptors. These data are considered valuable for assessing and measuring changes in birth patterns and outcomes. These changes can be associated with, or indicative of, environmental changes or health effects. The State collects these data via birth and fetal death certificates. These data are used in the health profile.
- Morbidity Data - Morbidity data comprise information on illness (incidence and prevalence) in the living population.

The State of Missouri has several sources of ongoing data systems that measure specific morbidity germane to the profile. A variety of ways exist

to collect such data, including face-to-face interviews with people, health examinations, claims forms for medical care costs reimbursement, and hospital discharge and physician office visit abstracts.

(i) The Missouri Hospital Discharge System - This system collects morbidity-specific information related to hospitalized patients. Data from discharged patients' medical records are abstracted and entered into the hospital discharge file.

The discharge file is a source for measuring serious illness, as indicated by hospitalization. Geocoding permits assignment to residence area that is essential to the health profile for monitoring hazardous waste site operations.

The discharge data will be used to provide specific indicators of potential environmentally related serious illness, both reversible and irreversible. In addition, coverage and completeness of this data source must be assayed for purposes of the comparative analysis and time trends.

Discharge data are records of hospital stays. Individuals may have multiple hospital stays within a period of time for the same or related condition, or different conditions. Small area data and diagnoses of low frequency are particularly affected by readmissions for an individual in these circumstances. This situation may be reflected in these data.

On balance the hospital discharge data provide on-going information on morbidity trends and is used in the health profile.

(ii) The Missouri Cancer Registry - The cancer registry collects cases (incidence) of cancer as reported by physicians, hospitals or clinics. This system cannot be precisely appraised as to the extent and quality of coverage. Registry data are useful to examine site and age specific incidence and time period prevalence for tightly constructed special epidemiological

studies. Because of the potential coverage problems, data from this system have not been used in this profile. Based on the experience of staff at the Missouri Center for Health Statistics, the hospital discharge data provide more complete coverage of cancer morbidity. Therefore, the hospital discharge data are used in this report.

(iii) The Missouri Workman's Compensation File - This is a source based on legal requirements related to compensation claims. There are obvious limitations of the nature of the source, due to its lack of standardization, completeness, and reliability to serve as a source of objective ongoing reporting. Such data can be useful in identifying spot problems, or alerting health officials to potential hazards. Because of limitations, however, these data have not been used as a baseline source in this profile.

4.2 Population and Demographic Data

These sources provide the community, county and state descriptors and data on the population, available either as 1970 U.S. Census data, intercensal State of Missouri population estimates, and 1980 U.S. Census data. The 1980 U.S. Census data are currently available only on gross aggregate counts but are employed to the detail level published. These population and demographic data provide the basis (denominator data) for the specific rates of serious illness, and other allied rates required by the law, and technically appropriate to the health profile.

These data also provide the basis to determine the validity of rates, pooling, and adjustment procedures for the health profile analysis. This profile draws upon the currently available census data or population estimates.

The sources of data described above provide an adequate data base from which to develop appropriate health measures, describe current health status of the population, and can be used for monitoring changes in health status over time.

4.3 Bob's Home Services (BHS, Inc.) - Waste Site Specific Data Sources

Two separate sources of data can be derived from BHS data primarily on a forward basis, for monitoring. These two sources are BHS site substances reports or monitoring reports, and an annual BHS workers physical exam.

(i) BHS Substance Monitoring Reports.

These reports include:

- type of industrial waste disposed
- type of compound or contaminants disposed
- specific testing by analysts, including leachate analysis.

Data contained in these reports are used to identify specific waste hazards composition. In turn, the specific compound or family of compounds are to be monitored for health effects linked by epidemiological analysis. Certain wastes are not accepted at the site, and this provides information to be used to delimit health measures of indices for the purpose of the specificity of the profile.

Based on the leachate analysis from BHS, our review of the literature and known evidence, Appendix 2 provides a specific cross-listing of known principal waste components related to:

- signs, symptoms, and conditions
- companion ICD code, ninth revision where applicable.

These ICD groupings where applicable are contained in condition-specific monitoring groups. The health profile is directed to specific BHS operations.

(ii) BHS Physical Exams of Workers.

The annual physical exam procedure was reviewed by the Senior Medical and Epidemiology consultant. A standardized workers exam with emphasis on occupational medicine can be a valuable forward monitoring source. Current exams show no deleterious health effects on workers due to exposure at the waste site. However, due to potential lack of standardization, and technical considerations, worker physical exam results have not been included as part of the profile.

5. <u>The Health Profile Structure</u>

Based on the above considerations, five major technical considerations were used to develop the specific elements on which the health profile is built:

5.1 Technical reports and knowledge base; scientific literature and precedents for environmental health profiles have been reviewed. The following major sources have been reviewed:

- health effects/hazardous substance literature review
- NIOSH [National Institute of Occupational Safety and Health] summary and committee reports
- EPA [Environmental Protection Agency] hazardous substances, procedures, regulations, and reports
- OSHA [Occupational Safety and Health Administration] hazards and protection summaries and reports

- NCHS [National Center for Health Statistics] information and health statistics recommendations and procedures, collection, use, and analysis related to health and environmental effects
- State of Missouri [Center for Health Statistics] sources of data, and technical considerations on specific data and analysis

5.2 Timeliness and Availability of Data.

The data sets described in the previous section, Sources of State Data for the Profile Construction, are available for differing periods of time. Thus the baseline for various sets of data may differ dictated both by availability and comparability (see next section).

5.3 Comparability.

Over time, data from a specific data source may contain differences which unrecognized can lead to spurious inferences. Comparability considerations in the data sets described above include (see Technical Notes):

- completeness and coverage; for example, the hospital discharge data coverage and completeness vary over time
- changes in coding procedures; for example, there is a major change every 10 years in coding in the ICD (International Classification of Diseases). The ICD codes provide the standard used for disease classification. There are time trend considerations due to the change from ICD-8 to ICD-9 that would affect the base-line profile. These considerations where applicable are specifically stated.
- geocoding for areas, cities, and subareas; for example, consideration needs to be given to zip codes, and city code availability and

comparability. The profile uses zip code, county, and surrounding counties as comparative units with state experience.

- definition of health measures; for example, perinatal mortality rates computed with or without fetal deaths included in the denominator. These rates and indices are defined and the rationale summarized.

5.4 Statistical Error Rates

The numbers and the error bounds related to specific rates must be considered. This includes consideration of pooling of years or aggregating population or area units. The error rates provide a guage of the stability or non-stability of a particular rate.

In order to guide technical consideration of the error rates and to aid the technical reviewer, charts of approximate 95% confidence intervals on single rates (on a per 1000 population base) and for differences between two rates (on a per 1000 population base) have been developed for this report.

The confidence interval approach embodies the sampling error that can be expected in a given rate due to stochastic variation and frequency of an event(s) measured by the rate.

This assessment of variability in rates is of crucial importance since the population base and time period used vary with comparative geographic areas, specific health events, and time reference.

Thus, proper interpretation requires statistical testing and consideration of error in evaluating the important rates and ratios used to monitor hazardous waste sites. Inspection of Appendix 3 shows how these confidence intervals on rates (per 1000) vary dramatically based on the size of

the denominator (base population) and the relative frequency of the numerator (the health event of interest).

The rationale for both aggregation of data, and the time periods chosen for various data base elements are fully documented. Each data source requires separate aggregation considerations in order to provide appropriately stable derived rates and indices, and to take into account the effects of coding changes and quality and completeness of reporting trends over time. Principally selected birth and natality rates will reflect a five- to ten-year baseline; death certificate data, a two-year base; and hospital discharge, a one-year base as dictated by the technical considerations enumerated.

5.5 Adjustment Factors

This category includes the use of factors or procedures to adjust appropriately for underlying factors such as completeness of reporting or demographic factors that make one area "different" from another.

6. Indices Selection

The primary measures selected for the health profile are based on the considerations cited above.

This section summarizes the data sets and their reference periods used to derive the major indices, rates, ratios, and proportions employed in the health profile. The time period of coverage for each set has been predicated on the technical factors cited in Section 5 (above).

Specific table references are combined to provide a succinct but complete guide to the indices and rationale for use.

6.0 Summary Guide to Data Sources, Indices, Time Period, and Technical Considerations for the BHS Hazardous Wastesite Health Profile

6.1 NATALITY

Source: Birth Certificates

Birth rates

Table 1	1980	most current year	• descriptive only relates to total population, can be misleading to impute any health implications.

Fertility rates

Table 1	1980	most current year	• measures fertility

Low Birth Weight (under 2501 grams)

Table 3	1972-1976 1977-1980	aggregate years aggregate years	• measures development state of live births • aggregated to provide more stable comparison • correlated with gestation period less than 37 weeks

Gestation period less than 37 weeks

Table 7	1972-1976 1977-1980	aggregate years aggregate years	• measures gestation related to expected full term development • aggregated to provide more stable comparisons

Apgar Score less than 8 (at 5 minutes)

Table 8	1978-1980	aggregate years	• measures condition of infant at birth • available since 1978 only, and coded less than 8 • aggregated to provide more stable comparisons

Source: Birth Certificates and Fetal Death Certificates

Fetal death ratio

Table 2	1972-1976 1977-1980	aggregate years aggregate years	• a measure of fetal wastage • comparability with other natality measures • aggregated to provide more stable comparisons

Source: Birth Certificates, Fetal Death Certificates, and Death Certificates

Neonatal death and perinatal death rates

Table 5	1972-1976 1977-1980	aggregate years aggregate years	• measures of survival during gestation and around birth or immediately post-natal • comparability with other natality measures • aggregated to provide more stable comparisons

Source: Hospital Discharge Data

Congenital malformations

Table 4	1979	• measures anomalies of development • single year hospital discharge available • hospital discharge reflects better quality of reporting of events than birth certificates

6.2 MORTALITY

Source: Death Certificates

Infant death (excluding accidental deaths)

Table 6	1972-1976 1977-1980	aggregate years aggregate years	• measures early childhood mortality • accidental deaths excluded as no possible relation to hazardous waste exposure • aggregated to provide a more stable comparison

Table 12	1971-1980	time trend, single years	• track mortality changes • specimen analysis for temporal effects

Malignant neoplasm (by selected groups)

Table 9	1979-1980	aggregate years	• cause specific mortality known to be affected by hazardous waste (see Appendix 2) • selected groups aggregated for stability of rates but preserve subgroup specificity • 1979-1980 only to reflect ICD 9. Comparability with ICD 8 on state and local level doubtful and not used.

6.3 MORBIDITY

Source: Hospital Discharge Data

Malignant neoplasm rates (by selected causes)

Table 10	1979	• measure occurrence of selected cancer causes in the population • selected groups comparable to mortality tables and indicative of specific waste site hazards (see Appendix 2) • single available year of reliable reporting with coverage of comparable completeness among state and local units of analysis

Other primary diagnosis rates (by selected causes)

Table 11	1979	• measures occurrence of other selected causes related to possible hazardous waste exposure (see Appendix 2)

- limited to causes with specific physiological etiology; conditions influenced by psycho-social factors are not included
- single available year of reliable reporting with coverage of comparable completeness among state and local units for analysis

7. Analysis

The analysis and interpretation of the BHS Hazardous Waste Site Health Profile is derived from the state statute and basic health statistics considerations in order to:

1) identify selected serious illness conditions related to possible hazardous substances contamination and compare with the state average.

   This calls for appropriate geographic comparative units of reference for analysis.

2) provide a baseline descriptive profile to establish the current population health effects within the appropriate comparative geographical units.

   This calls for specific tables of the selected indices for these comparative units.

3) provide the appropriate time reference data and indices to permit forward monitoring of the health profile in subsequent years.

   A baseline and a period of before operations and after operations observation periods are available.

4) Establish appropriate statistical techniques for estimation of measures of health effects, and to objectively assess and test for the statistical significance of these measures.

The presence of natural variability from year to year is reflected in the data. Conclusions must take into account the statistical variability that is present.

The magnitude of the underlying events, whether relatively common in occurrence or less common, and the size of the populations of the various geographic units affect the variability of the measures of health effects.

The underlying population, time trends, rates and the differing nature of the health measures and data employed require selection of the appropriate statistical tools to permit objective and valid comparisons.

7.1 Geographic Factors

Geographic-specific definition of all data and derived measures were carefully considered. Each waste site and its surrounding areas must be considered. The Statutes call for a comparison of the site with State rates. This profile goes further to provide a set of nested comparisons: immediate surrounding site, county of site, related distance and geology considerations, counties, and the State. Statistically these nested geographic areas do not provide independent estimates; however, because of the comparable increase in population from one nested unit to the next larger aggregate in the case of BHS surrounding zip code, county, and state, the lack of strict independence is not a significant limitation on the comparative approach.

- zip code — the area immediately surrounding the BHS site. Zip code 63390 is the location of BHS operations. See Appendix 4 for a map showing zip code 63390 boundaries.
- county — Warren County, the location of the BHS site.

- aggregate counties — Warren and the two counties in close proximity to the BHS operation (Lincoln and St. Charles).
- state — the State of Missouri.

7.2 Demographic Factors

- age, where pertinent to the analysis and technical considerations age-specific or age-adjusted rates are included.

7.3 Statistical Stability and Comparability

Consistent with the statistical factors, previously cited statistical tests of significance, estimation, and confidence interval guides are used to provide objective assessment of the data.

7.4 Specific hazardous substances or industrial groups related to materials disposed at BHS landfill operation. (See Appendix 2 review.)

7.5 The analysis is responsive to the criteria above and is divided into four components:

1) Presentation of Descriptive Indices

Presents the selected health effects measures for each comparative civil division. Where possible it is further divided into pre and post operations periods. The pre operations period is defined as the years 1972-1976 period, and the post operations period as the years 1977-1980. The basic tables are presented in Appendix 5. These tables contain the frequencies, rates and indices selected for health effects monitoring.

2) <u>Examining Differences for Significance by Z-Score Approximations</u>

This section assesses the statistical significance of the indices presented in the Appendix 5 tables with respect to:

- differences among the rates among comparative groups within the pre-operation phase, and within the post operation phase.
- differences among the rates pre operational and post operational within a specific civil division.

Using the approximate Z-score confidence intervals (Appendix 3) provides a statistical screening procedure to assess the significance of differences among the rates.

The confidence interval tables in Appendix 3 provide the entries for the technical reader to examine specific rate differences. These confidence interval tables are for a 95% confidence interval. For ease of review the results of all the tests are summarized in tabular form in Section 8.

It should be noted that at the $\alpha = .05$ level, 5 out of 100 of the many approximate normal Z-scores examined will cause us to reject a hypothesis of no difference when in fact it is true. The multiway comparisons yield tests that are not independent of one another. Furthermore, not all the measures are themselves independent.

The test results summarized in Section 8 do provide appropriate statistical screening procedures to find potentially deleterious health conditions among the many observed differences in measures that may be due to chance alone.

3) Differences of Risks Using Standardized Mortality or Morbidity Rates (SMR) and Standardized Proportion Mortality or Morbidity Rates (SPMR)

The SMR and the SPMR procedures are presented to define the comparison of BHS surrounding areas with that of State experience. Standardized mortality or morbidity rates (SMR) help adjust for the effect of underlying population-age differences where the age-specific population is known. SMR's are constructed for the mortality data.

Standardized proportional or morbidity rates (SPMR) accomplish the same purpose of adjustment for underlying population differences when these differences are not directly observable. Since the hospital discharge data cannot be referred directly to the population subgroups, the SPMR procedure is used for the hospital discharge based morbidity measures.

The SMR and SPMR procedures in conjunction with current data are most appropriate procedures for assessing the current relative hazards appraisal required by Missouri Statute.

4) Time Trends

Time series analysis can be useful in examining patterns or trends in the health profile measures. However, the limited period of observation on most measures places current restrictions on the use of this technique with currently available data.

As yearly observations accrue, an on-going health profile based on annual data may be analyzed by more sophisticated trend analysis.

Appendix 6 contains a technical discussion of Time Series analysis and a recommended statistical analytic approach (ARIMA) that may be employed in the future.

Time trends over the current period can be examined empirically for the appearance of any potential or suspected emerging trend. Therefore, time series has been examined only via graphs for the natality data as a specimen analysis.

8. Summary of Findings

This section summarizes the findings based on the presentation of the data via rates, trends, time periods, and the statistical methods described.

The interpretation is based on the specifics of the statutes, the assumption of an ongoing monitoring function, and the statistical strengths or limitations of the data and indices previously described.

8.1 Descriptive Tables of Frequency and Rates of Selected Indices Tables 1-11.

The rates in Tables 1-11 are summarized in tabular form below. The rates were screened using the approximate Z-test confidence interval approach given in Appendix 3.

The standard comparison is taken as the state rate. Where the data permitted, some tables reflect the additional comparison of dividing the observations, pre-BHS operations (1972-1976) and post-BHS operations (1977-1980). The state comparison permits examination for effects as indicated by the law. The two time period comparison, where possible, sharpens the

analysis by comparing rates for changes before and after BHS operations began, within each civil division.

The summary table identifies:

- the specific rate
- the direction of any negative effect
- the time comparisons in the table
  - the state rate as the standard
  - the time trend before and after BHS operations
- the summary results of the table
  - no specific differences noted, given error rates
  - monitoring an elevated rate indicating that these rates should be examined for underlying population or other factors including hazards that can cause these differences
- other common risk factors or underlying health and population factors beyond environmental hazards that also can affect these rates (although not an exhaustive list).

Bearing in mind that the multitude of rate comparisons is large and many not independent, the evidence in Tables 1-11 indicates that the state rates are not exceeded in most of the indices presented. However, note that several of the natality measures while not significantly different are elevated and should be monitored. Recognizing the perturbations in the small area data the profile can be complemented by examining the cause-numerator event information on the certificates. Subsequent time period data will be necessary to establish any definite trend.

A subsequent section (8.3) provides a more precise statistical tool using cause-specific data based on mortality and morbidity data sources.

SUMMARY OF ANALYTIC RESULTS, TABLES 1-11

Aggregated Rates	Measure	Direction of Potential Negative Health Impact and Type of Comparison	Findings	Moderating Factors
Table 1	fertility†	reduction compared to state	no effect	depends heavily on other demographic factors
Table 2	fetal death rate	elevated before-after compared to state	no effect	depends heavily on health, demographic factors, and genetic predisposition
Table 3	low birth weight	elevated before-after compared to state	no effect	as above
Table 4	aggregate birth anomalies	elevated compared to state	no effect	genetic pedigree
	cause-specific	elevated compared to state	no effect	genetic pedigree
Table 5	perinatal*	elevated before-after compared to state	no effect monitor	general health status, prenatal care, genetic factors, events around delivery
	neonatal	elevated before-after compared to state	no effect monitor	as above

†Population data for before-after comparison not available.

*perinatal and neonatal not statistically independent

SUMMARY OF ANALYTIC RESULTS (continued)

Aggregated Rates	Measure	Direction of Potential Negative Health Impact and Type of Comparison	Findings	Moderating Factors
Table 6	infant death rate*	elevated before-after compared to state	no effect monitor	as above, post-natal care, and exposure to infectious diseases
*not statistically independent of the perinatal and neonatal rates				
Table 7	gestation < 37 weeks*	elevated before-after compared to state	no effect monitor	error in estimation, health, prenatal care, and genetics
*not independent of low birth weight				
Table 8	Apgar Score < 8	elevated compared to state	no effect	preexisting, prenatal, circumstances at birth
Table 9	malignant neoplasm death*	elevated compared to state	no effect	cause-specific variable, etiology, age distribution and demographic factors
*total not statistically independent of specific cause rates				
Table 10	malignant neoplasm, hospital discharge	elevated compared to state	no effect	as above
Table 11	diagnoses, hospital discharge	informational only		

8.2 Time Trend

The time trend data is presented as a demonstration analysis. Because of limitations in the number of observed periods time trend analysis is not strictly applicable except as empirical observation.

Since the profile is assumed to provide a baseline, it is desirable to address this technique.

Table 12 and Figure 1 provide a specimen of such analysis and a plot of annual infant mortality rates. In general, a downward trend is indicated in all civil divisions considered, although the trend is somewhat erratic in smaller areas. Also, the number of infant deaths is too small in the surrounding site to discern any meaningful trend. If more meaningful time-series data can be accumulated, we could examine them using more rigorous statistical techniques. Appendix 6 provides a technical discussion of time trend analysis and a specific procedure that may be used as the observational periods accrue over time. Examples of data series relevant in this context are included in the Appendix.

8.3 Analysis with Standardized Mortality or Morbidity Rates (SMR) and Standardized Proportional Mortality or Morbidity Rates (SPMR)

The SMR and SPMR are appropriate indices to aid in the clarity of the health profile. As presented in references in Appendix 7 these statistics can control for underlying differences in population distribution, where these differences are directly observable (SMR) or where the differences may exist but are not directly observable (SPMR).

The SMR and SPMR are highly appropriate in examining hazardous exposure-linked, cause-specific mortality and morbidity data.

Table 13 shows standardized mortality ratios (SMR) of malignant neoplasms for the three-county aggregate. The standard population used in this computation is the 1980 Missouri age/cause-specific mortality rates. The chi-square value associated with each SMR is presented to facilitate the test to see whether a given SMR differs significantly from unity (standard).

In general, cancer SMRs of the three-county area are lower than the state ratios. The 1979 SMR of digestive organs for the three-county area is significantly lower than the standard. On the other hand, the 1980 SMR of the same cancer site is slightly higher than the standard, but it fails to attain statistical significance. Alternatively, this observation can be stated as follows. The SMR of digestive organs for the three-county area significantly increased from 1979 to 1980, but it did not significantly exceed the state's rate. The SMR of residual cancer sites was slightly higher than the state's rate in 1979 but decreased below the state level in 1980.

Table 14 presents an analysis of hospital discharge data comparing the three-county area with Missouri with respect to selected neoplasm sites. First, as in Table 12, we examined standardized morbidity ratio. With the exception of leukemia all SMRs are less than unity indicating that the three-county area has relatively lower cancer incidence than Missouri. In fact, SMRs for digestive, other sites and all sites are significantly lower than the state. Although leukemia incidence is higher than that of the state, it fails to attain a statistical significance.

Second, we examined standardized proportional morbidity ratio to demonstrate usefulness of this measure in future use. This measure does not require any population data, but it is equivalent to the relative SMR which utilizes population data. Theoretical discussion is presented in references in Appendix 7.

This measure can be used to assess whether there has been any significant shift in incidence of specific cancer as compared with total cancer, adjusting for age-difference in proportional morbidity. Since this can be computed quickly based on hospital discharge data, it can be used to conduct a preliminary screening of excess morbidity. More definite assessment of morbidity can be made at a later date when population data become available.

TECHNICAL NOTES

Note 1. The table provided by the Missouri Center for Health Statistics is included to present data as to the completeness of the hospital discharge reporting system. Based on information provided by the Missouri Center, discharge data are estimated to be 80% complete (personal communication).

Note 2. The comparability of causes of death following the 10-year changes in the classification codes is provided through use of comparability ratios. These ratios, constructed at the national level, have not been used in this report since their applicability on a state or local level is highly questionable. A report by the North Carolina Center for Health Statistics is included in this section to point out the difficulties associated with the application of national ratios to a state or local level.

Note 3. A companion table of causes of death as given in Table 11 for hospital discharges was not prepared due to the low frequencies of the events for geographic areas other than total state.

Note 4. The natality and related mortality measures in Tables 1-8 were selected as potential sentinel health events. These would be sensitive for a monitoring system of serious hazardous wastes disposal producing adverse health effects. The events have been described in the literature as they may relate to hazardous waste disposal sites (see References - Appendix 2).

Note 5. Mortality data are presented for 2 years only, 1979 and 1980. This was done in order to eliminate difficulties associated with the use of national level comparability ratios. The single year, 1979, was used for hospital discharge data because the Missouri Center for Health Statistics indicated this was the only year of data available.

Comparison of Vital Statistics Birth and Death Frequencies with Hospital Discharge Frequencies, by Residence Area
1979

Residence Area	Deaths-Age <65			Deaths--Age 65+			Births		
	HD	VS	%	HD	VS	%	HD	VS	%
Missouri	5,155	7,377	70	16,176	18,987	85	56,850	76,056	75
Surrounding Site	5	6	83	3	7	43	43	63	68
Warren County	11	13	85	36	56	64	141	216	65
Aggregate Counties*	98	168	58	260	389	67	1,939	3,211	60

Source: Missouri Center for Health Statistics

NOTE: HD = Hospital Discharge File
VS = Vital Statistics File

*Aggregate counties include Warren, Lincoln and St. Charles

II. CHANGES IN THE CAUSE-OF-DEATH CLASSIFICATION SYSTEM

About every 10 years since 1900, what is now the International Classification of Diseases (ICD) is revised in order to incorporate the latest state-of-the-art in disease classification. Each revision produces some break in the comparability of cause-of-death statistics, and the Ninth Revision—first applied to 1979 deaths—is no exception. In fact, there are some serious breaks in comparability for a number of causes.

In order to interpret mortality trends, the National Center for Health Statistics (NCHS) provides national estimates of the discontinuity associated with a change in the ICD. To date, these "ratios of comparability" between the Eighth and Ninth revisions have been reported for 72 selected causes of death and 10 selected causes of infant death (2). More detailed analyses, including the construction of age-race-sex-specific ratios for each of 72 causes, are in progress.

Methodology

The method used by NCHS to construct comparability ratios was recommended by the International Conference for the Sixth Revision of the ICD which convened in France in 1948. In the present case, the comparability ratios are based on (a) all deaths in 1976 coded according to the Eighth Revision and (b) a sample of the 1976 deaths coded according to the Ninth Revision. For a particular cause, the denominator of the ratio is given by (a) while the numerator is an annual estimate derived from (b) of the number of 1976 deaths assigned to the comparable Ninth Revision cause. Data year 1976 was the most recent available at the time these ratios were constructed.

Once constructed, a ratio is applied to the number of deaths or death rate under the preceding revision. The ratio examined here may be applied to the years 1968 through 1978 inclusive although there is no guarantee that ratios for

1976 are applicable to other years. U.S. ratios also may not be applicable to a particular state, as will be seen, much less to a particular county. However, the acquisition of age-race-sex-specific ratios from NCHS (promised by 1982) should allow a state or county to compute more realistic ratios for the particular area and over time. In the meantime, examination of the U.S. ratios for the causes of this volume (certain site-specific cancers excluded) will reveal major changes in the ICD.

Comparability Ratios

A ratio of 1.0000 indicates that the same number of deaths was assigned to a particular underlying cause whether the Eighth or Ninth Revision was used. This can result from a perfect correspondence between the revisions or from compensating changes. Usually, a ratio of less than 1.0000 results from decreased assignments to the cause or from the Ninth Revision category representing only a part of the Eighth Revision category with which it is compared. Finally, a ratio of more than 1.0000 results from increased assignments to the cause or from the Ninth Revision category being broader than the Eighth Revision category with which it is compared. Table A shows the corresponding Eighth and Ninth revision codes and U.S. comparability ratios for selected causes. Note that ratios for site-specific cancers are available only for breast cancer (1.0089) and leukemia (1.0070).

Major ICD Changes for Volume 2 Causes

The following summary of changes addresses causes in the order of their appearance in Table A. Some causes where the comparability ratio is very close to 1.0000 are omitted.

- Despite internal changes, heart disease as an entire entity did not change very much. The comparability ratio of 1.0126 involves the transfer of unspecified heart failure from "symptoms and ill-defined conditions" (Eighth Revision 782.4).

Table A

Comparable Category Numbers for Selected Leading Causes of Death According to the Ninth and Eighth Revisions of the International Classification of Diseases with Comparability Ratios

Cause of Death (Ninth Revision)	Category Numbers According to the Ninth Revision	Category Numbers According to the Eighth Revision	Comparability Ratio
Diseases of Heart	390-398,402,404-429	390-398,402,404,410-429	1.0126
Acute Myocardial Infarction	410	410	1.0003
Other Ischemic Heart Disease	411-414	411-413	.7592
Hypertension with or without Renal Disease	401,403	400,401,403	1.2703
Cerebrovascular Diseases	430-438	430-438	1.0049
Atherosclerosis	440	440	1.0649
Cancer	140-208	140-209	1.0028
Diabetes Mellitus	250	250	.9991
Pneumonia and Influenza	480-487	470-474,480-486	.9264
Chronic Obstructive Pulmonary Disease and Allied Conditions	490-496	490-493	1.8846
Chronic Liver Disease and Cirrhosis	571	571	1.0110
Nephritis, Nephrotic Syndrome, and Nephrosis	580-589	580-584	1.7397
Motor Vehicle Accidents	810-825	810-823	1.0117
Other Accidents and Adverse Effects	800-807,826-949	800-807,825-949	.9841
Suicide	950-959	950-959	1.0032
Homicide and Legal Intervention	960-978	960-978	1.0057

- A major problem appears in the category other ischemic heart disease where a ratio of .7592 is due to the removal from this category of "cardiovascular disease, unspecified" (Eighth Revision 412.4) and "cardiovascular disease without mention of chronic ischemic heart disease, with hypertensive disease" (Eighth Revision 412.2).

- For hypertension, the comparability ratio of 1.2703 results from revised rules regarding the treatment of hypertension in combination with cardiovascular disease (CVD). In the Eighth Revision, hypertension always linked with CVD to become "hypertensive heart disease." In the Ninth Revision, this linkage occurs only when it is stated that the CVD is due to hypertension, and otherwise, the death is assigned to hypertension.

- The Eighth Revision fourth digits denoting the presence of hypertension in ischemic heart and cerebrovascular diseases no longer exist, making it impossible to count mentions of hypertension exactly as before. The new fourth digits for hypertensive disease indicate whether the disease was specified as malignant, benign, or neither.

- The ratio of 1.0649 for atherosclerosis (formerly arteriosclerosis) is due to changes in linkage rules. These changes affect underlying counts only, not mentions.

- For cancer as a whole, the Eighth and Ninth Revisions are virtually the same. However, malignant neoplasms specified as secondary are now coded to "unspecified site" rather than to the secondary site. Reductions in site-specific deaths that are due to this change cannot presently be quantified; NCHS promises comparability ratios at this level of detail late this year. However, for the state as a whole, only cancer of the pancreas and cancer of the cervix uteri show noticeable reductions between 1978 and 1979 (10.9 and 16.7 percent respectively).

- The comparability ratio of .9264 for pneumonia and influenza (formerly, influenza and pneumonia) is due largely to the removal from this category of deaths attributed to congenital, aspiration or acute interstitial pneumonia.

- The NCHS ratio of 1.8846 for chronic obstructive pulmonary diseases and allied conditions is intended to make Eighth Revision deaths due to bronchitis, emphysema, and asthma (Eighth Revision 490-493) comparable to the expanded Ninth Revision category

bronchiectasis (Eighth Revision 518) and unspecified chronic obstructive lung disease (Eighth Revision 519.3). The 1978 Leading Causes of Mortality had already added in 519.3 to form an expanded category, so the ratio of 1.8846 is only applicable to bronchitis, emphysema, and asthma figures from 1977 and earlier volumes.

- The category chronic liver disease and cirrhosis (formerly, cirrhosis of the liver) now includes alcoholic liver damage unspecified and other unspecified chronic liver disease.

- With a ratio of 1.7397, the large increase in the number of deaths assigned to nephritis, nephrotic syndrome and nephrosis (formerly, nephritis and nephrosis) results from the Ninth Revision's inclusion of uremia, acute tubular nephrosis, and renal failure, not otherwise stated.

- The category motor vehicle accidents now includes specific codes for nontraffic accidents involving a motor-driven snow vehicle or other off-road motor vehicle. The code for streetcar accidents has been removed.

- A reduction in deaths attributed to other accidents and adverse effects is due to new rules whereby an adverse effect takes precedence over the external cause. For example, aplastic anemia resulting from the administration of chloromycetin is coded to aplastic anemia in the Ninth Revision as opposed to "surgical and medical complications and misadventures" in the Eighth Revision.

In sum, the Volume 2 categories substantially affected by the ICD revision, and for which comparisons to 1978 and earlier years should be made very carefully using the comparability ratios, are: other ischemic heart disease; hypertension; pneumonia and influenza; chronic obstructive lung disease; and nephritis, nephrotic syndrome, and nephrosis.

Evaluation of Comparability Ratios

Table B applies the U.S. comparability ratios to N.C. deaths during 1975 through 1978 and compares the percent change in unadjusted deaths from 1977 to 1978 to the percent change in deaths from 1978 (adjusted) to 1979 (actual). Where there is a large difference between the two percent changes, we may

Table B

1975-1978 Adjusted and 1979
Actual Deaths with Percent Changes

North Carolina, 1979

Cause	Ratio-adjusted Deaths 1975	1976	1977	1978	1979 Deaths	Percent Differences 1977 and 1978 Unadjusted Deaths*	Percent Differences 1978 Adjusted and 1979 Actual Deaths
Diseases of Heart							
Acute Myocardial Infarction	16,820	17,029	17,142	17,665	17,337	+ 3.0	- 1.9
Other Ischemic Heart Disease	8,401	8,342	8,219	8,325	8,076	+ 1.3	- 3.0
Hypertension with or without Renal Disease	4,930	5,072	5,131	5,362	4,698	+ 4.5	-12.4
Cerebrovascular Diseases	221	255	231	183	230	-20.9	+25.7
Atherosclerosis	5,277	5,066	5,047	4,716	4,688	- 6.6	- 0.6
Cancer	607	617	667	654	577	- 1.9	-11.8
Diabetes Mellitus	7,865	8,266	8,605	8,935	9,099	+ 3.8	+ 1.8
Pneumonia and Influenza	862	867	819	795	799	- 2.9	+ 0.5
Chronic Obstructive Pulmonary Disease and Allied Conditions	1,296	1,252	1,244	1,323	1,053	+ 6.3	-20.4
Chronic Liver Disease and Cirrhosis	976	954	918	873	1,088	+14.2	+24.6
Nephritis, Nephrotic Syndrome, and Nephrosis	737	666	726	657	711	- 9.5	+ 8.2
Motor Vehicle Accidents	431	440	538	494	445	- 8.1	- 9.9
Other Accidents and Adverse Effects	1,542	1,588	1,457	1,510	1,537	+ 3.7	+ 1.8
Suicide	1,707	1,551	1,637	1,622	1,512	- 0.9	- 6.8
Homicide and Legal Intervention	740	683	734	658	703	-10.4	+ 6.8
	783	687	636	664	667	+ 4.4	+ 0.5

*Unadjusted numbers are from the 1977 and 1978 Leading Causes of Mortality, and may be obtained by dividing the numbers in this table by the comparability ratios in Table A.

suspect that the comparability ratio does not sufficiently adjust for classification changes. Large differences (greater than 10 percent) appear for other ischemic heart disease, hypertension, pneumonia and influenza, chronic obstructive pulmonary disease, chronic liver disease and cirrhosis, and suicide. In all of these cases except chronic obstructive pulmonary disease, there is reversal of sign between the two percent changes, and the difference is as great as 46.6 percentage points for hypertension. For hypertension as underlying cause, the 1978 death figure appears to be an aberration with the 1979 figure much more in line with earlier years. This illustrates the potential problem of using death data for a single year, especially for the less frequent causes. Suicide and liver disease deaths have also fluctuated substantially from year to year. For pneumonia and influenza, it appears that 1978 and earlier deaths should be downward adjusted by more than .9268 in order to bring them in line with the Ninth Revision coding rules.

One way to directly evaluate the validity of using the U.S. comparability ratios for North Carolina is to directly compare adjusted deaths to the actual Eighth Revision codes that correspond to the new Ninth Revision category. This comparison for chronic obstructive pulmonary diseases is given below.

	1976	1977	1978
Ratio-adjusted deaths (1.8846 applied to Eighth Revision 490-493)	954	918	873
Actual deaths due to Eighth Revision 490-493,518,519.3	1,024	1,075	1,236

For North Carolina, the comparability ratio fails to compensate for the additional deaths due to 518 and 519.3. This is apparent also in Table B. And the discrepancy has increased as certifiers use more and more the term "chronic obstructive pulmonary disease" in lieu of a more definitive diagnosis—a prime

example of how a ratio based on a single year's deaths may not be applicable to other years. It is therefore suggested that the NCHS ratio not be used in this case, but rather, actual deaths due to Eighth Revision codes 490-493, 518, and 519.3 should be determined and compared to Ninth Revision codes 490-496.

The data in Table B suggest that the comparability ratio for other ischemic heart disease does not go far enough in downward-adjusting N.C. deaths. A comparison of adjusted and actual deaths, shown below, points to the same conclusion.

	1976	1977	1978
Ratio-adjusted deaths (.7592 applied to Eighth Revision 411-413)	5,072	5,131	5,362
Actual deaths due to Eighth Revision 411,412.1,412.3,413	4,320	4,337	4,622

The discrepancy here appears related to N.C.'s greater assignment to Eighth Revision 412.2 and 412.4 (diagnoses left out of the Ninth Revision category), i.e., these categories accounted for 14 percent of N.C heart disease deaths in 1976 compared to 11 percent of U.S. heart disease deaths. Again, actual counts in the appropriate Eighth Revision categories would be preferable to the use of the U.S. ratio in North Carolina. These counts may be obtained from our Detailed Mortality Statistics volumes and corresponding county printouts or microfiche.

Most classification changes do not lend themselves to the type of accounting used for these two cause groups since subcategories of four-digit codes are in many cases involved and these are not readily quantifiable. Though we have pointed out the major discontinuities for the causes of this volume, the reader should be aware of other changes reported by NCHS for these causes and for other categories (2).

APPENDIX 1

Health Profile for Hazardous Waste Disposal or Treatment Facility

MISSOURI DEPARTMENT OF NATURAL RESOURCES
P.O. Box 1368 1915 Southridge Drive Jefferson City, Missouri 65102 (314) 751-3241

HEALTH PROFILE FOR HAZARDOUS WASTE DISPOSAL OR TREATMENT FACILITY

As required in 260.395.7(5) RSMo. 1978 as amended, a health profile shall be submitted with the application for a permit for either a disposal or treatment facility. The intended purpose of this legislative directive is two-fold: (1) to provide baseline data to the regulatory agency so as to allow for future comparisons and (2) to protect the facility owner-operator from spurious allegations of causing detrimental changes in the public health. One of the key phrases in the statute is "serious illness"; "serious illness" should be interpreted to mean an illness that may cause or significantly contribute to an increase in mortality or an increase in reversible or irreversible, incapacitating effects on the health of humans.

