140280

APPENDIX A

FIELD DOCUMENTATION FORMS

Field Sample Log Book Format
Daily Time Log
Field Meter Instrument Calibration Log
Boring Log
Observation Well Installation Diagram
Piezometer Installation Diagram
Well Development Form
Water Elevation Form
Infield Permeability Test Form
Well Purging and Sample Collection

Field Sample Logbook Format

(Bound notebook, with sequential pages)

ITR No.	OTR No.	CRL Sample Number	Site Specific Sample Number	Collection			RAS				SAS Residential Well Organics	SAS TP, COD TSS, TDS	SAS Residential Well Inorganics	Shipment Info			Comments
				Date	Time	Who	Volatiles	Extractables	PCB/Pest.	Inorganics				Date Sent	Lab	Airbill #	

Recorded by ______________

QC'd by ______________

DONOHUE & ASSOCIATES, INC. CLIENT ____ DATE ____

CONSULTING ENGINEERS PROJECT ____ BY ____

SHEBOYGAN, WISCONSIN PROJECT NO. ____ PAGE NO. ____

Weather: A.M. ____
P.M. ____

Temp. Range Hi ____ Low ____ Frost Depth ____

Equipment Used ____

Contractor's Personnel ____ Hrs ____

Donohue Observer(s) ____

Time Log indicating work in progress, remarks

7:00 - 7:30 ____
7:30 - 8:00 ____
8:00 - 8:30 ____
8:30 - 9:00 ____
9:00 - 9:30 ____
9:30 - 10:00 ____
10:00 - 10:30 ____
10:30 - 11:00 ____
11:00 - 11:30 ____
11:30 - 12:00 ____
12:00 - 12:30 ____
12:30 - 1:00 ____
1:00 - 1:30 ____
1:30 - 2:00 ____
2:00 - 2:30 ____
2:30 - 3:00 ____
3:00 - 3:30 ____
3:30 - 4:00 ____
4:00 - 4:30 ____
4:30 - 5:00 ____
5:00 - 5:30 ____
5:30 - 6:00 ____
6:00 - 6:30 ____

Items requiring follow-up:

cc: <u>Visitors</u> <u>Representing</u>

FIELD METER
INSTRUMENT CALIBRATION LOG:
pH METER

	4.0 BUFFER		7.0 BUFFER		10.0 BUFFER			
Date Calibrated	True Value	Meter Reading	True Value	Meter Reading	True Value	Meter Reading	Adjustments	CAL By

COMMENTS: ______________________________

pH Meter: MFG __________ Model __________ EPA ID # __________

Buffers: 4 Source __________ Date Opened __________

7 Source __________ Date Opened __________

10 Source __________ Date Opened __________

FIELD METER
INSTRUMENT CALIBRATION LOG:
TEMPERATURE, CONDUCTIVITY, DISSOLVED OXYGEN

	THERMOMETER				CONDUCTIVITY			D.O. METER			
Date Calibrated	NBS Reference °C	Field Thermometer °C	Correction Factor °C	CAL By	True Value umhos	Meter Readings umhos	CAL By	Air Temp. °C	Calc. D.O. Air (mg/L)	Read D.O. Air (mg/L)	CAL By

COMMENTS: ______________________________

Thermometer # __________ EPA ID # __________

Conductivity Meter: MFG __________ Model __________ EPA ID # __________

Conductivity Standard: MFG __________ Opened Date: __________

D.O. Meter: MFG __________ Model __________ EPA ID # __________

Sheet __ of ____

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COMPUTER AIDED DESIGN/DRAFTING

BORING LOG

SITE: ____________ PROJECT NO. __________

SOIL BORING NO. ○

DRILLING METHOD: ____________
FOREMAN: ____________
ASSISTANT: ____________
GEOL./ENG'R. ____________
LOG BY: ____________

WATER LEVEL READINGS

DATE	TIME	DEPTH	
____	____	____	W.D.
____	____	____	S.C.R.
____	____	____	A.C.R.
____	____	____	HRS. A.D.
____	____	____	HRS. A.D.

GROUND SURFACE ELEV. ________
PHYSICAL SETTING: ________
DATE START: ________
DATE COMPLETE: ________

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA								USCS	SOIL DESCRIPTION	COMMENTS
		NO.	T	A	R	PENETRATION						
						1st	2nd	3rd	N			

SHEET___OF____

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DRILLING DATA

SOIL BORING NUMBER

ADDITIONAL DRILLING DATA

Split Tube Size______ID______OD
Hammer Wt.________lb______in drop
Thin Wall Tube Size___OD
Casing Used________LF_____Dia.
Casing Hammer______lb______in drop
Drill Rod Size________________
Drill Bit Type________(a)______(b)
Drill Bit Size________(a)______(b)
Auger Type_________OD
Hollow Stem Auger___ID
Core Barrel Size______ID_____Length
Core Bit Serial________________
Core Bit Serial________________
Drill Mud Type________________
Drill Mud Formula______________
Depth Drill Mud Used____________
Back Filled Date_______________
Method____________by___________
Drill Rig Mfg. Mod._____________
Other Equip__________________
Other Equip._________________

DRILLING INFORMATION

1 Record measurements in tenths of feet
2 For samples, record sample type (split spoon, shelby, core) depths, sample interval, length of sample recovered
3 Record first encountered water and any other distinct water producing zones
4 Record blow counts (density), hammer weight, length of fall for driven samples
5 Record use of drilling fluids, fluid type, source of water, fluid losses, interval (and soil type) where fluid loss occurred, if determinable, quantitive estimate of volume of fluid lost
6 Record drilling equipment used and general drilling procedures
7 Record all problems encountered during drilling
8 Collect samples of backfill, grout, and concrete
9 Report general drilling conditions, (temperature, raining, etc.)

Soil/Rock Description Requirements

1 Soil
- a. Written classification
- b USCS symbol
- c Estimated % of secondary components "% and size gravel, cobbles
- d Color, mottling
- e Plasticity (general)
- f Consistency (cohesive) or density (non-cohesive)
- g Moisture
- h Texture/fabric/bedding
- i. Depositional environment

2 Rock
- a Classification
- b Lithologic characteristics
- c Bedding/banding
- d Color
- e Hardness
- f Degree of cementation
- g Texture
- h Structure
- i Degree of weathering
- j. Solution or void conditions
- k Primary and secondary estimated hydraulic conductivity, rationale
- l Note natural and coring induced rock breaks and lost core including probable reason for. Include number of fractures per foot, number of fractures per total length of recovery

Texture	Abbreviation	Size	Abbreviation	Soil Particle Size
Boulder	Bo			Over 3.0"
Gravel	Gr	Large	L	1.0" to 3.0"
		Medium	M	.38" to .99"
		Small	Sm	2.0mm to .38"
Sand	S	Coarse	Co	.75mm to 1.99mm
		Medium	M	.25mm to .74mm
		Fine	F	.05mm to .24mm
Silt	Si			.002mm to .049mm
Clay	C			Smaller than .022mm

Consistency	Abbreviation	N	Density	Abbreviation	N
Very Soft	VS	0-2	Very Loose	VL	0-4
Soft	S	3-4	Loose	L	5-9
Medium	M	5-8	Medium Dense	MD	10-29
Stiff	St	9-16	Dense	D	30-49
Very Stiff	VST	17-30	Very Dense	VD	50+
Hard	H	Over 30			

% of Dry Weight	Term	Abbreviation
0-10	Trace or Occassional	TR or OC
11-20	Little	LI
21-35	Some	SO
36-50	And or With	& or W/

CONDITIONS FOR USE OF SOIL BORING LOG

This field soil boring log records the soil descriptions and other data observed or measured in the field by qualfied soil technicians. The soils between the samples may have been determined by the "feel" of the drill bit or wash cuttings. The changes between the soil strata may be transitional rather than abrupt, particularly with respect to color, weathering, and consistency changes. The amount of large sized gravel or boulders is generally estimated because the sampling tubes seldom retain these larger sized soil particles. Delayed readings of ground water levels mav not be entered on this field log.

Sheet ___ of ____

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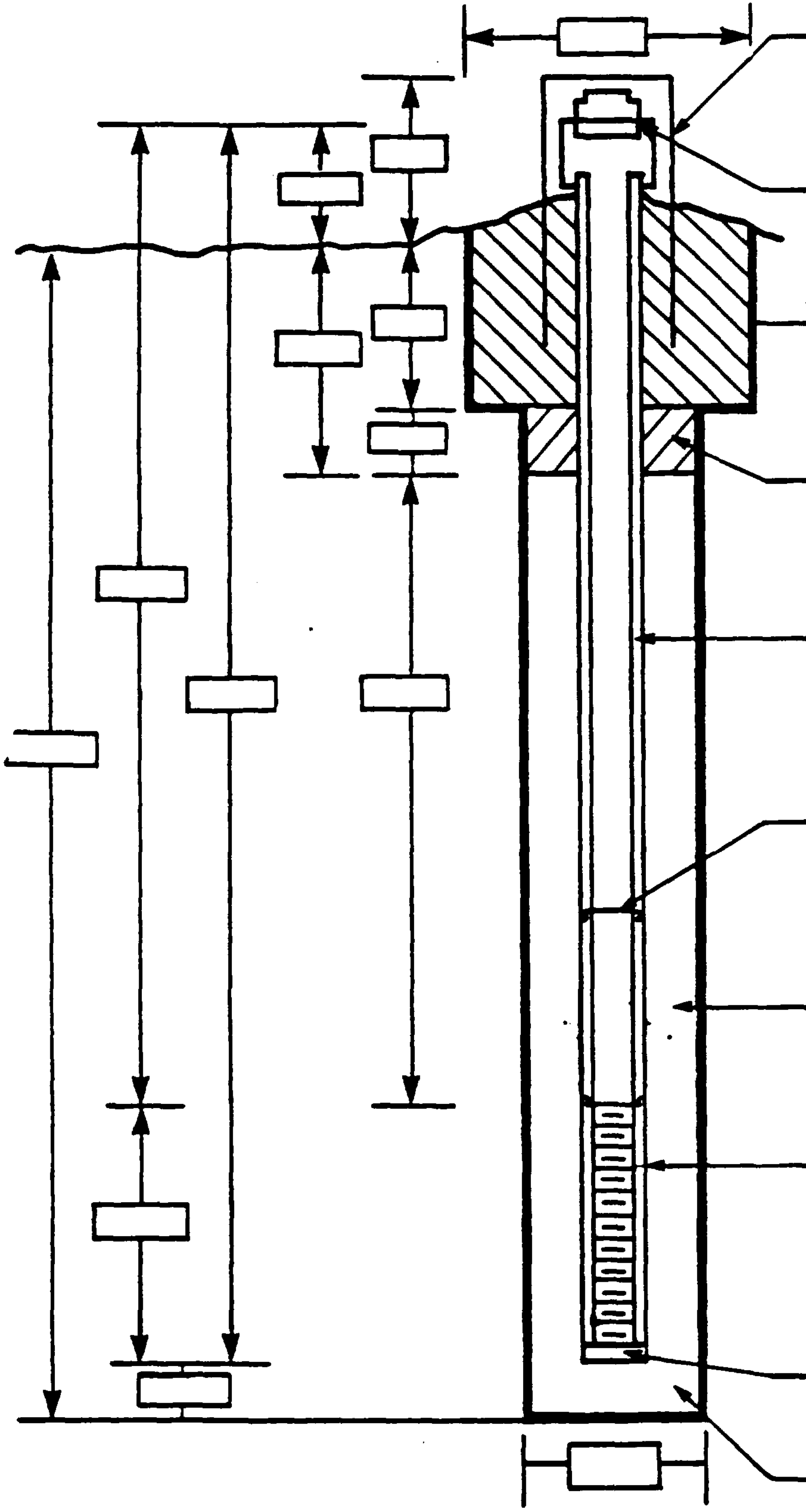
OBSERVATION WELL INSTALLATION DIAGRAM

Well No. __________

Site: ____________________ Date: __________

By: ____________________ Project No. __________



Protective Casing

Guard Posts

Type ________ Vented ________ Type ________

Diameter ________ Locked ________

Length ________ Key ________

Plug

Type ____________________

Vented ____________________

Concrete Collar

Quant. Cement ______ lbs. + Quant. Water ____ gal.

Total Quant. ________ gal. ____________

Manufacturer ____________________

Seal

Powder/Granular/Pellets Quant. ________ gal. ______

Manufacturer ____________________

Hydrated ____________ gal., Time ____________

Pipe

Type ____________________

O.D. ____________ " ____ Manufacturer ____________

I.D. ____________ " ____ Schedule ____________

Length/per sec. ____________ No. of sec. ________

Joints

Threaded Flush Joint

Teflon Taped Yes/No

Tape ____________________

Manufacturer ____________________

Backfill

Type(s) ____________________

Source ____________________

Volume ____________________

Screen

Type ____________ Slot Size ____________

O.D. ____________ " ____ No. Slots/ft. ____________

I.D. ____________ " ____ Schedule ____________

Manufacturer ____________________

Length/per sec. ____________ No. of sec. ________

Cap

Type ____________________

Material

____

Notes: Water Source ____________________

____

____

Sheet ___ of ______

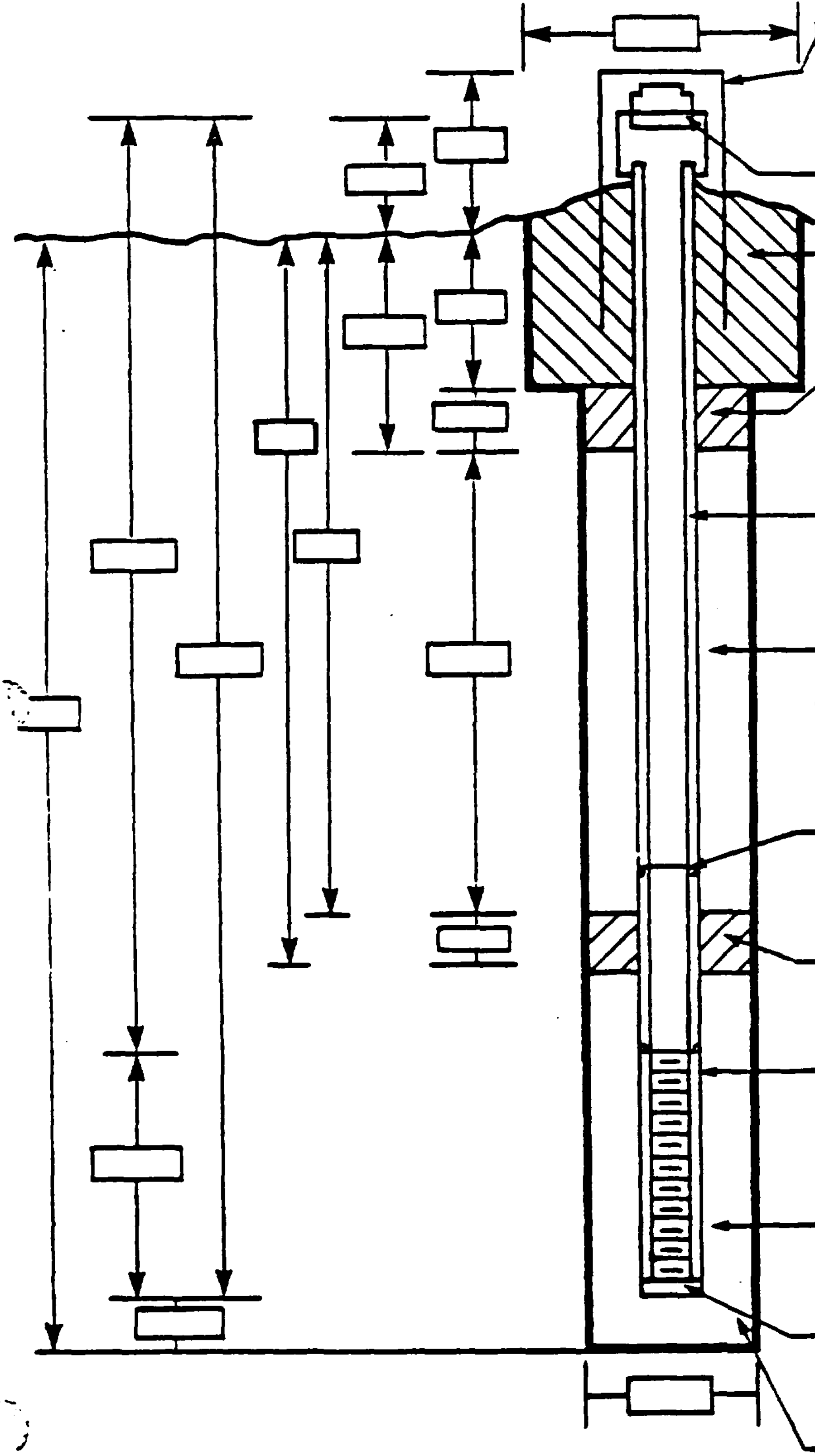
Donohue

PIEZOMETER INSTALLATION DIAGRAM

Well No. ________

Site: ____________________ Date: ____________

By: ____________________ Project No. __________



Protective Casing

Guard Posts

Type ________ Vented ________ No. ________

Diameter ________ Locked ________ Type ________

Length ________ Key ________

Plug

Type ________ Vented ________

Concrete Collar

Manufacturer ____________________

Cement ________ lbs. + Water ________ gal.

Total Quantity ____________________ gal.

Seal

Manufacturer ____________________

Powder/Granular/Pellets Quant. ________ gal.