The health profile should address three main courses of data: mortality (death certificates). morbidity (hospital discharge), and natality (fetal death and birth certificates). Additionally, the state cancer registry and Division of Workmen's Compensation may be able to provide other specific information of value in describing the health status in the area of concern. Discussion of measurements of health characteristics should be focused on comparisons between state, county, and site specific rates. Site specific rates should reflect a geographic area of approximately 3 to 5 mile radius around the site. A minimum of five years data will be required for statistical analysis and averaging of rate computations; qualitative technical difficulties in data resulting in time periods of less than five years should be fully explained and justified in the text of the report.

In selecting health characteristics for measurement and analysis, it should be remembered that the statute specifically refers to "illness which might be attributable to environmental contamination." For wastes with known adverse health effects, conditions reflecting these effects should be selected for inclusion in the report; for wastes with unknown, or undocumented, health effects, conditions reflecting possible routes of exposure should be selected for inclusion in the report. For example, mental and nervous system conditions might be selected to reflect the effect of heavy metal wastes; liver and kidney conditions might be selected to reflect the impact of organic pesticide wastes with unknown health effects. Time spent describing deaths due to automobile accidents, illnesses due to communicable diseases, or rates of marriages and divorces will rarely be of help in assessing the impact of the site on public health. Explanation of the justification for including certain health measurements should be given in the narrative discussion in the body of the report.

APPENDIX 2

Health Effects-Disease-Substance Review

Health Effects-Disease-Substance Review (BHS)

Waste	Signs, Symptoms, Conditions	Ninth ICD No.
Arsenic Trioxide	Ulceration and perforation of nasal septum, Hyperpigmentation and hyperkeratoses of skin palmar and plantar surfaces; lung cancer(1)	162
2,4-D 2,4-Dichlorophen-oxyacetic acid	Hypo- and hyperexcitation of central nervous system with massive exposures(2), Controversary about induction of soft tissue sarcomas(3)	171
Asbestos	Asbestosis, cancer of lung, mesothelioma of pleura and peritoneum(4)	162,163 501
Chlordane	Blurred vision, cough, ataxia, delirium, convulsions, death(5)	
Formaldehyde	Irritant of eyes and respiratory tract, primary irritation and sensitization of skin(6)	
Phenol	Irritant of eyes, mucous membrane and skin; system absorbtion causes convulsions, liver and kidney damage(7)	
Mercury	Respiratory irritation, digestive disturbances, marked renal damage, neurologic and psychological disturbances, mercurialism(8)	583-585
Toxaphene	Convulsions, coma, death(9)	
Barium	Irritation of eyes and mucous membranes, pneumoconiosis(10)	502-504
Chromium VI Chromic acids Chromates	Severe irritant of nasopharynx, larynx, lungs and skin; causes lung cancer(11)	162
Bis (2-ethylhexyl) Phthalate	Very low toxicity; teratogenic in mice(12)	
Lead	Severe gastrointestinal disturbances, anemia, lead encephalopathy, motor weakness(13)	
Thiram	Irritant of eyes, mucous membranes and skin; sensitization dermatitis(14a)	

Waste	Signs, Symptoms, Conditions	Ninth ICD No.
Cyanides (alkalai)	Metabolic asphyxiation and rapid death(14b)	
Manganese	Chronic exposure causes a condition similar to Parkinson's disease. Headache, personality changes(15)	
Pentachloraphenol	Irritation of eyes and upper respiratory tract, increased metabolic rate, weakness, anorexia, weight loss, sweating, fever; chloracne(16)	
Lindane	Irritation of eyes, nose, throat; convulsions; cyanosis. May cause aplastic anemia(17).	
Endrin	Epileptiform convulsions, dizziness, lethargy, anorexia(18)	
Methoxychlor	A convulsant with low toxicity for humans(19)	
Maleic Anhydride	Severe irritation and sensitization of skin and respiratory tract. Dermatitis and bronchial asthma(20)	493

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APPENDIX 3

Charts and Methods Used to Determine 95% Confidence Intervals on Rates and Differences among Rates

CHART 1

95% Confidence Interval

Denominator Number	Single Rates							
	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0
100	±9.8	±13.9	±17.0	±19.6	±21.9	±24.0	±25.9	±27.7
250	6.2	8.8	10.7	12.4	13.8	15.2	16.4	17.5
500	4.4	6.2	7.6	8.8	9.8	10.7	11.6	12.4
1,000	3.1	4.4	5.4	6.2	6.9	7.6	8.2	8.8
2,000	2.2	3.1	3.8	4.4	4.9	5.4	5.8	6.2
2,500	2.0	2.8	3.4	3.9	4.4	4.8	5.2	5.5
5,000	1.4	2.0	2.4	2.8	3.1	3.4	3.7	3.9
10,000	1.0	1.4	1.7	2.0	2.2	2.4	2.6	2.8
25,000	0.6	0.9	1.1	1.2	1.4	1.5	1.6	1.8
50,000	0.4	0.6	0.8	0.9	1.0	1.1	1.2	1.2
100,000	0.3	0.4	0.5	0.6	0.7	0.8	0.8	0.9
250,000	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6
500,000	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4

Denominator Number	Single Rates							
	25	30	40	50	60	70	80	90
100	31.0	33.9	39.2	43.8	48.0	51.8	55.4	58.8
250	19.6	21.5	24.8	27.7	30.4	32.8	35.1	37.2
500	13.8	15.2	17.5	19.6	21.5	23.2	24.8	26.3
1,000	9.8	10.7	12.4	13.8	15.2	16.4	17.5	18.6
2,000	6.9	7.6	8.8	9.8	10.7	11.6	12.4	13.1
2,500	6.2	6.8	7.8	8.8	9.6	10.4	11.1	11.8
5,000	4.4	4.8	5.5	6.2	6.8	7.3	7.8	8.3
10,000	3.1	3.4	3.9	4.4	4.8	5.2	5.5	5.9
25,000	2.0	2.1	2.5	2.8	3.0	3.3	3.5	3.7
50,000	1.4	1.5	1.8	2.0	2.1	2.3	2.5	2.6
100,000	1.0	1.1	1.2	1.4	1.5	1.6	1.8	1.8
250,000	0.6	0.7	0.8	0.9	1.0	1.0	1.1	1.2
500,000	0.4	0.5	0.6	0.6	0.7	0.7	0.8	0.8

CHART 2
95% Confidence Interval for Differences of Two Rates

CI_2	Confidence Interval I																
	.2	.4	.6	.8	1.0	1.5	2.0	3.0	4.0	5.0	7.5	10.0	12.5	15.0	20.0	25.0	30.0
.2	.3	.4	.6	.8	1.0	1.5	2.0	3.0	4.0	5.0	7.5	10.0	12.5	15.0	20.0	25.0	30.0
.4		.6	.7	.8	1.0	1.6	2.0	3.0	4.0	5.0	7.5	10.0	12.5	15.0	20.0	25.0	30.0
.6			.8	1.0	1.2	1.6	2.1	3.0	4.0	5.0	7.5	10.0	12.5	15.0	20.0	25.0	30.0
.8				1.1	1.2	1.7	2.2	3.1	4.1	5.1	7.5	10.0	12.5	15.0	20.0	25.0	30.0
1.0					1.4	1.8	2.2	3.2	4.1	5.1	7.6	10.0	12.5	15.0	20.0	25.0	30.0
1.5						2.1	2.5	3.4	4.3	5.2	7.6	10.1	12.6	15.1	20.0	25.0	30.0
2.0							2.8	3.6	4.4	5.4	7.8	10.1	12.6	15.1	20.1	25.1	30.1
3.0								4.2	5.0	5.8	8.1	10.4	12.8	15.3	20.2	25.2	30.1
4.0									5.6	6.4	8.5	10.8	13.1	15.5	20.4	25.3	30.2
5.0										7.1	9.0	11.2	13.5	15.8	20.6	25.5	30.4
7.5											10.6	12.5	14.6	16.8	21.4	26.1	30.9
10.0												14.1	16.0	18.0	22.4	26.9	31.6
12.5													17.7	19.5	23.6	28.0	32.5
15.0														21.2	25.0	29.2	33.5
20.0															28.3	32.0	36.0
25.0																35.4	39.0
30.0																	42.4

Note: Used in conjunction with Chart 1: see Appendix 3 (continued). To use this chart determine the confidence interval for each rate from Chart 1 and find the confidence interval for the difference of the rates from this chart.

$$D \pm \sqrt{(C.I._1)^2 + (C.I._2)^2}$$

CHART 2 (continued)
95% Confidence Interval for Differences of Two Rates

Cl_2	Confidence Interval 1					
	40.0	50.0	60.0	70.0	80.0	90.0
.2	40.0	50.0	60.0	70.0	80.0	90.0
.4	40.0	50.0	60.0	70.0	80.0	90.0
.6	40.0	50.0	60.0	70.0	80.0	90.0
.8	40.0	50.0	60.0	70.0	80.0	90.0
1.0	40.0	50.0	60.0	70.0	80.0	90.0
1.5	40.0	50.0	60.0	70.0	80.0	90.0
2.0	40.0	50.0	60.0	70.0	80.0	90.0
3.0	40.1	50.1	60.1	70.1	80.0	90.0
4.0	40.2	50.2	60.1	70.1	80.1	90.1
5.0	40.3	50.2	60.2	70.2	80.2	90.1
7.5	40.7	50.6	60.5	70.4	80.4	90.3
10.0	41.2	51.0	60.8	70.7	80.6	90.6
12.5	41.9	51.5	61.3	71.1	81.0	90.9
15.0	42.7	52.2	61.8	71.6	81.4	91.2
20.0	44.7	53.8	63.2	72.8	82.5	92.2
25.0	47.2	55.9	65.0	74.3	83.8	93.4
30.0	50.0	58.3	67.1	76.2	85.4	94.9
40.0	56.6	64.0	72.1	80.6	89.4	98.5
50.0		70.7	78.1	86.0	94.3	103.0
60.0			84.8	92.2	100.0	108.2
70.0				99.0	106.3	114.0
80.0					113.1	120.4
90.0						127.3

Methods Used to Derive Confidence Interval Tables

ASSESSING STABILITY OF RATES AND CHANGES IN RATES

As indicated on page 4, an area's infant mortality rate (or any other rate) cannot be taken as the true rate for that area. It is an estimate and as such its variability must be assessed. The simplest method for doing this is the computation of a 95-percent confidence interval. This interval is defined so that it has 95-percent probability of including the true rate. The formula and an example are given in figure 3. The computations shown are derived under the assumption that the number of deaths in an area has a Poisson distribution.[14]

A useful rule is that any rate based on fewer than 20 cases in the numerator will have a 95-percent confidence interval which is about as wide as the rate itself (i.e., from 0.5r to 1.5r). Roughly speaking, this means all that can confidently be said about an area with 20 deaths out of, say, 1,000 live births is that the true rate is within 20 ± 10 per 1,000. Clearly

Figure 3. Confidence intervals for rates.

Let r = rate per 1,000 (e.g., infant mortality rate)

n = denominator upon which rate is based (e.g., number of live births or number of live births plus fetal deaths)

The limits of the 95-percent confidence interval are:

upper limit: $r + 61.981 \sqrt{\frac{r}{n}}$

lower limit: $r - 61.981 \sqrt{\frac{r}{n}}$

For an area with 3 deaths and 100 live births:

$$r = \frac{3}{100} \times 1{,}000 = 30$$

$$61.981 \sqrt{\frac{r}{n}} = 61.981 \sqrt{\frac{30}{100}} = 33.948$$

upper limit: 63.948

lower limit: -3.948

In this case the limits are so wide that the interval (-4.0, 64.0) includes negative values, which are impossible.

Suppose the numbers of births and deaths increased tenfold. Then $r = \frac{30}{1{,}000} \times 1{,}000 = 30$

$$61.981 \sqrt{\frac{r}{n}} = 61.981 \sqrt{\frac{30}{1{,}000}} = 10.735$$

upper limit: 40.735

lower limit: 19.265

The interval (19.3, 40.7) is much narrower than the one in the first situation, but it still shows that the area's true rate is not known with much precision.

Source: Statistical Notes for Health Planners: Joel C. Kleinman, Number 2, July 1976, National Center for Health Statistics, Hyattsville, Md.

Figure 4. Confidence intervals for the ratio of two independent rates.

Let

r_1 = rate for period 1 (or area 1)

d_1 = number of deaths for period 1 (or area 1)

r_2 = rate for period 2

d_2 = number of deaths for period 2

$R = r_1/r_2$

Then the limits of the 95-percent confidence interval are

$$\text{upper limit:} \quad R + 1.96R\sqrt{\frac{1}{d_1} + \frac{1}{d_2}}$$

$$\text{lower limit:} \quad R - 1.96R\sqrt{\frac{1}{d_1} + \frac{1}{d_2}}$$

Consider the following example:

Year	*Number of infant deaths*	*Number of live births*	*Infant mortality rate per 1,000*
1961-65	200	5,000	40
1966-70	100	4,000	25

$$R = \frac{40}{25} = 1.6$$

$$1.96R\sqrt{\frac{1}{d_1} + \frac{1}{d_2}} = 1.96\,(1.6)\,(.1225) = .384$$

upper limit: $1.6 + .384 = 1.984$

lower limit: $1.6 - .384 = 1.216$

Thus the rate in 1961-65 is from 1.22 to 1.98 times the 1966-70 rate with 95-percent confidence. Since this interval does not include 1, there was a statistically significant ($P < .05$) decrease in the area's infant mortality rate.

The confidence interval for the ratio of two independent rates can also be easily obtained from the confidence intervals for each rate. If the confidence intervals for each rate are

$$r_1 \pm 61.981\sqrt{\frac{r_1}{n_1}} = r_1 \pm CL_1$$

$$r_2 \pm 61.981\sqrt{\frac{r_2}{n_2}} = r_2 \pm CL_2$$

then the confidence interval for $R = \frac{r_1}{r_2}$ is

$$R \pm R\sqrt{\left(\frac{CL_1}{r_1}\right)^2 + \left(\frac{CL_2}{r_2}\right)^2}$$

Figure 5. Confidence intervals for the difference between two independent rates.

r_1 = rate for period 1 (or area 1)

n_1 = denominator upon which r_1 is based

r_2 = rate for period 2 (or area 2)

n_2 = denominator upon which r_2 is based

$D = r_1 - r_2$

The limits of the 95-percent confidence interval are

upper limit: $D + 61.981 \sqrt{\frac{r_1}{n_1} + \frac{r_2}{n_2}}$

lower limit: $D - 61.981 \sqrt{\frac{r_1}{n_1} + \frac{r_2}{n_2}}$

Using the same example as in figure 4,

$$D = 40 - 25 = 15$$

$$\frac{r_1}{n_1} = \frac{40}{5{,}000} = .008$$

$$\frac{r_2}{n_2} = \frac{25}{4{,}000} = .00625$$

$$\sqrt{\frac{r_1}{n_1} + \frac{r_2}{n_2}} = \sqrt{.01425} = .1194$$

$$61.981 \sqrt{\frac{r_1}{n_1} + \frac{r_2}{n_2}} = 7.399$$

upper limit: $15 + 7.399 = 22.399$

lower limit: $15 - 7.399 = 7.601$

Thus the difference between the two rates is between 7.6 and 22.4 with 95-percent confidence. Since this interval does not include zero, the rates are significantly different at the 5-percent level.

The confidence interval for the difference between two independent rates can also be easily obtained from the confidence intervals for each rate. If the confidence intervals for each rate are

$$r_1 \pm 61.981 \sqrt{\frac{r_1}{n_1}} = r_1 \pm CL_1$$

$$r_2 \pm 61.981 \sqrt{\frac{r_2}{n_2}} = r_2 \pm CL_2$$

then the confidence interval for $D = r_1 - r_2$ is

$$D \pm \sqrt{CL_1^2 + CL_2^2}$$

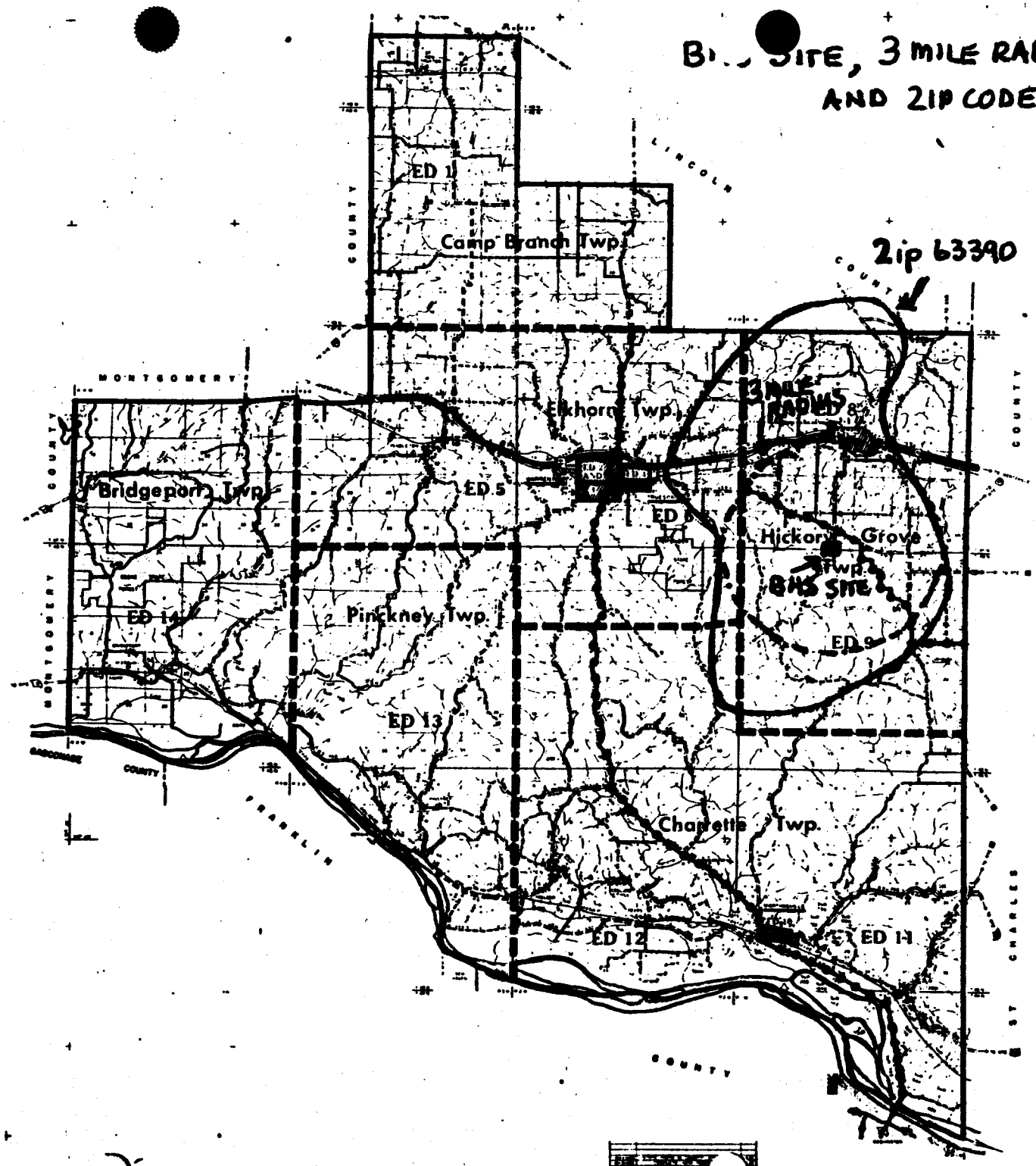
APPENDIX 4

Warren County and Surrounding Area

Waste Site Operation

(Zip Code 63390)

BIG SITE, 3 MILE RADIUS AROUND THE SITE AND ZIP CODE 63390 CONTOUR



DETAIL MAPS ARE AVAILABLE FOR:

ED	NAME	STATUS
2,3	WARRENTON	city
4	TRUESDALE	town
7	WRIGHT CITY	city
10	MARTHASVILLE	city

LEGEND

Boundary Symbols and Identification

- State
- County
- Minor Civil Division
- Incorporated Place
- Unincorporated Place
- Enumeration District Line
- Enumeration District Number — ED 51

ALL ENUMERATION DISTRICT NUMBERS PRECEDED BY 219-
ENUMERATION DISTRICTS 1 TO 14
DISTRICT OFFICE CODE 0612

ENTIRE COUNTY IN CONGRESSIONAL DISTRICT NO. 9

GENERAL HIGHWAY MAP
WARREN COUNTY
MISSOURI

PREPARED BY THE
MISSOURI STATE HIGHWAY DEPARTMENT
DIVISION OF HIGHWAY PLANNING
IN COOPERATION WITH THE
DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

SCALE

PRICE 10

APPENDIX 5

TABLES

TABLE 1

Resident Live Births, Birth Rates, Fertility Rates, by Surrounding Site, Warren County, Aggregate Counties,* and Missouri: 1980

	Surrounding Site	Warren County	Aggregate Counties	Missouri
Births	67	253	3314	78,588
Birth Rate[1]	17.1	17.0	18.3	16.0
Fertility Rate[2]	NA	81.3	79.8	71.0

[1]Births per 1000 population.

[2]Births per 1000 women age 15-44.

Sources: Missouri Vital Statistics 1980; and unpublished data from Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

TABLE 2

Number and Rate of Fetal Deaths by Surrounding Site, Warren County, Aggregate Counties,* and Missouri, by Time Periods

Years	Surrounding Site	Warren County	Aggregate Counties	Missouri
1977-80				
Number of Fetal Deaths	4	7	89	2,840
Fetal Death Rate[1]	16.5	7.8	7.2	9.5
1972-76				
Number of Fetal Deaths	3	10	122	4,078
Fetal Death Rate[1]	13.5	11.5	10.2	11.7

[1]Fetal deaths per 1000 live births.

Sources: Missouri Vital Statistics; and unpublished data from Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

TABLE 3

Number and Rate of Low Birth Weight Infants by Surrounding Site, Warren County, Aggregate Counties,* and Missouri, by Time Periods

Year	Surrounding Site	Warren County	Aggregate Counties	Missouri
1977-80				
Low Birth Weight Infants[1]	23	67	668	20,469
Rate of Low Birth Weight	94.7	75.1	54.4	68.2
1972-76				
Low Birth Weight Infants[1]	21	75	797	25,466
Rate of Low Birth Weight	92.5	86.6	66.4	73.2

[1]Births under 2501 grams per 1000 live births.

Sources: Missouri Vital Statistics; and unpublished data from Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

TABLE 4

Number and Rate of Live Births with Congenital Malformations by Surrounding Site, Warren County, Aggregate Counties,* and Missouri: 1979

Type (ICD-9-CM Code)	Surrounding Site	Warren County	Aggregate Counties	Missouri Total
740-742	0	0	7	82
743-744	0	0	2	99
745-747	0	2	8	255
748	0	1	1	40
749	0	0	5	84
750-751	0	0	6	167
754-756	1	1	13	335
757	0	0	4	165
758	0	0	2	52
759	0	0	3	40
Total Anomalies	2	5	64	2,067
Total Births with Anomalies	2	5	55	1,822
Total Births	43	141	1,939	56,850
$\frac{\text{Total Births with Anomalies}}{\text{Total Births}} \times (1000)$	46.5	35.4	28.4	32.0

Sources: Missouri Hospital Discharge Data, 1979, from Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

TABLE 5

Number and Rate Perinatal and Neonatal Deaths by Surrounding Site, Warren County, Aggregate Counties,* and Missouri in Two Time Periods

Years	Surrounding Site	Warren County	Aggregate Counties	Missouri
1977-80				
	Number of Events			
Perinatal	9	19	169	5,717
Neonatal	5	12	80	2,877
	Rate per 1000 live births			
Perinatal	37.2	21.3	13.8	19.0
Neonatal	20.6	13.5	6.5	9.6
1972-76				
	Number of Events			
Perinatal	6	27	261	8,357
Neonatal	3	17	139	4,279
	Rate per 1000 live births			
Perinatal	26.4	31.2	21.7	24.0
Neonatal	13.2	19.6	11.6	12.3

Sources: Missouri Vital Statistics; and unpublished data from Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

TABLE 6

Number and Rate of Infant Deaths (Excluding Accidental or Violent Deaths) by Surrounding Site, Warren County, Aggregate Counties,* and Missouri in Two Time Periods

	Surrounding Site	Warren County	Aggregate Counties	Missouri
1977-80				
Number of Infant Deaths	8	15	111	3,991
Infant Death Rate[1]	32.9	16.8	9.0	13.3
1972-76				
Number of Infant Deaths	6	20	162	5,684
Infant Death Rate[1]	26.4	23.1	13.5	16.3

[1]Infant deaths per 1000 live births (excluding accidental or violent deaths).

Sources: Missouri Vital Statistics 1976-80; and unpublished data from Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

TABLE 7

Number and Rate of Infants Born with Gestation Period of Less Than 37 Weeks, by Surrounding Site, Warren County, Aggregate Counties,* and Missouri in Two Time Periods

	Surrounding Site	Warren County	Aggregate Counties	Missouri
1977-80				
Number with < 37 weeks gestation	30	89	837	23,883
Rate with < 37 weeks gestation	123.5	99.8	68.1	79.5
1972-76				
Number with < 37 weeks gestation	18	68	834	28,756
Rate with < 37 weeks gestation	79.3	78.5	69.4	82.7

Source: Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

TABLE 8

Number and Rate per 1000 Live Births with 5 Minute Apgar Score < 8 by Surrounding Site, Warren County, Aggregate Counties,* and Missouri: 1978-80

	Surrounding Site	Warren County	Aggregate Counties	Missouri
Number with Apgar Score Less than 8	10	29	313	10,812
Percent with Apgar Score Less than 8	54.6	42.8	32.8	47.6

Source: Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

TABLE 9

Number and Rate of Malignant Neoplasm Deaths by Surrounding Site, Warren County, Aggregate Counties,* and Missouri: 1979-80

Cause (ICD-9 Category)	Surrounding Site	Warren County	Aggregate Counties	Missouri
	Number of Events			
Digestive (150-159)	1	7	96	4,956
Respiratory (160-165)	1	8	121	5,440
Leukemia (204-208)	0	0	17	789
Other Sites	10	31	200	8,606
Total (140-208)	12	46	434	19,791
	Rate per 100,000 population[1]			
Digestive (150-159)	25.5	40.3	53.0	100.8
Respiratory (160-165)	25.5	53.7	66.8	110.6
Leukemia (204-208)	0.0	0.0	9.4	16.0
Other Sites	255.4	208.1	110.4	175.0
Total (140-208)	306.4	308.7	239.5	402.5

Source: Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

[1]1980 population used as denominator.

TABLE 10

Number and Rate of Hospital Discharges for Malignant Neoplasms by Surrounding Site, Warren County, Aggregate Counties,* and Missouri: Annual Average, 1979

Cause (ICD-9-CM Category)	Surrounding Site	Warren County	Aggregate Counties	Missouri
		Number of Events		
Digestive (150-159)	3	16	101	5,696
Respiratory (160-165)	1	8	121	5,305
Leukemia (204-208)	0	0	32	1,138
Other Sites	16	51	476	22,264
Total (140-208)	20	75	730	34,803
		Annual Rate per 10,000 Population		
Digestive (150-159)	7.7	10.7	5.6	11.6
Respiratory (160-165)	2.6	5.4	6.7	10.8
Leukemia (204-208)	0.0	0.0	1.8	2.3
Other Sites	40.9	34.2	26.3	45.3
Total (140-208)	51.1	50.3	40.3	70.8

Source: Missouri Center for Health Statistics, 1979.

*Aggregate counties include Warren, Lincoln, and St. Charles.

TABLE 11

Number of Selected Primary Diagnoses of Hospital Discharges by Site, Warren County, Aggregate Counties,* and Missouri: 1979

Cause (ICD-9-CM) Category)	Surrounding Site	Warren County	Aggregate Counties	Missouri
		Number of Events		
2771				23
284			2	297
3577				6
4781		1	6	233
4930			2	164
501			1	10
502				11
503				3
504				3
584		1	2	177
585		1	14	1,018
9890				3
9892				4
9893			1	27
9894			2	41
9895		1	4	299
9896				2
9898			2	30
9899				10
Total	0	4	36	2,361
Total Discharges	445	1,732	15,970	651,736

Source: Unpublished data from Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

TABLE 12

Number and Rate of Infant Deaths[1] (excluding accidental or violent deaths) by Surrounding Site, Warren County, Aggregate Counties,* and Missouri by Years, 1972-1980

	1972	1973	1974	1975	1976	1977	1978	1979	1980
Surrounding Site									
Accidental	0	0	0	0	0	0	1	0	0
Non-accident	2	2	1	0	1	1	1	3	3
Infant Death Rate	58.8	40.8	20.8	00.0	21.7	16.6	18.8	47.6	44.8
Warren County									
Accidental	0	0	0	0	0	0	1	0	0
Non-accidental	5	4	5	4	2	5	2	3	5
Infant Death Rate	27.9	28.5	27.6	22.4	10.6	23.4	9.6	13.8	19.8
Aggregate County									
Accidental	1	1	2	1	1	1	1	0	1
Non-accidental	36	36	32	38	20	34	25	26	26
Infant Death Rate	15.0	15.0	13.2	16.1	7.9	12.3	8.3	8.0	7.8
Missouri									
Accidental	54	52	47	35	26	31	36	39	32
Non-accidental	1275	1167	1128	1088	1026	1007	1043	1003	938
Infant Death Rate	17.6	17.0	16.2	15.8	14.9	13.8	14.4	13.2	11.9

[1]Infant deaths (excluding accidental or violent deaths) per 1000 live births.

Source: Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln and St. Charles.

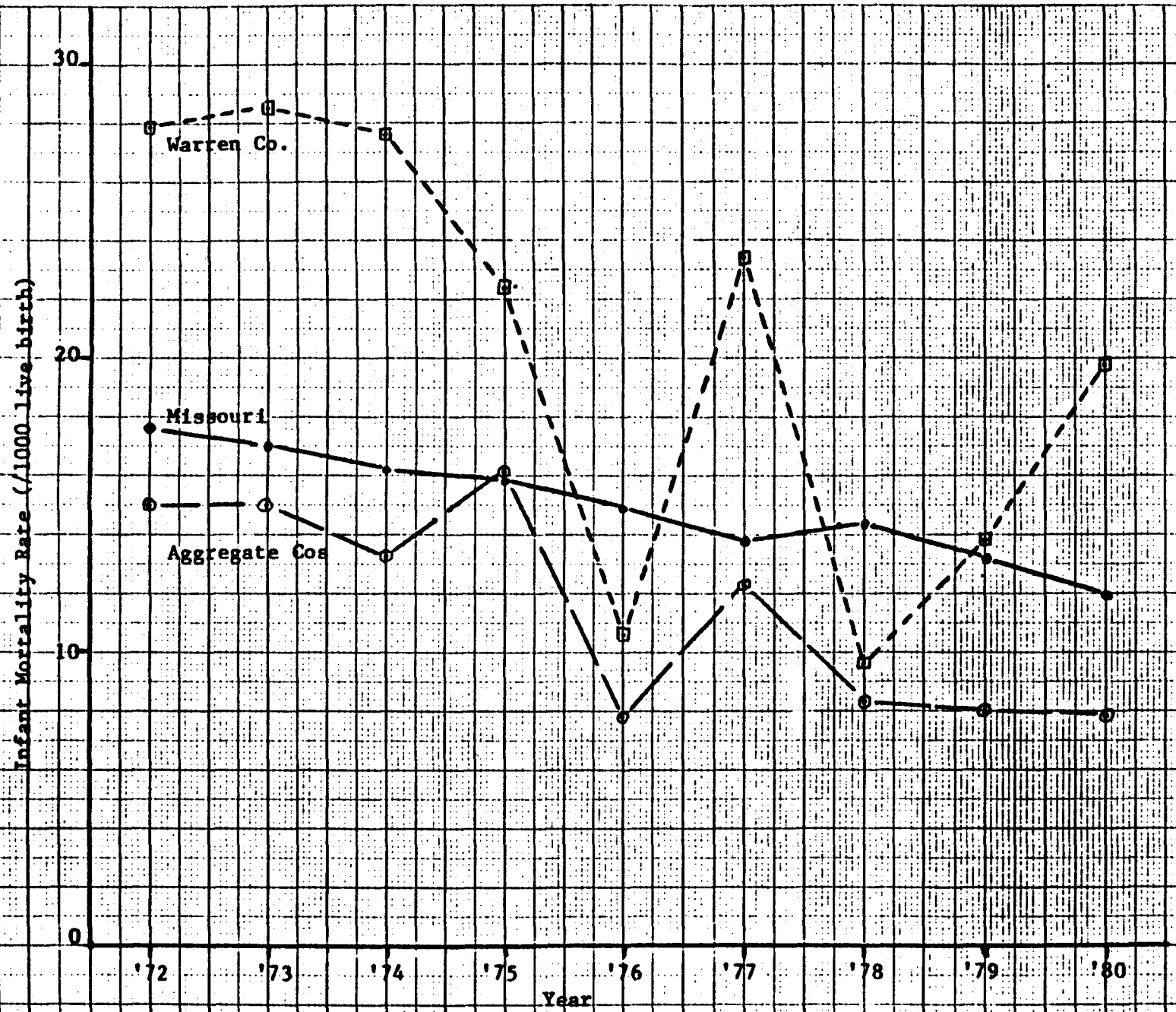


Figure 1 Infant Mortality Rates (excluding accidental and violent deaths)

TABLE 13

Standardized Mortality Ratio* of Malignant Neoplasm Deaths for Aggregate Counties and Missouri: 1979 and 1980

Neoplasm Sites (ICD-9)	Aggregate Counties**		Missouri	
	1979 SMR ($\chi^2(1)$)	1980 SMR ($\chi^2(1)$)	1979 SMR ($\chi^2(1)$)	1980 SMR
Digestive (150-159)	.655 (6.56)+	1.032 (0.06)	.996 (0.04)	1.000
Respiratory (160-165)	.911 (0.49)	.955 (0.14)	1.008 (0.17)	1.000
Leukemia (204-208)	.863 (0.18)	.926 (0.05)	1.078 (2.29)	1.000
Other Sites	1.112 (1.24)	.847 (2.49)	1.026 (2.78)	1.000
All Sites (140-208)	.935 (0.96)	.925 (1.37)	1.015 (2.28)	1.000

*Computed using the 1980 Missouri specific rates as the standard.

**Include Warren, Lincoln, and St. Charles Counties.

+Significantly different from the standard (Missouri, 1980) at .05 level.

TABLE 14

Standardized Ratio of Malignant Neoplasm Hospital Discharges for Aggregate Counties: 1979

Neoplasm Sites (ICD-9)	Standardized Morbidity Ratio* ($\chi^2(1)$)	Standardized Proportional Morbidity** Ratio	Relative SMR***
Digestive (150-159)	.768 (7.08)+	.851 (2.63)	.902
Respiratory (160-165)	.948 (0.34)	1.163 (2.75)	1.114
Leukemia (204-208)	.918 (0.23)	1.019 (0.011)	1.079
Other Sites	.845 (13.62)+	1.000 (0.00)	.993
All Sites (140-208)	.851 (19.00)+	1.000 (---)	1.000

*Computed using the 1979 Missouri age-specific morbidity rates as the standard.

**Computed using the 1979 Missouri age-specific proportions of all neoplasms as the standard.

***Computed dividing SMR of specific neoplasm by SMR of all neoplasm sites.

+Significantly different from unity at .05 level.

APPENDIX 6

Time Series

Time Series Analysis

The problem of assessing the impact of a discrete intervention on an environmental or social process can be conceptualized as quasi-experimental time series as suggested by Campbell and Stanley (1966). In this conceptualization, an intervention (establishment of a dump site) breaks the time series into two segments, pre-intervention and post-intervention series. The null hypothesis that the intervention had no impact on the time series can be tested by comparing the pre- and post-intervention segments of the time series.

While the conceptualization appears to be simple, the statistical analysis of quasi-experimental time series requires careful deliberation considering the nature and scope of the data. Ordinary least-squares regression estimates which assume uncorrelated adjacent error terms are seldom well suited for time series data. When the structure of serial dependence is known, the difference between pre- and post-intervention series levels may be estimated from a generalized least-squares model. However, this approach is of limited use, since the structure of serial dependence is seldom known. A more practical approach is empirical modeling of serial dependence as a time series process. In any time series, there may be three sources of "noise" which could obscure the intervention: (1) trend, seasonality, and random error. The analysis will be confounded if the model does not account for these types of "noise." For the purpose of accounting for all three types of "noise," the general class of Auto Regressive Integrated Moving Average (ARIMA) models can be used. [The use of ARIMA models for analyzing time series quasi-experiments is suggested by Box and Tiao (1975).] Once these sources of variance have been modeled, the impact of an intervention can be tested and measured.

The problem of building an ARIMA model for a time series is not a routine task. Unless the ARIMA model is statistically adequate and parsimonious (or substantially meaningful), its application will lead to invalid inferences. The model building strategy calls for an interative procedure. First, a model should be identified based on the autocorrelation and partial autocorrelation functions, parameters need to be estimated, and then the model should be diagnosed for statistical adequacy examining the model residuals. If the model is not satisfactory, it is necessary to return to the identification stage to explore other possibilities. For example, the series is nonstationary, it needs to be differenced. There may be many ARIMA models which will fit a time series, but only one of these models will be the most parsimonious for the given task. The model building therefore requires not only statistical expertise but also thorough understanding of the nature of the time series process and the intervention.

Once a proper model has been built this model can be used for impact assessment. If addition of the intervention component to the model increases the explanatory power of the model by a statistically significant quantity, we may conclude that the external intervention has had a statistically significant impact on the time series. The intervention component can be specified in several distinct functions. We think of the impact in terms of two characteristics: onset and duration. An impact on a time series may be either abrupt or gradual in onset and either permanent or temporary in duration. Based on these characteristics four patterns of impact can be conceptualized. Based on the nature of the problem, we can select one of these impact patterns, so the null hypothesis will concern not only the statistical significance of an impact but also on its form. Considering the nature of our problem, it is reasonable to test for a gradual, permanent impact.

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Box, G.E.P. and G.C. Tiao (1975) "Intervention Analysis with Application to Economic and Environmental Problems." J of Amer Stat Asso 70:70-92.

Resident Live Births by Surrounding Sites, Warren County, Aggregate Counties,* and Missouri, 1972-1980

Year	Surrounding Site	Warren	Aggregate Counties	Missouri
	Number	Number	Number	Number
1980	67	253	3,314	78,588
1979	63	216	3,211	76,056
1978	53	209	3,009	72,654
1977	60	214	2,755	72,957
1976	46	188	2,539	68,781
1975	50	178	2,364	68,442
1974	48	181	2,423	69,412
1973	49	140	2,293	68,605
1972	34	179	2,392	72,597

Source: Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

Number and Rate* of Live Births Under 2500 Grams by Surrounding Site, Warren County, Aggregate Counties, and Missouri

Year	Surrounding Site		Warren		Aggregate Counties		Missouri	
	Number	Rate*	Number	Rate*	Number	Rate*	Number	Rate*
1980	8	119.4	22	87.0	189	57.0	5249	66.8
1979	5	79.4	13	60.2	184	57.3	5102	67.1
1978	6	113.2	15	71.8	153	50.8	5073	69.8
1977	4	66.7	17	79.4	142	51.5	5045	69.2
1976	3	65.2	11	58.5	147	57.9	4997	72.7
1975	3	60.0	19	106.7	170	71.9	4949	72.3
1974	5	104.2	18	99.4	161	66.4	5156	74.3
1973	5	102.0	16	114.3	151	65.9	5006	73.0
1972	5	147.1	11	61.5	168	70.2	5358	73.8

Source: Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

**Rate per 1,000 live births.

Number and Rate* of Fetal Deaths by Surrounding Site, Warren County, Aggregate Counties,** and Missouri, 1972-1980

Year	Surrounding Site		Warren		Aggregate Counties		Missouri	
	Number	Rate*	Number	Rate*	Number	Rate*	Number	Rate*
1980	0	0.0	0	0.0	13	3.9	680	8.7
1979	1	15.9	1	4.6	34	10.6	693	9.1
1978	2	37.7	3	14.4	20	6.6	719	9.9
1977	1	16.7	3	14.0	22	8.0	748	10.3
1976	0	0.0	2	10.6	21	8.3	750	10.9
1975	1	20.0	3	16.8	30	12.7	788	11.5
1974	1	20.8	2	11.0	29	12.0	848	12.2
1973	1	20.4	3	21.4	25	10.9	812	11.8
1972	0	0.0	0	0.0	17	7.1	880	12.1

Source: Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

*Rate per 1,000 live births.

Number and Rate* of Perinatal Deaths by Surrounding Sites, Warren County, Aggregate Counties,** and Missouri, 1972-1980

Year	Surrounding Site		Warren		Aggregate Counties		Missouri	
	Number	Rate*	Number	Rate*	Number	Rate*	Number	Rate*
1980	1	14.9	3	11.9	32	9.7	1320	16.8
1979	4	63.5	4	18.5	54	16.8	1416	18.6
1978	3	56.6	5	23.9	34	11.3	1498	20.6
1977	1	16.7	7	32.7	49	17.8	1483	20.3
1976	0	0.0	3	16.0	37	14.6	1497	21.8
1975	1	20.0	6	33.7	59	25.0	1596	23.3
1974	2	41.7	7	38.7	62	25.6	1711	24.6
1973	2	40.8	6	42.9	56	24.4	1689	24.6
1972	1	29.4	5	27.9	47	19.6	1864	25.7

Source: Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

*Rate per 1,000 live births.

Number and Rate* of Neonatal Deaths by Surrounding Sites, Warren County, Aggregate Counties,** and Missouri, 1972-1980

Year	Surrounding Site		Warren		Aggregate Counties		Missouri	
	Number	Rate*	Number	Rate*	Number	Rate*	Number	Rate*
1980	1	14.9	3	11.9	19	5.7	640	8.1
1979	3	47.6	3	13.9	20	6.2	723	9.5
1978	1	18.9	2	9.6	14	4.7	779	10.7
1977	0	0.0	4	18.7	27	9.8	735	10.1
1976	0	0.0	1	5.3	16	6.3	747	10.9
1975	0	0.0	3	16.8	29	12.3	808	11.8
1974	1	20.8	5	27.6	33	13.6	863	12.4
1973	1	20.4	3	21.4	31	13.5	877	12.8
1972	1	29.4	5	27.9	30	12.5	984	13.6

Source: Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

*Rate per 1,000 live births.

Number and Rate* of Births of Gestation Under 37 Weeks
Surrounding Site, Warren County, Aggregate
Counties,** and Missouri, 1972-1980

Year	Number	Rate*	Number	Rate*	Number	Rate*	Number	Rate*
1980	10	149.3	28	110.7	223	67.4	6344	80.7
1979	11	174.6	23	106.5	227	70.7	6000	78.9
1978	6	113.2	16	76.6	199	66.1	5926	81.6
1977	3	50.0	22	102.8	188	68.2	5613	76.9
1976	2	43.5	10	53.2	180	70.9	5831	84.8
1975	4	80.0	17	95.5	165	69.8	5474	80.0
1974	6	125.0	19	105.0	174	71.8	5592	80.6
1973	4	81.6	9	64.3	164	71.5	5685	82.7
1972	2	58.8	13	72.6	151	63.1	6174	85.0

Source: Missouri Center for Health Statistics.

*Aggregate counties include Warren, Lincoln, and St. Charles.

**Rate per 1000 live births.

APPENDIX 7

Method and Use of SMR and SPMR

Analysis and Interpretation

Armitage, P. Statistical Methods in Medical Research, Oxford: Blackwell, 1974, pp 388-391.

the same in each case.

INDIRECT METHOD

This method is more easily thought of as a comparison of observed and expected deaths than in terms of standardized rates. In the special population the total number of deaths observed is $\sum r_i$. The number of deaths expected if the age-specific death rates were the same as in the standard population is $\sum n_i P_i$. The overall mortality experience of the special population may be expressed in terms of that of the standard population by the ratio of observed to expected deaths:

$$M = \frac{\sum r_i}{\sum n_i P_i}. \tag{12.22}$$

When multiplied by 100 and expressed as a percentage, (12.22) is known as the *Standardized Mortality Ratio* (SMR).

To obtain the variance of M we can use the result $\mathrm{var}(r_i) = n_i p_i q_i$, and regard the P_i as constants without any sampling fluctuation (since we shall often want to compare one SMR with another using the same standard population; in any case the standard population will often be much larger than the special population, and $\mathrm{var}(P_i)$ will be much

smaller than $\mathrm{var}(p_i)$). This gives

$$\mathrm{var}(M) = \frac{\sum n_i p_i q_i}{(\sum n_i P_i)^2}. \tag{12.23}$$

As usual, if the p_i are small, $q_i \simeq 1$ and

$$\mathrm{var}(M) \simeq \frac{\sum r_i}{(\sum n_i P_i)^2}. \tag{12.24}$$

If the purpose of calculating $\mathrm{var}(M)$ is to see whether M differs significantly from unity, $\mathrm{var}(r_i)$ could be taken as $n_i P_i Q_i$, on the assumption that p_i differs from a population value P_i by sampling fluctuations. If again the P_i are small, and $Q_i \simeq 1$, we have

$$\mathrm{var}(M) = \frac{\sum n_i P_i}{(\sum n_i P_i)^2} = \frac{1}{\sum n_i P_i}, \tag{12.25}$$

the reciprocal of the total expected deaths. Denoting the numerator and denominator of (12.22) by O and E (for 'observed' and 'expected'), an approximate significance test would be to regard O as following a Poisson distribution with mean E. If E is not too small, the normal approximation to the Poisson leads to the use of $(O-E)/\sqrt{E}$ as a standardized normal deviate, or, equivalently, $(O-E)^2/E$ as a $\chi^2_{(1)}$ variate. This is, of course, the familiar formula for a $\chi^2_{(1)}$ variate.

Example 12.10

Table 12.10 shows some occupational mortality data, a field in which the SMR is traditionally used. The special population is that of farmers in 1951, aged 20 to 65 years. The standard population is that of all males in these age groups, whether occupied or retired. Deaths of farmers over a 5 year period are used to help reduce the sampling errors, and the observed and expected numbers are expressed on a 5 year basis.

The SMR is

$$100M = \frac{(100)(7{,}678)}{11{,}005} = 69{\cdot}8 \text{ per cent},$$

and

$$\begin{aligned}\mathrm{var}(\mathrm{SMR}) &= 10^4\,\mathrm{var}(M)\\ &\simeq \frac{(10^4)(7{,}678)}{(11{,}005)^2} \qquad \text{from (12.24)}\\ &= 0{\cdot}634,\end{aligned}$$

and

$$\mathrm{SE}(\mathrm{SMR}) = 0{\cdot}80 \text{ per cent.}$$

or $\sqrt{.634}$!

Table 12.10 Mortality of farmers in England and Wales, 1949–53, in comparison with that of the male population.

Age i	(i) Annual death rate per 100,000, all males (1949–53) $\frac{1}{5}P_i \times 10^5$	(ii) Farmers, 1951 census population n_i	(iii) Deaths of farmers 1949–53 r_i	(iv) Deaths expected in five years $5 \times$ (i) $\times$ (ii) $\times 10^{-5}$ n_iP_i
20–	129·8	8,481	87	55
25–	152·5	39,729	289	303
35–	280·4	65,700	733	921
45–	816·2	73,376	1,998	2,994
55–64	2,312·4	58,226	4,571	6,732
			7,678	11,005

Source: Registrar General's Decennial Supplement, England and Wales 1951, Occupational Mortality, Part II, Vol. 2 (1958).

The smallness of the standard error of the SMR in Example 12.10 is typical of much vital statistical data, and is the reason why sampling errors are often ignored in this type of work. Indeed there are problems in the interpretation of occupational mortality statistics which often overshadow sampling errors. For example, occupations may be less reliably stated in censuses than in the registration of deaths, and this may lead to biases in the estimated death rates for certain occupations. Even if the data are wholly reliable, it is not clear whether a particularly high or low SMR for a certain occupation reflects a health risk in that occupation or a tendency for selective groups of people to enter it. In Example 12.10, for example, the SMR for farmers may be low because farming is healthy, or because unhealthy people are unlikely to enter farming or are more likely to leave it. Note also that in the lowest age group there is an *excess* of deaths among farmers (87 observed, 55 expected). Any method of standardization carries the risk of over-simplification, and the investigator should always compare age-specific rates to see whether the contrasts between populations vary greatly with age.

The method of indirect standardization is very similar to that described as the comparison of observed and expected frequencies on p. 372. Indeed if, in the comparison of two groups, A and B, the standard population were defined as the pooled population $A+B$, the methods

would be precisely the same. It was stated on p. 372 that the ap
significance test for the comparison of observed and exp
quencies was Cochran's test (p. 371), and we have seen (p.
Cochran's test is equivalent to a comparison of two *direct*-sta
rates. There is thus a very close relationship between the
indirect methods when the standard population is chosen to b
of the two special populations.

12.7 GOODNESS OF FIT OF FREQUENC DISTRIBUTIONS

It is often useful to regard a random variable as following a
distributional form; common examples are the normal, bin
Poisson distributions. The observed frequencies at different
in different grouping intervals, of the variables will not be
those expected by theory, and the question arises whethe
crepancy between observed and expected frequencies can
explained by sampling fluctuation.

In the examples mentioned above, a theoretical probabilit
tion can be fitted by using certain simple statistics calculated
data. For a normal distribution, for instance, we need to es
mean μ and variance σ^2 by the sample mean $\bar{x}$ and estimate o
s^2 (after application of Sheppard's correction if necessary)
binomial the parameter π is estimated by the sample mean $\bar{r}$ o
n (using the notation of section 2.5). For the Poisson the pa
is estimated by $\bar{x}$ (see section 2.6). Expected values of the fr
can now be calculated, from exact formulae in the case of the
and Poisson distributions and from tables in the case of th
distribution.

Suppose the frequency for any value or grouping interval i
by O_i, and the expected value by E_i. Then if E_i is a small fract
normal frequency, the random variation of O_i about E_i is appr
represented by a Poisson distribution. Unless E_i is qu
$(O_i - E_i)/\sqrt{E_i}$ can be taken as approximately a standardize
deviate, and $(O_i - E_i)^2/E_i$ as a $\chi^2_{(1)}$ variate. If there were k
quencies, and if all the deviations $O_i - E_i$ were independent,
expect from the general theory of section 3.4 that the familia

$$X^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

In this case not only the numerator but also the denominator of SMR(i) must be estimated using the $\hat{p}_{ij}$'s obtained from the test populations; in particular, the best estimate of SMR(i) is then given by

$$\widehat{\mathrm{SMR}}(i) = \sum_{j=1}^{c} n_{ij}\hat{p}_{ij} \Big/ \sum_{j=1}^{c} n_{ij}\hat{p}_{0j}, \qquad i = 1, 2, \ldots, p, \tag{2.1}$$

where $\hat{p}_{0j} = \sum_{i=1}^{p} n_{ij}\hat{p}_{ij} / \sum_{i=1}^{p} n_{ij}$. The corresponding best estimate of $P(i)$ is $\hat{P}(i) = \hat{x}_0 \widehat{\mathrm{SMR}}(i)$, where $\hat{x}_0$ is obtained by substituting $\hat{p}_{0j}$ for p_{0j} and $n_{.j} = \sum_{i=1}^{p} n_{ij}$ for n_{0j} in the expression for x_0.

The use of a "pooled standard" of the form (2.2) is not without precedent. For example, researchers associated with the Evans County Coronary Heart Disease Study (Cassel et al., 1970) have compared the SMR of white males having low systolic blood pressure with that of white males having high systolic blood pressure, the categories being age groups and the standard population consisting of all white males in Evans County, Georgia. Similar pooled standards were used to study the effects of other physiological factors as well. Although decisions about the choice of standard are essentially arbitrary and depend somewhat upon personal philosophy, the use of a pooled standard is suggested when the response under study (e.g., incidence of coronary heart disease or cancer of the cervix) has not been the subject of a previous investigation conducted under comparable conditions (e.g., the same definition of disease, the same age groups, etc.).

It is important to emphasize the distinction between the above two choices of the standard population because the different estimates (2.1) and (2.2) necessitate the use of different procedures for testing H_0. These approaches are described in the next two sections.

3. Testing H_0 when π_0 is Chosen Independently of the Test Populations

If we define the vector

$$\hat{\boldsymbol{\theta}}' = (\widehat{\mathrm{SMR}}(1), \widehat{\mathrm{SMR}}(2), \ldots, \widehat{\mathrm{SMR}}(p)),$$

where $\widehat{\mathrm{SMR}}(i)$ is given by (2.1), then it follows that

$$E(\hat{\boldsymbol{\theta}}') = \boldsymbol{\theta}' = (\mathrm{SMR}(1), \mathrm{SMR}(2), \ldots, \mathrm{SMR}(p))$$

and

$$\mathrm{var}(\hat{\boldsymbol{\theta}}) = \mathbf{D} = \mathrm{diag}(\sigma_1^2, \sigma_2^2, \ldots, \sigma_p^2),$$

where

$$\sigma_i^2 = \sum_{j=1}^{c} n_{ij}p_{ij}(1 - p_{ij}) \Big/ \Big(\sum_{j=1}^{c} n_{ij}p_{0j}\Big)^2, \qquad i = 1, 2, \ldots, p.$$

In this framework, the hypothesis H_0 can equivalently be written as

$$H_0 : \mathbf{C}\boldsymbol{\theta} = \mathbf{0},$$

where the $(k-1) \times p$ matrix $\mathbf{C}$ has as its $(j-1)$-th row the vector $\mathbf{c}'_{j-1} = (0, 1, 0, \ldots, 0, -1, 0, \ldots, 0)$ having -1 in the i_1-th position, $+1$ in the i_j-th position, and zeros elsewhere, $j = 2, 3, \ldots, k$. From a general criterion due to Wald (1943), it can be shown that

$$T_1 = \hat{\boldsymbol{\theta}}'\mathbf{C}'(\mathbf{C}\hat{\mathbf{D}}\mathbf{C}')^{-1}\mathbf{C}\hat{\boldsymbol{\theta}}$$

is approximately distributed as a central χ^2 variable with $(k-1)$ degrees of freedom when H_0 is true, where $\hat{\mathbf{D}} = \mathrm{diag}(\hat{\sigma}_1^2, \hat{\sigma}_2^2, \ldots, \hat{\sigma}_p^2)$ is the matrix obtained from $\mathbf{D}$ by replacing p_{ij} by $\hat{p}_{ij}$ everywhere it appears. We would then reject H_0 at the α level of significance if $T_1 > \chi^2_{k-1;1-\alpha}$, where $\chi^2_{k-1;1-\alpha}$ is the upper $100(1-\alpha)$% point of the central χ^2_{k-1} distribution.

For the special case of H_0 when $k = p$ (so that we are testing the equality of all p SMR's or all p indirect rates), $\mathbf{C}$ is simply the $(p-1) \times p$ matrix

$$\begin{bmatrix} 1 & -1 & 0 & \cdots & 0 \\ 1 & 0 & -1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & 0 & 0 & \cdots & -1 \end{bmatrix}. \tag{3.1}$$

When $k = 2$, we may alternatively use as the test statistic

$$Z = [\widehat{\mathrm{SMR}}(i_1) - \widehat{\mathrm{SMR}}(i_2)]\,(\hat{\sigma}_{i_1}^2 + \hat{\sigma}_{i_2}^2)^{-1/2},$$

which is approximately distributed as a standard normal random variable when H_0 is true. In this case we would reject H_0 at the α level of significance when $|Z| > Z_{1-\alpha/2}$, where $Z_{1-\alpha/2}$ is the $100(1-\alpha/2)$% point of the standard normal distribution.

The use of T_1 to test hypotheses which involve an SMR(i) for which $\hat{p}_{ij}$ is equal to 0 or 1 for every j requires special attention since the estimated variance of $\widehat{\mathrm{SMR}}(i)$ is zero. Such a situation can be handled by either choosing an estimate of p_{ij} according to some criterion other than maximum likelihood (e.g., $(d_{ij} + 1)/(n_{ij} + 2)$ is the Bayes estimate for a uniform prior on p_{ij}) or deciding not to test hypotheses about SMR(i).

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On Testing Hypotheses Concerning Standardized Mortality Ratios*

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This paper describes tests of hypotheses concerning the equality of any k standardized mortality ratios (or, equivalently, of any k indirect adjusted rates) from p ($k \leq p$) populations. The distinction is made between the situation where the standard population is chosen independently of the p populations and one where the standard is formed by pooling all p populations. Different test procedures are required for these two situations. When the pooled standard is used, the appropriate test procedure is applicable only when $k = p$. Experimental evidence is given showing that when the pooled standard is used both test procedures lead to the same conclusion concerning the hypothesis for the case $k = p$. The recommendation is made, therefore, to use the "incorrect" test procedure when the standard is a pooled one even when $k < p$.

1. INTRODUCTION

Suppose that there are p test populations $\pi_1, \pi_2, \ldots, \pi_p$, a standard population π_0, and c categories, where the term "test population" denotes a collection of individuals under study. We shall regard a test population as a sample from the universe, for only then is there any point in discussing statistical estimation and hypothesis testing (see Chiang (1961), Section I, for comments along this line). Let

n_{ij} = the number of individuals in category j of π_i,

p_{ij} = the true probability of death in category j of π_i,

d_{ij} = the observed number of deaths in category j of π_i,

$i = 0, 1, \ldots, p$, $j = 1, 2, \ldots, c$. Then, the *standardized mortality ratio* SMR(i) for population π_i is defined to be

$$\mathrm{SMR}(i) = \sum_{j=1}^{c} n_{ij} p_{ij} \Big/ \sum_{j=1}^{c} n_{ij} p_{0j}, \qquad i = 0, 1, \ldots, p. \tag{1.1}$$

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(note that SMR(0) = 1.) SMR's are used to compare mortality among populations with different age distributions and (1.1) is essentially a weighted average of the proportions for the c categories (usually age groups), the weights being determined from the standard population.

In this paper we shall be concerned with testing the following general hypothesis, namely

$$H_0 : \mathrm{SMR}(i_1) = \mathrm{SMR}(i_2) = \cdots = \mathrm{SMR}(i_k), \tag{1.2}$$

where $1 \leq i_1 < i_2 < \cdots < i_k \leq p$ and $2 \leq k \leq p$. Since the indirect adjusted death rate $P(i)$ is equal to $\alpha_0 \mathrm{SMR}(i)$, where α_0 is $\sum_{j=1}^{c} n_{0j} p_{0j} / \sum_{j=1}^{c} n_{0j}$, the overall proportion of deaths in the standard population, it is clear that testing H_0 is equivalent to testing that $P(i_1) = P(i_2) = \cdots = P(i_k)$. Hence, in what follows we can restrict ourselves to considering tests of H_0.

Finally, although we have presented the problem in a mortality-type setting, the techniques developed below can validly be used in any situation where the response is dichotomous (e.g., was or was not a migrant, did or did not have cancer).

2. CHOICE OF π_0 AND ITS EFFECT ON TESTS OF H_0

When the standard population π_0 is chosen independently of the test populations $\pi_1, \pi_2, \ldots, \pi_p$, then it is reasonable to assume, for all practical purposes, that the quantities $p_{0j} = d_{0j}/n_{0j}$ are nonstochastic (cf., Chiang (1961), Hill (1956), Keyfitz (1966)). An example of such a situation would be one in which the test populations are all the different counties in England in 1963 and the standard is the U.S. population in 1963 or the 1945 population of France. In this case the best estimate of SMR(i) is

$$\widehat{\mathrm{SMR}}(i) = \sum_{j=1}^{c} n_{ij} \hat{p}_{ij} \Big/ \sum_{j=1}^{c} n_{ij} p_{0j}, \qquad i = 1, 2, \ldots, p, \tag{2.1}$$

where $\hat{p}_{ij} = d_{ij}/n_{ij}$ is approximately normally distributed for large n_{ij}, has mean p_{ij} and variance $p_{ij}(1 - p_{ij})/n_{ij}$, and is uncorrelated with $\hat{p}_{i'j'}$ unless both $i = i'$ and $j = j'$. The corresponding best estimate of $P(i)$ is $\hat{P}(i) = \alpha_0 \widehat{\mathrm{SMR}}(i)$.

However, the situation is quite different when the standard population is formed by pooling the test populations together so that p_{0j} has the structure

$$p_{0j} = \sum_{i=1}^{p} n_{ij} p_{ij} \Big/ \sum_{i=1}^{p} n_{ij}, \qquad j = 1, 2, \ldots, c. \tag{2.2}$$

4. Testing H_0 when π_0 is Formed from the Test Populations

When p_{0j} is of the form (2.2) so that the estimate of SMR(i) is given by (2.3), the procedure for testing H_0 depends on the relationships expressed in the following lemmas.

Lemma 4.1. *When p_{0j} has the form* (2.2), *then* $\sum_{i=1}^{p} a_i \mathrm{SMR}(i) = 1$, *where* $a_i = \sum_{j=1}^{c} n_{ij} p_{0j} \sum_{i=1}^{p} \sum_{j=1}^{c} n_{ij} p_{0j}$.

Proof. From (1.1),

$$\sum_{i=1}^{p} a_i \mathrm{SMR}(i) = \sum_{i=1}^{p} \left(\sum_{j=1}^{c} n_{ij} p_{ij} \Big/ \sum_{i=1}^{p} \sum_{j=1}^{c} n_{ij} p_{0j} \right)$$

$$= \sum_{i=1}^{c} \left(\sum_{j=1}^{p} n_{ij} p_{ij} \right) \Big/ \sum_{i=1}^{c} \sum_{j=1}^{p} n_{ij} p_{0j},$$

and the result then follows by using (2.2).

Lemma 4.2. *When p_{0j} has the form* (2.2), then SMR(1) = SMR(2) = ... = SMR(p) *if and only if there is a subset of* ($p - 1$) SMR's *all equal to one.*

Proof. If SMR(1) = SMR(2) = ... = SMR(p) = μ, say, then, from Lemma 4.1, $\mu \sum_{i=1}^{p} a_i = 1 = \mu$ since $\sum_{i=1}^{p} a_i = 1$. If there is a subset of ($p - 1$) SMR's all equal to one, then, taking this subset to be the first ($p - 1$) SMR's, it follows from Lemma 4.1 that $\sum_{i=1}^{p-1} a_i + a_p \mathrm{SMR}(p) = 1$, or $\mathrm{SMR}(p) = (1 - \sum_{i=1}^{p-1} a_i) a_p = a_p/a_p = 1$. This completes the proof.

Lemma 4.3. *Let* $W'_{ii'} = \sum_{j=1}^{c} n_{ij} n_{i'j} (p_{ij} - p_{i'j})/n_{.j}$ and define $W'_i = \sum_{i'=1}^{p} W'_{ii'}$, $i, i' = 1, 2, \ldots, p$.
Then,

(i) $W'_{ii'} = -W'_{i'i}$ *and* $W'_{ii'} = 0$ *if* $i = i'$,

(ii) $\sum_{i=1}^{p} W'_i = 0$,

(iii) *when p_{0j} has the form* (2.2), SMR(i) = 1 *if and only if* $W'_i = 0$, $i = 1, 2, \ldots, p$.

Proof. (i) Trivial.

(ii) $\sum_{i=1}^{p} W'_i = \sum_{i=1}^{p} \sum_{j=1}^{c} n_{ij} p_{ij} - \sum_{i'=1}^{p} \sum_{j=1}^{c} n_{i'j} p_{i'j} = 0$.

(iii) Using (1.1) and (2.2), we have

$$\mathrm{SMR}(i) - 1 = \left(\sum_{j=1}^{c} n_{ij} p_{ij} \Big/ \sum_{j=1}^{c} n_{ij} p_{0j} \right) - 1$$

$$= \left[\sum_{j=1}^{c} n_{ij} p_{ij} - \sum_{j=1}^{c} n_{ij} \left(\sum_{i'=1}^{p} n_{i'j} p_{i'j} \Big/ \sum_{i'=1}^{p} n_{i'j} \right) \right] \Big/ \sum_{j=1}^{c} n_{ij} p_{0j}$$

$$= \left[\sum_{j=1}^{c} n_{ij} \left(\sum_{i'=1}^{p} n_{i'j} p_{ij} - \sum_{i'=1}^{p} n_{i'j} p_{i'j} \right) \Big/ n_{.j} \right] \Big/ \sum_{j=1}^{c} n_{ij} p_{0j}$$

$$= \sum_{i'=1}^{p} \left[\sum_{j=1}^{c} n_{ij} n_{i'j} (p_{ij} - p_{i'j}) n_{.j} \right] \Big/ \sum_{j=1}^{c} n_{ij} p_{0j}$$

$$= \sum_{i'=1}^{p} W'_{ii'} \Big/ \sum_{j=1}^{c} n_{ij} p_{0j} = W'_i \Big/ \sum_{j=1}^{c} n_{ij} p_{0j}.$$

This completes the proof.

So, when p_{0j} is of the form (2.2), it follows from Lemma 4.2 and from part (iii) of Lemma 4.3 that testing the hypothesis that SMR(1) = SMR(2) = ... = SMR(p)(= 1) or that $P(1) = P(2) = \ldots = P(p)(= a_0)$ is equivalent to testing the hypothesis that $W'_i = 0$ for every i, $i = 1, 2, \ldots, p$. The appropriate test statistic for this latter hypothesis is

$$T_2 = \hat{W}'C'(C\hat{\Sigma}C')^{-1} C\hat{W},$$

where $\hat{W}'$ and $\hat{\Sigma}$ are the estimates of $W' = (W'_1, W'_2, \ldots, W'_p)$ and $\Sigma = ((\mathrm{cov}(W'_i, W'_{i'})))_{i,i'=1}^{p}$ obtained by putting $\hat{p}_{ij}$ for p_{ij}, and where C is given by (3.1). (From parts (ii) and (iii) of Lemma 4.3, it follows that one can alternatively use for C the matrix obtained by deleting any one row of the identity matrix of order p.) The statistic T_2 is approximately distributed as a central χ^2 variate with ($p - 1$) degrees of freedom when the hypothesis that $W = 0$ is true.

The determination of the elements of Σ is somewhat tedious but straightforward. In particular,

$$\mathrm{cov}(W'_i, W'_{i'}) = \sum_{t=1}^{p} \sum_{t'=1}^{p} \mathrm{cov}(W'_{it}, W'_{i't'})$$

can be evaluated directly from the following formulae (see part (i) of Lemma 4.3):

$\mathrm{cov}(\Pi'_{il}, \Pi'_{i'l'}) = 0$ if either $i = l$, $i' = l'$, or both, or if i, l, i' and l' are all different;

$$\mathrm{cov}(\Pi'_{il}, \Pi'_{i'l'}) = -\mathrm{cov}(\Pi'_{il}, \Pi'_{l'i'}) = -\mathrm{cov}(\Pi'_{li}, \Pi'_{i'l'}) = \mathrm{cov}(\Pi'_{li}, \Pi'_{l'i'}),$$

$$\mathrm{cov}(\Pi'_{il}, \Pi'_{il'}) = \sum_{j=1}^{c} n_{ij}n_{lj}n_{l'j}\, p_{ij}(1 - p_{ij})/n_{.j}^2$$

if i, l and l' are all different; and, for $i = l$,

$$\mathrm{var}(\Pi'_{il}) = \sum_{j=1}^{c} \frac{n_{ij}^2 n_{lj}^2}{n_{.j}^2}\left[\frac{p_{ij}(1 - p_{ij})}{n_{ij}} + \frac{p_{lj}(1 - p_{lj})}{n_{lj}}\right].$$

For the special case $p = 2$, the test statistic takes the form $\Pi'^2_{12}/\widehat{\mathrm{var}}(\Pi'_{12})$, which is approximately distributed as χ_1^2 when SMR(1) = SMR(2). This case has been studied by Cochran (1954) and Quade (unpublished).

Unfortunately, the above procedure cannot be used to test the general hypothesis H_0 given by (1.2) when k is to be strictly less than p. To illustrate the difficulty, consider the case where $k = 2 < p$ and we wish to test H_0 : SMR(i_1) = SMR(i_2). Then, because p exceeds k, we cannot claim that this hypothesis is equivalent to the hypothesis that $\Pi'_{i_1} - \Pi'_{i_2} = 0$, which is necessary for the test statistic T_2 to be appropriate.

One can apparently get around this obstacle by deciding to form the pooled standard using only the k test populations whose SMR's are to be compared. However, as can be seen from (2.2), this changes the basic structure of the SMR's under test and so rejection of (1.2) in this case does not necessarily imply rejection when the pooled standard is based on all p test populations. Another approach, which does not call for a modification of the standard to suit the test, is suggested by the findings in the next section.

5. Some Experimental Results

Computer programs have been prepared which calculate SMR's and indirect rates for $p \leq 10$ populations and $c \leq 20$ categories. One of these programs is written in Fortran IV for the IBM 360 computer at the Triangle University Computation Center (TUCC) and the other in Time-Sharing Fortran for the Call-A-Computer system. These programs allow the user to specify the standard population or to instruct the computer to form the standard by pooling the test populations. The user of either program may test hypotheses of the form (1.2) as described in Sections 3 and 4.

These programs were used to compare the two test procedures presented in this paper in the situation where the standard population is formed by pooling

TABLE I

Values of T_1 and T_2 Obtained by Testing H_0 for $k = p$ When the Standard is Formed by Pooling the Test Populations

Number of Populations p	"Incorrect" T_1	"Correct" T_2
2	28.2136	28.7157
2	16.9346	17.4983
2	21.2930	21.6004
2	10.2976	10.1884
2	10.4231	10.8275
2	1.7373	1.7946
2	3.1895	3.2292
2	7.6659	7.3038
2	0.1513	0.1533
2	0.0475	0.0476
2	1.2320	1.2488
2	0.1386	0.1450
2	1.4684	1.4437
2	1.9818	1.9965
2	0.1872	0.1947
2	1.3005	1.2828
2	1.4704	1.4462
2	0.2089	0.2131
2	0.4434	0.4296
2	0.5522	0.5302
2	2.2685	2.1455
2	0.0042	0.0043
2	0.0361	0.0466
2	2.6843	2.7078
3	0.0016	0.0016
3	3.5495	3.5685
3	8.1122	7.8162
3	10.4558	10.8670
3	2.5145	2.4496
3	10.6485	10.5651
3	17.0558	17.6127
4	21.6299	21.9669
4	23.9671	24.6090
4	20.3859	20.9092
4	16.6307	16.4557
4	7.1490	7.0270
4	9.7703	9.6688
4	3.6639	3.6656

est populations. The results obtained should be of considerable interest use researchers who have incorrectly used the test procedure described ction 3 when they should have employed that of Section 4, for it is conble that inferences drawn from using the "incorrect" test statistic could be ed when the "correct" one is used.

e data used in this computer study was obtained from the Evans County nary Heart Disease Study mentioned earlier. There were 38 different data each partitioned into the same $c = 7$ age groups; 25 of the sets were based o populations, 7 on three, and 6 on four. The hypothesis (1.2) for $k = p$ ested and the values of the test statistics T_1 and T_2 for each data set are nted in Table 1.

can be seen from Table 1 that, despite the rationale for preferring the test edure of Section 4, both test statistics give almost exactly the same numerical s in each case. This motivates us to make the conjecture (and, at present, nly a conjecture) that a test of the hypothesis (1.2) when the pooled standard rmed from all p test populations and the "incorrect" test procedure ed on 3 is used will yield fairly reliable results not only when $k = p$ but also he case when $k = p$.

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Equilibrium Studies of Two Locus Haploid Populations with Recombination*

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Introduction

Recently there has been a revival of interest in the equilibrium properties of the two-locus haploid system with recombination. The sources of this interest are, first, the problem of reduction of linkage or evolution of supergenes (Nei, 1967, 1969) and, second, the problem of the advantage of sexual over asexual reproduction (Crow and Kimura, 1965; Maynard Smith, 1968; Eshel and Feldman, 1970). A third reason for studying these equilibrium properties is to make statements concerning the time-dependent behavior of the gametic balance when the starting conditions are known.

It has been assumed in the literature that in the general haploid two-locus models no polymorphic equilibria can be stable. However, I believe there is only one case which has been examined to any extent. This is the model where AB, Ab, aB and ab have fitnesses 1, $1 - s$, $1 - s$ and 1, respectively. In this case, the equilibria corresponding to fixation in AB and ab are locally stable while their domains of attraction are separated by the surface on which AB and ab have equal frequencies. On this surface, there is an unstable equilibrium given by

$$\hat{x}_1 = \hat{x}_4 = 1 - \hat{x}_2, \qquad (1)$$

$$\hat{x}_2 = \hat{x}_3 = \frac{1}{4}\left\{1 + \frac{\alpha}{2} + \alpha\beta - \sqrt{1 + \alpha^2\left(\frac{1}{4} + \beta^2\right) + \alpha(1 - \alpha\beta)}\right\},$$

where $\alpha = r/(1 - r)$, $\beta = (1 - s)/s$ and $\hat{x}_1, \hat{x}_2, \hat{x}_3, \hat{x}_4$ are the equilibrium frequencies of AB, Ab, aB and ab, respectively (see, e.g., Nei, 1967). Here r is the recombination fraction.

Let the fitnesses of AB, Ab, aB and ab be w_1, w_2, w_3, w_4, respectively. If $w_4 > w_1 = w_2, w_3$ then $\hat{x}_4 = 1$ is locally stable, and $\hat{x}_1 = 1$ is locally stable

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COMPARISON OF THE PROPORTIONATE MORTALITY RATIO AND STANDARDIZED MORTALITY RATIO RISK MEASURES

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Two commonly used measures of differential mortality risks in epidemiologic studies are the standardized mortality ratio (SMR) and the proportionate mortality ratio (PMR). The SMR is the statistic of choice when the population-at-risk by age, race, sex is known. It provides information on a study group's overall risk of dying as well as risks for specific causes of death. On the other hand, the PMR is a tool for estimating cause-specific risks when the available data consist only of deaths without knowledge of the characteristics of the population from which the data came. A proportionate mortality study does not yield information on the total force of mortality, and cause-specific PMRs are only approximations to what an SMR analysis would have produced.

Recently, both measures have received considerable attention in the context of methodologies used in occupational mortality studies (1–6). The reports of those studies tend to treat each method separately without discussing their interrelationship in detail. In this paper, we illustrate the inherent relationship between the SMR and PMR methods by performing both types of analyses on each of several sets of data. Our purpose is to give investigators lacking a strong background in biostatistical methods a basic understanding of some of the risk measures they use in everyday practice.

Abbreviations: ICD, International Classification of Diseases; PMR, proportionate mortality ratio; SMR, standardized mortality ratio.

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GENERAL PRINCIPLES

Initially, we will ignore the problem of adjustment for confounding factors, such as age, in order to present the ideas as simply as possible. Table 1 contains notation which will be used to demonstrate certain relationships among the statistical measures discussed in this paper. The following relationships exist among the three sets of ratios in table 1:

$$\frac{d_i}{d} = \frac{d_i}{n} + \frac{d}{n} \qquad (1)$$

$$\frac{D_i}{D} = \frac{D_i}{N} + \frac{D}{N}. \qquad (2)$$

In a proportionate mortality study, the relative risk of a particular cause in the study group is estimated by comparing the relative frequencies d_i/d and D_i/D. From equations 1 and 2, we see that each of these proportions is a function of the cause-specific death rate and the total death rate. We generally assume that the ratio of proportions ($d_i/d \div D_i/D$) yields about the same result as the ratio of cause-specific rates ($d_i/n \div D_i/N$).

Let us examine this assumption algebraically. From equations 1 and 2, we can write:

$$\frac{d_i/d}{D_i/D} = \frac{d_i/n}{D_i/N} \times \frac{D/N}{d/n}, \qquad (3)$$

which can be rewritten as:

$$\frac{d_i}{d(D_i/D)} = \frac{d_i}{n(D_i/N)} \times \frac{D/N}{d/n},$$

which is equivalent to:

$$\frac{\text{Observed deaths}}{\text{Expected deaths*}} = \frac{\text{Observed deaths}}{\text{Expected deaths†}} \times \frac{\text{Comparison Group total death rate}}{\text{Study Group total death rate}}$$

* Based on ratio of specific cause to all causes.
† Based on ratio of specific cause to number at risk.

or, in other terms:

$$\text{PMR} = \text{SMR} \times \text{Factor} \qquad (4)$$

where Factor = ratio of overall death rates (Comparison Group to Study Group).

Thus, the relative risk estimate using proportions is a function of the SMR and the ratio of total death rates (Comparison Group to Study Group). It follows that the ratio of porportions (PMR) is the same as the ratio of rates (SMR) if, and only if, the overall death rates in the two groups are equal; i.e., $d/n = D/N$.