Hydrated ________ gal., Time ________

Pipe

Type ____________ " Schedule ________

O.D. ____________ " Manufacturer ________

I.D. ____________ "

Length per sec. ________ No. of sec. ________

Cement - Bentonite Grout

Mix ________ Cement ________ Bentonite

Cement ________ lbs. + Bentonite ________ lbs. +

Water ________ gals.

Total Quantity gals. ________

Manufacturers ____________ ____________

Joints

Threaded Flush ____________________

Teflon Taped Yes/No

Manufacturer ____________________

Seal

Powder/Pellets Quant. ________ gals.

Hydrated ________ gal., Time ________

Screen

Type ____________ Slot Size ________

O.D. ________ " No. Slots/ft. ________

I.D. ________ " Schedule ________

Length per sec. ________ No. of sec. ________

Manufacturer ____________________

Backfill

Type ____________________

Source ____________________

Volume ____________________ gal.

Cap

Type ____________________

Volumes ____________________

Material

____

Notes: Water Source ____________________

____

____

Sheet ________ of ______

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Well Development

Project No. ____________ Site ______________________________

Method of Development Pumped ________ Bailed ________ Blown ________ Surge Block ______________________

Equipment ________ Airlift ________ N2 Lift ________ In. Bailer ________ Length ________ Ft. Material ______________________

Pump ________ Manufacturer ______________________________ Diameter ______________________

Description of site (weather, temp, soil conditions) ______________________________

Well No Time	Depth to Water	Depth to Bottom	Volume Removed (gal.)	Depth After	pH	Cond.	Color	Odor Y/N	Temp.	Turbidity	Comments

Additional Notes: ______________________________

Entered on computer ______________________ Signature ______________________________ Date ____/____/____

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WATER ELEVATION

PROJECT NO ____________ SITE ____________

WELL NUMBER	ELEVATION OF TOP OF PIPE	DEPTH TO WATER	WATER ELEVATION	DEPTH TO BOTTOM	WELL INTEGRITY				COMMENTS
					LOCKED	CAPPED	CRACKED	OBSTRUCT	

DESCRIPTION OF SITE ____________

SOIL CONDITIONS ____________

WEATHER ____________ TEMPERATURE ____________

ENTERED ON COMPUTER ____ SIGNATURE ____________ DATE ____________

Sheet ____ of ____

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INFIELD PERMEABILITY TEST

Project No. ____________ Site ______________________________

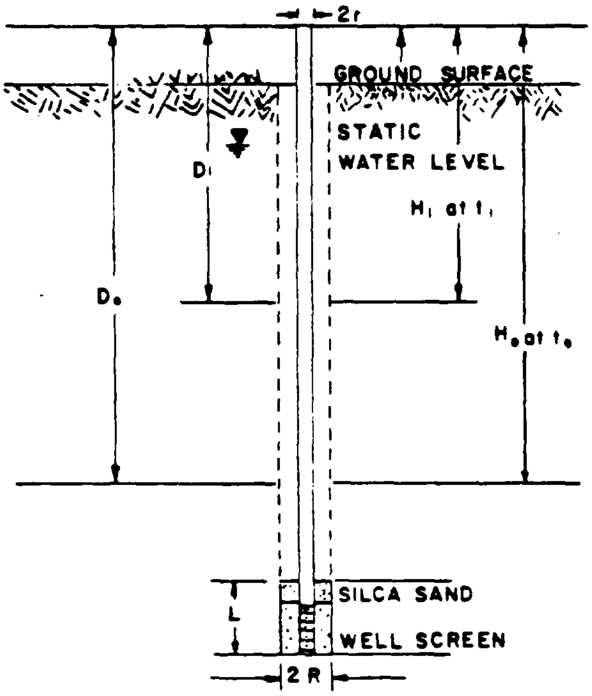
Client ______________________ Well Screened In ____________ (formation) Diameter of Pipe (ft.) ________ (2r)

Well Drilled By ______________________ Static Water Level ____________ (SWL) Screen Length (ft.) ________

Date Test Performed ______________________ Diameter of Hole (ft.) ________ (2R) "L" Length (ft.) ________ (note below)

Top of Pipe Elevation ______________________ Vol. Removed ________ Depth to Top of Screen ________

Estimated m = KH/KV



Hvorslev Equation for Piezometer in Anisotropic Soil

$$K_t = \frac{r^2}{2L\,(t_2 - t_1)} \ln\left(\frac{mL}{R}\right) \ln\left(\frac{H_1}{H_2}\right) (.508)$$

$= K_t$ cm/sec

READING	Time (min.)	DEPTH TO WATER (FT) AFTER BAILING D_t	D_t-SWL=H_t (ft)	H_t / H_0
t_0				
t_1				
t_2				
t_3				
t_4				
t_5				
t_6				
t_7				
t_8				
t_9				
t_{10}				
t_{11}				
t_{12}				
t_{13}				
t_{14}				
t_{15}				
t_{16}				
t_{17}				
t_{18}				
t_{19}				
t_{20}				
t_{21}				
t_{22}				
t_{23}				
t_{24}				

Notes: ____

Test Performed By ______________________ Date ____________

Calculations By ______________________ Date ____________

Checked By ______________________ Date ____________

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Well Purging and Sample Collection

Project No. ______________ Site ______________

Method of Purging Pumped ______ Bailed ______

Equipment ______ Airlift ______ N2 Lift ______ In. Bailer ______ Length ______ Ft. Material ______

Pump ______ Manufacturer ______ Diameter ______ Description of site ______
(weather, temp., soil, conditions)

Well No. / Time	Depth to Water	Depth to Bottom	Volume Calculated (gal.)	Volume Removed (gal.)	Depth After	pH	Cond.	Temp	Turbidity Y/N	Comments

Notes ______________

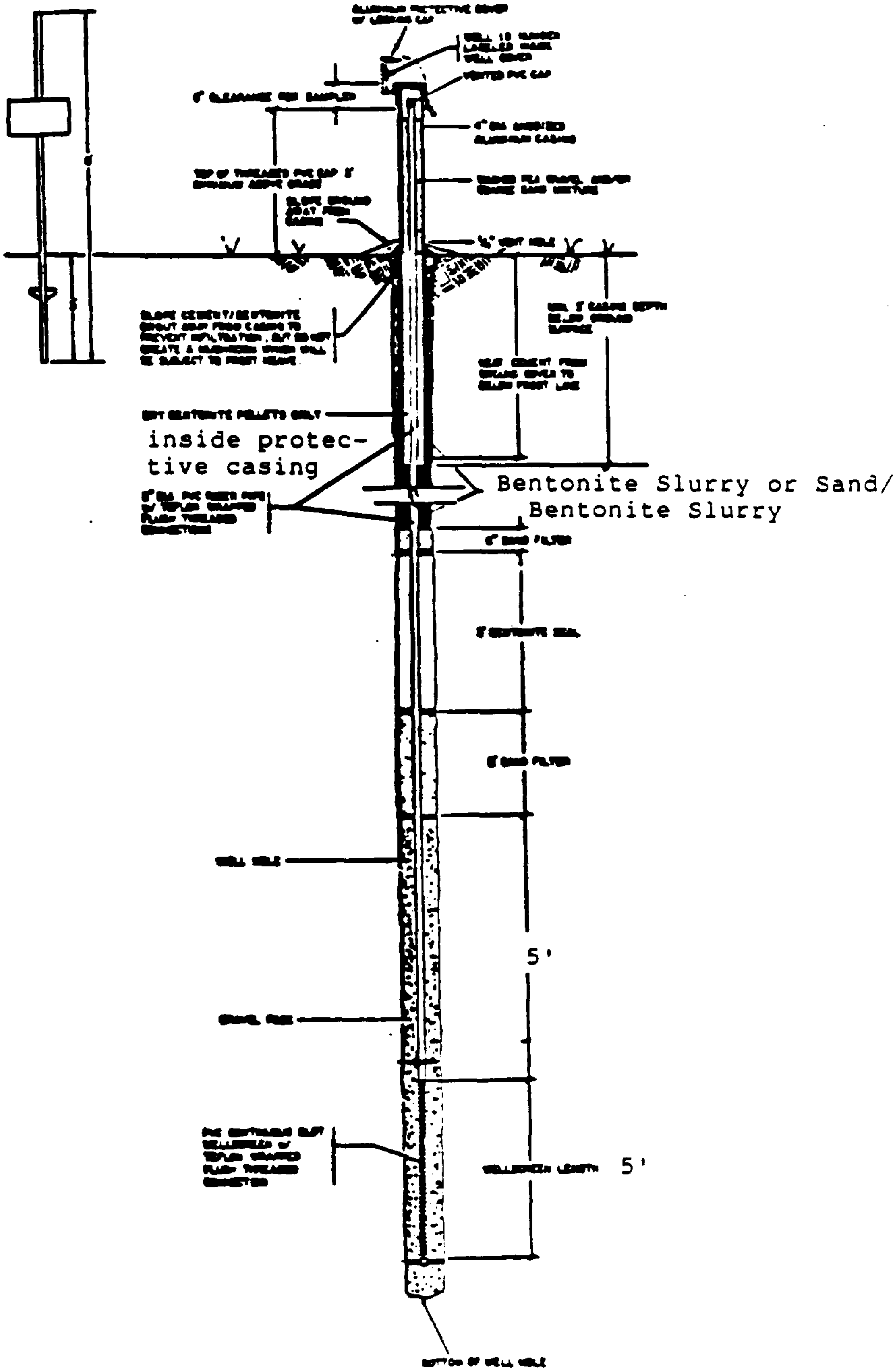
______________ Signature ______________ Date ______

P.M./86

APPENDIX B

SCHEMATICS

Piezometer Construction



Schematic of Piezometer Construction

APPENDIX C

FIELD METER CALIBRATION PROCEDURES

Thermometer
pH Meter
Conductivity Meter

FILTRATION UNIT OPERATION

THERMOMETER

Measurement Techniques for Water Temperature

Temperature measurements should be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

If a thermometer is used on a collected water sample:

1. Rinse the thermometer with a portion of the collected sample.
2. Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of contamination, the thermometer should not be inserted into samples which will undergo subsequent chemical analysis.
3. Record values on field forms.