Now, in actual practice, the assumption of equality of death rates for all causes is often unrealistic. For example, industrial populations generally have a significantly lower overall mortality rate than the general population (attributable to the so-called "healthy worker effect" (7)); i.e., $D/N > d/n$, so that in equation 3, $(D/N + d/n) > 1$. Hence, even if there is no difference in the actual relative risk for a given cause (i.e., $d_i/n = D_i/N$), the ratio of relative frequencies $(d_i/d + D_i/D)$ will exceed unity, indicating that the employed group is at greater risk of dying from the specified cause than is the general population.

To illustrate this point, suppose we know that the study group's overall mortality is 75 per cent of the comparison group; i.e., $d/n = 0.75\ (D/N)$ or Factor = $D/N \div d/n = 1/0.75 = 1.33$. Then from equation 4, we have PMR = 1.33 × SMR. Thus, the ratio of relative frequencies (PMR) is 33 per cent greater than the actual relative risk (SMR), and in the situation where no difference in risk exists (i.e., SMR equals unity), the PMR will indicate a 33 per cent increase.

Conversion rule

If the above relationships are extended to summary estimates of relative risks across all levels of a confounding factor

Table 1
Notation for statistical quantities discussed in text

Quantity	Study group	Comparison group
Number at risk	n	N
Total deaths (all causes)	d	D
Deaths from a specific cause	d_i	D_i
Proportion of total deaths due to a specific cause	$\frac{d_i}{d}$	$\frac{D_i}{D}$
Overall death rate (all causes)	$\frac{d}{n}$	$\frac{D}{N}$
Death rate from a specific cause	$\frac{d_i}{n}$	$\frac{D_i}{N}$

(e.g., age), cause-specific PMRs and SMRs are the same if the overall death rate of the study group equals that of the comparison group within *each* age group.

The equality shown in equation 4 holds for a given age group within which no further age adjustment is done. It does not necessarily hold for the age-adjusted PMR and SMR, but a rough approximation is suggested. Thus, rearranging equation 4 and putting it in terms of summary measures over all ages, we have:

$$\text{SMR (specific cause)} \doteq \text{PMR (specific cause)} \times \text{SMR (overall)}. \quad (5)$$

Hence, given a set of cause-specific PMRs, one can get an idea of what the corresponding SMRs would look like under different assumptions about the ratio of the total mortality rates. (A fuller discussion of the conditions under which the conversion rule is applicable will be the subject of a separate report.)

Empirical results

Several sets of data are presented to illustrate in concrete terms the relationship between the PMR and SMR methods of analysis.

The first set of data is derived from a cohort mortality study of 2861 gray iron foundry workers who were employed at a single plant (Plant A) between 1938 and 1967 and were followed through December 31, 1967. Details of this study are published elsewhere (8) and only pertinent information is given here. Table 2 shows the results of the follow-up effort. For the purposes of this paper, war deaths and the "presumed dead" group are not counted in overall mortality but, instead, are withdrawn alive on the presumed date of death. Subjects lost to follow-up (unknown vital status) are treated as alive at the closing date of the study. Table 3 shows overall mortality patterns for white and non-white foundry workers in relation to the total US experience. It can be seen that at all ages under 65 years, non-white workers have a more favorable survival rate than do white workers (each in relationship to their counterparts in the general population), with a particularly striking difference at ages less than 45 years (SMR = 0.92 for whites and 0.48 for non-whites). The latter finding may be due, in part, to the more recent employment of non-whites and the unusual composition of the plant work force during World War II. From these data, we have chosen the total group of non-white workers (whose overall SMR is unusually low) and the subgroup of white workers who survived to age 65 years (whose overall SMR is close to unity) to illustrate relationships between cause-specific SMRs and PMRs.

Table 2

*Distribution of male foundry workers employed at plant A between 1938 and 1967 by race and vital status on January 1, 1968**

Vital status	White	Non-white
Known alive	1106	1243
Known dead	240	172
War deaths	3	
Presumed dead	10	10
Unknown	24 (1.7%)	56 (3.8%)
Total	1380	1481

* Data from Decouflé and Wood (8).

Example 1. White foundry workers over age 65 years versus the general population (table 4). Since white foundry workers have an overall SMR close to unity, one expects the cause-specific PMRs to be reasonable estimates of the corresponding SMRs. Table 4 shows the close agreement between the two sets of risk estimates. For each cause of death category, essentially the same conclusion as to magnitude of risk would be drawn from both sets of results. The last column illustrates the "conversion rule" between PMRs and SMRs. The "approximated SMRs" are closer to the actual SMRs than are the PMRs.

TABLE 3

Observed and expected deaths from all causes (1938–1967) and standardized mortality ratios (SMRs) by race and attained age—male foundry workers employed at plant A between 1938 and 1967¶

Attained age (years)	Whites			Non-whites		
	Observed deaths†	Expected deaths§	SMR*	Observed deaths‡	Expected deaths§	SMR*
Total	237	300.0	0.79*	172	315.0	0.55*
<45	34	37.0	0.92	52	109.2	0.48*
45–54	38	56.7	0.67*	52	99.7	0.52*
55–64	54	83.2	0.65*	39	74.5	0.52*
65+	111	123.2	0.90	29	31.6	0.92

¶ Data from Decouflé and Wood (8).
* $p < 0.05$.
† Excludes 10 presumed dead and three war deaths.
‡ Excludes 10 presumed dead.
§ Based on the race-, age- and time-specific mortality rates of the US male population.
* SMR = standardized mortality ratio = observed deaths divided by age- and calendar-year-adjusted expected deaths.

TABLE 4

Cause-specific mortality experience (1938–1967) of white male foundry workers (ages 65 years and over) employed at plant A between 1938 and 1967¶

Cause (ICD, 7th Revision)	Observed deaths†	PMR‡	SMR§	Conversion rule*
All causes	111	1.00	0.90	0.90
Cancer (140–205)	25	1.30	1.22	1.17
Digestive (150–159)	6	0.82	0.76	0.74
Respiratory (160–165)	5	1.12	1.09	1.01
All other	14	1.89*	1.76	1.70
Stroke (331, 332)	11	1.01	0.88	0.91
Circulatory disease (400–468)	44	0.78*	0.70*	0.70
Accidents, suicide, homicide (800–999)	7	1.82	1.62	1.64
All other causes	24	1.17	1.04	1.05

¶ Data from Decouflé and Wood (8).
* $p < 0.05$.
† Excludes two presumed dead.
‡ PMR = proportionate mortality ratio = observed deaths divided by age- and calendar-year-adjusted expected deaths. Expected deaths based on ratio of each cause to all causes in the US male population.
§ SMR = standardized mortality ratio = observed deaths divided by age- and calendar-year-adjusted expected deaths. Expected deaths based on cause-specific mortality rates of the US male population.
* Conversion rule: cause-specific PMR × overall SMR.

Example 2. Non-white foundry workers versus the general population (table 5). Based on the general principles outlined above, one expects that cause-specific PMRs in this group are overestimates of the corresponding SMRs. Table 5 shows results consistent with the theoretical considerations. PMRs and SMRs are so divergent in this example that one would come to opposite conclusions as to risks for several diseases. For example, the PMR for respiratory cancer indicates a statistically significant two-fold increase, whereas the SMR shows that the risk is little different from expectation (SMR = 1.14). The PMR for circulatory disease suggests no difference in risk for foundry workers, but the SMR shows a statistically significant deficit approaching half of what was expected. We applied the

TABLE 5

Cause-specific mortality experience (1938–1967) of non-white male foundry workers employed at plant A between 1938 and 1967¶

Cause (ICD, 7th Revision)	Observed deaths†	PMR‡	SMR§	Conversion rule*
All causes	172	1.00	0.55*	0.55
Cancer (140–205)	35	1.53*	0.88	0.84
Digestive (150–159)	14	1.61	0.92	0.89
Respiratory (160–165)	12	1.99*	1.14	1.09
All other	9	1.11	0.65	0.61
Stroke (331, 332)	9	0.62	0.36*	0.34
Circulatory disease (400–468)	54	0.93	0.53*	0.51
Accidents, suicide, homicide (800–999)	27	1.07	0.52*	0.59
All other causes	47	0.92	0.48*	0.51

¶ Data from Decouflé and Wood (8).

* $p < 0.05$.

† Excludes 10 presumed dead.

‡ PMR = proportionate mortality ratio = observed deaths divided by age- and calendar-year-adjusted expected deaths. Expected deaths based on ratio of each cause to all causes of death in the US male population.

§ SMR = standardized mortality ratio = observed deaths divided by age- and calendar-year-adjusted expected deaths. Expected deaths based on cause-specific mortality rates of the US male population.

* Conversion rule: cause-specific PMR × overall SMR.

rough conversion rule to these data and the results are shown in the fourth column. A very good "fit" is obtained for all cause of death categories. Thus, one gets an idea of what the actual cause-specific SMRs would look like utilizing the observed PMRs together with an assumption about the overall mortality rates. In fact, Monson et al. (9) used this reasoning in assessing the validity of their site-specific cancer risks (PMRs) in a study of vinyl chloride workers.

Example 3. Cigarette smokers versus non-smokers (table 6). These data are taken from the study of smoking and mortality among US veterans reported by Kahn (10). The extensive appendices to this report permit computation of various relative risk estimates not shown in the main tables and text. Since the overall mortality rate of cigarette smokers greatly exceeds that of non-smokers, each of the cause-specific PMRs is well below the corresponding SMR. It is interesting to note that for disease categories with very high SMRs (e.g., emphysema and cancers of the esophagus, larynx and lung), the PMRs are still markedly elevated and indicate a significantly high risk. On the other hand, for prostatic cancer and cardiovascular disease, the PMR approach fails to show an increased risk when a real one does in fact exist. Violent deaths appear to be significantly lower among smokers in the PMR analysis, but are significantly increased in the SMR analysis. The conversion rule yields approximate cause-specific SMRs that are quite close to the actual ones in this set of data.

DISCUSSION

This paper has focused on bias in proportionate mortality studies arising from large differences in the overall death *rates* of study and comparison groups. Thus, PMRs will *overstate* risks when the study group's overall mortality rate is *lower* than that of the comparison group, while, conversely, PMRs will *underestimate* risks when the study group's overall mortality rate is *higher* than the comparison group. If the discrepancy between overall mortality rates is great enough, errone-

TABLE 6

Mortality experience of current cigarette smokers versus persons who never smoked or only smoked occasionally—US veterans study, July, 1954–December, 1962¶

Cause (ICD, 7th Revision)	Observed deaths	PMR†	SMR‡	Conversion rule§
All causes	15644	1.00	1.68*	1.68
Cancer (140–205)	3422	1.22*	2.06*	2.05
Esophagus (150)	77	3.44*	5.55*	5.78
Intestines (152–153)	313	0.69*	1.15*	1.16
Larynx (161)	40	6.13*	9.89*	10.30
Lung and bronchus (162–163)	1116	6.54*	10.92*	10.99
Prostate (177)	242	1.02	1.67*	1.71
Emphysema (527.1)	272	7.43*	12.16*	12.48
All cardiovascular diseases (330–334, 400–468)	9580	0.95*	1.59*	1.60
Violence (800–962, 970–971)	575	0.65*	1.12*	1.09

¶ Data from Kahn (10).

* $p < 0.05$.

† PMR = proportionate mortality ratio = observed deaths divided by age-adjusted expected deaths. Expected deaths based on ratio of each cause to all causes of death among non-smokers.

‡ SMR = standardized mortality ratio = observed deaths divided by age-adjusted expected deaths. Expected deaths based on cause-specific mortality rates of non-smokers.

§ Conversion rule: cause-specific PMR × overall SMR.

ous, even opposite, conclusions can be reached from SMR and PMR analyses on the same data.

Generally, one does not know the relative magnitude of overall death rates for a particular study group and comparison group. Hence, it may be difficult, if not impossible, to assess the validity of a set of cause-specific PMRs in the light of issues raised here. However, occupational health investigators can obtain data from previous cohort mortality studies of industrial populations with the general population as the comparison group so that they can make an estimate of what the overall SMR might be (at least a reasonable interval estimate) (11). Since, in these cases, the overall SMR is most likely less than unity, the magnitude of cause-specific PMRs should be judged, not in relation to an expected value of 1.00, but against a greater value, e.g., the reciprocal of the estimated overall SMR.

We have constructed PMRs using the ratio of deaths from a specific cause to a base consisting of *all deaths*. When it is thought that the overall mortality rates differ greatly between study and comparison groups, consideration should be given to choosing as a base a collection of cause categories for which death rates are not likely to differ very much. For example, when industrial populations are compared to the general population on a rate basis, the SMR for cancer is usually close to unity (7, 12, 13). Thus, in examining site-specific cancer risks, the ratio of deaths from a particular cancer site to all cancer deaths might be more appropriate (14). One study (15) adjusted for possible unequal overall mortality by using all deaths *except* those due to cancer (all sites) and respiratory diseases as the base for computing expected deaths.

With respect to the "conversion rule" described here, it should be pointed out that there are situations in which it is useless. Specifically, derivation of approximate cause-specific SMRs utilizing an estimate of the true overall SMR and the observed PMRs is not valid when study and comparison groups differ greatly with respect to the age distribution of populations-at-risk and total deaths.

Finally, it should be noted that the concepts and examples presented here refer

to well-defined populations and *all* deaths occurring in these populations over specified time periods. The conclusions reached may not be applicable to a PMR study in which the available data represent a subset of all deaths among members of a well-defined population. Examples of the latter situations are collections of deaths reported to employers and labor unions in connection with payment of life insurance claims and death benefits. Data gathered from these sources are generally incomplete since they exclude, in the case of companies, employees not on the payroll (nor pensioned) at the time of death and, for labor unions, members not in good standing (i.e., dues paying) when death occurs. In these situations, special care should be taken in interpreting findings.

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ON THE UTILITY OF PROPORTIONAL MORTALITY ANALYSIS*

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Abstract—The Standardized Mortality Ratio (SMR) is a commonly used epidemiologic tool for evaluating a test population with respect to a standard. Computation of the measure requires that the size and demographic composition of the test population-at-risk (PAR) be known. In the absence of this knowledge of the PAR, some have turned to evaluations based on proportional mortality rates, a method which is generally regarded as deficient because of the inability of relative measures to provide information about absolute rates.

Often, the ratio of the cause-specific SMR to the underlying 'force of mortality' (i.e. the SMR for all causes) is of interest; this ratio is referred to herein as the relative SMR (RSMR). It is shown in this paper, both empirically and in a theoretical framework, that the RSMR is close in value to the (age) standardized proportional mortality ratio (SPMR), this closeness being expressible in the form of a 'confidence interval' involving the SPMR. Computation of the SPMR does not require knowledge of the PAR.

1. GENERAL CONSIDERATIONS

1.1 *Definitions: absolute and relative measures of death rate*

A basic strategy of epidemiology is the comparison of health-related data between two populations. Frequently, the comparison is between a test population (i.e. the population being studied) and some appropriate referent (standard) population. The procedure typically utilizes the ratio of observed events to expected events, the latter calculated in 'standardized' fashion with respect to such concomitant variables as age, race and sex.

For reference, several measures used for this comparison are defined symbolically below:

1. Cause i specific Absolute Death Rate: $\mathrm{ADR}_i = \dfrac{d_{i.}}{N_{\mathrm{PAR}}}$,
2. Cause i specific Standardized Mortality Ratio: $\mathrm{SMR}_i = \dfrac{d_{i.}}{D_{\mathrm{E}i}}$,
3. All causes Standardized Mortality Ratio: $\mathrm{SMR} = \dfrac{d_{..}}{D_{\mathrm{EA}}}$,
4. Relative Standardized Mortality Ratio: $\mathrm{RSMR}_i = \dfrac{\mathrm{SMR}_i}{\mathrm{SMR}}$,
5. Cause i specific Proportional Mortality Ratio: $\mathrm{PMR}_i = \dfrac{d_{i.}}{d_{..}}$,
6. Cause i specific Standardized Proportional Mortality Ratio: $\mathrm{SPMR}_i = \dfrac{d_{i.}}{D_{\mathrm{EP}i}}$,

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where

$d_{i.}$ ≡ observed number of deaths due to cause i in the test population; N_{PAR} ≡ number of people in the test population; D_{Ei} ≡ expected number of deaths due to cause i based on applying cause i death rates for each of the referent subpopulations (e.g. strata based on age) to the number of people in each of the corresponding test subpopulations; D_{EA} ≡ similar to D_{Ei}, except that total (all causes) death rates for each referent subpopulation are used; $d_{..}$ ≡ total observed number of deaths in the test population; D_{EPi} ≡ expected number of deaths from cause i based on applying referent subpopulation PMR_i's to the number of deaths in each of the test subpopulations.

Measures 1, 2 and 3 above are absolute measures requiring knowledge of the size of the PAR, while measures 5 (the PMR) and 6 (the SPMR) require *only* knowledge of deaths. However, the PMR suffers from a well-recognized limitation associated with such '*numerator-based*' statistics-namely, that the observation of a *relative* excess (or deficit) of deaths in the test population does not necessarily indicate an *absolute* excess (or deficit) in the death rate due to that same cause. [See, for example, Refs (4, 6, pp. 59–60, 7).] Table 1 below illustrates this point.

Table 1. Hypothetical mortality data for white males

	Data description	Test population	Standard population
1.	Stomach Cancer deaths	30	200
2.	All other deaths	970	9800
3.	Total deaths	1000	10,000
4.	Population-at-risk	100,000	500,000
5.	Proportion of all deaths due to stomach cancer	0.03	0.02
6.	Death rate for stomach cancer	3/10,000	4/10,000
7.	Death rate for all other causes	97/10,000	196/10,000
8.	Death rate for all causes	100/10,000	200/10,000

Assuming, for simplicity's sake, that the age composition of the two white male populations is identical, then the four rates (items 5–8) can be directly compared. Clearly, the *proportion* of deaths due to stomach cancer is higher in the test population than in the standard population (0.03 *vs* 0.02), and yet the *absolute* death rate for stomach cancer is lower in the test population than in the standard population (3/10,000 vs 4/10,000).

1.2. *Discussion of RSMR and SPMR*

The summary statistic most often used to compare observed and expected death rates, across the full age-range of interest, is the *Standardized Mortality Ratio* (SMR). (See Definitions 2 and 3 given earlier.) Given the assumption of identical age composition for the two populations in Table 1, the following two SMR s can be calculated:

$$\text{Stomach cancer: SMR} = \frac{3/10{,}000}{4/10{,}000} = 0.75.$$

$$\text{All causes: SMR} = \frac{100/10{,}000}{200/10{,}000} = 0.50.$$

Now, as mentioned above, the SMR for stomach cancer is calculated directly, without knowledge of items 7 and 8 in Table 1. However, herein lies a limitation in the meaningfulness of a cause-specific SMR: it necessarily lacks any relativity to the underlying (all causes) force of mortality within the test population. In other words, simply to say that, compared to the standard population, there is a 25% deficit of stomach cancer deaths in the test population would be to ignore the fact that, since there is an overall mortality deficit of 50% in the test population (i.e. all-causes SMR = 0.50), the death rate from stomach cancer in the test population is higher than would be expected on the basis of the overall death rate. In order to express the actual stomach cancer

mortality experience of this population relative to its overall mortality experience, a 'corrected' or relative SMR (RSMR) can be calculated as:

$$\text{Cause-specific RSMR} = \frac{\text{Cause-specific SMR}}{\text{All-causes SMR}}.$$

For example, the RSMR for stomach cancer (Table 1) is:

$$\text{RSMR} = \frac{0.75}{0.50} = 1.50.$$

Note that this procedure produces a mortality ratio that is essentially relative, and therefore one that no longer expresses the absolute deviation of the observed cause-specific death rate from the expected rate. However, the loss of absolute information resulting from this correction procedure is offset by the following considerations:

1. The correction procedure is an addition to, not a substitute for, the initial calculation of a regular SMR. (In practice, this adjustment is often made reflexively by the person scanning a schedule of SMR's that includes the all-causes and various cause-specific SMR's.)

2. In reality, the difference between the regular and relative SMR's is usually much less than in the above contrived example. The all-causes SMR lies within the range 0.80–1.25 for most test populations. The correction procedure therefore simply makes clearer the meaningfulness of the observed mortality experience from a specific cause.

3. Because of the difficulty in obtaining an 'ideal' standard population, the regular cause-specific SMR is often of dubious meaning, since it implies that the value of 1 is the proper baseline figure for comparison purposes. For instance, in the field of industrial occupational epidemiology, it is common practice to compare the test population to some general community population (often the national population). This is typically a matter of necessity rather than choice. Consequently, because of the 'healthy worker' selection process (whereby, to be employable on the production line, a person must be fairly healthy and active), the mortality experience of an industrial population in an industry free of serious mortality hazard usually results in an overall SMR of about 0.80–0.95. Hence, it is really this overall SMR that should be regarded as the 'baseline' against which cause-specific SMR's should be evaluated.

In a way exactly analogous to the age-standardization procedure used to obtain an SMR, a *Standardized Proportional Mortality Ratio* (SPMR) can be calculated from the sets of age-specific mortality data for two populations. (See Definition 6 given earlier.) For example, given the assumption of identical age composition for the two populations in Table 1, the stomach cancer SPMR is calculated as 0.03/0.02 = 1.50.

Because of the previously mentioned pitfalls of 'numerator' analysis, proportional mortality rates have been used sparingly in mortality studies. For this reason, the SPMR, as a formal summary statistic, has been largely overlooked in the literature. Whereas the analysis of absolute mortality rates typically turns upon the calculation of SMR's, the analysis of proportional mortality rates appears to have not yet assumed any procedural orthodoxy. Different authors treat numerator data in various ways [e.g. Refs (1, 3–5)], but the potential of the SPMR as an important index of mortality appears to have been largely overlooked.

Note from the above calculations for stomach cancer that the SPMR has exactly the same value as the RSMR. That is, the SPMR, despite the absence of information on the PAR, appears to provide a short-cut to the calculation of the RSMR, whose usefulness has been described above. Of course, the Table 1 data, with its assumption of population identicality with respect to age distribution is unrealistic. What, therefore, is the general relationship between the SPMR and the RSMR?

The principal objective of this paper is to note empirically that the SPMR provides a good approximation to the RSMR. Under certain assumptions, the accuracy of this approximation may be quantified; in particular, a 'confidence interval' may be con-

structed about the (sample) SPMR which with high probability contains the (sample) RSMR. This is explored in Section 2 below.

Assuming, based on the discussion above, that the cause-specific RSMR is of central interest, it is reasonable to ask under what circumstances one would be concerned with approximating it by the SPMR. The basic circumstance is both obvious and common—the situation wherein mortality data are available, but the population source cannot be quantified. This situation might arise in several ways. Firstly, death certificates may have accumulated historically over a number of years in a well-defined population setting (e.g. an industrial population), for which insufficient information is available for 're-constructing' the original PAR. [See, for example, Moss *et al.* (7).] Secondly, deaths might be occurring in a general community setting for which it is not possible to determine accurately the size and composition of the PAR.

In the next section, the relationship between the RSMR and the SPMR is explored in a quantitative fashion.

2. STATISTICAL CONSIDERATIONS

It is the purpose of this section to quantify the relationship between the SPMR and RSMR, with specific attention being given to a theoretical examination of why the SPMR empirically seems to be a very useful approximation to the RSMR.

The following notation will be used throughout. Consider a specified cause of death (i, say) and, for standardization purposes, suppose that there are g age groups, with $n_{.j}$ the size of the jth age group PAR. Let

$d_{i.}$ = observed number of deaths due to cause i in the test population,

$d_{.j}$ = observed number of deaths in the jth age group of the test population,

$d_{..} = \sum_{j=1}^{g} d_{.j}$ = total observed number of deaths in the test population,

p_{ij} = cause i death rate for the jth age group of the standard population,

$p_{.j}$ = all-causes death rate for the jth age group of the standard population.

Then, the usual computational formulae for SPMR_i and RSMR_i can be written as follows:

$$\mathrm{SPMR}_i = \frac{d_{i.}}{\sum_{j=1}^{g} a_{ij} d_{.j}},$$

where $a_{ij} = p_{ij}/p_{.j}$ = proportion of all deaths due to cause i in the jth age group of the standard population; and:

$$\mathrm{RSMR}_i = \frac{\text{SMR (cause } i)}{\text{SMR (all causes)}} = \frac{d_{i.} \Big/ \sum_{j=1}^{g} n_{.j} p_{ij}}{d_{..} \Big/ \sum_{j=1}^{g} n_{.j} p_{.j}}.$$

To facilitate the subsequent analysis and to emphasize the similarity in structure between SPMR_i and RSMR_i, it is convenient to rewrite the above expressions in the following equivalent forms:

$$\mathrm{SPMR}_i = \frac{d_{i.}}{d_{..} \sum_{j=1}^{g} a_{ij} \bar{\omega}_j} \tag{1}$$

and

$$\mathrm{RSMR}_i = \frac{d_{i.}}{d_{..} \sum_{j=1}^{g} a_{ij} \omega_j}. \tag{2}$$

where:

$$\hat{\omega}_j = \frac{d_{.j}}{d_{..}} \qquad \text{and} \qquad \omega_j = n_{.j}p_{.j} \Big/ \sum_{j=1}^{g} n_{.j}p_{.j}$$

are, respectively, the *observed* and *expected* proportions of deaths occurring in the jth age group of the test population. The notation suggests that $\hat{\omega}_j$ is, in some sense, an approximation to ω_j. Note that:

$$\sum_{j=1}^{g} \hat{\omega}_j = \sum_{j=1}^{g} \omega_j = 1.$$

From (1) and (2), SPMR_i and RSMR_i are equal if:

$$\sum_{j=1}^{g} a_{ij}\hat{\omega}_j = \sum_{j=1}^{g} a_{ij}\omega_j, \tag{3}$$

or, equivalently, using $\hat{\omega}_j = d_{.j}/d_{..}$ and rearranging, if:

$$\sum_{j=1}^{g} a_{ij}(d_{.j} - \omega_j d_{..}) = 0.$$

Formally, if either the $\{a_{ij}\}$ do not vary with j or if $\omega_j = \hat{\omega}_j$ for each j, then (3) holds; the latter condition implies that the all causes SMR's calculated for each age group, the $\{d_{.j}/n_{.j}p_{.j}\}$, must be equal (but not necessarily equal to 1). Neither of these conditions can be expected to hold in practice, but empirical evidence supports the approximate equality of the weighted sums in (3).

Another approach to comparing the SPMR and RSMR is by examination of the inequality:

$$\left|\frac{\text{RSMR}_i}{\text{SPMR}_i} - 1\right| < k_i, \tag{4}$$

or, equivalently from (1) and (2):

$$\left|\frac{\sum_{j=1}^{g} a_{ij}\hat{\omega}_j}{\sum_{j=1}^{g} a_{ij}\omega_j} - 1\right| < k_i.$$

It is our goal to specify k_i independently of the $\{n_{.j}\}$, which are unknown quantities when information on the PAR is unavailable.

For completeness, it is worthwhile mentioning that one can find inequalities of the form (4) which are wholly *deterministic*, e.g.:

$$\left|\frac{\text{RSMR}_i}{\text{SPMR}_i} - 1\right| \le \frac{\sum_{j=1}^{g} a_{ij}\max(\hat{\omega}_j, 1 - \hat{\omega}_j)}{\min_j a_{ij}}.$$

However, such inequalities appear to be much too crude and are generally uninformative in actual practice.

Thus, we turn next to a *probabilistic* statement of the form:

$$\Pr\left\{\left|\frac{\text{RSMR}_i}{\text{SPMR}_i} - 1\right| < k_i\right\} \ge (1 - \alpha), \tag{5}$$

or equivalently:

$$\Pr\{(1 - k_i)\text{SPMR}_i < \text{RSMR}_i < (1 + k_i)\text{SPMR}_i\} \ge (1 - \alpha). \tag{6}$$

The above statement is exactly in the form of a confidence interval* for RSMR_i.

*Strictly, we are not considering a confidence interval for a parameter, since RSMR_i is itself a random variable.

In order to proceed further along these lines, we will assume that, conditional on the total number of deaths $d_{..}$, the $\{d_{.j}\}$ are multinomially distributed with parameters $\{\omega_j\}$. (In words, we are assuming that the expected number of deaths due to all causes in each age group of the test population is roughly the same as that for the standard population. While this assumption may be questioned, the conclusions it has yielded appear robust based on the examples presented below.) If:

$$\mathbf{a}_i' = (a_{i1}, a_{i2}, \ldots, a_{ig}),$$

$$\hat{\omega}' = (\hat{\omega}_1, \hat{\omega}_2, \ldots, \hat{\omega}_g),$$

and

$$\omega' = (\omega_1, \omega_2, \ldots, \omega_g),$$

then the above assumption implies that:

$$\mathrm{E}\left(\sum_{j=1}^{g} a_{ij}\hat{\omega}_j\right) = \mathrm{E}(\mathbf{a}_i'\hat{\omega}) = \mathbf{a}_i'\omega$$

and

$$\mathrm{var}\left(\sum_{j=1}^{g} a_{ij}\hat{\omega}_j\right) = \mathbf{a}_i' V \mathbf{a}_i,$$

where $d_{..}\ V = \mathrm{diag}(\omega_1, \omega_2, \ldots, \omega_g) - \omega\omega'$. It can be shown that a good computational formula for $\mathrm{var}(\mathbf{a}_i'\hat{\omega})$ is

$$\mathbf{a}_i'\hat{V}\mathbf{a}_i = \frac{1}{d_{..}}\left[\sum_{j=1}^{g} a_{ij}^2\omega_j - \left(\sum_{j=1}^{g} a_{ij}\omega_j\right)^2\right];$$

the estimator $\mathbf{a}_i'\hat{V}\mathbf{a}_i$ of $\mathbf{a}_i'V\mathbf{a}_i$ is then obtained by using $\hat{\omega}_j$ for ω_j in the above formula.

Again, the multinomial model we are proposing is only expected to provide a reasonable approximation to, and not an exact representation of, the true state of affairs. One saving feature is that we are actually dealing with a linear combination of random variables (which are constrained to sum to unity), and such a linear combination could be expected to be robust to aberrations in its individual components. The examples we shall presently consider seem to support this contention.

Without making any further assumptions, it is now possible to obtain a statement of the form (5) using Tchebysheff's Theorem [e.g. see Cramér (2), p. 183]. If X is a random variable with mean μ and variance σ^2, this thoerem says that

$$\Pr\{|X - \mu| < t\sigma\} \geq 1 - 1/t^2 \text{ for any } t > 0.$$

Under our model,

$$\frac{\mathrm{RSMR}_i}{\mathrm{SPMR}_i} = \frac{\mathbf{a}_i'\hat{\omega}}{\mathbf{a}_i'\omega}$$

has mean 1 and variance $\mathbf{a}_i'V\mathbf{a}_i/(\mathbf{a}_i'\omega)^2$, so that for $t = \alpha^{-1/2}$ we have

$$\Pr\left\{\left|\frac{\mathrm{RSMR}_i}{\mathrm{SPMR}_i} - 1\right| < \alpha^{-1/2}(\mathbf{a}_i'V\mathbf{a}_i)^{1/2}/\mathbf{a}_i'\omega\right\} \geq (1 - \alpha);$$

this statement is exactly of the form (5) with

$$k_i = \alpha^{-1/2}(\mathbf{a}_i'V\mathbf{a}_i)^{1/2}/\mathbf{a}_i'\omega$$

If $\hat{k}_i$ denotes the estimate of k_i obtained by using $\hat{\omega}_j$ for ω_j in the above expression, then, for $\alpha = 0.01$, it follows from (6) that we have *approximately*

$$\Pr\{(1 - \hat{k}_i)\mathrm{SPMR}_i < \mathrm{RSMR}_i < (1 + \hat{k}_i)\mathrm{SPMR}_i\} \geq 0.99 \tag{7}$$

when $\hat{k}_i = 10(\mathbf{a}_i'V\mathbf{a}_i)^{1/2}/\mathbf{a}_i'\hat{\omega}$.

3. EMPIRICAL RESULTS

One reasonable way to evaluate the reliability of the approximate confidence interval (7) is to apply it to several sets of data for which the requisite information is available

Table 2. Behavior of the confidence interval (7) of Section 2 for various data sets and various causes of death

(2A) Data source: white miners

Age group j	Total deaths in age group d_j	Number in age group n_j	$\hat{\omega}_j$	ω_j
20–24	292	74598	0.0391	0.0361
25–29	357	85077	0.0478	0.0409
30–34	341	80845	0.0456	0.0478
35–44	1095	148870	0.1465	0.1609
45–54	1784	102649	0.2387	0.2782
55–59	1554	42494	0.2079	0.2150
60–64	2051	30037	0.2744	0.2211

Cause of death i	d_i	SPMR,	$(1-\hat{\delta}_i)$SPMR,	$(1+\hat{\delta}_i)$SPMR,	RSMR,	$\alpha_i\omega$	$\alpha_i\hat{\omega}$
Tuberculosis	540	1.458	1.388	1.528	1.418	0.0510	0.0496

(2B) Data source: tire plant I

Age group j	Total deaths in age group d_j	Number in age group n_j	$\hat{\omega}_j$	ω_j
40–54	132	16139	0.0698	0.0715
55–64	333	15409	0.1760	0.2002
65–84	1427	19799	0.7542	0.7283

Cause of death i	d_i	SPMR,	$(1-\hat{\delta}_i)$SPMR,	$(1+\hat{\delta}_i)$SPMR,	RSMR,	$\alpha_i\omega$	$\alpha_i\hat{\omega}$
ICD 200–209 (Leukemia Group)	36	1.207	1.179	1.235	1.197	0.0518	0.0158
ICD 151 (Stomach Cancer)	36	1.646	1.614	1.678	1.652	0.0115	0.0116
ICD 160–163 (Respir. Cancer)	92	0.877	0.830	0.924	0.865	0.0563	0.0554

(2C) Data source: tire plant II

Age group j	Total deaths in age group d_j	Number in age group n_j	$\hat{\omega}_j$	ω_j
40–44	7	3160	0.0029	0.0053
45–49	55	7729	0.0232	0.0212
50–54	83	9220	0.0350	0.0418
55–59	168	9967	0.0708	0.0718
60–64	306	11317	0.1290	0.1253
65–69	457	11474	0.1926	0.1865
70–74	531	9404	0.2238	0.2344
75–79	476	5800	0.2005	0.2000
80–84	290	2321	0.1222	0.1136

Cause of death i	d_i	SPMR,	$(1-\hat{\delta}_i)$SPMR,	$(1+\hat{\delta}_i)$SPMR,	RSMR,	$\alpha_i\omega$	$\alpha_i\hat{\omega}$
ICD 140–239	436	1.040	1.008	1.072	1.038	0.18790	0.18760
ICD 140–149	7	0.530	0.493	0.567	0.528	0.00558	0.00556
ICD 150–159	152	1.150	1.128	1.172	1.150	0.05570	0.05568
ICD 158	8	0.808	0.757	0.860	0.807	0.00418	0.00417
ICD 160–163	120	0.856	0.794	0.919	0.853	0.05931	0.05905
ICD 170–174	8	0.837	0.791	0.884	0.833	0.00405	0.00403
ICD 180–189	86	1.200	1.137	1.264	1.206	0.03036	0.03019
ICD 190–199	32	0.916	0.864	0.967	0.911	0.01490	0.01472
ICD 204–207	25	1.470	1.445	1.495	1.469	0.00717	0.00717
ICD 200–209	52	1.323	1.280	1.367	1.318	0.01662	0.01656
ICD 210–239	6	1.275	1.197	1.353	1.264	0.00200	0.00196
ICD 240–279	52	1.152	1.143	1.162	1.152	0.01902	0.01901
ICD 284	3	2.273	2.181	2.364	2.274	0.00056	0.00056
ICD 285	2	2.122	1.938	2.305	2.134	0.00039	0.00040
ICD 290–315	5	0.747	0.621	0.872	0.737	0.00286	0.00282
ICD 320–389	16	1.043	0.999	1.086	1.036	0.00651	0.00646
ICD 390–458	1448	1.031	1.013	1.050	1.033	0.59050	0.59180
ICD 460–519	460	2.571	2.503	2.640	2.576	0.07524	0.07539
ICD 571	30	0.816	0.680	0.953	0.803	0.01575	0.01549
ICD 680–709	1	0.682	0.659	0.705	0.685	0.00062	0.00062
ICD 800–999	91	0.890	0.773	1.083	0.876	0.04380	0.04306
ICD 950–959	30	1.328	1.101	1.546	1.302	0.00971	0.00952

and then see how it behaves. Table 2 below summarizes the results of such an application to three sets of data. One data set is taken from a D.H.E.W. Vital Statistics Report on 1950 Tuberculosis Mortality Among U.S. White Miners. The second data source represents preliminary findings concerning the mortality experience of hourly employees and ex-employees at a major tire manufacturing plant in Akron, Ohio over the 9-yr period 1/1/64–12/31/72. The third data set concerns the mortality experience of white male hourly employees at a major tire manufacturing plant in Akron, Ohio (distinct from the plant of the second data set) over the 10-yr period 1/1/64–12/31/73. U.S. 1950 mortality data for men with work experience and U.S. national mortality statistics for 1968 provide the corresponding standard population figures.

From Table 2, it can be seen that in every instance the confidence interval calculated using (7) did indeed enclose the actual RSMR value. (It should be noted that while corresponding values of ω_j and $\hat{\omega}_j$ differ widely in some cases, the weighted sums $a_i'\omega$ and $a_i'\hat{\omega}$ are very close to one another in value.) While this admittedly does not constitute an unequivocable endorsement of the procedure, it is nevertheless an encouraging finding. We can only hope that other researchers will subject our methodology to similar evaluations using their own data sets.

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Addendum: Health Profile: Hazardous Waste Disposal Facility

Prepared for: BHS, Inc.
Wright City, MO 63390

This addendum is provided in response to the comments of Dr. Mohammed N. Akhter raised in his letter of 6 May 1982 (appended) to Robert J. Schreiber concerning the Health Profile submitted by BHS as part of the application process for BHS' waste site operation.

Introduction:

We have addressed each point specifically raised in Dr. Akhter's letter. In general the health profile:

1. was structured to be read and understood by a diverse audience of both technical and non-technical readers, and the interested public and waste site operators. This required a good deal of balance in both detail and organization of the report. We attempted to present the rationale, results, and analysis so that they could be read by a general readership, and have parallel technical back-up in suitably separated sections.

2. Carefully considered the ramifications of a profile that provides a solid baseline for on-going health effects monitoring. Working with a one-page guideline, the profile was developed to provide the broadest coverage yet be inclusive of health effects that could be measured with statistical reliability, to focus on the immediate and surrounding sites, and to use health indicators that address potential waste site influenced health effects. Again a balance is required, and the aspects of forward monitoring were carefully considered in order to meet the law and its intent.

Response to the specific points raised in Dr. Akhter's letter of May 6, 1982.

This section responds to each question raised in the letter. The question or comment is stated and the response follows.

1. The profile was difficult to follow and understand. The report could have easily been shortened without sacrificing much substance. A table of contents would have helped.

   The profile was written to meet the specific requirements of the law and the guidelines. Because this was the first profile for the BHS site, additional material was provided to give adequate background and suggestions for the future. This report is addressed to three audiences: 1. State officials and regulators; 2. technical and methodological experts, and 3. interested, concerned members of the public and waste site operators. While these three audiences have the same general interests their needs for information, specificity and interpretation differ. However, it was deemed important that the profile and its presentation meet the requisites of these differing audiences in

order to meet the intent of the state statutes. An attempt was made to write the profile so that both a trained biostatistician and concerned layman can benefit from the analysis.

The attached table of contents may be helpful in understanding the organization of the profile. The following provides a justification of each section. (A Table of Contents is provided as a separate page to be inserted in the BHS Health Profile Document.)

Introduction
Provides the statutory basis for the profile.

Purpose of the Health Profile
Interprets the intent of the law and guidelines for developing the profile.

Detection of Health Effects of Hazardous or Toxic Substance
Documents scientific disciplines for which the Profile is based.

Sources of State Data for the Profile Construction
Documents the data sources used in the profile and reviews their strengths and weaknesses.

Health Profile Structure
Discussion of the technical considerations of the data which must be recognized to interpret the data properly.

Indices Selection
Describes the sentenal health events used to monitor the health of the population.

Analysis
Describes the basis under which the data are analyzed.

Summary of Findings
Summarizes the results of the analysis.

Technical Notes
Technical notes for the proper interpretation of the profile and data.

Appendix 1 - Health Profile
Department of Natural Resources guidelines for a health profile.

Appendix 2 - Health Effects-Disease-Substance Review
Documentation of chemicals to be deposited at BHS site. Any known health effects and ICD code number and bibliography related to the chemicals is provided.

Appendix 3 - Statistical Significance Charts
The statistical significance charts used to determine confidence intervals of the rates.

Appendix 4 - Map
Map of Warren county and zip code 63390 surrounding the BHS waste site.

Appendix 5 - Tables
Tables of each of the health indices specific to the BHS profile.

Time Series
Explanation of the time series techniques of analysis. Accompanying time series data are provided.

SMR and SPMR Analysis
Explanation of the SMR and SPMR techniques of analysis.

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2. There needs to be some discussion of exactly how zip code 63390 relates to the 3-5 mile radius suggested in the guidelines.

   In conforming to the 3-5 mile radius suggested in the guideline we reviewed the surrounding site zip codes for their geographic coverage. Zip code 63390 approximates this requirement and, coequally important to meeting the guideline requisites, provides a definitive unit to retrieve the pertinent health data.

   Appendix 4, the surrounding site map, has been redrawn to show the 3-5 mile radius around the site. Zip code 63390 meets the requisites for surrounding site area coverage. The redrawn map is enclosed.

3. In Appendix 2 "Health Effects-Disease-Substance Review" some ICD-9 codes, such as 780.3 for convulsions or 285.9 for anemia, are omitted from the list of toxins and codes without explanation.

   The ICD9 Codes were provided for those selected conditions in Appendix 2 which represent the most definitive outcomes for which tabulations would be meaningful for comparative and analytical treatment.

   Those conditions identified with specific codes were considered indicator conditions for,

   1) monitoring purposes
   2) providing the most specificity in terms of serious illness relationships strongly related to hazard substances compounds
   3) having the least potential for introducing other confounding underlying effects.

   Codes were not provided where conditions did not meet these criteria, in order to preclude their consideration for tabular and analytical development. The code exclusions represented general signs, symptoms, or conditions which were not considered as having a degree of specificity for inferential analysis with respect to site operations. For example convulsions and anemia are two such conditions having multicausative factors. The occurrence of, and etiology of such conditions would add more noise to the profile than enlightenment, hence the profile rather than recite what is left out, concentrates and enumerates those conditions of known risk.

4. Only cancer mortality and morbidity is examined in much detail in the analysis. While this is probably due to the small numbers involved for other diseases, the reasoning should be stated explicitly in the text.

   As mentioned in the comment, the information on other causes was omitted because of small numbers. The criterion of adequate numbers was given in the narrative (Section 5), and referred to specifically in Technical Note 3 (p. 29), relating to the companion table of causes of death. For example, there were no deaths for the site zip code and Warren county categories for the 19 selected causes given in Table 11 for the Hospital Discharges. The comparable Table 11 for mortality

would have resulted in essentially 0 cells for all areas for all the causes listed except for the State entries in the table. This holds for Maternal Deaths as well.

5. Fully understanding the problems associated with the changes from ICD-8 to ICD-9, it would have been advantageous to examine cancer mortality for years before 1979 in order to increase the numerator size. Similarly, congenital anomalies from the hospital discharge file could be collected for data years before 1979.

   As noted in the reviewer's comment and the North Carolina Center for Health Statistics' Report: It is recognized that it would have been advantageous to examine cancer mortality for years prior to 1979. However, this was specifically addressed in the profile with the inclusion of the article on comparability ratios using State data prepared by the North Carolina Center for Health Statistics. The problems noted at the state level in this report would have even more effect on information based on geo-political subdivisions. Because of instability of these ratios they were not included in the profile. We believe the precision of theprofile would be compromised by inclusion of data of unknown comparability. This could lead to erroneous interpretation when future years data are compared with the base line presented in this profile.

6. The benefit derived from the "aggregate counties" grouping is questionable. Most of the population in this area is in St. Charles County which is much more metropolitan in nature than residents around the site area.

   The "aggregate counties" data were included as part of the nested comparison approach (Section 7.1 p. 17). As documented in the report, the surrounding site data can be compared to both the State level and larger surrounding county data. This sharpens the ability of the profile to detect differences and trends in health profile outcomes. The State itself is a mix of rural and urban components, hence the surrounding, county, and aggregate county levels provide a progressive comparative basis. In addition these nested level provide a measure of "spill-over" adverse health effects into immediately surrounding areas.

Addendum 2. Health Profile, Hazardous Waste Disposal Facility

Prepared for: BHS, Inc.
Wright City, Missouri 63390

Introduction

This addendum is provided in response to the comments by Joseph B. Reichart, raised in his letter of 14 June 1982 (appended) to Robert J. Schreiber concerning BHS' responses to the critiques and comments raised by the Missouri Division of Health in their initial review of the BHS Health Profile.

The appended data and analysis are provided as specified in Mr. Reichart's letter to cover the two conditions described in his letter:

1. cancer mortality for the period 1972-1978 and
2. congenital malformations for the period 1976-1978.

The analysis includes the site area, Warren County, and Missouri as specified in the letter.

We recognize the State as the arbiter of the Health Profile. Although we raised technical reservations concerning the use and period of the data requested, we do wish to comply fully with the State's review.

The analysis follows the request and guidelines implicit in Mr. Reichart's letter, consistent with the original profile. The Missouri State Center for Health Statistics was most cooperative in providing the additional data requested for this addendum.

SPECIFIC ANALYSES REQUESTED IN

MR. JOSEPH B. REICHERT'S LETTER

OF JUNE 14, 1982

A. Live Births with Congenital Anomalies

Table 1 summarizes the frequency of events by type of congenital anomaly for the years 1976-1978. Frequencies for both the site and for Warren County were small even when aggregated for the three year period.

Tests of significance (Poisson-based) of the total rate of malformation were carried out for the site versus Missouri and Warren County versus Missouri for the periods specified in Mr. Reichart's letter. Results of these tests, using 95% confidence levels were:

1. Site versus Missouri - not significant.
2. Warren County versus Missouri - significant.

This latter result indicates that the aggregated period rate (1976-1978) of congenital anomalies in Warren County (65.7) is significantly higher than the State of Missouri (27.3). Three factors must be considered in evaluating this result; 1) the high degree of variability associated with small numbers, 2) the differential degree of reporting these events in the hospital discharge data system, and 3) the aggregation of the specific years and factors in these years contributing to possible heterogeneity of experience. It is, therefore, recommended that additional data be reviewed as these become available both in terms of current years and in terms of improved completeness of the data files of the Missouri Center for Health Statistics. Monitoring of these events in Warren County should be instituted consistent with the recommendations made in the initial BHS Health Profile.

The rate for the site, though not statistically significant compared with the State, is subject to the same constraints on the data as noted above. The observed rate for the site, which was higher than the State, suggests similar review and monitoring be carried out for the site area as for Warren County as subsequent years of experience are accrued.

B. Deaths Due to Malignant Neoplasms.

Table 2 summarizes the frequencies and rates for the major categories of death due to malignant neoplams for the Site, Warren County, and Missouri: for the period 1972-1978. Deaths have been aggregated for the seven year period and the mid-period population, 1975, was used as the base. Population estimates over this period showed only minor variations.

Tests of significance were carried out (Poisson-based) for the Site versus Missouri and Warren County versus Missouri for each cause of death category shown, and for the total malignant neoplasm deaths. Rates for both the site and Warren County were not significantly different from the State of Missouri. Generally, rates for the site area were lower than, or equal to, those for the state; for Warren County, rates for the respiratory system and for leukemia were slightly higher than the State, and lower for the other two categories as compared to the State. The overall rate for the county was higher than for Missouri.

The higher rates for Warren County, though not statistically significant, should be monitored for these causes. Any subsequent elevated rates which are shown to be statistically significant should be followed by an epidemiological investigation before any causal relationships can be established.

TABLE 1

Number of Live Births with Congenital Anomalies by Type, and Total Rate by Site, Warren County, and Missouri, 1976-1978

Type (ICD Category)[1]	Site	Warren County	Missouri
Brain and Nervous System (740-742)	0	0	220
Eye, Ear, Face and Neck (743-744)	0	3	320
Heart and Circulatory System (745-747)	0	4	444
Respiratory System (748)	0	0	112
Cleft Lip and Palate (749)	0	0	215
Upper Alimentary Tract and Digestive System (750-751)	0	1	330
Genital Organs and Urinary System (752-753)	1	1	794
Musculoskeletal System (754-756)	3	9	1,448
Integument (757)	0	0	202
Other and Unspecified (758-759)	0	1	234
Total Anomalies (740-759)	4	19	4,319
Total Live Births with Anomalies	4	18	3,774
Total Live Births	68	274	138,307
Rate per 1,000 Live Births	58.8	65.7	27.3

[1]Includes H-ICDA-2 and Corresponding ICD-8 categories.

Note: As shown in the Technical Notes of the original report, hospital discharge data for births were lower for the site area and Warren County when compared to the State. Rates were adjusted subsequent to the tests for significance and re-tested. Results were unchanged; the unadjusted figures are presented in the table.

Sources: Missouri Vital Statistics, 1976-1978; Missouri Center for Health Statistics.

TABLE 2

Number and Rate of Deaths Due to Malignant Neoplasms by Site, Warren County, and Missouri, 1972-1978

Cause (ICD-8 Category)	Site		Warren County		Missouri	
	Number	Rate	Number	Rate	Number	Rate
Digestive System (150-159)	9	229.8	42	344.3	16,706	350.5
Respiratory System (160-165)	13	332.0	49	401.6	15,547	326.1
Leukemia (204-208)	1	25.5	9	73.8	2,729	57.2
All Other Sites	12	306.4	72	590.2	29,328	615.2
Total (140-208)	35	893.8	172	1409.8	64,310	1349.1

Note: Rate per 100,000 estimated mid-period (1975) population for Missouri and Warren County; 1980 population used for site due to lack of available data. Estimates provided by Missouri Center for Health Statistics.

Sources: Missouri Vital Statistics, 1972-78; Missouri Center for Health Statistics.

APPENDIX E

HAZARDOUS WASTE SPILL EMERGENCY RESPONSE

1. Immediate Action:

(a) In the event of a discharge (spill) of Hazardous Waste, the person responsible for the waste (Driver) at the time of the discharge shall immediately:

I Take appropriate action to minimize the threat to Human health and the environment

(A) Shoveling of waste back into container;
(B) Temporary dam or berm to contain waste; and
(C) Drivers have the authorization to hire, purchase or otherwise acquire equipment and supplies to contain a spill.

Note: Utilize appropriate safety equipment as indicated on the safety sheet at all times.

II Notify one representative of B.H.S., Inc. of the Spill

(A) Mike Gill	(Home 314-625-2064)
(B) Ben Moore	(Home 314-625-2864)
(C) Bruce Bote	(Home 314-456-3666)

III Give notice to the National Response Center (1-800-424-8802) and to the Department in the appropriate state.

(A) Mo. DNR	(314-751-3241)
(B) Nebraska	(402-471-2186)
(C) Illinois	(217-782-6760)
(D) Iowa	(515-281-8921)
(E) Kansas	(913-862-9360)

Note: When calling the above numbers ask for the Hazardous Waste Spill Coordinator at State level.

(b) Provide the following information when reporting the spill:

I Name, phone number, and address of person responsible for the discharge;

II Name, title and phone number of individual reporting;

III Time and date of discharge;

IV Location of Discharge - as specific as possible including nearest town, city, highway or waterway;

V Description contained on the manifest or other pertinent documents and the amount of waste discharged;

VI Cause of discharge; and

VII Emergency action taken to minimize the threat to human health and the environment.

2. <u>Secondary Action:</u>

(a) Start to locate available equipment (Highlift, dumptrucks) as needed for clean-up.

(b) If Weather indicates possible movement of waste (rain) then driver will receive authorization to commence clean-up. This will come from verbal report to B.H.S., inc. representative.

(c) The drive is the on scene representative of B.H.S., inc. until the Emergency Spill Coordinator arrives.

APPENDIX F

W I L S O N L A B O R A T O R I E S

528 NORTH NINTH STREET - P.O. BOX 1856 - SALINA, KANSAS 67402-1856 - (913) 825-7166

LABORATORY REPORT. PAGE

CLIENT: WCC (13CV61)
ATTN: NEIL WILLIAMS
5055 ANTIOCH ROAD
OVERLAND PARK, KS 66202

DATE RPTD. 10 26 83
DATE RCVD: 09 26 83
PURCHASE AUTH:
FILE NO.: 83-9588
ORDER NO.: 6132

LAB NUMBER: 8309035[illegible]
SAMPLE DESCRIPTION: 0 L

DATE SAMPLED: [illegible]
TIME SAMPLED: [illegible]

ANALYSIS	CONCENTRATION	UNITS	SOGW--
4,4'-DDD	ND(1.0)	UG/L	244-96
4,4'-DDE	ND(1.0)	UG/L	244-96
4,4'-DDT	ND(1.0)	UG/L	244-96
A-BHC	ND(1.0)	UG/L	244-96
ALDRIN	ND(1.0)	UG/L	244-96
B-BHC	ND(1.0)	UG/L	244-96
CHLORDANE	ND(1.0)	UG/L	244-96
DIELDRIN	ND(1.0)	UG/L	244-96
ENDOSULFAN	ND(1.0)	UG/L	244-96
ENDOSULFAN II	ND(1.0)	UG/L	244-96
ENDOSULFAN SULFATE	ND(1.0)	UG/L	244-96
ENDRIN	ND(1.0)	UG/L	244-96
ENDRIN ALDEHYDE	ND(1.0)	UG/L	244-96
HEPTACHLOR	ND(1.0)	UG/L	244-96
HEPTACHLOR EPOXIDE	95.5	UG/L	244-96
LINDANE	11.4	UG/L	244-96
PCB 1016	ND(10)	UG/L	244-96
PCB 1221	ND(10)	UG/L	244-96
PCB 1232	ND(10)	UG/L	244-96
PCB 1242	ND(10)	UG/L	244-96
PCB 1248	ND(10)	UG/L	244-96
PCB 1254	ND(10)	UG/L	244-96
PCB 1260	ND(10)	UG/L	244-96
TOXAPHENE	ND(1.0)	UG/L	244-96
TOTAL ORGANIC CARBON (SPARGED)	1400	MG/L	[illegible]
U V SCANA	SEE ATTACHED		
GC/MS VOLATILE COMPOUNDS			
1V. ACROLEIN	NOT ANALYZED	UG/L	263-31
2V. ACRYLONITRILE	NOT ANALYZED	UG/L	263-31
3V. BENZENE	16.	UG/L	263-31
4V. BIS(CHLOROMETHYL)ETHER	ND(10)	UG/L	263-31
5V. BROMOFORM	ND(10)	UG/L	263-31
6V. CARBON TETRACHLORIDE	ND(10)	UG/L	263-31
7V. CHLOROBENZENE	ND(10)	UG/L	263-31
8V. CHLORODIBROMOMETHANE	ND(10)	UG/L	263-31

W I L S O N L A B O R A T O R I E S

LABORATORY REPORT

CLIENT: WCC (1[illegible]51)

FILE NO.. 83-[illegible]
ORDER NO.: [illegible]

LAB NUMBER: 83090357 (CONT.)

ANALYSIS	CONCENTRATION	UNITS	BOOK/PAGE
9V. CHLOROETHANE	ND(10)	UG/L	263-31
10V. 2-CHLOROETHYLVINYL ETHER	ND(10)	UG/L	263-31
11V. CHLOROFORM	13.	UG/L	263-31
12V. DICHLOROBROMOMETHANE	ND(10)	UG/L	263-31
13V. DICHLORODIFLUOROMETHANE	ND(10)	UG/L	263-31
14V. 1,1-DICHLOROETHANE	260.	UG/L	263-31
15V. 1,2-DICHLOROETHANE	2000.	UG/L	263-31
16V. 1,1-DICHLOROETHYLENE	ND(10)	UG/L	263-31
17V. 1,2-DICHLOROPROPANE	ND(10)	UG/L	263-31
18V. 1,3-DICHLOROPROPYLENE	ND(10)	UG/L	263-31
19V. ETHYLBENZENE	210.	UG/L	263-31
20V. METHYL BROMIDE	ND(10)	UG/L	263-31
21V. METHYL CHLORIDE	33.	UG/L	263-31
22V. METHYLENE CHLORIDE	3600.	UG/L	263-31
23V. 1,1,2,2-TETRACHLOROETHANE	ND(10)	UG/L	263-31
24V. TETRACHLOROETHYLENE	60.	UG/L	263-31
25V. TOLUENE	3300.	UG/L	263-31
26V. 1,2-TRANSDICHLOROETHYLENE	1600.	UG/L	263-31
27V. 1,1,1-TRICHLOROETHANE	52.	UG/L	263-31
28V. 1,1,2-TRICHLOROETHANE	ND(10)	UG/L	263-31
29V. TRICHLOROETHYLENE	33.	UG/L	263-31
30V. TRICHLOROFLUOROMETHANE	ND(10)	UG/L	263-31
31V. VINYL CHLORIDE	680.	UG/L	263-31
CALCIUM BY AA	660.	MG/L	239-4[illegible]
SODIUM	220.	MG/L	239-4[illegible]

*COMMENTS: 3.0 MAXIMUM ABS AT 240 NANOMETERS.

--CONCLUSION--LAB NUMBER: 83090357 [illegible] L

ND(), WHERE NOTED, INDICATES NONE DETECTED WITH THE DETECTION LIMIT IN PARENTHESES.

ANALYSES WERE PERFORMED ON SAMPLES AS RECEIVED BY WILSON LABS UTILIZING APPROVED PROCEDURES PUBLISHED IN THE FEDERAL REGISTER, VOL. 44, NO. 233, DEC. 3, 1979 (69566-69575) AND AS AMENDED IN THE FED. REG., VOL. 44, NO. 244, DEC. 18, 1979.

WILSON LABORATORIES

Robert Self, CRV

ROBERT F. SELF
PARTNER

MMTL
Analytical Services

206 South Keene Street
Columbia, MO 65201
314/874-8080

114 East Elm, Suite 3
O'Fallon, MO 63366
314/281-2858

Client: Bob's Home Service
Route 1, Box 116F
Wright City MO 63390

Date Reported: 03/29/85
Date Sampled: 02/11/85
Date Received: 02/18/85

Attention: Mike Gill

MMTL Report No: 18293

Customer P. O. Number:

MMTL Account No: 10007

REPORT OF ANALYSIS

Sample No.	Units	Results
LEACHATE SAMPLE		
BOD5	MG/L	690
COD	MG/L	2000
Carbon, Total Organic	MG/L	480
Residue, Total Suspended	MG/L	16
Nitrogen, Ammonia	MG/L	34
Nitrogen, Kjeldahl	MG/L	46
Sulfate	MG/L	2100
Sulfide	MG/L	142
Sulfite	MG/L	110
Phenol	UG/L	32000
Total Aluminum	MG/L	< .1
Total Barium	MG/L	.3
Total Boron	MG/L	1
Total Cobalt	MG/L	< .03
Total Iron	MG/L	.81
Total Manganese	MG/L	1.3
Total Antimony	UG/L	< 5
Total Arsenic	UG/L	90
Total Cadmium	MG/L	< .01
Total Chromium	MG/L	.04
Total Copper	MG/L	.02
Total Lead	MG/L	< .1
Total Mercury	UG/L	< .5
Total Nickel	MG/L	.20
Total Selenium	UG/L	7
Total Silver	MG/L	.02
Total Zinc	MG/L	.05

Comments:

VOLATILE ORGANICS - COMPOUND LIST

	VOLATILE ORGANICS	CONCENTRATION (UG/L)	DETECTION LIMIT (UG/L)
1V.	CHLOROMETHANE	10	10
2V.	VINYL CHLORIDE	BDL	10
3V.	CHLOROETHANE	BDL	10
4V.	BROMOMETHANE	BDL	10
5V.	ACROLEIN	BDL	100
6V.	ACRYLONITRILE	BDL	100
7V.	METHYLENE CHLORIDE	5200(1)	10
8V.	TRICHLOROFLUOROMETHANE	BDL	10
9V.	1,1-DICHLOROETHYLENE	BDL	10
10V.	1,1-DICHLOROETHANE	270	10
11V.	TRANS-1,2-DICHLOROETHYLENE	75	10
12V.	CHLOROFORM	BDL	10
13V.	1,2-DICHLOROETHANE	1000	10
14V.	1,1,1-TRICHLOROETHANE	180	10
15V.	CARBON TETRACHLORIDE	BDL	10
16V.	BROMODICHLOROMETHANE	BDL	10
17V.	1,2-DICHLOROPROPANE	BDL	10
18V.	TRANS-1,3-DICHLOROPROPENE	BDL	10
19V.	TRICHLOROETHYLENE	38	10
20V.	BENZENE	12	10
21V.	CIS-1,3-DICHLOROPROPENE	BDL	10
22V.	1,1,2-TRICHLOROETHANE	BDL	10
23V.	DIBROMOCHLORMETHANE	BDL	10
24V.	BROMOFORM	BDL	10
25V.	1,1,2,2-TETRACHLOROETHYLENE	11	10
26V.	1,1,2,2-TETRACHLOROETHANE	BDL	10
27V.	TOLUENE	2400(1)	10
28V.	CHLOROBENZENE	BDL	10
29V.	ETHYLBENZENE	210	10
30V.	2-CHLOROETHYL VINYL ETHER	BDL	10

BDL = BELOW DETECTION LIMIT

(1) Quantitated using secondary ion

ACID EXTRACTABLE ORGANICS - COMPOUND LIST

	ACID EXTRACTABLE ORGANICS	CONCENTRATION (UG/L)	DETECTION* LIMIT (UG/L)
1A.	PHENOL	16000	2500
2A.	2-CHLOROPHENOL	BDL	2500
3A.	2-NITROPHENOL	BDL	2500
4A.	2,4-DIMETHYLPHENOL	BDL	2500
5A.	2,4-DICHLOROPHENOL	BDL	2500
6A.	P-CHLORO-M-CRESOL	BDL	2500
7A.	2,4,6-TRICHLOROPHENOL	BDL	2500
8A.	2,4-DINITROPHENOL	BDL	25000
9A.	R-NITROPHENOL	BDL	2500
10A.	4,6-DINITRO-O-CRESOL	BDL	25000
11A.	PENTACHLOROPHENOL	BDL	2500

BDL=BELOW DETECTION LIMIT

*Sample analyzed using a 100:1 dilution, thus the higher than normal detection limits.

BASE-NEUTRAL EXTRACTABLE ORGANICS - COMPOUND LIST

	BASE-NEUTRAL EXTRACTABLE ORGANICS	CONCENTRATION UG/L	DETECTION LIMIT UG/L
1B.	N-NITROSODIMETHYLAMINE	BDL	10
2B.	BIS (2-CHLOROETHYL) ETHER	BDL	10
3B.	1,3-DICHLOROBENZENE	BDL	10
4B.	1,4-DICHLOROBENZENE	BDL	10
5B.	1,2-DICHLOROBENZENE	BDL	10
6B.	BIS (2-CHLOROISOPROPYL) ETHER	BDL	10
7B.	HEXACHLOROETHANE	BDL	10
8B.	N-NITROSODI-N-PROPYLAMINE	BDL	10
9B.	NITROBENZENE	BDL	10
10B.	ISOPHORONE	110	10
11B.	BIS (2-CHLOROETHOXY) METHANE	BDL	10
12B.	1,2,4-TRICHLOROBENZENE	BDL	10
13B.	NAPHTHALENE	91	10
14B.	HEXACHLOROBUTADIENE	BDL	10
15B.	HEXACHLOROCYCLOPENTADIENE	BDL	10
16B.	2-CHLORONAPHTHALENE	BDL	10
17B.	DIMETHYLPHTHALATE	BDL	10
18B.	ACENAPHTHYLENE	BDL	10
19B.	2,6-DINITROTOLUENE	BDL	10
20B.	ACENAPHTHENE	BDL	10
21B.	2,4-DINITROTOLUENE	BDL	10
22B.	DIETHYLPHTHALATE	BDL	10
23B.	FLUORENE	BDL	10
24B.	4-CHLOROPHENYL PHENYL ETHER	BDL	10
25B.	DIPHENYLAMINE (N-NITROSO)	BDL	10
26B.	1,2-DIPHENYLHYDRAZINE (AZOBENZENE)	BDL	10
27B.	4-BROMOPHENYL PHENYL ETHER	BDL	10
28B.	HEXACHLOROBENZENE	BDL	10
29B.	PHENANTHRENE	BDL	10
30B.	ANTHRACENE	BDL	10
31B.	DI-N-BUTYLPHTHALATE	BDL	10
32B.	FLUORANTHENE	BDL	10
33B.	BENZIDINE	BDL	10
34B.	PYRENE	BDL	10
35B.	BUTYLBENZYLPHTHALATE	BDL	10
36B.	BENZO(A)ANTHRACENE	BDL	10
37B.	3,3'-DICHLOROBENZIDINE	BDL	10
38B.	CHRYSENE	BDL	10
39B.	BIS (2-ETHYLHEXYL)PHTHALATE	BDL	10
40B.	DI-N-OCTYLPHTHALATE	BDL	10
41B.	BENZO(B)FLUORANTHENE	BDL	10
42B.	BENZO(K)FLUORANTHENE	BDL	10
43B.	BENZO(A)PYRENE	BDL	10
44B.	INDENO(1,2,3-C,D)PYRENE	BDL	25
45B.	DIBENZO(A,H)ANTHRACENE	BDL	25
46B.	BENZO(G,H,I)PERYLENE	BDL	25

BDL=BELOW DETECTION LIMIT

APPENDIX G

office use
Request
No._____

MISSOURI DEPARTMENT OF NATURAL RESOURCES
HAZARDOUS WASTE DISPOSAL REQUEST

I. GENERAL INFORMATION

	Applicant	Waste Hauler
Name:	B.H.S., Inc	B.H.S., Inc
Address:	Rt. 1 Box 116-F	Same
City,State,Zip:	Wright City,Mo. 63390	Same
Contact Person	Michael D. Gill	Same
Telephone No.	314-745-3371	Same

	Waste Generator	Waste Location
Name:	Mobay Chemical Co.	State Id # 01231-024
Address:	P.O. Box 4913	Same
City,State,Zip:	Kansas City, Mo.64120	Same
Contact Person:	John Lawson	Same
Telephone No.	816-242-2000	Same

II. WASTE CHARACTERIZATION

A. Name of waste - Main wastewater treatment sludge

B. Description of generation process - Solids from the primary, secondary and tertiary treatment facilities after centrifuging

C. Basic physical state @ 70 F - Sludge

pH - 4.5 to 9.5	Flash Point - N/A C
% Moisture - 50 to 70 %	Specific Gravity-1.1 to 1.5 mg/l
Pumpable - No	Odor - Moderate to strong
Free Fluid - No	Free Flowing - No
% Organic Liquid - < 5 %	Vol @ 600 C - 70 to 90 %

D. Known hazards of the waste - Listed by Mo. DNR regulatory direction only

E. Chemical composition -

Sanitary solids 5 - 15 %	Secondary solids	10 - 20 %
Tertiary solids 2 - 5	Water	Balance
Dirt/Clay/Salts & other inert solids		5 - 15 %

III. QUANTITY OF WASTE & GENERATION RATE

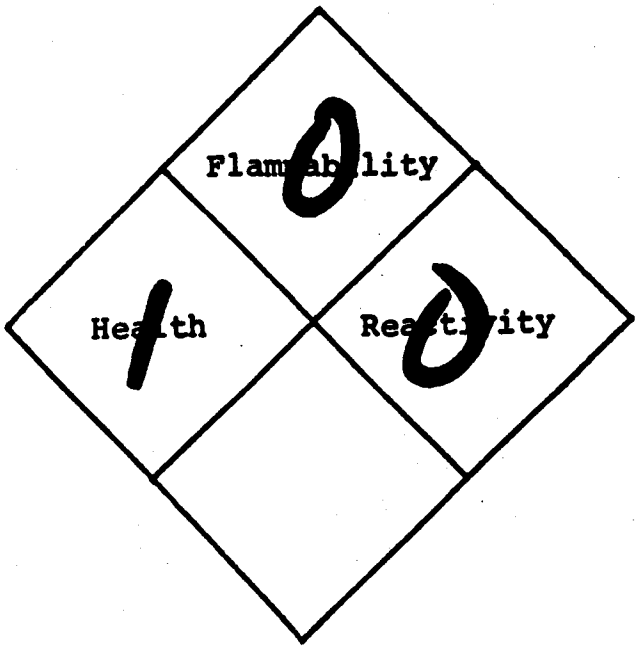
A. Amount of waste on hand for immediate disposal - 500 cu. yds.

B. Rate of generation - One time only

IV. TRANSPORTATION

A. Containers used for transportation - 10 - 20 cu.yd. boxes

0 - No Hazard
1 - Minor Irritation
2 - Hazard With Long Exposure
3 - Hazard With Short Exposure
4 - Hazard Immediately With Exposure



B. Type of Vehicle - roll-off

C. Label identification - NA-9189

D. Route of transportation - I435 to I70 to Wright City to H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill - Wash exposed skin with soap and water. Shovel into container.

B. Necessary safety equipment for handling waste - Rubber gloves, safety glasses, portable eye wash, apron

C. Safety precautions during handling - Incompatible with strong acids

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment - None

B. Amount and frequency of disposal - One time only

C. Disposal technique - General trench area

office use
Request
No. BHS-0683

MISSOURI DEPARTMENT OF NATURAL RESOURCES
HAZARDOUS WASTE DISPOSAL REQUEST

I. GENERAL INFORMATION

	Applicant	Waste Hauler
Name:	B.H.S.,Inc	B.H.S., Inc
Address:	Rt. 1 Box 116-F	Same
City,State,Zip:	Wright City,Mo. 63390	Same
Contact Person	Michael D. Gill	Same
Telephone No.	314-745-3371	Same

	Waste Generator	Waste Location
Name:	Ford Motor Co. K.C.	State Id #_____001
Address:	P.O.Box 11009	Same
City,State,Zip:	Kansas City, MO 64119	Same
Contact Person:	Paul Brinkman	Same
Telephone No.	816-459-1486	Same

II. WASTE CHARACTERIZATION

A. Name of waste - Waste Water Treatment Sludge.(F006)

B. Description of generation process - Precipitation of heavy metals then dewatered using a filter press.

C. Basic physical state @ 70 F - Sludge.

pH - 9.4	Flash Point - >200 F
% Moisture - 57 %	Specific Gravity - 1.6
Pumpable - No	Odor - None
Free Fluid - No	Free Flowing - No
% Organic Liquid - < 5 %	Vol @ 600 C - 78 %

* Physical Analysis by BHS, INC on samples taken from the discharge at the Ford Plant 9/11/84.

D. Known hazards of the waste - Toxic

E. Chemical composition - (in mg/l)

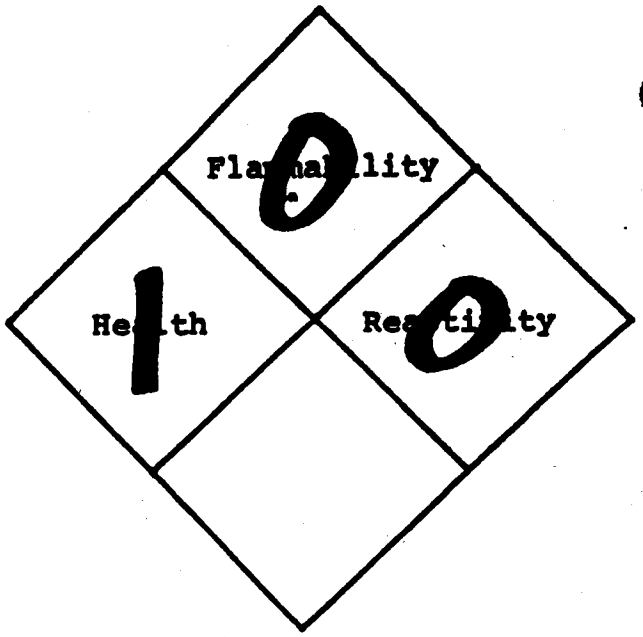
Arsenic	<.25	Barium	1.0
Cadmium	<.05	Chromium	< .25
Lead	<.25	Mercury	< .01
Selenium	<.05	Silver	< .25

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal - 0, presently using another disposal site.

B. Rate of generation - 60 cubic yards per week.

0 - No Hazard
1 - Minor Irritation
2 - Hazard With Long Exposure
3 - Hazard With Short Exposure
4 - Hazard Immediately With Exposure



IV. TRANSPORTATION

A. Containers used for transportation - 20 cubic yard gondola.

B. Type of Vehicle - Tractor trailer

C. Label identification - NA 9189

D. Route of transportation - I70 to Wright City to H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill - Wash exposed skin with soap and water. Shovel into container.

B. Necessary safety equipment for handling waste - Rubber gloves, safety glasses, portable eye wash

C. Safety precautions during handling - Incompatible with strong acids. Avoid contact with skin.

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment - None

B. Amount and frequency of disposal - 60 cubic yards per week.

C. Disposal technique - General trench.

Sample Description: Lagoon Sludge

Parameter	Results
Total Concentration	
Arsenic	0.61 mg/kg
Barium	650 mg/kg
Cadmium	2 mg/kg
Chromium	220 mg/kg
Lead	1,300 mg/kg
Mercury	0.02 mg/kg
Silver	0.33 mg/kg
Zinc	2,600 mg/kg
Copper	50 mg/kg
Nickel	960 mg/kg
Iron	2,000 mg/kg
Phenol	7 mg/kg
Cyanide	0.40 mg/kg
Methylene Chloride	< 10 mg/kg
Perchloroethylene	< 10 mg/kg
Density	1.08 g/ml

Methodology - as per Federal Register 41, No. 232 and 43, No. 243.

cc: Mr. Paul Sgriccia

Approved: Alan Kerschen

Alan Kerschen
Laboratory Director

LANGSTON LABORATORIES, INC.

Laboratory Report

Received: April 28, 1980
Completed: May 29, 1980

LLI Project No.: 80-4238

Submitted by: Ford Motor Company
Highway 69
Claycomo, MO 64119
Attn: Mr. Paul Brinkman
P. O. No.: KNP 096520

Sample Description: Lagoon Sludge

Parameter	Results
pH	7.3
Toxic Extraction Test	
Arsenic	< 0.01 mg/liter
Barium	0.12 mg/liter
Cadmium	< 0.01 mg/liter
Chromium	< 0.01 mg/liter
Lead	0.06 mg/liter
Mercury	< 0.01 mg/liter
Selenium	< 0.01 mg/liter
Silver	< 0.01 mg/liter
Endrin	< 0.001 mg/liter
Lindane	< 0.001 mg/liter
Methoxychlor	< 0.01 mg/liter
Toxaphene	< 0.001 mg/liter
2,4-D	< 0.05 mg/liter
2,4,5-TP Silvex	< 0.05 mg/liter
Phenols	1.2 mg/liter
Flash Point	> 200°F
Corrosivity	Non Corrosive
Volatiles at 100°C	73.4%
Volatiles at 600°C	81.4%
Acidity (as $CaCO_3$)	550 mg/liter
Water Solubility at 25°C	1.0%
Water Solubility at 100°C	3.9%
Appearance	Muddy
Odor	Moderate Organic
Boiling Point	N/A

9-13-84

office use
Request
No. BHS-0684

MISSOURI DEPARTMENT OF NATURAL RESOURCES
HAZARDOUS WASTE DISPOSAL REQUEST

I. GENERAL INFORMATION

	Applicant	Waste Hauler
Name:	B.H.S., Inc	B.H.S., Inc
Address:	Rt. 1 Box 116-F	Same
City,State,Zip:	Wright City,Mo. 63390	Same
Contact Person	Michael D. Gill	Same
Telephone No.	314-745-3371	Same

	Waste Generator	Waste Location
Name:	Ford Motor Co. KC	State Id #_____-002
Address:	P.O.Box 11009	Same
City,State,Zip:	Kansas City, MO 64119	Same
Contact Person:	Paul Brinkman	Same
Telephone No.	816-459-1486	Same

II. WASTE CHARACTERIZATION

A. Name of waste - Paint Sludge and paint filter debris.

B. Description of generation process - Paint pigments from automotive painting process.

C. Basic physical state @ 70 F - Sludge.

pH - 6.4	Flash Point - 155 F
% Moisture - 29 %	Specific Gravity - 1.04
Pumpable - No	Odor - None
Free Fluid - No	Free Flowing - No
% Organic Liquid - < 5 %	Vol @ 600 C - 62 %

Physical analysis confirmed by samples taken by BHS on 9/11/84.