If a temperature meter or probe is to be used, the instrument should be calibrated according to the manufacturer's recommendations and a National Bureau of Standards (NBS) certified thermometer or one that is traceable to NBS certification before field use. Cross-checks and duplicate field analyses should agree within ±0.5 degrees C. A cross-check with a calibrated NBS certified thermometer shall be made at least semi-annually and within one week before use in the field.

Thermometers should also be checked against the NBS reference thermometer. Results of all calibration should be recorded on the Field Meter Log Sheet.

Source: Ebasco Rem III Program Guidelines No. FT-7.10.

ARCS/RP/AK1

SPECIFIC CONDUCTANCE

It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below:

1. Check batteries and calibrate instrument before going into the field. Potassium chloride standard solutions with a specific conductance closest to the values expected in the field should be used. The table below may be used for guidance:

SPECIFIC CONDUCTANCE OF KCl SOLUTIONS AT 25 DEGREES CENTIGRADE

Concentration	Specific	Conductance
mol/L	mg/L	umhos/cm
0.0001	7.456	14.94
0.0005	37.28	73.90
0.001	74.56	147.0
0.005	372.8	717.8
0.00702	523.4	1000
0.01	745.6	1413
0.02	1591.2	2767

NOTE: This table has been modified from **Standard Methods for the Examination of Water and Wastewater** (1980).

2. Record the true and actual meter readings on the Field Meter Calibration Form.

3. Rinse the cell with one or more portions of the sample to be tested.

4. Immerse the electrode in the sample and measure the conductivity.

5. Read and record the results in a field log book. Adjust the temperature setting to the sample temperature.

6. Repeat the procedure with fresh sample until reproducible (+/-10%) results are obtained.

If the specific conductance measurements become erratic, or inspection shows that any platinum black has flaked off the electrode, replatinization of the electrode is necessary. See the manufacturer's instructions for details.

Source: Ebasco Rem III Program Guidelines No. FT-7.10.

ARCS/RP/AK1

pH METER

Two field methods are available for pH measurement: the pH meter and pH indicator paper. Indicator paper is used only when a rough estimate of the pH is required, for example to check proper acid/base preservation of samples. The pH meter is used when a more accurate measurement is needed. The response of a pH meter can be affected by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

Equipment

The following equipment is needed for taking pH measurements:

1. Orion portable pH meter, or equivalent.
2. Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs).
3. pH indicator paper, such as Hydrion or Alkacid, to cover the pH range 2 through 12.
4. Buffer solutions of pH 4,7 and 10, or other buffers which bracket the expected pH range.

Because of the diversity of pH meters currently available on the market, the investigator has the option of selecting the unit that best meets his investigative needs and field limitations. Digital meters are preferred, as opposed to deflection meter outputs, because of the relative ease in reading response for in-situ measurements.

Measurement Techniques for Field Determination of pH

1. pH Meter

The following procedure is used for measuring pH with a pH meter:

a. The instrument and batteries should be checked and calibrated in the laboratory prior to initiation of the field effort.

b. The accuracy of the buffer solutions used for field and laboratory calibration should be checked. Buffer solutions need to be changed due to degradation upon exposure to the atmosphere. (The date of preparation of each buffer should be included on the bottle label.) Record source of buffer and date opened on Field Meter Log Sheet.

c. Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer solution for field transport or storage. This is not applicable for all electrodes as some must be stored dry.

d. Make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).

e. Immerse the electrode(s) in a pH-7 buffer solution.

f. Adjust the temperature compensator to the proper temperature (on modes with automatic temperature adjustment, immerse the temperature probe into the buffer solution). Alternately, the buffer solution may be immersed in the sample and allowed to reach temperature equilibrium before equipment calibration. It is best to maintain buffer solution at or near expected sample temperature before calibration.

g. Adjust the pH meter to read 7.0.

h. Remove the electrodes(s) from the buffer and rinse well with demineralized water. Immerse the electrode(s) in pH-4 or 10 buffer solution (depending on the expected pH of the sample) and adjust the slope control to read the appropriate pH. At least three successive readings during calibration, one minute apart, should be within ±0.1 pH unit. For best results, the standardization and slope adjustments should be repeated at least once daily before use.

i. Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the log book.

j. Read and record the pH of the solution, after adjusting the temperature compensator to the sample temperature. pH should be recorded to the nearest 0.1 pH unit on the Field Meter Calibration Log.

k. Rinse the electrode(s) with demineralized water.

l. Keep the electrode(s) immersed in water when not in use.

The sample used for pH measurement should never be saved for subsequent conductivity or chemical analysis. All pH electrodes leak small quantities of electrolytes (e.g., sodium or potassium chloride) into the solution. Precipitation of saturated electrolyte solution, especially at colder temperatures, or in cold water, may result in slow electrode response. Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, should be noted on the Field Meter Calibration Log.

Source: Ebasco Rem III Program Guidelines No. FT-7.10.

FILTRATION UNIT

Samples collected for dissolved metals analysis will be filtered in the field immediately after collecting the sample. The filtering process is designed to remove suspended sediment from the sample. Such suspended material can react with the sample and may change the concentration of certain dissolved constituents. Following the filtering process, samples will be preserved using appropriate chemical preservatives.

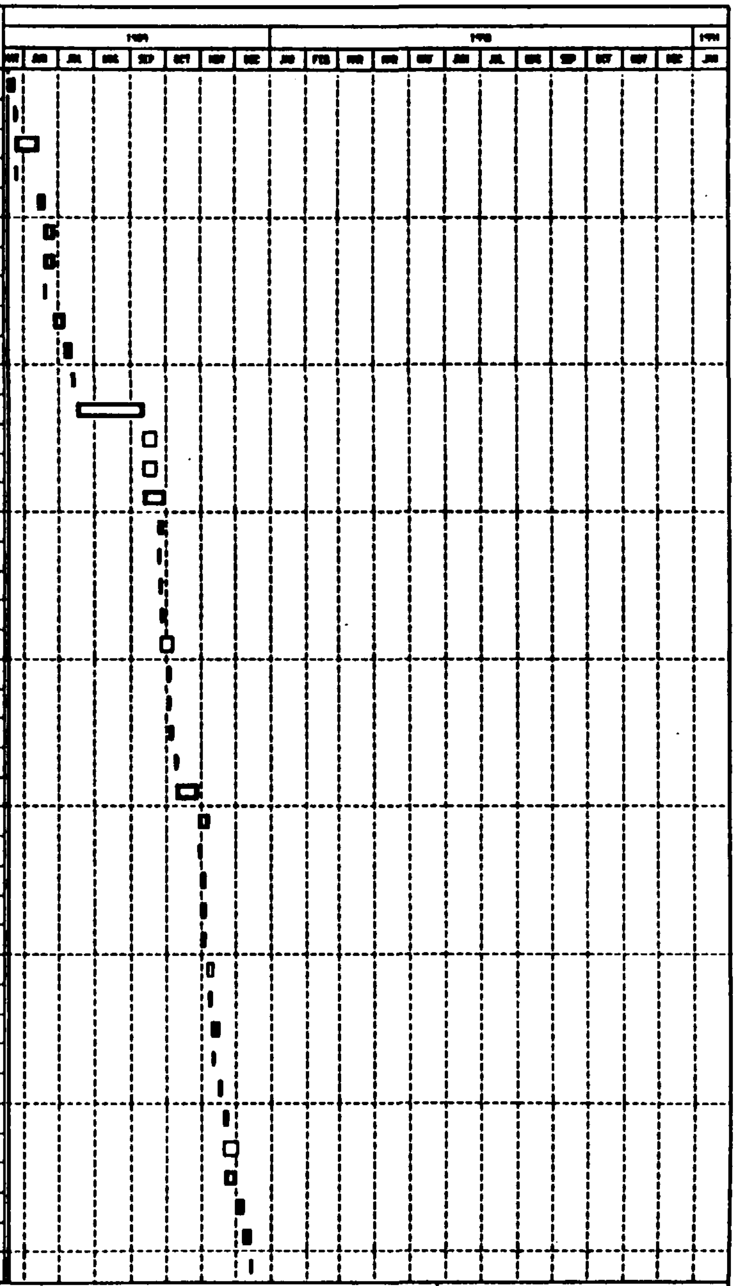
Field filtering procedures are as follows:

1. The filtering apparatus will be set up according to the manufacturers directions.
2. A 0.45 micron membrane filter will be used. If the sample is highly turbid, a pre-filter may be needed to prevent clogging.
3. A minimum of 500 ml of reagent grade water will be flushed through the filtering apparatus prior to filtering the sample in order to reduce the risk of altering the composition of the sample by the filtering operation.
4. The sample will be pumped through the filter and the first 100-200 ml discarded.
5. The remaining volume of sample will be collected in the RAS metal sample containers.
6. The filter membrane (and the pre-filter is used) will be removed after the sample is collected and discarded.
7. The filtering apparatus and tubing will be flushed with 500 ml reagent grade water.
8. The filter apparatus will then be reassembled for the next sample.
9. The sample label, traffic reports, and chain-of-custody forms will indicate that the sample was field filtered.

APPENDIX D

PROJECT SCHEDULE

ACTIVITY ID	ACTIVITY DESCRIPTION	ORIG DUR	TOTL FLT	EARLY START	EARLY FINISH
1	PROJECT INITIATION	4	0	19MAY89	24MAY89
3	EPA PROJECT KICKOFF MEETING	1	0	25MAY89	25MAY89
5	BACKGROUND DATA REVIEW	12	0	26MAY89	13JUN89
7	TECHNICAL SCOPING MEETING	1	11	26MAY89	26MAY89
9	DEVELOP PROJECT APPROACH	4	0	14JUN89	19JUN89
11	PREPARE COST & SCHEDULE ESTIMATES	6	0	20JUN89	27JUN89
13	PREP DRAFT WORKPLANS -SAP-QAPP-HSP-DMP	6	0	20JUN89	27JUN89
15	PRE-QAPP MEETING	1	5	20JUN89	20JUN89
17	DONOHUE QC REVIEW	6	0	28JUN89	6JUL89
19	PRINTING & REPORT ASSEMBLY	4	0	7JUL89	12JUL89
21	SUBMIT DRAFT WORK PLANS TO EPA	2	0	13JUL89	14JUL89
23	EPA REVIEW & COMMENT	40	0	17JUL89	11SEP89
27	WORK PLAN REVISIONS	9	28	12SEP89	22SEP89
29	COST & SCHEDULE REVISIONS	9	28	12SEP89	22SEP89
43	PREPARE SUBCONTRACT SOW & SPECIFICATIONS - MW	14	0	12SEP89	29SEP89
35	DONOHUE QC REVIEW/WORK PLANS	3	28	25SEP89	27SEP89
37	PRINTING & FINAL WORK PLAN ASSEMBLY	1	28	25SEP89	25SEP89
39	SUBMIT TO EPA	1	28	26SEP89	26SEP89
31	MEETING WITH MPCA & SITE RECONNAISSANCE	1	0	27SEP89	27SEP89
41	EPA REVIEW & APPROVAL	8	28	27SEP89	6OCT89
33	SITE STATUS SUMMARY MEMO/FINALIZE WELL LOCATIONS	3	326	2OCT89	4OCT89
45	INTERNAL QC REVIEW	3	0	2OCT89	4OCT89
47	REVISE BID DOCUMENTS	2	0	5OCT89	6OCT89
49	PRE-BID CONFERENCE	1	0	9OCT89	9OCT89
51	CONDUCT BIDDING	14	0	10OCT89	27OCT89
54	EPA REVIEW & APPROVAL	6	0	30OCT89	6NOV89
55	ARRANGE FOR EQUIPMENT	2	3	30OCT89	31OCT89
57	BID ANALYSIS & NEGOTIATIONS	3	3	1NOV89	3NOV89
59	PREPARE FIELD NOTEBOOK	3	3	1NOV89	3NOV89
61	CONTACT LANDOWNERS/ACCESS COORDINATION	3	3	1NOV89	3NOV89
63	SUBCONTRACTOR COORDINATION	4	3	6NOV89	9NOV89
60	AWARD CONTRACT	2	0	7NOV89	8NOV89
56	MOBILIZATION - MONITORING WELLS	5	0	9NOV89	15NOV89
64	CLP LAB COORDINATION	1	3	10NOV89	10NOV89
65	MW FACILITIES SET UP	2	0	16NOV89	17NOV89
67	INSTALL WT WELLS	3	0	20NOV89	22NOV89
79	CONDUCT FIELD AUDITS	8	284	20NOV89	1DEC89
71	INSTALL PIEZOMETERS	6	0	21NOV89	30NOV89
75	WELL ABANDONMENT	4	0	1DEC89	6DEC89
81	REPAIR WELLS	4	0	7DEC89	12DEC89
82	SURVEY NEW WELL LOCATIONS	2	0	13DEC89	14DEC89



Activity Bar/Early Dates
Critical Activity
Progress Bar

Primavera Systems, Inc. [illegible]