D. Known hazards of the waste - Toxic

E. Chemical composition - (in mg/l)

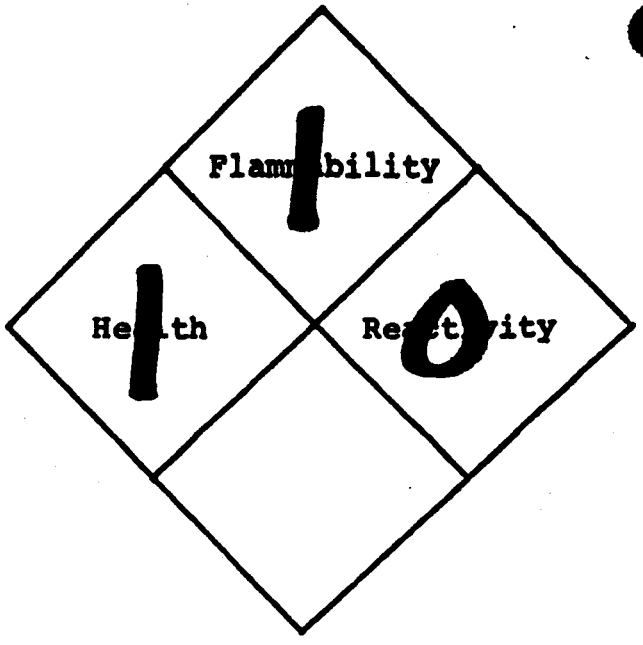
Arsenic	<.25	Barium	1.0
Cadmium	<.05	Chromium	< .25
Lead	0.56	Mercury	< .01
Selenium	<.05	Silver	< .25

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal - 0, presently using another facility.

B. Rate of generation - 140 cubic yards per month.

0 - No Hazard
1 - Minor Irritation
2 - Hazard With Long Exposure
3 - Hazard With Short Exposure
4 - Hazard Immediately With Exposure



IV. TRANSPORTATION

A. Containers used for transportation - 20 cubic yard gondola.

B. Type of Vehicle - Tractor trailer roll-off.

C. Label identification - NA 9189

D. Route of transportation - I70 to Wright City to H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill - Wash exposed skin with soap and water. Shovel into container.

B. Necessary safety equipment for handling waste - Rubber gloves, safety glasses, portable eye wash

C. Safety precautions during handling - Avoid contact with skin.

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment - None

B. Amount and frequency of disposal - 140 cubic yards per month.

C. Disposal technique - General trench.

LANGSTON LABORATORIES, INC.

Laboratory Report

Received: April 28, 1980
Completed: May 29, 1980

LLI Project No.: 80-4239

Submitted by: Ford Motor Company
Highway 69
Claycomo, MO 64119

Attn: Mr. Paul Brinkman
P. O. No.: KNP 096520

Sample Description: Delpack Paint Sludge

Parameter	Results
pH	9.9
Toxic Extraction Test	
Arsenic	< 0.01 mg/liter
Barium	0.09 mg/liter
Cadmium	0.01 mg/liter
Chromium	23 mg/liter
Lead	0.04 mg/liter
Mercury	< 0.01 mg/liter
Selenium	< 0.01 mg/liter
Silver	0.01 mg/liter
Endrin	< 0.001 mg/liter
Lindane	< 0.001 mg/liter
Methoxychlor	< 0.01 mg/liter
Toxaphene	< 0.001 mg/liter
2,4-D	< 0.05 mg/liter
2,4,5-TP Silvex	< 0.05 mg/liter
Phenols	< 0.1 mg/liter
Flash Point	> 200°F
Corrosivity	Non Corrosive
Volatiles at 100°C	36.5%
Volatiles at 600°C	59.7%
Acidity (as $CaCO_3$)	N/A
Water Solubility at 25°C	0.56%
Water Solubility at 100°C	0.61%
Appearance	Mixed Color Sludge
Odor	Heavy Organic
Boiling Point	N/A

2005 West 103rd Terrace Leawood, KS 66206 913/341-7800

Sample Description: Delpack Paint Sludge

Parameter	Results
Total Concentration	
Arsenic	1.7 mg/kg
Barium	91 mg/kg
Cadmium	0.3 mg/kg
Chromium	750 mg/kg
Lead	6 mg/kg
Mercury	0.13 mg/kg
Silver	0.22 mg/kg
Zinc	1,300 mg/kg
Copper	25 mg/kg
Nickel	70 mg/kg
Iron	10,300 mg/kg
Phenol	0.3 mg/kg
Cyanide	0.10 mg/kg
Methylene Chloride	< 10 mg/kg
Perchloroethylene	< 10 mg/kg
Density	1.00 g/ml

Methodology - as per Federal Register 41, No. 232 and 43, No. 243.

cc: Mr. Paul Sgriccia

Approved: Alan Kerschen

Alan Kerschen
Laboratory Director

BHS0574

office use
Request
No._____

MISSOURI DEPARTMENT OF NATURAL RESOURCES
HAZARDOUS WASTE DISPOSAL REQUEST

I. GENERAL INFORMATION

	Applicant	Waste Hauler
Name:	B.H.S.,Inc	J.S. Alberici Const.
Address:	Rt. 1 Box 116-F	2150 Kienlen Ave
City,State,Zip:	Wright City,Mo. 63390	St. Louis,Mo. 63121
Contact Person	Michael D. Gill	Lynn Farley
Telephone No.	314-745-3371	314-261-2611

	Waste Generator	Waste Location
Name:	Ford Motor Co.	State Id # 01574-001
Address:	6250 Lindbergh	Same
City,State,Zip:	Hazelwood, Mo. 63042	Same
Contact Person:	Bob Sieveking	Same
Telephone No.	314-731-1300	Same

II. WASTE CHARACTERIZATION

A. Name of waste - Dirt contaminated with Paint

B. Description of generation process - Clean-up of old fill area.

C. Basic physical state @ 70 F - Solid
pH - Approx. 7
% Moisture - 24 %
Pumpable - No
Free Fluid - No
% Organic Liquid - < 5 %
Flash Point -None
Specific Gravity - 1.2 - 1.5
Odor - None
Free Flowing - No

D. Known hazards of the waste - None

E. Chemical composition - See enclosed analysis

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal - 10,000 cubic yards.

B. Rate of generation - One time only

IV. TRANSPORTATION

A. Containers used for transportation - 10 - 20 cubic yard bulk

B. Type of Vehicle - Roll-offs and dump trailers

C. Label identification - None

D. Route of transportation - Lindbergh to I270 to I70 to Wright City to H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill - Wash exposed skin with soap and water. Shovel into container.

B. Necessary safety equipment for handling waste - gloves

C. Safety precautions during handling - Incompatible with strong acids

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment - None

B. Amount and frequency of disposal - 10 - 20 cu. yds. per trip, up to 11 trucks with 3 turns per day

C. Disposal technique - General trench area

VII. CERTIFICATION

If granted this request, we the undersigned agree to abide by the rules, regulations, orders and decisions of the Missouri Department of Natural Resources and the requirements specified in this application. We hereby certify that the subject waste and the proposed disposal procedures are compatible with the geological and environmental setting of the disposal site. We affirm that the infromation in this application is to the best of our knowledge and belief, true, complete and accurate, and understand that in the event of any false or fraudulent information in this request or of failure to operate the disposal operation in a proper and legal manner, the disposal permit may be revoked.

_____ _____

Signature of Applicant Date

E.P. Toxicity Data for Buried Wastes
Ford St. Louis Assembly Plant

The data below was obtained from leaching a composite of 30-35 samples of waste materials from 14 representative borings. RCRA leaching and subsequent metals analysis was conducted by Envirodyne Engineers of St. Louis. Envirodyne also determined the flash point and the percent volatile material at both 100° C. and 600° C.

Parameter	Result
As	<0.01 mg/l
Ba	<2.0 "
Cr	<0.1 "
Hg	<0.0002 "
Se	<0.005 "
Ag	<0.001 "
Cd	<0.1 "
Pb	<1.0 "
% vol. at 100° C	24%
% vol. 100° - 600° C	17%
Flash point	> 200° F.

Prepared by:
Stationary Source Environmental Control
Ford Motor Company

6-19-84

RONALD E. RICH
HAZARDOUS MATERIAL
AND WASTE WATER SPECIALIST
ANT ENG. & ENVIRONMENTAL PLANNING

)F NATURAL RESOURCES
)ISPOSAL REQUEST

office use
Request
No. BHS-BHS0659

CHRYSLER CORPORATION

P.O. BOX 1919, DETROIT, MI 48288 313/956-2124

		Waste Hauler
Name:	B.H.S.,Inc	B.H.S., Inc
Address:	Rt. 1 Box 116-F	Same
City,State,Zip:	Wright City,Mo. 63390	Same
Contact Person	Michael D. Gill	Same
Telephone No.	314-745-3371	Same

	Waste Generator	Waste Location
Name:	Chrysler Corp.	State Id # 01028-005
Address:	1001 No HWY Dr.	Fed Id # MOD
City,State,Zip:	Fenton, Mo. 63026	Same
Contact Person:	Ken Hermann	Same
Telephone No.	314-343-2500	Same

II. WASTE CHARACTERIZATION

A. Name of waste - Waste water treatment sludge.

B. Description of generation process - Heavy metals are flocculated out then allowed to settle in sedimentation lagoons. Solids from lagoons are being filter for disposal.

C. Basic physical state @ 70 F - sludge

pH - 11.9 *	Flash Point - XXX C
% Moisture - 53 % *	Specific Gravity - 1.33 gm/ml *
Pumpable - No	Odor - None
Free Fluid - No	Free Flowing - No
% Organic Liquid - < 5 %	Vol @ 600 C - 68 % *

* Analysis performed by Laclede Lab on 18 June 1984

D. Known hazards of the waste - Toxic

E. Chemical composition - T.E.P. Analysis

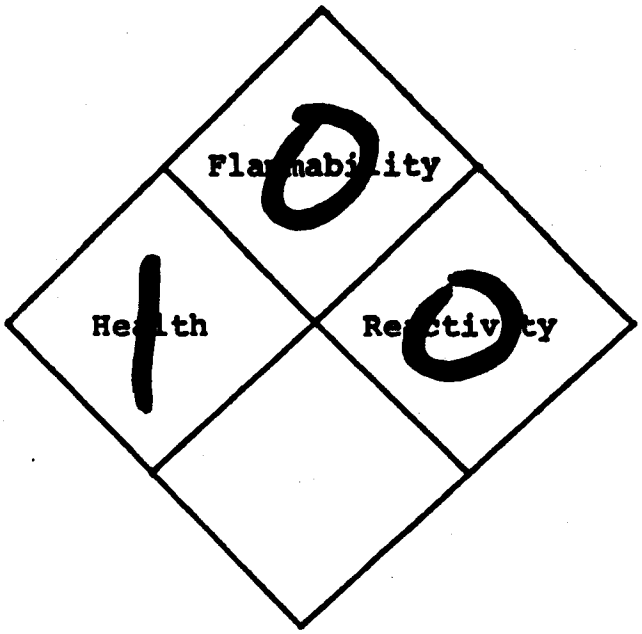
Barium	1.2 mg/l	Chromium	.033 mg/l
Lead	4.9	Nickel	1.58

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal - 370 cu yd

B. Rate of generation - 400 cu yd per year

0 - No Hazard
1 - Minor Irritation
2 - Hazard With Long Exposure
3 - Hazard With Short Exposure
4 - Hazard Immediately With Exposure



IV. TRANSPORTATION

A. Containers used for transportation - 15 to 20 cu yd bulk

B. Type of Vehicle - Roll-Off Truck

C. Label identification - Hazardous Waste Solid NOS

D. Route of transportation - I44 to I270 to 40 to I70 to Wright City to H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill - Wash exposed skin with soap and water. Shovel into container.

B. Necessary safety equipment for handling waste - Rubber gloves, safety glasses, portable eye wash

C. Safety precautions during handling - Incompatible with strong acids

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment - None.

B. Amount and frequency of disposal - 400 cu yd per year

C. Disposal technique - General trench.

RONALD E. RICH
HAZARDOUS MATERIAL
AND WASTE WATER SPECIALIST
PLANT ENG. & ENVIRONMENTAL PLANNING

6-19-84

office use
Request
No. BHS-BHS0659

)F NATURAL RESOURCES
)ISPOSAL REQUEST

CHRYSLER CORPORATION

P.O. BOX 1919, DETROIT, MI 48288 313/956-2124

		Waste Hauler
Name:	B.H.S.,Inc	B.H.S., Inc
Address:	Rt. 1 Box 116-F	Same
City,State,Zip:	Wright City,Mo. 63390	Same
Contact Person	Michael D. Gill	Same
Telephone No.	314-745-3371	Same

	Waste Generator	Waste Location
Name:	Chrysler Corp.	State Id # 01028-005
Address:	1001 No HWY Dr.	Fed Id # MOD
City,State,Zip:	Fenton, Mo. 63026	Same
Contact Person:	Ken Hermann	Same
Telephone No.	314-343-2500	Same

II. WASTE CHARACTERIZATION

A. Name of waste - Waste water treatment sludge.

B. Description of generation process - Heavy metals are flocculated out then allowed to settle in sedimentation lagoons. Solids from lagoons are being filter for disposal.

C. Basic physical state @ 70 F - sludge

pH - 11.9 *	Flash Point - XXX C
% Moisture - 53 % *	Specific Gravity - 1.33 gm/ml *
Pumpable - No	Odor - None
Free Fluid - No	Free Flowing - No
% Organic Liquid - < 5 %	Vol @ 600 C - 68 % *

* Analysis performed by Laclede Lab on 18 June 1984

D. Known hazards of the waste - Toxic

E. Chemical composition - T.E.P. Analysis

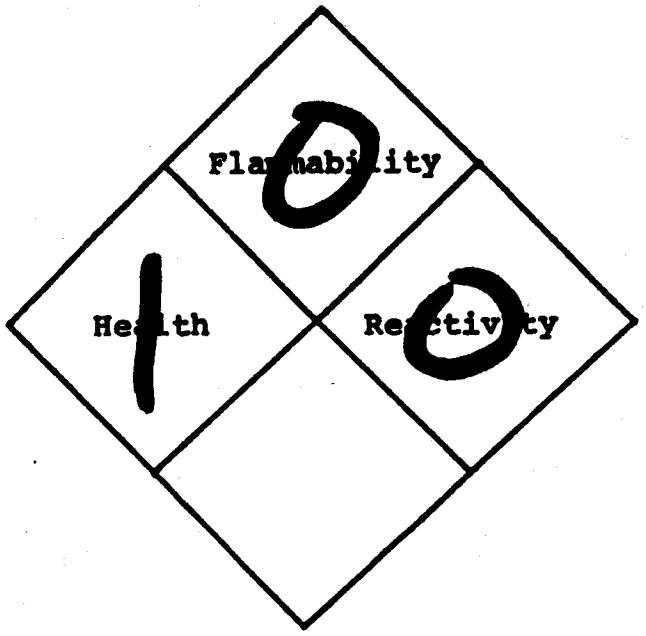
Barium	1.2 mg/l	Chromium	.033 mg/l
Lead	4.9	Nickel	1.58

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal - 370 cu yd

B. Rate of generation - 400 cu yd per year

0 - No Hazard
1 - Minor Irritation
2 - Hazard With Long Exposure
3 - Hazard With Short Exposure
4 - Hazard Immediately With Exposure



IV. TRANSPORTATION

A. Containers used for transportation - 15 to 20 cu yd bulk

B. Type of Vehicle - Roll-Off Truck

C. Label identification - Hazardous Waste Solid NOS

D. Route of transportation - I44 to I270 to 40 to I70 to Wright City to H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill - Wash exposed skin with soap and water. Shovel into container.

B. Necessary safety equipment for handling waste - Rubber gloves, safety glasses, portable eye wash

C. Safety precautions during handling - Incompatible with strong acids

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment - None.

B. Amount and frequency of disposal - 400 cu yd per year

C. Disposal technique - General trench.

6-19-84

RONALD E. RICH
HAZARDOUS MATERIAL
AND WASTE WATER SPECIALIST
ENG. & ENVIRONMENTAL PLANNING

)F NATURAL RESOURCES
)ISPOSAL REQUEST

office use
Request
No. BHS-BHS0654

CHRYSLER CORPORATION

P.O. BOX 1919, DETROIT, MI 48288 313/956-2124

		Waste Hauler
Name:	B.H.S.,Inc	B.H.S., Inc
Address:	Rt. 1 Box 116-F	Same
City,State,Zip:	Wright City,Mo. 63390	Same
Contact Person	Michael D. Gill	Same
Telephone No.	314-745-3371	Same

	Waste Generator	Waste Location
		State Id # 01028-005
Name:	Chrysler Corp.	Fed Id # MOD
Address:	1001 No HWY Dr.	Same
City,State,Zip:	Fenton, Mo. 63026	Same
Contact Person:	Ken Hermann	Same
Telephone No.	314-343-2500	

II. WASTE CHARACTERIZATION

A. Name of waste - Waste water treatment sludge.

B. Description of generation process - Heavy metals are flocculated out then allowed to settle in sedimentation lagoons. Solids from lagoons are being filter for disposal.

C. Basic physical state @ 70 F - sludge

pH - 11.9 *	Flash Point - XXX C
% Moisture - 53 % *	Specific Gravity - 1.33 gm/ml *
Pumpable - No	Odor - None
Free Fluid - No	Free Flowing - No
% Organic Liquid - < 5 %	Vol @ 600 C - 68 % *

* Analysis performed by Laclede Lab on 18 June 1984

D. Known hazards of the waste - Toxic

E. Chemical composition - T.E.P. Analysis

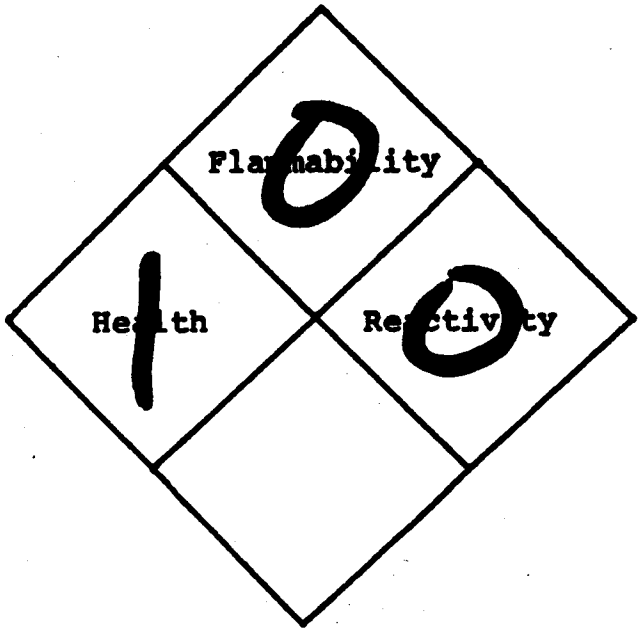
Barium	1.2 mg/l	Chromium	.033 mg/l
Lead	4.9	Nickel	1.58

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal - 370 cu yd

B. Rate of generation - 400 cu yd per year

0 - No Hazard
1 - Minor Irritation
2 - Hazard With Long Exposure
3 - Hazard With Short Exposure
4 - Hazard Immediately With Exposure



IV. TRANSPORTATION

A. Containers used for transportation - 15 to 20 cu yd bulk

B. Type of Vehicle - Roll-Off Truck

C. Label identification - Hazardous Waste Solid NOS

D. Route of transportation - I44 to I270 to 40 to I70 to Wright City to H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill - Wash exposed skin with soap and water. Shovel into container.

B. Necessary safety equipment for handling waste - Rubber gloves, safety glasses, portable eye wash

C. Safety precautions during handling - Incompatible with strong acids

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment - None.

B. Amount and frequency of disposal - 400 cu yd per year

C. Disposal technique - General trench.

RONALD E. RICH
HAZARDOUS MATERIAL
AND WASTE WATER SPECIALIST
PLANT ENG. & ENVIRONMENTAL PLANNING

6-19-84

office use
Request
No. BHS-BHS0654

)F NATURAL RESOURCES
)ISPOSAL REQUEST

CHRYSLER CORPORATION

P.O. BOX 1919, DETROIT, MI 48288 313/956-2124

		Waste Hauler
Name:	B.H.S.,Inc	B.H.S., Inc
Address:	Rt. 1 Box 116-F	Same
City,State,Zip:	Wright City,Mo. 63390	Same
Contact Person	Michael D. Gill	Same
Telephone No.	314-745-3371	Same

	Waste Generator	Waste Location
Name:	Chrysler Corp.	State Id # 01028-005
Address:	1001 No HWY Dr.	Fed Id # MOD
City,State,Zip:	Fenton, Mo. 63026	Same
Contact Person:	Ken Hermann	Same
Telephone No.	314-343-2500	Same

II. WASTE CHARACTERIZATION

A. Name of waste - Waste water treatment sludge.

B. Description of generation process - Heavy metals are flocculated out then allowed to settle in sedimentation lagoons. Solids from lagoons are being filter for disposal.

C. Basic physical state @ 70 F - sludge

pH - 11.9 *	Flash Point - XXX C
% Moisture - 53 % *	Specific Gravity - 1.33 gm/ml *
Pumpable - No	Odor - None
Free Fluid - No	Free Flowing - No
% Organic Liquid - < 5 %	Vol @ 600 C - 68 % *

* Analysis performed by Laclede Lab on 18 June 1984

D. Known hazards of the waste - Toxic

E. Chemical composition - T.E.P. Analysis

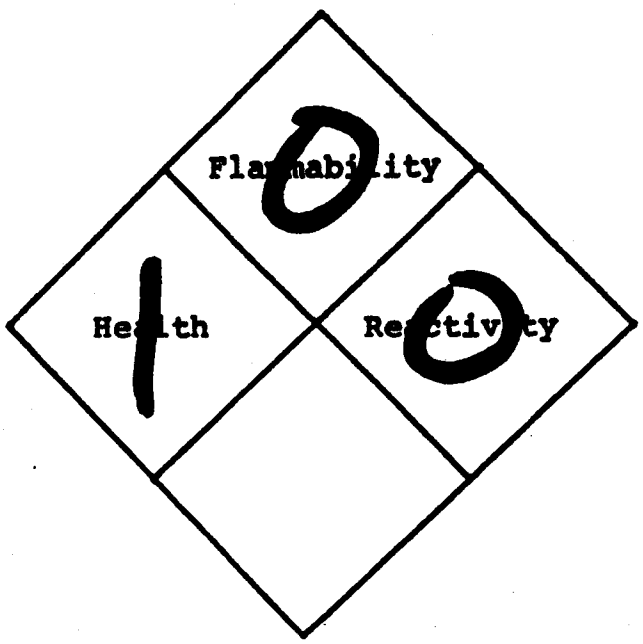
Barium	1.2 mg/l	Chromium	.033 mg/l
Lead	4.9	Nickel	1.58

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal - 370 cu yd

B. Rate of generation - 400 cu yd per year

0 - No Hazard
1 - Minor Irritation
2 - Hazard With Long Exposure
3 - Hazard With Short Exposure
4 - Hazard Immediately With Exposure



IV. TRANSPORTATION

A. Containers used for transportation - 15 to 20 cu yd bulk

B. Type of Vehicle - Roll-Off Truck

C. Label identification - Hazardous Waste Solid NOS

D. Route of transportation - I44 to I270 to 40 to I70 to Wright City to H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill - Wash exposed skin with soap and water. Shovel into container.

B. Necessary safety equipment for handling waste - Rubber gloves, safety glasses, portable eye wash

C. Safety precautions during handling - Incompatible with strong acids

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment - None.

B. Amount and frequency of disposal - 400 cu yd per year

C. Disposal technique - General trench.

RONALD E. RICH
HAZARDOUS MATERIAL
AND WASTE WATER SPECIALIST
PLANT ENG. & ENVIRONMENTAL PLANNING

6-19-84

office use
Request
No. BHS-BHS0654

)F NATURAL RESOURCES
)ISPOSAL REQUEST

CHRYSLER CORPORATION

P.O. BOX 1919, DETROIT, MI 48288 313/956-2124

		Waste Hauler
Name:	B.H.S.,Inc	B.H.S., Inc
Address:	Rt. 1 Box 116-F	Same
City,State,Zip:	Wright City,Mo. 63390	Same
Contact Person	Michael D. Gill	Same
Telephone No.	314-745-3371	Same

	Waste Generator	Waste Location
Name:	Chrysler Corp.	State Id # 01028-005
Address:	1001 No HWY Dr.	Fed Id # MOD
City,State,Zip:	Fenton, Mo. 63026	Same
Contact Person:	Ken Hermann	Same
Telephone No.	314-343-2500	Same

II. WASTE CHARACTERIZATION

A. Name of waste - Waste water treatment sludge.

B. Description of generation process - Heavy metals are flocculated out then allowed to settle in sedimentation lagoons. Solids from lagoons are being filter for disposal.

C. Basic physical state @ 70 F - sludge

pH - 11.9 *	Flash Point - XXX C
% Moisture - 53 % *	Specific Gravity - 1.33 gm/ml *
Pumpable - No	Odor - None
Free Fluid - No	Free Flowing - No
% Organic Liquid - < 5 %	Vol @ 600 C - 68 % *

* Analysis performed by Laclede Lab on 18 June 1984

D. Known hazards of the waste - Toxic

E. Chemical composition - T.E.P. Analysis

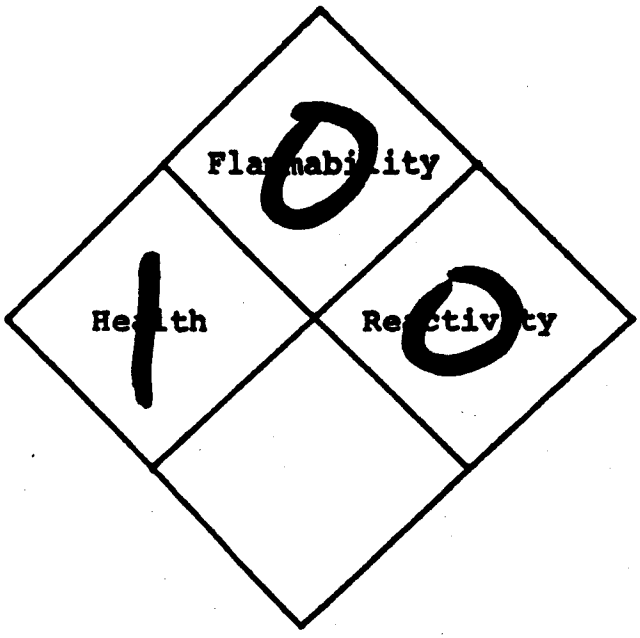
Barium	1.2 mg/l	Chromium	.033 mg/l
Lead	4.9	Nickel	1.58

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal - 370 cu yd

B. Rate of generation - 400 cu yd per year

0 - No Hazard
1 - Minor Irritation
2 - Hazard With Long Exposure
3 - Hazard With Short Exposure
4 - Hazard Immediately With Exposure



IV. TRANSPORTATION

A. Containers used for transportation - 15 to 20 cu yd bulk

B. Type of Vehicle - Roll-Off Truck

C. Label identification - Hazardous Waste Solid NOS

D. Route of transportation - I44 to I270 to 40 to I70 to Wright City to H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill - Wash exposed skin with soap and water. Shovel into container.

B. Necessary safety equipment for handling waste - Rubber gloves, safety glasses, portable eye wash

C. Safety precautions during handling - Incompatible with strong acids

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment - None.

B. Amount and frequency of disposal - 400 cu yd per year

C. Disposal technique - General trench.

RONALD E. RICH
HAZARDOUS MATERIAL
AND WASTE WATER SPECIALIST
PLANT ENG. & ENVIRONMENTAL PLANNING

6-19-84

office use
Request
No. BHS-BHS0659

)F NATURAL RESOURCES
)ISPOSAL REQUEST

CHRYSLER CORPORATION

P.O. BOX 1919, DETROIT, MI 48288 313/956-2124

		Waste Hauler
Name:	B.H.S.,Inc	B.H.S., Inc
Address:	Rt. 1 Box 116-F	Same
City,State,Zip:	Wright City,Mo. 63390	Same
Contact Person	Michael D. Gill	Same
Telephone No.	314-745-3371	Same

	Waste Generator	Waste Location
Name:	Chrysler Corp.	State Id # 01028-005
Address:	1001 No HWY Dr.	Fed Id # MOD
City,State,Zip:	Fenton, Mo. 63026	Same
Contact Person:	Ken Hermann	Same
Telephone No.	314-343-2500	Same

II. WASTE CHARACTERIZATION

A. Name of waste - Waste water treatment sludge.

B. Description of generation process - Heavy metals are flocculated out then allowed to settle in sedimentation lagoons. Solids from lagoons are being filter for disposal.

C. Basic physical state @ 70 F - sludge

pH - 11.9 *	Flash Point - XXX C
% Moisture - 53 % *	Specific Gravity - 1.33 gm/ml *
Pumpable - No	Odor - None
Free Fluid - No	Free Flowing - No
% Organic Liquid - < 5 %	Vol @ 600 C - 68 % *

* Analysis performed by Laclede Lab on 18 June 1984

D. Known hazards of the waste - Toxic

E. Chemical composition - T.E.P. Analysis

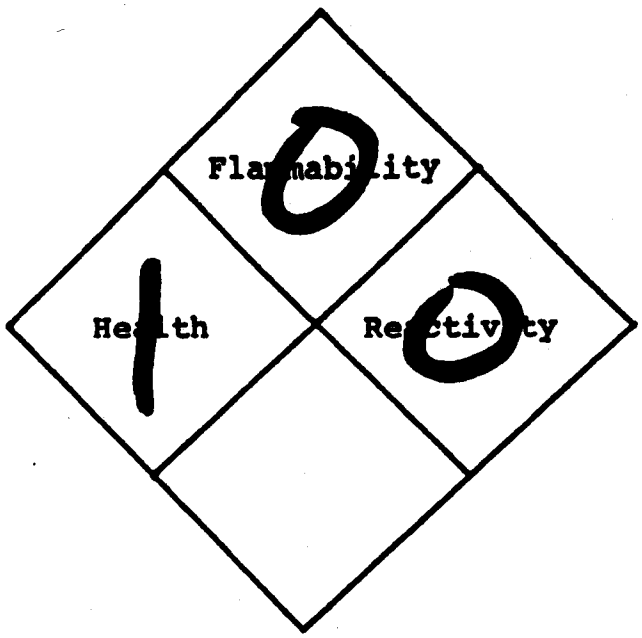
Barium	1.2 mg/l	Chromium	.033 mg/l
Lead	4.9	Nickel	1.58

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal - 370 cu yd

B. Rate of generation - 400 cu yd per year

0 - No Hazard
1 - Minor Irritation
2 - Hazard With Long Exposure
3 - Hazard With Short Exposure
4 - Hazard Immediately With Exposure



IV. TRANSPORTATION

A. Containers used for transportation - 15 to 20 cu yd bulk

B. Type of Vehicle - Roll-Off Truck

C. Label identification - Hazardous Waste Solid NOS

D. Route of transportation - I44 to I270 to 40 to I70 to Wright City to H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill - Wash exposed skin with soap and water. Shovel into container.

B. Necessary safety equipment for handling waste - Rubber gloves, safety glasses, portable eye wash

C. Safety precautions during handling - Incompatible with strong acids

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment - None.

B. Amount and frequency of disposal - 400 cu yd per year

C. Disposal technique - General trench.

M1002127:1

Monsanto

MONSANTO INDUSTRIAL CHEMICALS CO.
1700 South Second Street
St. Louis, Missouri 63177
Phone: (314) 622-1400
622-1469

December 20, 1983

Mr. Mike Gill
Bob's Home Service
Route 1, Box 116F
Wright City, Missouri 63390

Dear Mr. Gill:

We currently have up to 500 yd.^{3} of gravel and dirt contaminated with a mixture of Alachlor and Diethylaniline. I would estimate less than 25% of the material is organic. The compound is considered mildly toxic by oral ingestion, non-lethal by skin absorption and non-irritating upon skin contact.

At your request we collected samples of the material and performed the following analysis (averages reported).

Specific Gravity	- 2.42
pH (1:1 Material to Water)	- 7.3
% Volatiles @ 100°C	- 1.77%
% Volatiles @ 600°C	- 4.69%

Please understand that a truly representative sample of this type of material would be impossible to obtain. The estimate that possibly up to 25% of the material is organic represents a worse case situation. If this material is acceptable for landfill at up to 25%, then lower levels of organics should not be a problem.

For your information, I have a attached a copy of our state registration form for this material.

Please call if you have any questions.

phone #: 622-1469

Yours very truly,

Richard L. Koenig

Richard L. Koenig
Sr. Environmental Protection Technician

RLK:cs

Mike,
Dirt maybe transported by Nolan Contracting Co. (subcontractor to Wellington Co.) of St. Louis Mo.

office use
Request
No._____

MISSOURI DEPARTMENT OF NATURAL RESOURCES
HAZARDOUS WASTE DISPOSAL REQUEST

I. GENERAL INFORMATION

	Applicant	Waste Hauler
Name:	B.H.S. Inc	B.H.S., Inc
Address:	Rt. 1 Box 116-F	Same
City,State,Zip:	Wright City,Mo. 63390	Same
Contact Person	Michael D. Gill	Same
Telephone No.	314-745-3371	Same

	Waste Generator	Waste Location
Name:	Monsanto (Queeney)	State Id # 01002-127
Address:	1700 S. Second St.	Same
City,State,Zip:	St. Louis, Mo. 63177	Same
Contact Person:	Richard Koenig	Same
Telephone No.	314-622-1400	Same

II. WASTE CHARACTERIZATION

A. Name of waste - Dirt contaminated with Alachlor and Diethylaniline.

B. Description of generation process - Dirt from construction project involving a railroad spur.

C. Basic physical state @ 70 F - Solid

pH - 7.3	Flash Point - N/A C
% Moisture - 2 %	Specific Gravity - 2.42 gm/ml
Pumpable - No	Odor - None
Free Fluid - No	Free Flowing - No
% Organic Liquid - < 5 %	Vol @ 600 C - 5 %

D. Known hazards of the waste - Toxic

E. Chemical composition -

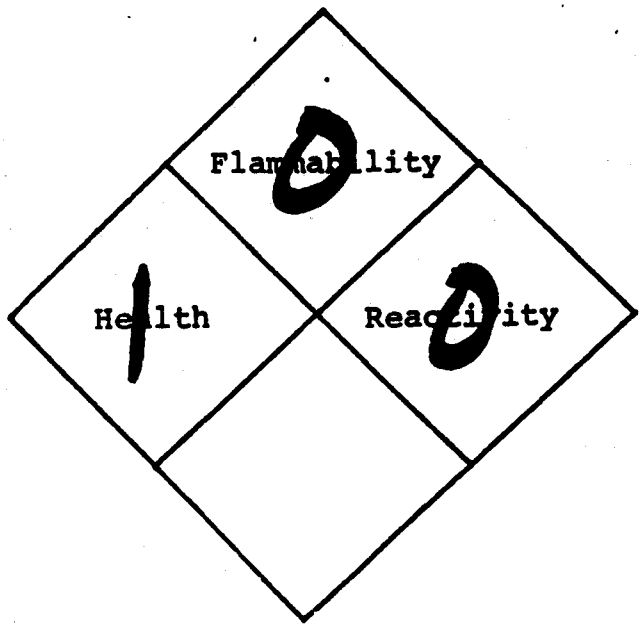
Dirt/Gravel	99 %	Alachlor	1 %
Diethylaniline	1 %		

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal - 500 cu yd

B. Rate of generation - One time only

0 - No Hazard
1 - Minor Irritation
2 - Hazard With Long Exposure
3 - Hazard With Short Exposure
4 - Hazard Immediately With Exposure



IV. TRANSPORTATION

A. Containers used for transportation - 20 cuyd bulk containers

B. Type of Vehicle - Dump trailer

C. Label identification - 9189

D. Route of transportation - Broadway to 40 to I70 to Wright City to H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill - Wash exposed skin with soap and water. Shovel into container.

B. Necessary safety equipment for handling waste - Rubber gloves, safety glasses, portable eye wash

C. Safety precautions during handling - Incompatible with strong acids and oxidizers

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment - None

B. Amount and frequency of disposal - 500 cuyd one time only

C. Disposal technique - General trench.

office use
Request
No._____

MISSOURI DEPARTMENT OF NATURAL RESOURCES
HAZARDOUS WASTE DISPOSAL REQUEST

I. GENERAL INFORMATION

	Applicant	Waste Hauler
Name:	B.H.S.,Inc	B.H.S., Inc
Address:	Rt. 1 Box 116-F	Same
City,State,Zip:	Wright City,Mo. 63390	Same
Contact Person	Michael D. Gill	Same
Telephone No.	314-745-3371	Same

	Waste Generator	Waste Location
Name:	Ramsey Corp.	State Id # 01245-017
Address:	1233 Manchester Rd.	Same
City,State,Zip:	Manchester, Mo. 63011	Same
Contact Person:	Roy Tiefenbrunn	Same
Telephone No.	314-394-3700	Same

II. WASTE CHARACTERIZATION

A. Name of waste - Wastewater treatment sludge

B. Description of generation process - Plating waste is neutralized then passed through filter press.

C. Basic physical state @ 70 F - Sludge

pH - 9	Flash Point - N/A C
% Moisture - 64 %	Specific Gravity - 1.25 gm/ml
Pumpable - No	Odor - None
Free Fluid - No	Free Flowing - No
% Organic Liquid - < 5 %	Vol @ 600 C - 71 %

D. Known hazards of the waste - Toxic

E. Chemical composition -

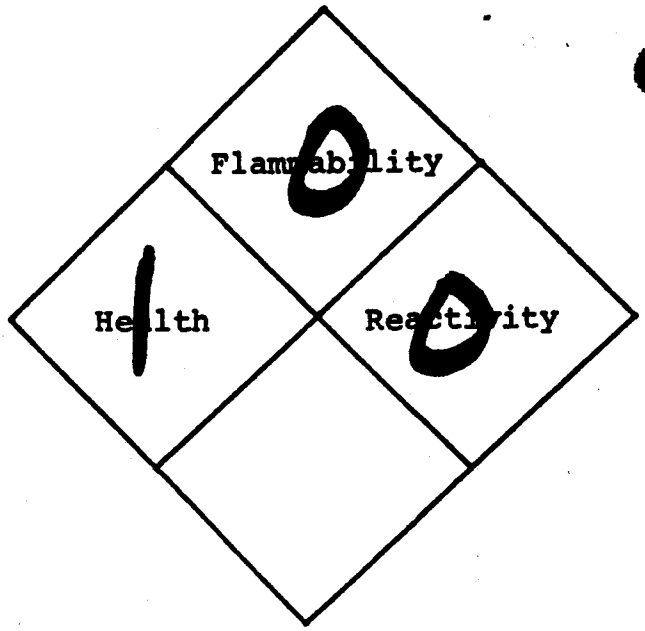
Barium	.003 %	Chromium	3.8 %
Lead	.11	Zinc	.0018
Oil & Grease	.74		

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal - None

B. Rate of generation - 30 cuyd per month

0 - No Hazard
1 - Minor Irritation
2 - Hazard With Long Exposure
3 - Hazard With Short Exposure
4 - Hazard Immediately With Exposure



IV. TRANSPORTATION

A. Containers used for transportation - 15 cuyd bulk containers

B. Type of Vehicle - Roll-off truck

C. Label identification - 9189

D. Route of transportation - Manchester to 141 to 40 to I70 to Wright City to H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill - Wash exposed skin with soap and water. Shovel into container.

B. Necessary safety equipment for handling waste - Rubber gloves, safety glasses, portable eye wash

C. Safety precautions during handling - Incompatible with strong acids

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment - None

B. Amount and frequency of disposal - 30 cuyd per month

C. Disposal technique - General trench.

Mailed to State 9-18-78

OFFICE USE
Request No. _____

MISSOURI DEPARTMENT OF NATURAL RESOURCES
HAZARDOUS WASTE DISPOSAL REQUEST

I. GENERAL INFORMATION

	Applicant	Waste Hauler
Name:	Bob's Home Service, Inc	Transenvironmental Corp.
Address:	R. R. 1, Box 116-F	R. R. 1, Box 116-F1
City, State, Zip:	Wright City, Mo. 63390	Wright City, Mo. 63390
Person to Contact:	James Zykan/Mike Gill	Mike Gill
Telephone Number:	314-745-3711	314-745-3711

	Waste Generator	Waste Location
Name:	Square D Company	same
Address:	4800 Paris Road	
City, State, Zip:	Columbia, Mo. 65201	
Person to Contact:	Richard Widdowson	
Telephone Number:	314-449-3756	

II. WASTE CHARACTERIZATION

A. Name of waste Plating rinse water waste treatment sludge

B. Description of generation process See enclosed diagram

C. Basic physical state @ 70°F

- [ ] Solid
- [x] Sludge (>20% solids)
- [ ] Slurry (<20% solids
- [ ] Liquid (<5% solids)
- [ ] Contained gas
- [ ] Other - specify _____

pH 7.6

Flash point n/a
Pensky-Martins Closed Cup (ASTM D-93-23)

Moisture % by weight 63.4

Specific gravity n/a

Pumpable: Yes _____ No No

Odor: Yes _____ No No

Fuel Value (BTU/lb) n/a

Liq. viscosity @ 70°F n/a c.p.

Free Fluid: Yes _____ No No

D. Known hazards of the waste

- [ ] Flammable
- [ ] Infectious
- [ ] Strong Oxidizer
- [x] Toxic
- [ ] Explosive
- [ ] Reactive
- [ ] Corrosive
- [ ] Other - specify _____

E. Chemical composition

Major Components	wt.%	Concentration ppm
1. See enclosed analysis		
2. (this analysis is from the		
3. Nebraska Plant but is typical		
4. of the Columbia, Plant)		
5.		
6.		
7.		
Total		

Attach chemical analysis except in the case of contaminated empty containers.

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal: None

(Generation will start around December, 1978)

B. Rate of generation (gallons, cubic yards, pounds, tons, per hour, day, week, month, year or one time only): 300 lbs. per day

IV. TRANSPORTATION

A. Containers used for transportation

- [x] DOT approved steel drums (55 gal)
- [ ] Used drums (____gal)
- [ ] Bulk (_____cubic yards)
- [ ] Fiber drums (____gal)
- [ ] Cases, cartons (size, number/case____)
- [ ] Paper bags
- [ ] Other - specify _____

B. Type of vehicle

- [x] Tractor-trailer
- [ ] Flatbed
- [ ] Roll-off/Lugger
- [ ] Tank truck
- [ ] Dump truck (with cover)
- [ ] Other _____

C. Label identification - Warning None

D. Route of transportation (location of waste to disposal site)
Route B to Bus. 70 to I70 to Wright City - H to M to B.H.S. Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill (attach additional information if necessary)
Wash exposed skin with soap and water. Shovel back into container and dispose of in proper area.

B. Necessary safety equipment for handling waste

- [x] Protective clothing/suit
- [ ] Rubber gloves
- [ ] Rubber boots
- [x] Face shield/goggles
- [ ] Respirator
- [ ] Gas Mask
- [ ] Self-contained breathing apparatus
- [ ] Absorbent
- [x] Portable eye wash/shower
- [ ] Lime _____ lbs
- [ ] Pump truck with water
- [ ] Type "B" fire extinguisher, fire blanket
- [ ] Other - specify _____

C. Safety precautions during handling (attach handling information supplied by generator or from other sources, including wastes or materials which are incompatible with this waste)
Take care not to ingest sludge

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment None

- [ ] De-watering
- [ ] Solid-liquid separation
- [ ] Other - specify _____
- [ ] Chemical fixation
- [ ] Neutralization

B. Amount and frequency of disposal

☐ One time only ☒ Periodic

Amount (gallons, cubic yards, tons, pounds) 47 drums

Amount/Time 57 drums every 4 months

C. Disposal technique

☒ Trench burial - location, type Alkaline

☐ Chemical landfill

☐ Storage tank for recovery liquids - tank no.

☐ Lagoon ☐ Soil blending

☐ Evaporation pond ☐ Spray irrigation

☒ Drilled cell Alkaline Area ☐ Land spreading

☐ Other - specify

VII. CERTIFICATION

If granted this request, we the undersigned agree to abide by the rules, regulations, orders and decisions of the Missouri Department of Natural Resources and the requirements specified in this application. We hereby certify that the subject waste and the proposed disposal procedures are compatible with the geological and environmental setting of the disposal site. We affirm that the information in this application is to the best of our knowledge and belief, true, complete and accurate, and understand that in the event of any false or fraudulent information in this request or of failure to operate the disposal operation in a proper and legal manner, the disposal area operating permit may be revoked.

Signature of Applicant Date

Signature of Technical Consultant Date

ENGINEERING SURVEYS AND SERVICES
TESTING LABORATORY
1113 Fay Street
Columbia, Missouri 65201
Phone: (314) 449-2646

Date 19 April 1983

Lab No. 749

Project: Industrial Waste-Square D Company

Location: Columbia, Missouri

Date Received: 11 March 1983 *

Sample No./ Description: 1/ Metal Hydroxide Sludge

TEST RESULTS (As Received Basis)

PARAMETER	
Volatiles @ 100°C, %	66.4
Volatiles @ 600°C, %	33.6 of Total Solid
pH	8.7
Specific Gravity @ 4°C	1.24
Moisture, %	66.4
Total Solid, %	33.6
Total Cyanide, ppm	≤2.0
Total Copper, ppm	1,065
Total Zinc, ppm	18,262
Total Magnesium, ppm	634
Total Chromium, ppm	1,088
Total Iron, ppm	2,692
Total Calcium, ppm	58,240
Total Nickel, ppm	21,008
Total Tin, ppm	666
Total Arsenic, ppm	≤1.0
Total Barium, ppm	270
Total Cadmium, ppm	7.3
Total Lead, ppm	5.2
Total Mercury, ppm	≤1.0
Total Silver, ppm	7.3
Total Sulfides, ppm	416

*Sample secured by Rich Widdowson at Square D Company

CC: 1 Widdowson

ENGINEERING SURVEYS AND SERVICES
BY: David A. Bennett

David A. Bennett, EIT

DNR 8-6-80

MISSOURI DEPARTMENT OF NATURAL RESOURCES
HAZARDOUS WASTE DISPOSAL REQUEST

OFFICE USE
Request No. _____

I. GENERAL INFORMATION

	Applicant	Waste Hauler
Name:	Bob's Home Service, Inc.	B.H.S., Inc. or licensed hauler
Address:	R. R. 1, Box 116-F	
City, State, Zip:	Wright City, Mo. 63390	
Person to Contact:	Mike Gill/Glennon Zykan	
Telephone Number:	314-745-3371	

	Waste Generator	Waste Location
Name:	Union Carbide Corporation	Union Carbide
Address:	P. O. Box 280	Highway 136 East
City, State, Zip:	Don Carrick	Maryville, Mo. 64468
Person to Contact:	Maryville, Mo. 64468	Clinton Harly
Telephone Number:	816-582-8131	

II. WASTE CHARACTERIZATION

A. Name of waste Complete cell scrap and partial cell scrap

B. Description of generation process Batteries that do not meet minimum specs and ~~waste~~ WASTE material

C. Basic physical state @ 70°F

- [x] Solid
- [ ] Sludge (>20% solids)
- [ ] Slurry (<20% solids
- [ ] Liquid (<5% solids)
- [ ] Contained gas
- [ ] Other - specify _____

pH > 7

Flash point none
Pensky-Martins Closed Cup (ASTM D-93-23)

Moisture % by weight 73.0% inside casing only

Specific gravity n/a

Pumpable: Yes _____ No no

Odor: Yes _____ No no

Fuel Value (BTU/lb) n/a

Liq. viscosity @ 70°F n/a c.p.

Free Fluid: Yes _____ No no

D. Known hazards of the waste

- [ ] Flammable
- [ ] Infectious
- [ ] Strong Oxidizer
- [x] Toxic
- [ ] Explosive
- [ ] Reactive
- [ ] Corrosive
- [ ] Other - specify _____

E. Chemical composition

Major Components	wt.%	Concentration ppm
1. zinc	13.5%	
2. water	13.0%	
3. Potassium hydroxide	6.5%	
4. Mercury	0.8%	
5. Miscellaneous	66.2% (see enclosed letter	
6.		
7.		
Total		

Attach chemical analysis except in the case of contaminated empty containers.

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal: 40 - 55 gallon drum

B. Rate of generation (gallons, cubic yards, pounds, tons, per hour, day, week, month, year or one time only): 4.3 cu. yds. per day

IV. TRANSPORTATION

A. Containers used for transportation

- [x] DOT approved steel drums (55 gal)
- [ ] Used drums (____gal)
- [ ] Bulk (_____cubic yards)
- [ ] Fiber drums (____gal)
- [ ] Cases, cartons (size, number/case____)
- [ ] Paper bags
- [ ] Other - specify _____

B. Type of vehicle

- [x] Tractor-trailer
- [ ] Flatbed
- [ ] Roll-off/Lugger
- [ ] Tank truck
- [ ] Dump truck (with cover)
- [ ] Other _____

C. Label identification - Warning **BHSXXXX "Controlled Waste - Federal and State Law prohibits Improper disposal"**

D. Route of transportation (location of waste to disposal site)
I29 to 71 ti I70 to Wright City - H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill (attach additional information if necessary) **Wash exposed skin with soap and water. Shovel back into containers.**

B. Necessary safety equipment for handling waste

- [ ] Protective clothing/suit
- [x] Rubber gloves
- [ ] Rubber boots
- [ ] Face shield/goggles
- [ ] Respirator
- [ ] Gas Mask
- [ ] Self-contained breathing apparatus
- [ ] Absorbent
- [ ] Portable eye wash/shower
- [ ] Lime _____ lbs
- [ ] Pump truck with water
- [ ] Type "B" fire extinguisher, fire blanket
- [ ] Other - specify _____

C. Safety precautions during handling (attach handling information supplied by generator or from other sources, including wastes or materials which are incompatible with this waste)
Incompatible with acids

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment **None**

- [ ] De-watering
- [ ] Solid-liquid separation
- [ ] Other - specify _____
- [ ] Chemical fixation
- [ ] Neutralization

B. Amount and frequency of disposal

☐ One time only ☒ Periodic

Amount (gallons, cubic yards, tons, pounds) **80 drums every one to two weeks**

Amount/Time _____

C. Disposal technique

☒ Trench burial - location, type **Alkaline**

☐ Chemical landfill

☐ Storage tank for recovery liquids - tank no. _____

☐ Lagoon ☐ Soil blending

☐ Evaporation pond ☐ Spray irrigation

☐ Drilled cell ☐ Land spreading

☐ Other - specify _____

VII. CERTIFICATION

If granted this request, we the undersigned agree to abide by the rules, regulations, orders and decisions of the Missouri Department of Natural Resources and the requirements specified in this application. We hereby certify that the subject waste and the proposed disposal procedures are compatible with the geological and environmental setting of the disposal site. We affirm that the information in this application is to the best of our knowledge and belief, true, complete and accurate, and understand that in the event of any false or fraudulent information in this request or of failure to operate the disposal operation in a proper and legal manner, the disposal area operating permit may be revoked.

_____ _____

Signature of Applicant Date

Michael D. Gill 8-1-90

Signature of Technical Consultant Date

CHARACTERIZATION [illegible]

PARTIAL CELL SCRAP

Quantity: **1.1 Cubic Yards / Day** -- (2640 Lbs. / Day)

Composition:	Pounds	% by Weight
Zinc Metal	356	13.5
Water (No Free Moisture)	343	13.0
Potassium Hydroxide (KOH)	172	6.5
Mercury Metal	21	0.8
*Miscellaneous Materials of Minimal Environmental Concern	1748	66.2
Total	2640	100

Form: Steel enclosed, 1.5 volt dry cells; quite similar to those used for toys, flashlights, radios, calculators, smoke alarms, etc. Most are without the outside jackets that constitute the label showing product identification and other sales information. Note the alkaline nature of this waste.

* Consists of Manganese Dioxide (MnO_2) 52%, steel 32%, carbon 6%, brass 3%, nylon [illegible]%, paper 2%, Portland cement 1%, CMC 1%, cellophane and rubber 1%.

COMPLETE CELL SCRAP

Quantity: 3.2 Cubic Yards / Day -- (7,880 Lbs. / Day)

Composition:	Pounds	% by Weight
Zinc Metal	1064	13.5
Water (No Free Moisture)	1024	13.0
Potassium Hydroxide (KOH)	512	6.5
Mercury Metal	63	0.8
*Miscellaneous Materials of Minimal Environmental Concern	5217	66.2
Total	7880	100%

Form: Steel enclosed, 1.5 volt dry cells; quite similar to those used for toys, flashlights, radios, calculators, smoke alarms, etc. Most are without the outside jacket that constitute the label showing product identification and other sales information. Note the alkaline nature of this waste.

* Consists of Manganese Dioxide (MnO_2) 52%, steel 32%, carbon 6%, brass 3%, nylon 2%, paper 2%, Portland cement 1%, CMC 1%, cellophane and rubber 1%.

3-3-81

OFFICE USE
Request No. _____

MISSOURI DEPARTMENT OF NATURAL RESOURCES
HAZARDOUS WASTE DISPOSAL REQUEST

I. GENERAL INFORMATION

	Applicant	Waste Hauler
Name:	Bob's Home Service, Inc.	B.H.S., Inc.
Address:	R. R. 1, Box 116-F	
City, State, Zip:	Wright City, Mo. 63390	same
Person to Contact:	Mike Gill/Glennon Zykan	
Telephone Number:	314-745-3371	

	Waste Generator	Waste Location
Name:	The Gates Rubber Company	(01616) same
Address:	1001 Petty Drive P. O. Box 8	
City, State, Zip:	Versailles, Missouri 65084	
Person to Contact:	~~Lee Stevens~~ ~~Tom Robinson~~ Carol Chamberlain	
Telephone Number:	314-378-5401	

II. WASTE CHARACTERIZATION

A. Name of waste Wastewater treatment sludge 001

B. Description of generation process Wastewater treatment sludge from zin electroplating operations.

C. Basic physical state @ 70°F

- [ ] Solid
- [x] Sludge (>20% solids)
- [ ] Slurry (<20% solids
- [ ] Liquid (<5% solids)
- [ ] Contained gas
- [ ] Other - specify _____

pH 6.9

Flash point none
Pensky-Martins Closed Cup (ASTM D-93-23)

Moisture % by weight 65%

Specific gravity 1.2

Pumpable: Yes _____ No no

Odor: Yes _____ No no

Fuel Value (BTU/lb) n/a

Liq. viscosity @ 70°F n/a c.p.

Free Fluid: Yes _____ No no

D. Known hazards of the waste

- [ ] Flammable
- [ ] Infectious
- [ ] Strong Oxidizer
- [x] Toxic
- [ ] Explosive
- [ ] Reactive
- [ ] Corrosive
- [ ] Other - specify _____

E. Chemical composition

Major Components	wt.%	Concentration ppm
1. See analysis		
2.		
3.		
4.		
5.		
6.		
7.		
Total		

Attach chemical analysis except in the case of contaminated empty containers.

III. QUANTITY OF WASTE & GENERATION RATE

A. Amount of waste on hand for immediate disposal: 35 drums

B. Rate of generation (gallons, cubic yards, pounds, tons, per hour, day, week, month, year or one time only): 0.5 cu. yards per week

IV. TRANSPORTATION

A. Containers used for transportation

- [ ] DOT approved steel drums (____gal)
- [x] Used drums (55 gal)
- [ ] Bulk (_____cubic yards)
- [ ] Fiber drums (____gal)
- [ ] Cases, cartons (size, number/case_____)
- [ ] Paper bags
- [ ] Other - specify _____

B. Type of vehicle

- [x] Tractor-trailer
- [ ] Flatbed
- [ ] Roll-off/Lugger
- [ ] Tank truck
- [ ] Dump truck (with cover)
- [ ] Other _____

C. Label identification - Warning BHSXXXX Controlled waste State and Federal law prohibit improper disposal. Manifest Document number.

D. Route of transportation (location of waste to disposal site) 52 to 54 to I70 to Wright City - H to M to Muenz to Site

V. SAFE HANDLING & EMERGENCY SPILL PROCEDURES

A. Emergency procedure to be followed in case of accidental spill (attach additional information if necessary) Wash exposed skin with soap and water. Shovel back into container.

B. Necessary safety equipment for handling waste

- [ ] Protective clothing/suit
- [x] Rubber gloves
- [ ] Rubber boots
- [x] Face shield/goggles
- [ ] Respirator
- [ ] Gas Mask
- [ ] Self-contained breathing apparatus
- [ ] Absorbent
- [ ] Portable eye wash/shower
- [ ] Lime _____ lbs
- [ ] Pump truck with water
- [ ] Type "B" fire extinguisher, fire blanket
- [ ] Other - specify _____

C. Safety precautions during handling (attach handling information supplied by generator or from other sources, including wastes or materials which are incompatible with this waste) Incompatible with acids

VI. TREATMENT, STORAGE, OR DISPOSAL

A. Pre-treatment None

- [ ] De-watering
- [ ] Solid-liquid separation
- [ ] Other - specify _____
- [ ] Chemical fixation
- [ ] Neutralization

B. Amount and frequency of disposal

☐ One time only ☒ Periodic

Amount (gallons, cubic yards, tons, pounds) Approximately 26 drums

Amount/Time 90 days

C. Disposal technique

☒ Trench burial - location, type Alkaline

☐ Chemical landfill

☐ Storage tank for recovery liquids - tank no. _____

☐ Lagoon ☐ Soil blending

☐ Evaporation pond ☐ Spray irrigation

☐ Drilled cell ☐ Land spreading

☐ Other - specify _____

VII. CERTIFICATION

If granted this request, we the undersigned agree to abide by the rules, regulations, orders and decisions of the Missouri Department of Natural Resources and the requirements specified in this application. We hereby certify that the subject waste and the proposed disposal procedures are compatible with the geological and environmental setting of the disposal site. We affirm that the information in this application is to the best of our knowledge and belief, true, complete and accurate, and understand that in the event of any false or fraudulent information in this request or of failure to operate the disposal operation in a proper and legal manner, the disposal area operating permit may be revoked.

_____ _____

Signature of Applicant Date

Michael D. Gill 2-27-91

Signature of Technical Consultant Date

#2542

MID-MISSOURI TESTING LABORATORY

DETERMINATIONS MADE IN ACCORDANCE WITH AWWA – WPCF – APHA STANDARD METHODS

506 NICHOLS COLUMBIA, MO 65201 314/442-0237

Date: January 20, 1981

Client: Gates Rubber Company, Attn: Lee Stevens

Date Received: January 8, 1981

Sample Collected By: Gates Rubber Company

SAMPLE

Parameter	Electro-plating Sludge			Date Analyzed
% Volatiles @ 100°C	64.6			1/15
% Volatiles @ 600°C	77.2			1/15
pH	6.9			1/8
Specific Gravity	1.24			1/15
Total Chromium % by Weight	1.6			1/13
Total Iron % by Weight	2.4			1/13
Total Zinc % by Weight	3.7			1/19

Approved Denise McDonald

APPENDIX H

APPENDIX A. INFORMATION REQUIREMENTS CHECKLIST

1. General Information

Reg. Cite	Description	Location in RCRA Permit Application
	Information in Part B Application	
270.14(b)(1)	General description of facility	Engineering Chapter 2
270.14(b)(2) and (3)	Chemical and physical analyses of wastes	Operations Manual Appendix "P"
270.14(b)(4)	Access control and security description of active portion	Operations Manual Chapter 9
270.14(b)(5), 270.17(d), and 270.21(d)	General inspection schedule and procedures	Operations Manual Chapter 7-K Appendix "G"
270.14(b)(6)	Preparedness and prevention documentation	Operations Manual Chapter 10, 11, 12
270.14(b)(7)	Contingency plan	Operations Manual Chapter 10, 11, 12
270.14(b)(8)	Preventive procedures	All of Part "B"
270.14(b)(11) (i) and (ii)	Facility location information	Geotechnical Report Page 1
270.14(b)(13)	Closure plan	Engineering Design Manual Chapter 6
270.14(b)(13)	Post-closure care plan	Operations Manual Chapter 13
270.14(b)(17)	Documentation of insurance	Financial Requirements

. General Information (continued)

. Cite	Description	Location in RCRA Permit Application
Information in Part B Application (continued)		
.14(b)(19)	Topographic map (site plotted on USGS quadrangle maps)	Part "B" Drawing 1 of 13 Exposure Report Figure 1
.21(a) and .17(a)	List of wastes placed or to be placed in each unit	Part "B" Application Part "B" Operations Manual Appendix "P"
Additional Information		
	Existing risk assessment reports and information, including liability insurance analyses, claims, and settlements	Exposure Report Appendix A, C, D
	Land use and zoning map(s) for an area of 4 miles around the unit	Warren County Master Plan Map and Figure 1
	Existing aerial photographs of the facility	Aerial Photo Map
	Identify and summarize any waste analysis data not already submitted; provide additional data as discussed in text	Exposure Report Chapter 1.3, 1.5 Appendix "G"
	Current estimate of annual amount of waste received and description of any pretreatment process used	Exposure Report Chapter 2.1
	Identification of any Federal, State, or local inspection or compliance records related to environmental and health programs; include descriptions of any major violations	Exposure Report Chapter 2.1

APPENDIX A. INFORMATION REQUIREMENTS CHECKLIST

2. Ground Water Pathway

Reg. Cite	Description	Location in RCRA Permit Application
	Information in Part B Application	
270.14(c)(1)	Interim status ground-water monitoring results	Operations Manual Page 4-1 Section C Hydrogeology Report pages 19-20 & Appendix "D"
270.14(c)(2)	Identification of uppermost aquifer, including flow rate and direction	Hydrogeology Report pages 32, 34, 37, 38
270.14(c)(3) and 270.14(b)(19)	Topographic maps related to ground-water protection (well location, water table elevation contours, etc.)	Hydrogeology Report plates 5, 27, 28, 29
270.14(c)(4) (i) and (ii)	Description of existing contamination	Operations Manual Appendix "O"
270.14(c)(5)	Detailed plans for ground-water monitoring program	Operations Manual Page 7-5 section J and page 10-10 section "N"
270.14(c)(6)	Description of detection monitoring program (if applicable)	Same as 270.14(c)(5)
270.14(c)(7) and (c)(7)(ii)	Description of compliance monitoring program and characterization of contaminated ground water (if applicable)	Same as 270.14(c)(5)
270.14(c)(7)(iv)	ACL demonstration (if any)	Operations Manual page 7-5 No Contaminat
270.14(c)(8)	Corrective action program (if applicable)	Operation Manual page 10-12, 10-13 and page 10-10 Section "N"
270.17(b)(1) 270.21(b)(1)	Description of liner and leachate collection systems (if applicable)	Design Manual page 4-2

2. Ground-Water Pathway (Continued)

Additional Information	Description	
	Existing map showing location of all known wells within three miles ; number and location of drinking water wells	Exposure Report Figure 1
	Discussion of ground-water uses within three miles of unit	Exposure Report Chapter 2.3
	Regional map showing areas of ground-water recharge and discharge	No Map Available
	Net precipitation using net seasonal rainfall or other available data	Exposure Report Chapter 2.3
	Unless otherwise reported to EPA, available well data indicating a release, and information on any affected public or private water supplies, including populations served	Exposure Report Chapter 3.1
	Any known food chain contamination due to prior release from the unit to ground water	Exposure Report Chapter 3.1

3. Surface Water Pathway

Reg. Cite	Description	Location in RCRA Permit Application
Information in Part B Application		
270.14(b)(11) (iii) thru (v)	Location information related to 100 yr flood plain including variance demonstrations	Design Manual page 2-1 Drawing 2 of 13
270.21(b)(2)	System for control of run-on from each peak discharge of 25 yr storm	Design Manual page 3-1 page 4-3
270.21(b)(3)	System for control of run-off from 24 hr, 25 yr storm	Design Manual page 4-3
270.17(b)(2)	Procedures/equipment to prevent overtopping	Operations Manual page 7-8 Section N and page 10-10 Section M-(4
270.17(b)(3)	Structural integrity of dikes	Operations Manual page 10-10 Section M-(4
Additional Information		
	Discussion of surface-water uses within three miles of the unit, including a map showing the location of all surface-water bodies and downstream drinking water intakes	Exposure Report Chapter 2.4 Figure 1
	Velocities of streams and rivers passing through and adjacent to the property	Exposure Report Chapter 2.4

3. Surface Water Pathway (Continued)

Reg. Cite	Description	
	Additional Information (continued)	
	Description of any system used to monitor surface-water quality, and a summary of the data	Exposure Report Chapter 2.4
	Description of known releases to surface water; the extent of contamination; remedial action, if any; and if known, severity of impact.	Exposure Report Chapter 3.2
	Any known food-chain contamination resulting from prior release from the unit to surface water	Exposure Report Chapter 3.2

4. Air Pathway

Reg. Cite	Description	Location in RCRA Rermit Application
Information in Part B Application		
270.14(b)(9), 270.21(f) and (g), 270.21(h) and (i)	Documentation of procedures to prevent accidental ignition or reaction	Operations Manual Chapter 3 page 1 Chapter 3 page 3 Chapter 3 page 4 Chapter 7-F
270.21(b)(5)	Plans to control wind dispersal of particulate matter at landfills	Operations Manual Chapter 7-F
270.14(b)(19)(v)	A wind rose showing prevailing windspeed and direction	Engineering Design Appendix "B"
Additional Information		
	Summary of air monitoring data and a description of current monitoring system, if any	Exposure Report Chapter 2.5
	Population within a four mile radius of the unit	Exposure Report Chapter 2.5
	Describe any known releases to air; the extent of contamination; remedial action, if any; and severity of impact, if known	Exposure Report Chapter 2.5

5. Subsurface Gas Pathway

eg. Cite	Description	Location in RCRA Application
Information in Part B Application		
	None in addition to General Information Requirements	----------
Additional Information		
	Any past disposal of municipal-type wastes in the unit; approximate quantities and dates of disposal, if known	Exposure Report Chapter 2.8
	Map location of any underground conduits within the site and known underground conduits within 1000 feet of property boundary	Exposure Report Figure 1
	Descriptions of any monitoring or control mechanisms for subsurface gas release; summmarize resulting data	None
	Description of any known releases; extent of contamination; remedial action taken, if any; and the severity of impact, if known	None

APPENDIX A. INFORMATION REQUIREMENTS CHECKLIST

6. Contaminated Soil Pathway

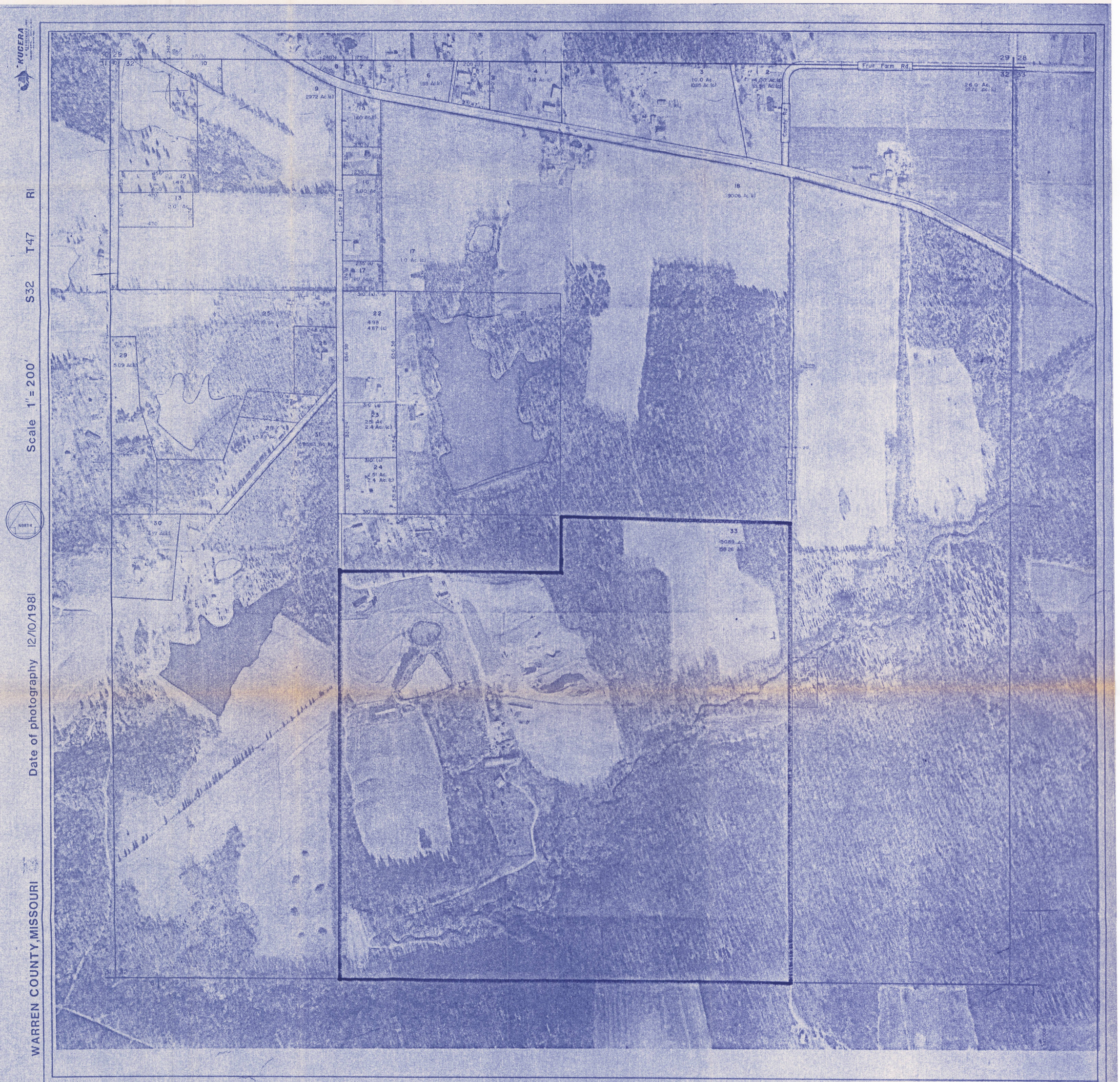
Reg. Cite	Description	Location in RCRA Permit Application
Information in Part B Application		
	None in addition to General Information Requirements	---------
Additional Information		
	If soil sampling has been done, a map showing areas of soil contamination, and a summary of analytical results	No Soil Contamination Exposure Report Chapter 2.6
	Description of the types of major releases that resulted in soil contamination, and any clean-up action	None
	Any known food-chain contamination resulting from the use of contaminated soils for raising crops	None

7. Transportation Information

Reg. Cite	Description	Location in RCRA Permit Application
	Information in Part B Application	Engineering Design Chapter 2 page 2
270.14(b)(10)	Traffic pattern, volume, and controls; access road characteristics.	
	Additional Information	
	Description of the types and capacities of vehicles used to transport waste	Exposure Report Chapter 2.7
	Identification of normal transport routes for hazardous waste into the site and within one mile of the facility entries	Exposure Report Chapter 2.7
	Description of procedures for clean-up of transportation-related spills or leaks	Exposure Report Appendix "E"
	Descriptions of any transportation accidents releasing hazardous wastes on-site, or in the immediate vicinity	Exposure Report Chapter 2.9

8. Management Practices Information

Req. Cite	Description	Location in RCRA Permit Application
Information in Part B Application		
270.14(b)(12) 264.16	Outline of programs to train employees to safely operate and maintain facility, including emergency response activities	Operations Manual Chapters 1, 2, 10 Appendix A,E,F
Additional Information		
	Summary of existing records on worker illness or injury, related to the operation of the unit; include summaries of Workman's Compensation claims, or hospital records	Exposure Report Chapter 2.2



OWNERSHIP MAP
WARREN COUNTY, MISSOURI
STATE TAX COMMISSION OF MISSOURI
WARREN COUNTY TAX ASSESSOR
COUNTY ENGINEERING AND SURVEYING CO., INC.