Project Start : 19MAY89
Project Finish: 17JAN91

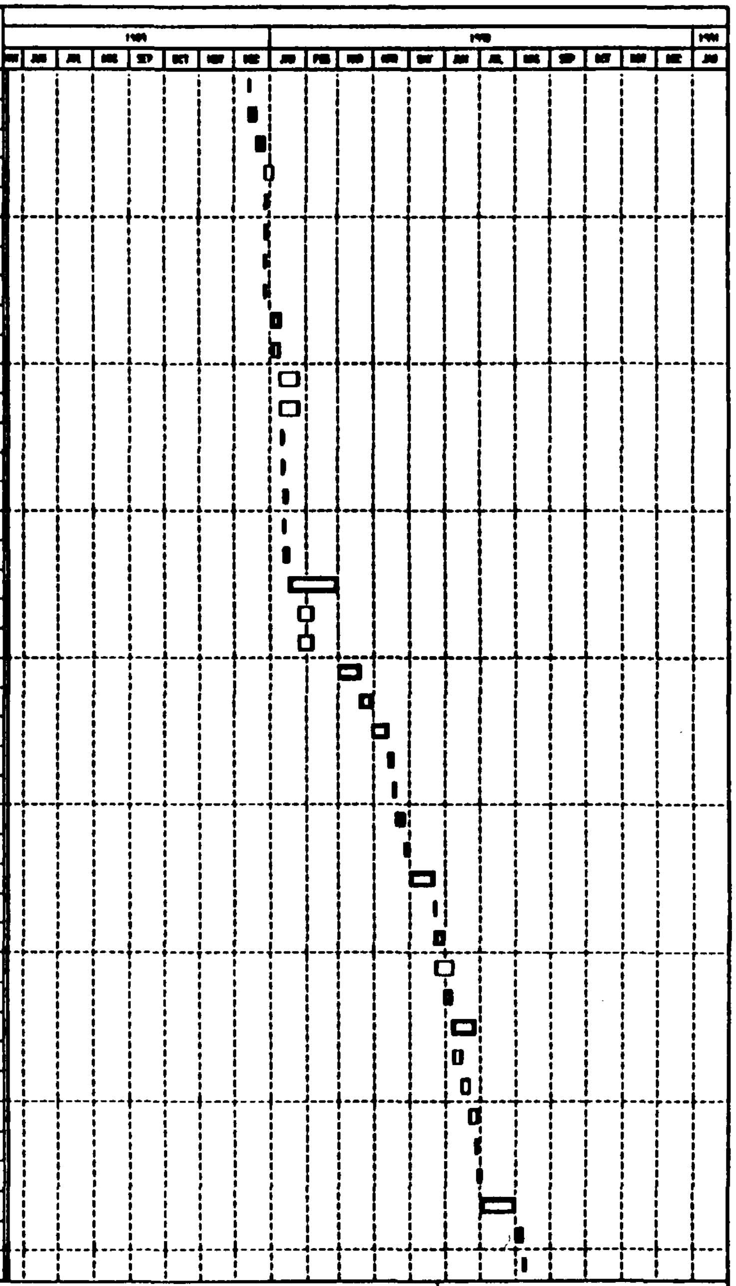
DONOHUE & ASSOCIATES - 20022
WA 13-5N45 SOUTH ANDOVER
PROPOSED PROJECT SCHEDULE

Sheet 1 of 3

Data Date: 19MAY89
Plot Date: 26SEP89

Date	Revision	Checked	Approved

ACTIVITY ID	ACTIVITY DESCRIPTION	ORIG DUR	TOTL FLT	EARLY START	EARLY FINISH
85	SUBCONTRACTOR COORDINATION	2	277	13DEC89	14DEC89
89	ARRANGE FOR EQUIPMENT & ACCESS	5	0	13DEC89	19DEC89
91	CONDUCT SLUG TESTS	4	0	20DEC89	26DEC89
93	SLUG TEST ANALYSIS	4	51	27DEC89	2JAN90
97	PRE-FIELD COORDINATION - GW	3	0	27DEC89	29DEC89
99	ARRANGE FOR EQUIPMENT - GW	3	0	27DEC89	29DEC89
101	SITE ACCESS COORDINATION - GW	2	1	27DEC89	28DEC89
103	ACCESS COORDINATION - PRIVATE WELLS - GW	2	1	27DEC89	28DEC89
105	PURGE/SAMPLE MONITOR WELLS	6	0	2JAN90	9JAN90
95	FIELD TECH MEMO - SLUG TESTS	4	51	3JAN90	8JAN90
119	SITE GEOLOGY & GEOTECH RESULTS	12	51	9JAN90	24JAN90
121	SLUG TEST & HYDRO EVALUATION	12	250	9JAN90	24JAN90
107	PURGE/SAMPLE PRIVATE WELLS	1	0	10JAN90	10JAN90
109	COLLECT WATER LEVEL INFORMATION	1	0	11JAN90	11JAN90
111	PACKAGE/SHIPPING - GW SAMPLES	2	0	12JAN90	15JAN90
112	CLP LAB COORDINATION	1	0	12JAN90	12JAN90
113	FIELD TECH MEMOS - GW SAMPLING	3	0	12JAN90	16JAN90
115	OBTAIN GROUNDWATER ANALYTICAL RESULTS	30	0	17JAN90	27FEB90
125	GEOLOGY TECH MEMO	8	51	25JAN90	5FEB90
127	HYDRO TECH MEMO	8	51	25JAN90	5FEB90
116	DATA VALIDATION	14	0	28FEB90	19MAR90
123	INPUT ANALYTICAL DATA	8	0	20MAR90	29MAR90
129	GROUNDWATER DATA EVALUATION	10	0	30MAR90	12APR90
131	CHEMISTRY TECH MEMO	3	0	13APR90	17APR90
133	DETERMINE MONITORING NEEDS	2	0	18APR90	19APR90
135	PRELIM ASSESSMENT TECH MEMO	5	0	20APR90	26APR90
137	EPA REVIEW MEETING	3	0	27APR90	1MAY90
139	AGENCY EVALUATION AND DETERMINATION	15	0	2MAY90	22MAY90
141	DETERMINE DISCHARGE AREAS	1	46	23MAY90	23MAY90
143	DATA REVIEW & PRESELECTION	5	0	23MAY90	30MAY90
145	OBTAIN & REVIEW PRIVATE WELL LOGS	10	46	24MAY90	7JUN90
147	PREPARE SOW & SCOPE - PUMP TEST	5	0	31MAY90	6JUN90
151	PREPARE TECH SPECS & CONTRACT DOCS. - PUMP TEST	14	0	7JUN90	26JUN90
149	DETERMINE POTENTIAL RECEPTORS	5	46	8JUN90	14JUN90
150	EVALUATE POTENTIAL RISKS	5	46	15JUN90	21JUN90
152	PREPARE TECH MEMO - RECEPTORS	5	46	22JUN90	28JUN90
155	INTERNAL QC REVIEW	2	0	27JUN90	28JUN90
157	REVISE BID DOCUMENTS - PUMP TEST	2	0	29JUN90	2JUL90
159	CONDUCT BIDDING - PUMP TEST	20	0	3JUL90	31JUL90
160	BID ANALYSIS & NEGOTIATIONS	5	0	1AUG90	7AUG90
161	EPA REVIEW & APPROVAL - PUMP TEST BIDS	2	0	8AUG90	9AUG90



▭	Activity Bar/Early Dates
▬	Critical Activity
▬▭	Progress Bar

Primavera Systems, Inc. 1984-1989

Project Start : 19MAY89
Project Finish: 17JAN91

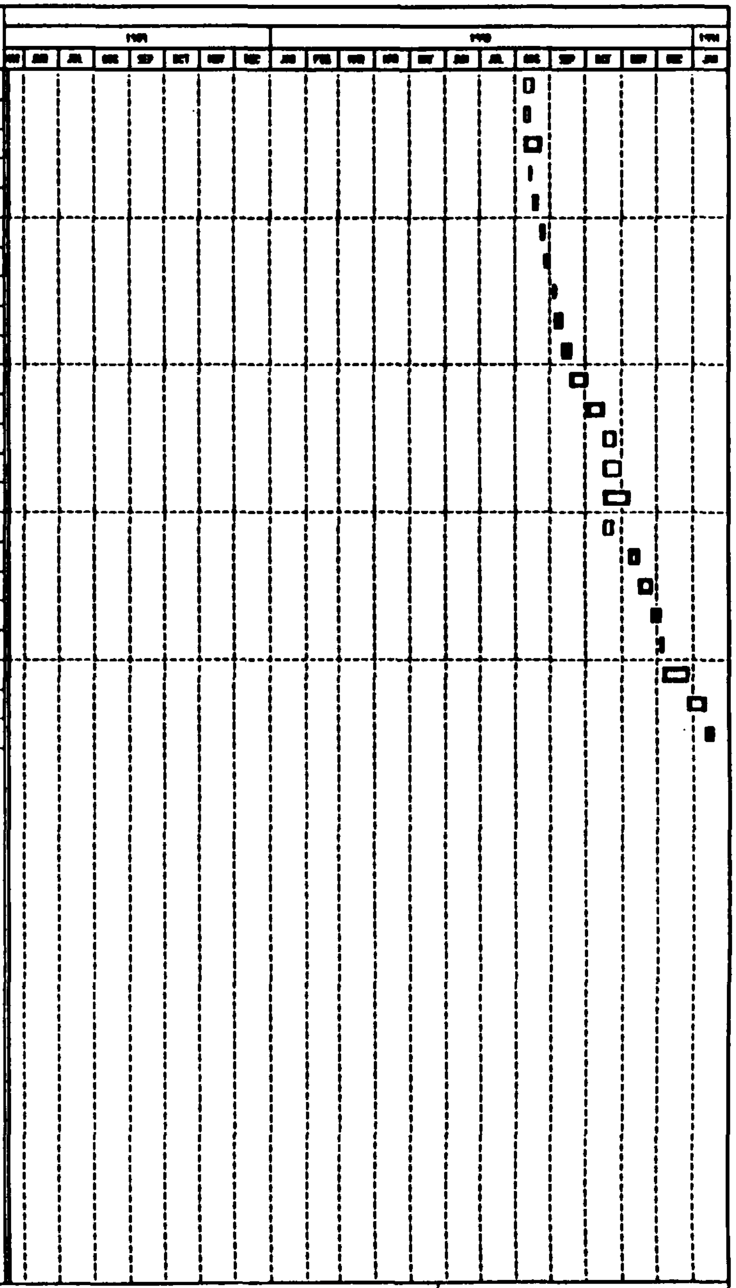
DONOHUE & ASSOCIATES - 20022
WA 13-5N45 SOUTH ANDOVER
PROPOSED PROJECT SCHEDULE

Sheet 2 of 3

Data Date: 19MAY89
Plot Date: 26SEP89

Date	Revision	Checked	Approved

ACTIVITY ID	ACTIVITY DESCRIPTION	ORIG DUR	TOTL FLT	EARLY START	EARLY FINISH
163	PREFIELD PREPARATION - PUMP TEST	5	3	10AUG90	16AUG90
165	SITE ACCESS - PUMP TEST	2	7	10AUG90	13AUG90
166	DRILLER MOBILIZATION	10	0	10AUG90	23AUG90
169	PRE-FIELD KICKOFF MEETING - PUMP TEST	1	7	14AUG90	14AUG90
167	FIELD SET-UP - PUMP TEST	2	3	17AUG90	20AUG90
171	WELL INSTALLATION - PUMP TEST	2	0	24AUG90	27AUG90
173	CONDUCT PUMP TEST	4	0	28AUG90	31AUG90
175	DEMOBILIZE - PUMP TEST	1	0	4SEP90	4SEP90
177	EVALUATE PUMP TEST DATA	5	0	5SEP90	11SEP90
179	PUMP TEST TECH MEMO	5	0	12SEP90	18SEP90
181	2-D HYDROLOGIC MODELING	10	0	19SEP90	2OCT90
183	HYDRO EVALUATION & MEMO	10	0	3OCT90	16OCT90
185	GEOLOGICAL CHARACTERIZATION	7	8	17OCT90	25OCT90
187	HYDROGEOLOGICAL CHARACTERIZATION	10	5	17OCT90	30OCT90
189	GROUNDWATER CHEMISTRY CHARACTERIZATION	15	0	17OCT90	6NOV90
191	ENGINEERING REVIEW OI DATA	5	10	17OCT90	23OCT90
193	ENGINEERING EVALUATION & REPORT PREPARATION	7	0	7NOV90	15NOV90
195	PREPARE RECOMMENDATIONS	5	0	16NOV90	26NOV90
197	INTERNAL QC REVIEW	5	0	27NOV90	3DEC90
199	SUBMIT DRAFT REPORT TO EPA	2	0	4DEC90	5DEC90
201	EPA REVIEW & COMMENT	15	0	6DEC90	27DEC90
203	PREPARE FINAL REPORT	10	0	28DEC90	10JAN91
205	PROJECT CLOSEOUT	5	0	11JAN91	17JAN91



▭ Activity Bar/Early Dates
▭ Critical Activity
▭ Progress Bar

Primavera Systems, Inc.

Project Start : 19MAY89
Project Finish: 17JAN91

DONOHUE & ASSOCIATES - 20022
WA 13-5N45 SOUTH ANDOVER
PROPOSED PROJECT SCHEDULE

Sheet 3 of 3

Data Date: 19MAY89
Plot Date: 26SEP89

Date	Revision	Checked	Approved

APPENDIX E

APRIL 1990 ADDENDUM

EXHIBIT A - FINAL SITE INVESTIGATION PLAN - ADDENDUM
EXHIBIT B - FINAL QUALITY ASSURANCE PROJECT PLAN - ADDENDUM

April 9, 1990

U.S. Environmental Protection Agency
Region V
Office of Superfund (5HS-11)
230 South Dearborn Street
Chicago, IL 60604

Attn: Mr. Bruce Sypniewski
Remedial Project Manager

Donohue
ENGINEERS
ARCHITECTS
SCIENTISTS

Re: EPA Region V ARCS Contract No. 68-W8-0093
EPA Work Assignment No. 13-5N45
Donohue Project No. 20022

<u>South Andover Design Investigation</u>
<u>Submittal of Work Plan Addenda</u>

Dear Mr. Sypniewski:

Enclosed with this correspondence are addenda to approved Work Plan documents prepared for the South Andover Design Investigation (DI). The enclosed revisions to the Final Site Investigation Plan (SIP) and Final Quality Assurance Project Plan (QAPP) are necessary to accommodate changes in our approved scope of work as discussed in the Work Plan Modification Request No. 1. As you are aware, the additional scope of services to be completed by Donohue for this project includes, among other tasks, the chemical analysis of soil samples to address the possibility of whether soil contamination occurs at select localities across the site.

Please note, the format of the enclosed Work Plan Addendum No. 1 allows for the revisions to be included as an appendix to the approved Work Plan. A revised Table of Contents and List of Appendices is included.

During an earlier telephone conversation, you expressed concern about obtaining timely approval from the EPA Quality Assurance Section (QAS) for the South Andover DI QAPP addendum. However, we believe that since this addendum involves only the addition of 18 soil samples for routine CLP organic and inorganic analysis, the time required for EPA QAS review and approval will be minimal, <u>provided</u> the entire approved DI QAPP is not re-reviewed.

As an alternative to expedite the QAPP addendum review process, you suggested the possibility of including the enclosed QAPP revisions within the QAPP currently being prepared for the South Andover Second Operable Unit RI/FS. However, while both projects

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P.O. Box 1067
Sheboygan, Wisconsin 53082-1067
414.458.8711
Telefax 414.458.0537

are occurring at the same site, such action appears inappropriate since each is a different work assignment with different goals and objectives.

We do not believe the time required for EPA approval of the DI QAPP addendum is critical for maintaining the project schedule. Rather, the schedule for this project is dependent upon the completion of other activities, including receiving indemnification pass-down and consent approval from EPA for the drilling subcontract. In addition, Donohue is currently evaluating with you the possibility of adjusting schedules to provide for concurrent implementation of the field programs for both work assignments. Such an effort is anticipated to increase overall program coordination and reduce total expenditures.

Finally, should you determine that acceleration of the current DI program schedule is needed, you may wish to request the EPA QAS to perform a priority review of the DI QAPP addendum.

Should you have any questions concerning this correspondence, please feel free to contact me at (414) 458-8711.

Very truly yours,

DONOHUE & ASSOCIATES, INC.

David S. Voight

David S. Voight
Site Manager

Marcia A. Kuehl

Marcia A. Kuehl
Site QC Officer

DSV/MAK:cmj

enc: As Noted

cc: <u>Donohue</u>

Roman Gau (1 copy)
Jim Garvin (without enclosures)

<u>EPA</u>

Marshall D. McReynolds (1 copy) (5MSC-TUB4)
Patricia Vogtman (2 copies) (5HR-11)

PMO Files (2 copies)

ARCS/O/L/DS7

EXHIBIT A

** ADDENDUM **

FINAL SITE INVESTIGATION PLAN

EPA Contract No.: 68-W8-0093
Work Assignment No.: 13-5N45
Donohue Project No.: 20022

**** ADDENDUM ****

SITE INVESTIGATION PLAN
SOUTH ANDOVER
DESIGN INVESTIGATION
ANDOVER COUNTY, MINNESOTA

APRIL 1990

Prepared by: David S. Voight Date: 4/9/90
David S. Voight
Site Manager, Donohue & Associates, Inc.

Approved by: Roman Gau by JWO Date: 4/13/90
Roman Gau, P.E.
ARCS Project Manager, Donohue & Associates, Inc.

Approved by: Michael Crosser Date: 4/13/90
Michael L. Crosser
ARCS V Technical Services/Quality Assurance Manager,
Donohue & Associates, Inc.

EXHIBIT A

Site Investigation Plan Addendum

South Andover Design Investigation
Work Assignment No.: 13-5N45

INTRODUCTION

The purpose of this addendum to the Final Site Investigation Plan (SIP) prepared for the South Andover First Operable Unit Design Investigation is to add several modifications which have resulted from information obtained during an on-site well inventory, and EPA rescoping of project requirements. Specifically, this addendum addresses the field screening and chemical analysis of soil samples collected during soil boring activities, abandonment of wells B3A and B3B, and deleting the abandonment of W26A.

The following portions of the Final Site Investigation Plan are affected by the present scope changes, and are included in this addendum:

1. Table 4-1
2. Section 5.2.3.3
3. Section 5.3.5.1
4. Section 5.2.5.3
5. Section 5.2.6

WORK PLAN REVISIONS

Appropriate changes to each section of the SIP which have been affected by the revised scope of services are given below.

Item 1: Table 4-1 Location of Proposed Monitoring Well Installation, Repair and Abandonments

1. Well Abandonment. Table 4-1 has been revised to include the abandonment of wells B3A and B3B.

2. Well Condition Reconnaissance and Possible Replacement. Monitoring well W26A has been determined to be usable, by the EPA and MPCA, and therefore will not require abandonment.

Item 2: Section 5.2.3.3. Monitoring Well Installation

1. Four monitoring wells will be installed within the surficial aquifer.

Item 3: Section 5.2.5 Soil Boring and Geotechnical Sampling

5.2.5.1 Introduction

Soil samples will be collected continuously at each new well location with a standard split spoon sampler. Each will be classified according to the USCS Soil Classification System by the on-site geologist or hydrogeologist. Samples will also be field screened with a photoionization detector (PID) for select volatile organic compounds (VOC). This will be accomplished by immediately placing a portion of each soil sample into an 8 ounce jar for VOC head-space equilibration testing, and the remaining samples into two volatile vials for possible laboratory analysis. Three soil samples from each borehole having the highest PID readings will be labeled, packaged and sent to the laboratory for analysis. If no PID readings above the background levels are detected during field screening, soil sample selection criteria will be based on the presence of visual contamination, or samples will be obtained from the first and last sample interval, and from the approximate middle of each boring.

Item 4: Section 5.2.5.3. Drilling and Sampling Procedures

1. Soil samples will be collected continuously in each soil boring until the total depth of the boring is reached.

Item 5: Section 5.2.6 Monitoring Well Installation

5.2.6.1 Introduction

1. This investigation will include the installation of six monitoring wells at locations formerly occupied by wells which have been, or are planned to be abandoned.