SUBDIVISION INDEX

LEGEND

TOWNSHIP LOCATOR

MAP SHEET INDEX

1/4 SECTION INDEX

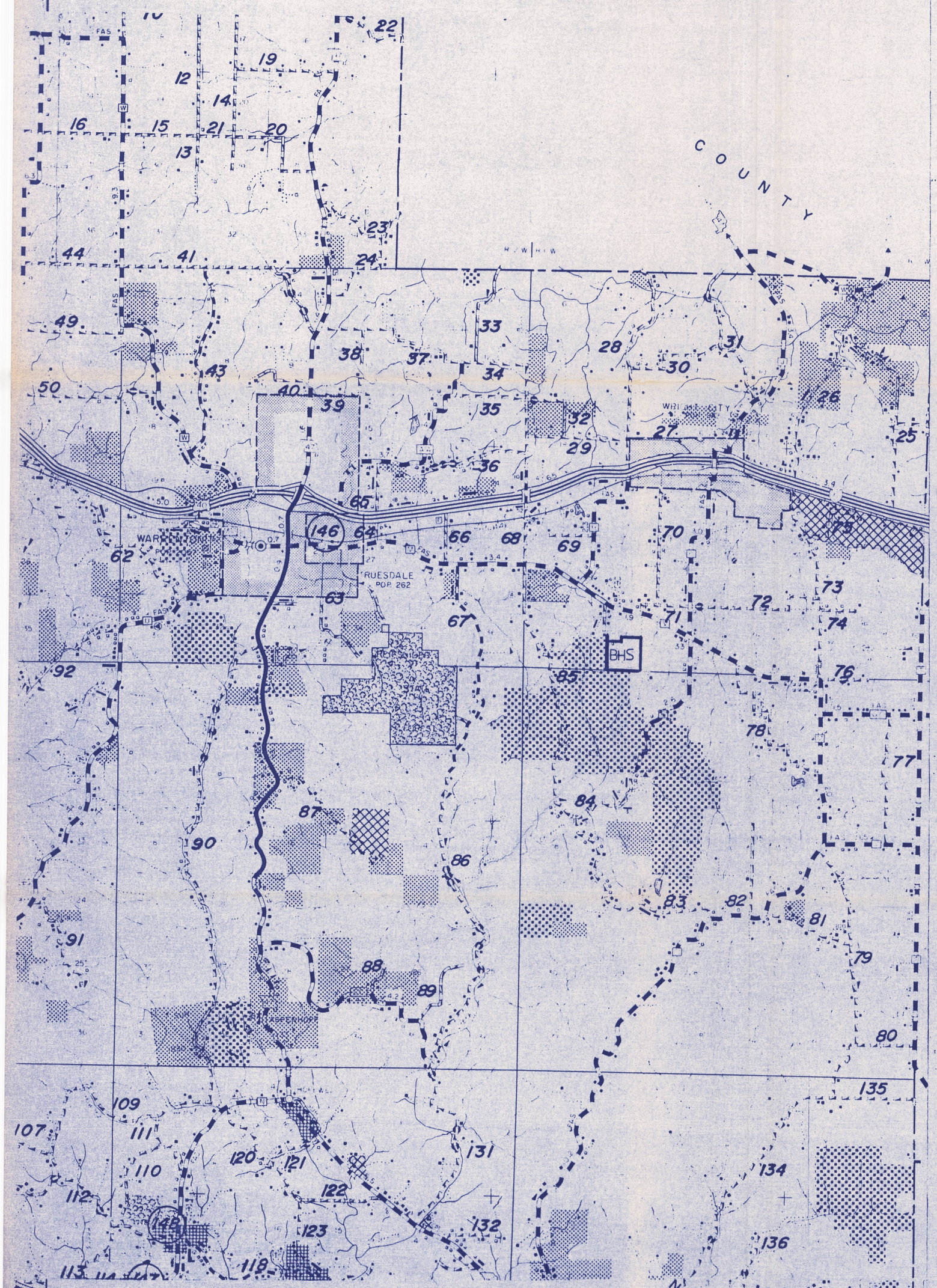
U.S. EPA HWGWTE
VOL. NO. ____ FIG. NO. ____
DOC. NO. TO13 002 603 011
REMARKS ____

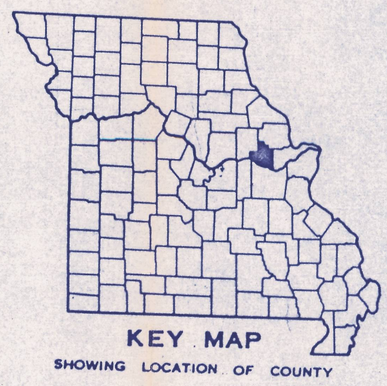
SEC. ____ TWP. ____ RNG. ____
MAP NO. ____

WARREN COUNTY MASTER PLAN

WARREN COUNTY, MISSOURI

MASTER PLAN MAP





KEY MAP

SHOWING LOCATION OF COUNTY

LEGEND

- Private Road
- Unimproved Road
- Graded and Drained Road
- Soil Surfaced Road
- Gravel or Stone Road
- Bituminous Road – Low Type
- Paved Road
- Frontage Road
- Divided Pavement
- City Streets
- Points between which Distances are Measured
- Interstate Numbered Highway
- U.S. Numbered Highway
- State Numbered Highway
- State Lettered Highway
- Designation of Road when Built
- Federal-aid Primary Highway System
- Federal-aid Secondary Highway System
- Railroad – Single Operating Company
- Railroads Adjacent – Separately Operated
- Railroad Station
- Railroad Grade Crossing
- Railroad Above
- Railroad Below
- Railroad Tunnel
- Military Air Field
- Commercial or Municipal Air Field
- Landing Area or Strip
- Airway Beacon Light
- Operated Ship and Barge Lines
- Dock Pier or Landing
- Ferry, TF : Toll FF : Free
- Navigable Stream
- Dam
- Dam with Lock
- Dam with Road
- Wide Stream
- Narrow Stream
- Intermittent Stream
- Drainage Ditch
- Marsh or Swamp Land
- Reservoir, Pond or Lake
- Reservoir with Dam
- Levee or Dike
- Levee or Dike with Road
- Natural Ford
- Paved Ford or Low Water Bridge
- Bridge – General (span longer than 20 feet)
- Small Bridges Closely Spaced
- Drawbridge
- Suspension Bridge
- Arch Bridge
- Steel Truss Bridge
- City, Town and Village Limits
- Delimited Urban Area Line
- Park or Reservation Boundary
- State Line
- County Line
- Civil Township Line

- Congressional Township Line
- Section Line
- Land Grant Survey Line
- Transmission Line
- Junkyards And Dumps: Refuse, Garbage or Trash; Auto Graveyard; Scrap Metal; Scrap Building Material; Sanitary Fill; Other
- Correctional Institution
- Radio or Television Station
- Scenic Site
- Small Park
- Roadside Park
- Picnic Grounds
- Playground Ball Field etc.
- Bathing Beach or Pool
- Drive-in Theatre
- Tourist Court or Motel
- Camp or Lodge
- Fish Hatchery
- Bird Sanctuary
- Game Farm or Preserve
- Country Club or Golf Course
- Fair Ground or Race Track
- Farm Unit (In Use / Not In Use)
- Dwelling other than Farm
- Dwellings Closely Spaced
- Seasonal Dwellings
- Seasonal Dwellings Closely Spaced
- Hotel or Inn
- Church
- Hospital
- Cemetery
- Church with Cemetery Adjacent
- Store or Small Business
- Factory or Industrial Plant
- Sawmill - Stationary
- Mine or Quarry
- Nursery
- School House
- Consolidated or Large School
- Post Office
- Town or Community Hall
- Mixed Cultural Features Closely Spaced
- County Home - Farm or Infirmary
- Pumping Station - Oil or Gas
- Combined Dwelling and Business
- Weight Station
- Forest Ranger Station
- Forest Lookout Tower
- SHD Maintenance Shed
- State Highway Patrol Station
- State Capitol
- County Seat
- Other Cities, Towns and Villages

LAND DEVELOPMENT CATEGORIES

- RD Residential Development
- PRD Planned Residential Development
- CID Commercial & Industrial
- AFM Agriculture & Forest Management
- CON Conservation
- FP Flood Plain
- GD General Development
- Incorporated Cities
- CD Community Development

GENERAL HIGHWAY MAP

WARREN COUNTY MISSOURI

PREPARED BY THE
MISSOURI STATE HIGHWAY DEPARTMENT
DIVISION OF PLANNING
IN COOPERATION WITH THE
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

SCALE

1 0 1 2 3 4 MILES

POLYCONIC PROJECTION

U.S. EPA HWGWTE
VOL. NO. ____ FIG. NO. ____
DOC. NO. TP 603 011
REF. ____

WELL LOG

#	NAME	YEAR	GLS #	TOWNSHIP	RANGE	SEC
1	Passionist Father School	1955	13615	47N	2W	26
2	George Bleighle *	1962	20893	47N	1W	21
3	Len Watson	1965	23214	47N	1W	31
4	Mueller	1967	25230	47N	2W	26
5	Bud Laykamp	1969	25366	47N	1W	23
6	Dr. Cortney *	1967	25450	47N	1W	31
7	Joe Stevenson	1966	25784	47N	1W	18
8	Wright City	1969	26237	47N	1W	17
9	Ed Gettinger	1969	26913	46N	2W	11
10	William Murphy	1967	26748	47N	1W	33
11	Armel Robinett	1969	26843	47N	1W	31
12	Charles Freeze	1968	26872	47N	1W	2
13	Church of The Nazarine	1969	26889	47N	1W	17
14	Bill Smith	1968	26687	46N	2W	11
15	Bill Hueffmeier *	1971	26966	47N	1W	33
16	Aspenhoff	1971	27016	46N	1W	6
17	Jeff Hoover	1972	27379	47N	2W	25
18	LaVerne Zykan			47N	1W	32
19	George Kallbnier	1965		46N	1W	18
20	Robert Hawkins	1970	27570	46N	1W	15
21	Walter Abrolet	1967		46N	1W	20
22	Little Village *	1940	6406	47N	1W	19
23	Walter Gerdeman	1966	24407	47N	1W	20
24	Dr. H.D. Brandt *	1941	7412	47N	1W	30
25	Joshua Jones *	1967	24671	47N	1W	10
26	Wright City	1973	27328	47N	1W	22
27	Wright City	1945	9224	47N	1W	21
28	Wright City	1939	5227	47N	2W	26
29	Passionist Father School	1955	14249	47N	2W	26
30	Theodore Bueker *	1966	25669	47N	2W	25
31	Aspenhoff	1977	28104	46N	1W	8
32	Stern Lehman	1967	25131	46N	1W	10
33	Robert Vaughn			47N	1W	32
34	Roger Hunt			47N	1W	32
35	Lillian Rupert			47N	1W	32
36	Harlan McLaughlin			47N	1W	32
37	Wil-Mar-Jim			47N	1W	32
38	Ed Hollenbeck			47N	1W	32
39	Delores Sigmund			46N	1W	5
40	Robert Vaughn			47N	1W	32
41	Edmund Hollenbeck			46N	1W	4
42	Aspenhoff			46N	1W	4
43	Steven Taylor			46N	1W	4
44	Richard Karn			46N	1W	5
45	Delores Froelick			46N	1W	5
46	Aspenhoff			46N	1W	8
47	William Hoffa			46N	1W	8
48	Unknown *			46N	1W	8
49	George Jaeger			47N	1W	33
50	Stephen Brown			47N	1W	33
51	Loretta Jaspering			47N	1W	34
52	Emmons Jaspering			47N	1W	34
53	Althea Maity			47N	1W	29
54	Richard Backus			47N	1W	28
55	Otto Hollenbeck			47N	1W	28
56	Virgil Witthaus			47N	1W	29
57	Virgil Witthaus			47N	1W	29
58	Lamond Schmidt			47N	1W	29
59	David Schindler			47N	1W	28
60	Larry Goodfellow			47N	1W	28
61	Otto Hollenbeck			47N	1W	28
62	Brenda Phegley			47N	1W	21
63	Charles Freeze			47N	1W	22
64	Missouri Quail Hunters			47N	1W	27
65	William Hartwig			47N	1W	27
66	Donald Cobb			47N	1W	26
67	Thomas Graviett			47N	1W	26
68	Michael Murphy			47N	1W	21
69	Edward Mueller			47N	1W	21
70	Unknown *			47N	1W	20
71	Otto Hollenbeck			47N	1W	20
72	N. Hepperman			47N	1W	29
73	Larry Eversmeyer			47N	1W	30
74	Lester Fowler			47N	1W	30
75	Raymond Filson			47N	1W	30
76	Ed Grobbe			47N	1W	30
77	John Trimbley			47N	1W	30
78	Scott Rogers			47N	1W	31
79	Billy McDaniel			47N	1W	32
80	LaVerne Zykan			47N	1W	32

U.S. EPA HYDROLOGY
VOL. NO. 7 PAGE NO.
DOC. NO. IO 603.01
REMARKS

*Current Property Ownership could not be derived from County Records

- WELL
- SURFACE WATER
- DRAINAGE
- FOREST AREA
- PLANNED RESIDENTIAL
- VACATION/WEEKEND HOMES
- COMMERCIAL

SCALE 1:24000

1 MILE — 1000 0 1000 2000 3000 4000 5000 6000 7000 FEET — 1 KILOMETER

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface
Secondary highway, hard surface — Unimproved road

Interstate Route — U. S. Route — State Route

FIGURE 1
08-08-85

T013-P02-603-012

19

ROUTING AND TRANSMITTAL SLIP

Date 8/23/85

TO: (Name, office symbol, room number, building, Agency/Post)	Initials	Date
1. Lucetta Flournoy		
2.		
3.		
4.		
5.		

	Action		File		Note and Return
	Approval		For Clearance		Per Conversation
	As Requested		For Correction		Prepare Reply
	Circulate		For Your Information		See Me
	Comment		Investigate		Signature
	Coordination		Justify		

REMARKS

I would appreciate any comments you may have on the enclosed case study which is being used in our location guidance work. I will call you to discuss further.

Thanks,

DO NOT use this form as a RECORD of approvals, concurrences, disposals, clearances, and similar actions

FROM: (Name, org. symbol, Agency/Post) George Dixon, OSW

Room No.—Bldg.

Phone No. 382-4494

5041-102

☆ U.S. G.P.O. 1984-421-529/402

OPTIONAL FORM 41 (Rev. 7-76)
Prescribed by GSA
FPMR (41 CFR) 101-11.206

Luetta Flournoy

Appendix D

Justification for the TOT Criteria

Based on Risk Analysis

August 1985

RECEIVED

AUG 27 1985

USEPA, RCRA Branch

2.3.3 Case Study D-3

Facility Description

This commercial waste management facility is located on 158 acres in the mid-west of the United States. Current operations include receipt and handling of wastes from a variety of generators including major manufacturers, small businesses, hospitals, public agencies and private citizens. In addition to current practices, two land disposal units, a covered storage warehouse and three surface impoundments are proposed. The facility obtained approval to operate a "Refuse Disposal Area" from the State Division of Health in 1971. In 1977, the facility was issued a permit to landfill special industrial waste materials in its current operating area. The existing units consist of four surface impoundments, two of which (SI1 and SI2) were constructed in 1977. Prior to obtaining hazardous waste facility permits, each was retrofitted with clay liners and leachate collection systems. Of these two impoundments, only SI2 is currently being used. Two additional impoundments, SI3 and SI3T, were also used to collect and manage surface runoff and liquid hazardous wastes from the facility. SI3 will be abandoned and replaced with a new impoundment; SI3T will be abandoned and excavated when the area 2 landfill is being constructed.

Climate

Weather conditions in the site area are moderate and typical of the Mid-West. Four distinct seasons are experienced each year. Monthly average temperatures range from a low of 33.3°F in January to 79.4°F in July. The average annual precipitation is

39.13 inches with a low in February of 2.04 inches and a high of 4.65 inches in June.

Summers tend to be quite moderate with very brief periods of high heat and humidity. Winters are not reported to be very severe with 32o F temperatures existing for generally 25 days per year. Snowfall averages a little over 18 inches per year. The average date of the last freeze is April 15, and the average date of the first freeze is October 20.

Regional Geology

The surficial features include a ridge that extends in a southeasterly - northwesterly direction. The local relief south of the ridge is rolling to hilly. The general surface drainage pattern appears dendritic, although many tributaries have angular characteristics. The highest surface water body is a lake which is located 2000 ft. due west of the project site and was formed by damming a tributary of a nearby creek. The permit application states that there is some evidence of karst topography located within two or three miles of the site.

The unconsolidated sediments in the area consist of loess, alluvium and glacial meterials. The loess is a thin (less than 5 ft thick) near surface layer that ranges from silty and clayey to sandy at its base.

Alluvial deposits are located in the active channels and lining the valley walls of the major surface drainage features and tributaries. These materials range from sands and gravels deposited under high velocity flow to silts and clays under relatively stagnant water conditions.

Glacial deposits of the Kansan glacier, which was the only glacial event to reach the area surrounding the site, are also evident. The glacial deposits include till, gravelly and sandy glacial drift and bouldery ground moraines deposited during both the advance and retreat of the glacier. The glacial deposits can further be differentiated into oxidized (shallower) and unoxidized (deeper) deposits.

Consolidated deposits in the area consits of limestone, shale, and sandstone of the Mississippian and Ordovician with depths ranging from 40 feet to over 200 feet. Regional bedrock stratigraphy is depicted in Figure 2.3-11. The application states that the regional area has not experienced seismic activity during Holocene time.

Regional Hydrology

Some minor amounts of subsurface water occur within the unconsolidated sediments in the alluvial deposits, and within the glacial drift and till. These quantities are reported to be inadequate for irrigation or singlefamily dwelling usage. Units reported to contain sufficient quantities of water range in depth from 200 to 600 feet in this regional area. Regional ground-water flow in the bedrock is reported to be to the north-west. There are three wells ranging in depths from 200 to 600 feet within 1/4 mile of the facility with at least one well being used for domestic, industrial, and agricultural purposes.

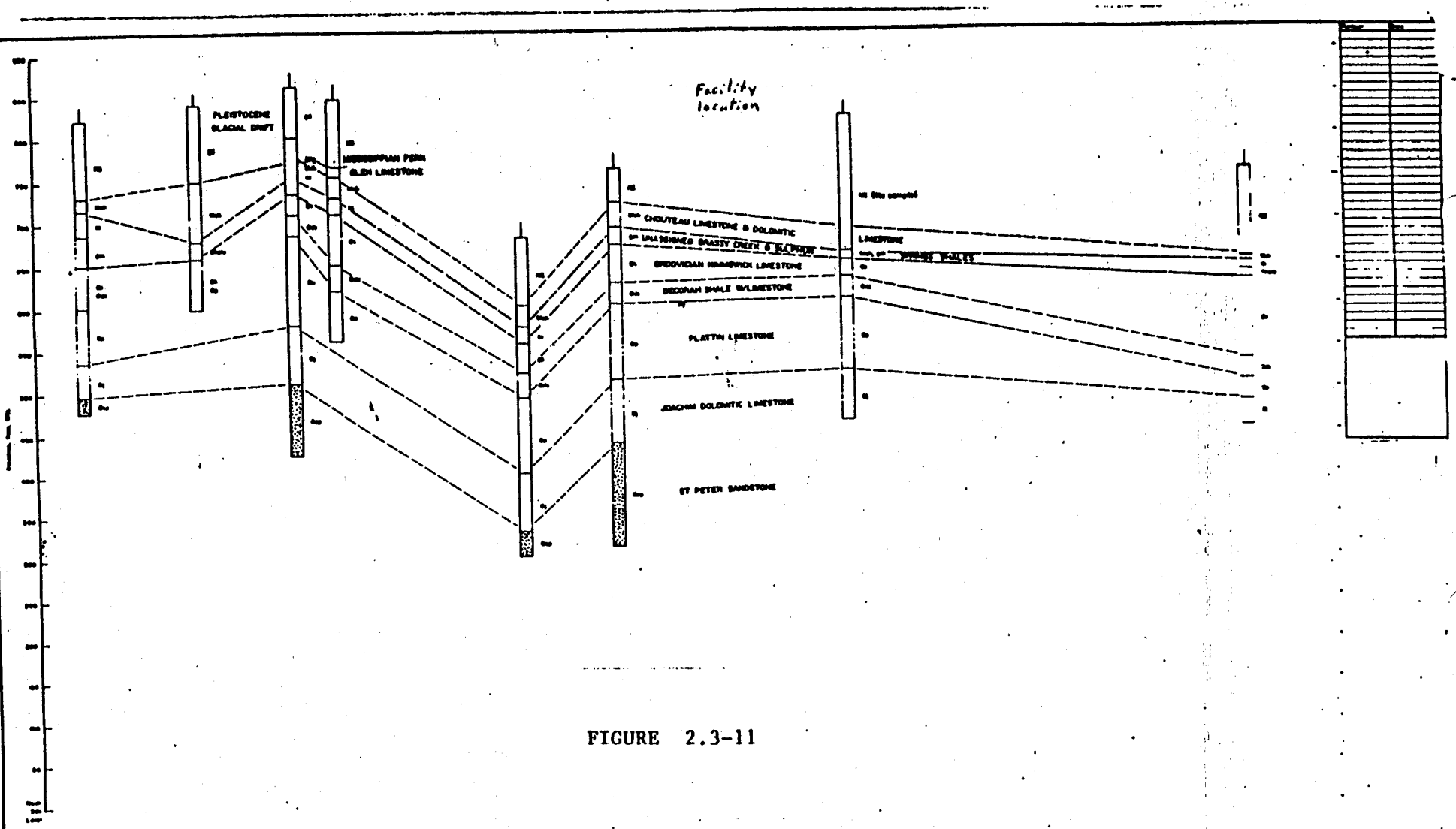


FIGURE 2.3-11

GENERALIZED REGIONAL GEOLOGIC SECTION B-B

Site Geology

Ground surface within the site is gently rolling to hilly with slopes of four to five percent near the head waters of the drainage features. The site is transected by three intermittent drainage streams/ditches which have developed narrow flood plains due to meandering. The application states there are no wetlands or sink holes within the project site.

The general site stratigraphy consists of loess; glacial drift; glacial fluvial deposits; glacial till; and a gravelly clay directly overlying the rock/refusal surface. Cross sections (Figures 2.3-12 and 2.3-13) depict the generalized subsurface geology. Cross section locations are shown on Figure 2.3-14.

The oxidized glacial drift is typically sand to clayey with colors ranging from gray to brownish yellow. This dessication cracks. Laboratory conductivity values ranged from 1.2×10^{-8} to 2.4×10^{-9}cm/sec. Horizontal hydraulic conductivities from field pressure testing revealed values ranging from 1×10^{-5} to 9×10^{-7}/sec.

The unoxidized glacial drift is gray to dark gray in color and is primarily a sandy silty clay. The sand content of the unit is reported to increase somewhat with depth. Laboratory permeability values were reported from 5.8×10^{-8} to 3.9×10^{-9}cm/sec. Field tests indicate a horizontal hydraulic conductivity of 1×10^{-6}cm/sec. Slug tests determined horizontal hydraulic conductivity values to range from 1×10^{-8} to 2×10^{-7}cm/sec.

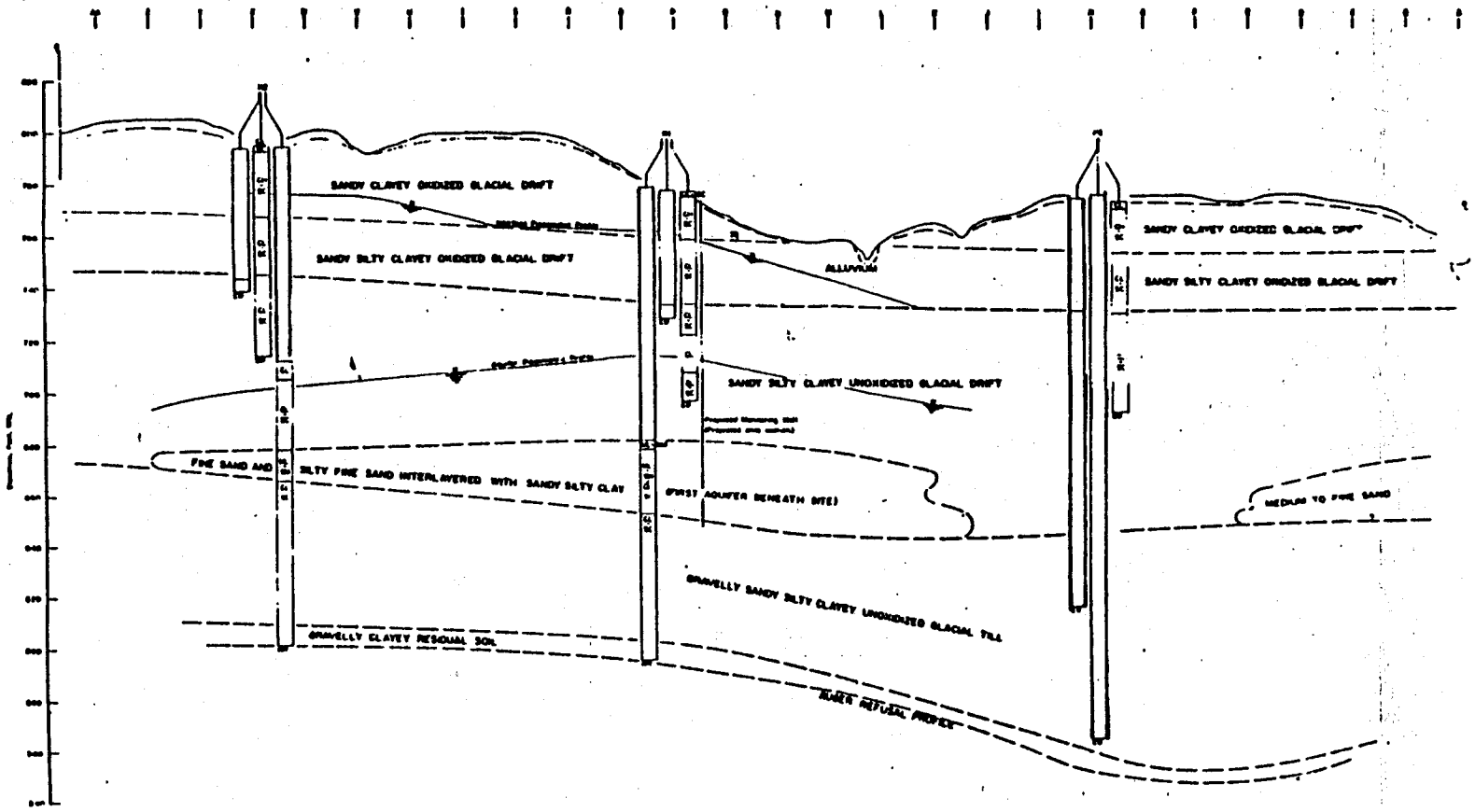


FIGURE 2.3-12

GENERALIZED GEOLOGIC SECTION A-A'

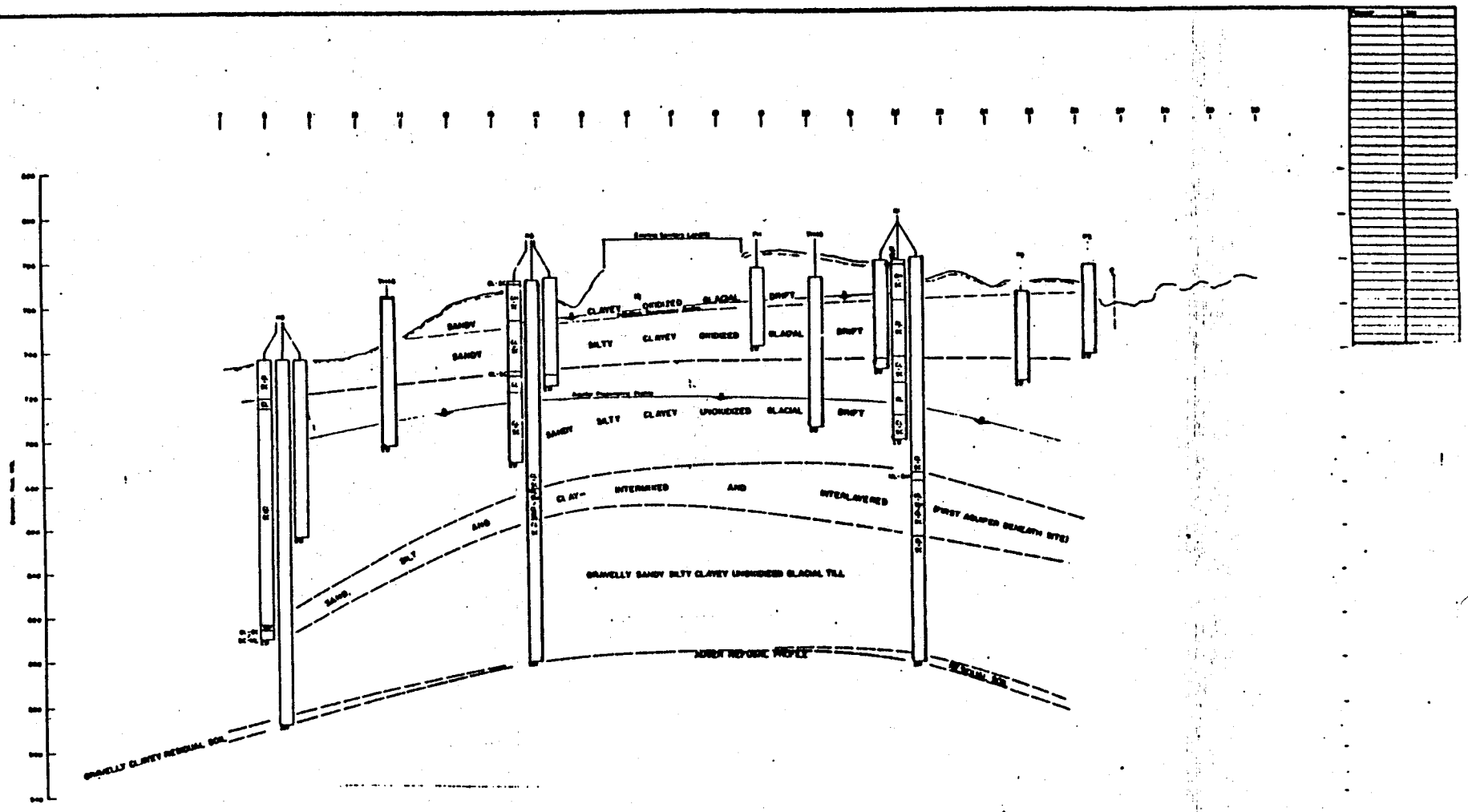


FIGURE 2.3-13 GENERALIZED GEOLOGIC SECTION E-E'

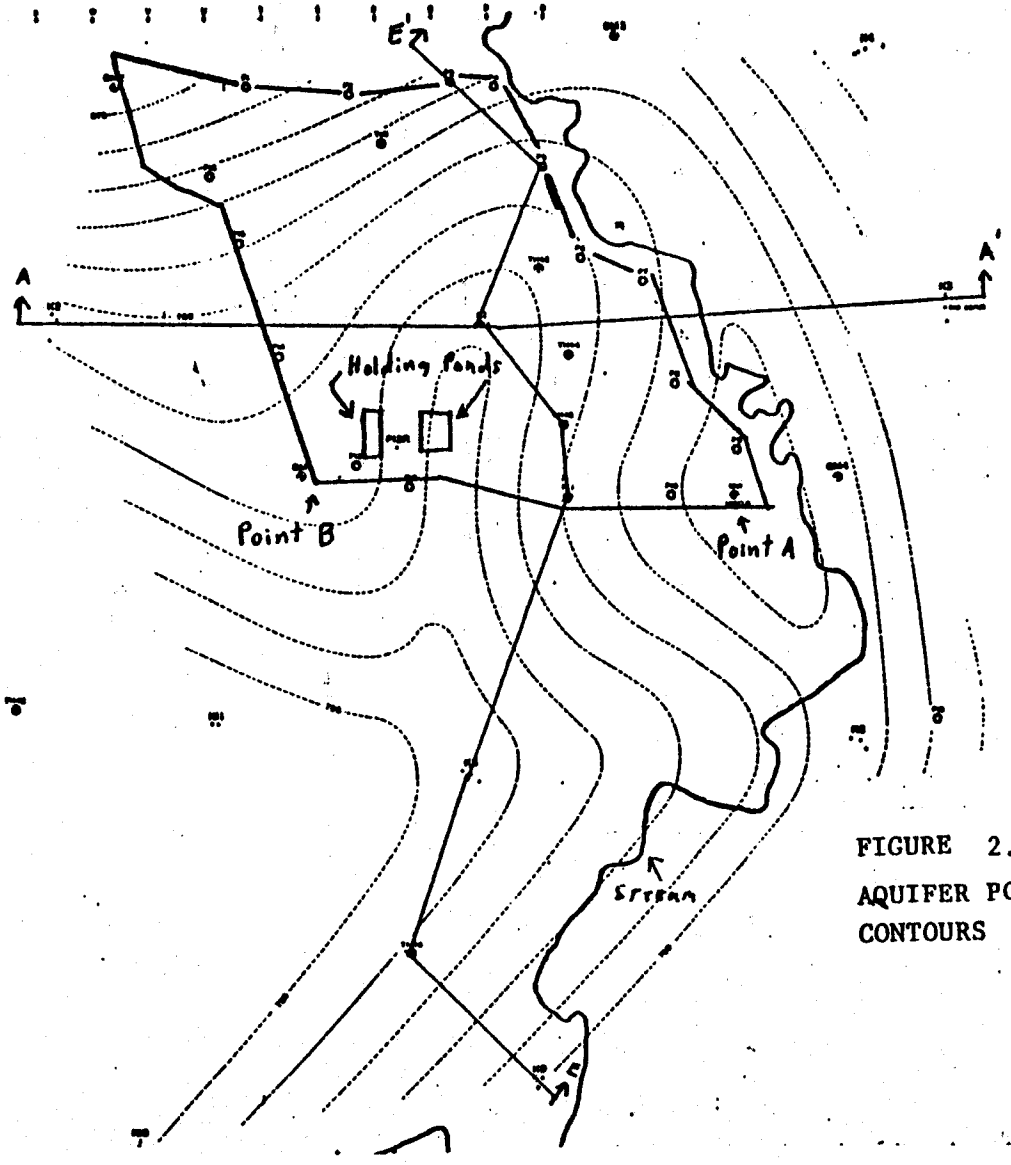


FIGURE 2.3-14
AQUIFER POTENTIOMETRIC CONTOURS

The glaciofluvial silt and fine sand generally tend to follow the same contours as the auger refusal surface which is inferred by the applicant to be bedrock. This unit is reported to be discontinuous below the site and believed to be point bar and deposits from glacial run-off. Horizontal hydraulic conductivity values from pressure testing reveal values on the order of 10^{-5}cm/sec.

The glacial till is generally a sandy, silty, clay with gravel seams and boulders. This unit was not field tested to derive conductivity values. However, a vertical conductivity value of 8×10^{-9}cm/sec is reported by the applicant.

A residual soil clay layer directly overlies the auger refusal surface. It is reported to contain extensive coarse to fine sand and gravel seams and has not been field or laboratory tested to attain hydraulic conductivity values. The application description concerning bedrock is somewhat limited with auger refusal inferred to be bedrock.

Site Hydrology

Site hydrologic conditions were characterized through the installation of piezometers to define subsurface conditions at the oxidized/unoxidized glacial drift interface, within the drift above the glaciofluvial deposit, within the glacioluvial deposits and at the soil-rock/refusal surface.

Oxidized/Unoxidized Drift Interface

Information concerning this interface is not definitive due to minimal monitoring well installation data from previous studies. The source of water at the interface is reported to be two man-made surface impoundments in the northwest area of the

site. A ground-water velocity of five to ten feet per year was reported by the applicant using field determined conductivity values, measured hydraulic gradients and a laboratory measured effective porosity of .35 (EPA default value is .01).

Subsurface ground water is reported to occur under perched conditions in the unoxidized unit. Very little explanation is provided in the permit application discussing how head data were obtained, and the interpretation of this head data appears to be ambiguous. Also, although laboratory tests are stated to indicate unsaturated conditions in the unoxidized drift, the hydrologic regime and the limited head data depicted in cross section A - A^1 suggests that all formations are saturated and therefore no perched zones would be present. Downward gradients have been measured ranging from .5 to 1.3 across the site.

Glaciofluvial Deposits

Figure 2.3-14 depicts the potentiometric contours of the uppermost aquifer, the property boundaries, and points A and B of the A, B, C, D configuration. This unit is defined by the applicant as the uppermost aquifer, in the report, mainly due to its higher hydraulic conductivity values. No pumping near the facility is reported to occur from this unit. From potentiometric contours this unit appears to have radial flow with the source being to the southwest. Using a field tested conductivity value of 1×10^{-3} cm/sec, a gradient of .06 and a default value effective porosity of .20, a ground water velocity of 310 ft/yr. was calculated.

Soil-Rock Interface

The application states that there is no hydrologic connection between the bedrock and the overlying unconsolidated sediments. This statement appears to be based upon previous studies that state that there is insufficient artesian pressure to raise the water level into the sediments and that the residual soils above the bedrock act as a low permeability zone.

Time of Travel

Two TOT_{100} calculations for horizontal flow in the upper glacial drift are presented below. One uses an applicant-stated effective porosity while the other uses an EPA default value. Two TOT calculation values were completed due to the uncertainty in the laboratory tested effective porosity reported by the applicant:

	Applicant-stated n_e	default value n_e
Hydraulic conductivity (pressure tests)	$1x10^{-5}$cm/sec	$1x10^{-5}$cm/sec
Hydraulic gradient (measured from piezometers)	.02	.02
Effective porosity	.35	.01
Velocity	.58 ft/yr	20 ft/yr
TOT_{100}	170 yrs	5 yrs

A time of travel to the aquifer was also calculated using a field tested hydraulic conductivity of 1 x 10^{-6}cm/sec in the unoxidized drift, an applicant-reported vertical gradient of 1.3, and an EPA default value of .01 for effective porosity, a velocity of .4 ft/day was calculated. The drift is approximately

50 feet thick through the center of the site; therefore, a time of travel to the aquifer assuming vertical flow would be approximately 0.3 yr.

Plume Information

Minimal amounts of monitoring have been conducted to determine the extent of contamination in the ground water. These data are presented in Table 2.3-7. There is a reported upgradient well (the B well) which is located in the southwest corner of the site. Well MW (the A well), whose location is shown in Figure 2.3-14, is stated to be downgradient This well is reported to contain elevated levels of 1,1,2,2 tetra-chloroethane, chromium and nickel. Very little can be said about the plume size and extent at the facility due to the limited data provided. It can, however, be stated that the stream running diagonally through the site has been impacted by contaminant migration. It is also unclear at what interval monitoring well (MW) is screened. This well is reported to be 175 feet deep, and from this data, it may be inferred that the contamination reaches this depth.

Another concern regarding the monitoring is that constituents found in leachate analysis (particularly 1,2 transdichloroethylene, toluene, methylene chloride and 1,2 dichloroethane) have not been monitored for in the ground water. Due to these factors, only limited speculations concerning the plume can be made.

Health Risk Assessment

The only hazardous constituents observed in the single ground water sample available for this case study were 1,1,2,2 tetrachloroethane, chromium and nickel.

Table 2.3-7: Contaminant Concentrations (ppb)

Constituent	Leachate	Ground Water		Surface Water	
		BG Well	DG Well(MW)	Upstream Sample	Downstream Sample
Aluminum	NA	142	2970	98	640
Chromium	NA	<5	8	NA	NA
Nickel	NA	<10	17	NA	NA
bis (2-Ethylhexyl) phthalate	NA	NA	NA	<10	38.0
1,1,2,2-Tetrachloroethane	<10	<1	2	NA	NA
1,2-Dichloroethane	2000	NA	NA	NA	NA
1,2-Trans dichloroethylene	1600	NA	NA	NA	NA
Toluene	3300	NA	NA	NA	NA
Methylene chloride	3600	NA	NA	NA	NA

NA = not available

The CAG has identified 1,1,2,2 tetrachloroethane as a carcinogen with a carcinogenic potency of 0.20 $(mg/kg/day)^{-1}$. Lifetime exposure to drinking water with 2 ppb of this constituent is estimated to represent an increased lifetime cancer risk of 1.1×10^{-5}.

Chromium and nickel have been identified as carcinogens when they are inhaled, but the CAG has not recommended carcinogenic potencies for ingestion. Both substances are also recognized as systemic toxicants. Assuming that all of the chromium detected in the monitoring well is hexavalent, the hazard index for the two substances is 0.16, as shown below:

Constituent	Concentration (ppm)	Exposure (mg/kg/day)	ADI (mg/kg/day)	Hazard Index
Chromium (VI)	.008	.0002	.0021	.11
Nickel	.017	.0005	.01	.049
Total	--	---	---	.16

If the chromium is assumed to be trivalent, the total hazard index will be smaller.

Several hazardous constituents appeared in high concentration in the leachate analysis, but these were not analyzed in the reported ground-water sample. As shown in Table 2.3-7, these substances include 1,2 dichloroethane, methylene chloride (both carcinogens), and toluene (a systemic toxicant). The presence of these constituents in the leachate analysis suggests that they may also be present in the ground water.

Contamination has also been observed in the stream flowing past the site, though the information available for this case study did not allow determination of whether this contamination is due to discharge of contaminated ground water or to contaminated surface runoff. The contamination is evident in the elevated concentration of inorganic constituents such as aluminum (see Table 2.3-7), but the only hazardous constituent observed was bis(2-ethylhexyl) phthalate at a concentration of 38 ppb. This is a systemic toxicant with an ADI of 0.60 mg/kg/day; therefore, ingestion of 2 litres/day of stream water would represent an exposure of 0.0011 mg/kg/day and a hazard index of 0.0018.

Exposure Assessment

Regional public and private water supply wells tap the bedrock water reserve, particularly the water at a depth of 200 to 400 feet beneath the ground surface. No supply wells are known to tap water from the first aquifer.

The bedrock monitoring well draws water from a depth of 160 to 175 feet. The elevated constituent levels observed in this well indicate that the bedrock aquifer has been contaminated. The nearest supply well is located 900 feet from the facility in an upgradient direction and draws from the bedrock aquifer. No nearby downstream drinking water wells were identified in the materials viewed in preparing this case study. However, the evidence presented indicates a significant potential for contamination of existing water supplies.