EXHIBIT B

** ADDENDUM **

FINAL QUALITY ASSURANCE PROJECT PLAN

EPA Contract No.: 68-W8-0093
Work Assignment No.: 13-5N45
Donohue Project No.: 20022

**** ADDENDUM ****

FINAL QUALITY ASSURANCE PROJECT PLAN
SOUTH ANDOVER
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

APRIL 1990

Prepared for:

U.S. Environmental Protection Agency
Emergency and Remedial Response Branch
Region V
230 South Dearborn Street
Chicago, Illinois 60604

EPA Contract No.: 68-W8-0093
Work Assignment No.: 13-5N45
Donohue Project No.: 20022

**** ADDENDUM ****

FINAL QUALITY ASSURANCE PROJECT PLAN
SOUTH ANDOVER
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

APRIL 1990

Prepared by: Marcia A. Kuehl Date: 4/9/90
Marcia A. Kuehl
Site QC Officer, Donohue & Associates

Approved by: David Voight Date: 4/9/90
David S. Voight
Site Manager, Donohue & Associates

Approved by: Michael L Crosser Date: 4/13/90
Michael L. Crosser
ARCS V Technical Services/Quality Assurance Manager,
Donohue & Associates

Reviewed by: Roman Gau by JLP Date: 4/13/90
Roman Gau, P.E.
ARCS Project Manager, Donohue & Associates

Reviewed by:____________________ Date:____________________
Curtis Ross
Central Regional Laboratory Director, U.S. EPA Region V

Approved by:____________________ Date:____________________
Valerie Jones
Quality Assurance Officer, U.S. EPA Region V

Approved by:____________________ Date:____________________
Bruce Sypniewski
Remedial Project Manager, U.S. EPA Region V

EXHIBIT B

Quality Assurance Project Plan Addendum

South Andover Design Investigation
Work Assignment No.: 13-5N45

INTRODUCTION

The purpose of this Quality Assurance Project Plan (QAPP) addendum is to make necessary modifications to the existing approved QAPP to provide for the chemical analysis of soil collected during the installation of six monitoring wells. Monitoring well installation was addressed in the approved QAPP dated August 21, 1989, but geotechnical analyses only were included. To maximize the site characterization information obtained during the well installation program, the EPA and MPCA have requested the addition of chemical analysis on the samples. Only those revised sections of the approved QAPP that apply to the addition of soil chemical analyses are included in this addendum:

1. Section 3.5.1
2. Section 3.5.2
3. Table 3-2
4. Table 3-3
5. Section 5.5
6. Section 9.0

WORK PLAN REVISIONS

Appropriate changes to each section of the QAPP which has been affected by the revised scope of services are given below.

Item 1: Section 3.5.1 Project Tasks

1. The tasks listed in the August 21, 1989, approved QAPP are to be revised as indicated:

    * Install six wells.
    * Soil samples collected for grain size, Atterburg limits, RAS organics and RAS inorganics, during the monitoring well installation at 3 depths at each well location to yield 18 samples.

Item 2: Section 3.5.2 Intended Data Usage

1. Site Characteristics

Confirm and define the nature and extent of groundwater contamination, and obtain information useful for assessing whether soil contamination occurs at select areas of the site.

Item 3: Table 3-2

This table has been revised to include the addition of 18 soil samples collected for the analysis of grain size, Atterberg limits, VOAs, TCL, BNAs, PCB/pesticides and TAL inorganics from monitoring well installations.

Item 4: Table 3-3

The soil matrix was added to the table with DQO level IV for CLP analyses and DQO level III for soil physical analyses.

Item 5: Section 5.5 Accuracy, Precision, Completeness, Sensitivity of Analyses

Groundwater and soil samples will be analyzed using the CLP.

Item 6: Section 9.0 Analytical Procedures

Analytical procedures to be used for the South Andover DI are:

- CLP RAS organics and inorganics methods for groundwater and soil samples (DQO Level 4).

ARCS/P/SANDOVER/AQ3

Table 3–2
Sampling and Analysis Summary
Andover Site, Minnesota

							Field QC					Lab QC		
Sample Matrix	Field Parameters	DQO Level	Lab Parameters	DQO Level	Lab	Field Samples	BB	TB	FB	FD	Total to Lab	LD or MSD	MS	Purpose of Samples
GROUNDWATER B2A B4C B6A B7C B7A W1C B9A W21C W1A W23C W9A *W17A W16A *B2B W19A W21A W26A B4B B6B B7B W1B W21B W23B	pH	I	–	–	–	23	–	–	3	3	–	–	–	Assess well stabilization after purging
	Conductivity	I	–	–	–	23	–	–	3	3	–	–	–	
	Temperature	I	–	–	–	23	–	–	–	3	–	–	–	
	Water Level	I	–	–	–	23	–	–	–	–	–	–	–	Hydrogeological monitoring for water table level
			TCL VOAs	IV	CLP	23	–	3** Max	3	3	29 Max	2 MSD	2	Characterize groundwater contamination for design of extraction system
			TCL BNAs	IV	CLP	23	–	–	3	3	29	2 MSD	2	
			TCL PCB/Pest	IV	CLP	3	–	–	1	1	5	1 MSD	1	
			TAL Inorganics	IV	CLP	23	–	–	3	3	29	2 LD	2	
			COD	V	SAS	23	–	–	3	3	29	3 LD	3	Assess organic loading factor, solids content, phosphorus content for input to design of system extraction and selection of discharge option
			TP	V	SAS	23	–	–	3	3	29	3 LD	3	
			TSS	V	SAS	23	–	–	3	3	29	3 LD	–	
			TS	V	SAS	23	–	–	3	3	29	3 LD	–	

* Proposed by Donohue in addition to scope

** The number of matrix totals exclude trip blank samples

Legend

TCL = Target Compound List
TAL = Target Analyte List
BB = Background Blank
TB = Trip Blank
FB = Field Blank
FD = Field Duplicate
LD = Lab Duplicate
MSD = Matrix Spike Duplicate
MS = Matrix Spike

Table 3 - 2 (continued)

Sampling and Analysis Summary Andover Site, Minnesota

							Field QC					Lab QC		
Sample Matrix	Field Parameters	DQO Level	Lab Parameters	DQO Level	Lab	Field Samples	BB	TB	FB	FD	Total to Lab	LD or MSD	MS	Purpose of Samples
Residential Wells RW01 RW03 RW04 RW06	**pH**	I	–	–	–	4	–	–	1	1	–	–	–	**Assess well groundwater quality indicators**
	Conductivity	I	–	–	–	4	–	–	1	1	–	–	–	
	Temperature	I	–	–	–	4	–	–	–	1	–	–	–	
			Volatiles	V	CRL/ CLP SAS	4	–	1**	1	1	6	1 MSD	1	**Characterize groundwater contamination for design of extraction system**
			BNAs	V	CRL/ CLP SAS	4	–	–	1	1	6	1 MSD	1	
			PCB/Pests	V	CRL/ CLP SAS	1	–	–	1	1	3	1 MSD	1	
			Metals/CN	V	CRL/ CLP SAS	4	–	–	1	1	6	1 LD	1	
Soil from Monitoring well Installation borings			**Grain size**	III	PS	9 Max	–	–	–	–	9	–	–	**Geological characterization**
			Atterberg Limits	III	PS	9 Max	–	–	–	–	9	–	–	
			TCL VOAs	IV	CLP	18	–	–	2	2	22	1 MSD	1	**Assess existing nature and extent of soil contamination in new monitoring well locations**
			TCL BNAs	IV	CLP	18	–	–	2	2	22	1 MSD	1	
			TCL PCB/pest	IV	CLP	18	–	–	2	2	22	1 MSD	1	
			TAL Inorganics	IV	CLP	18	–	–	2	2	22	1 LD	1	

Legend
TCL = Target Compound List
TAL = Target Analyte List
BB = Background Blank
TB = Trip Blank
FB = Field Blank
FD = Field Duplicate
LD = Lab Duplicate
MSD = Matrix Spike Duplicate
MS = Matrix Spike
PS = Pool Subcontractor

* Proposed by Donohue in addition to scope

** The number of matrix totals exclude trip blank samples

TABLE 3-3

DQO LEVELS

SITE
NAME: SOUTH ANDOVER
NUMBER:
PHASE: DESIGN INVESTIGATION

EPA REGION V

DATE:
CONTRACTOR: DONOHUE & ASSOCIATES
SITE MANAGER: DAVID S. VOIGHT

	FIELD ANALYSIS			LABORATORY ANALYSIS					
MATRIX	pH	COND	TEMP	RAS INORGANICS	RAS EXTRACT-ABLES	RAS VOLATILES	SAS TP, COD, TSS, TDS	SAS CRL/CLP RESIDENTIAL WELL ANALYSES	SOIL PHYSICAL
RESIDENTIAL WELLS	1	1	1					5	
GROUND WATER	1	1	1	4	4	4	5		
SOIL				4	4	4			3

EPA Contract No.: 68-W8-0093
Work Assignment No.: 13-5N45
Donohue Project No.: 20022

ATTACHMENT 1

FINAL QUALITY ASSURANCE PROJECT PLAN DESIGN INVESTIGATION ACTIVITIES

SOUTH ANDOVER
DESIGN INVESTIGATION
ANDOVER, MINNESOTA
SEPTEMBER, 1989

Prepared for:

U.S. Environmental Protection Agency
Emergency and Remedial Response Branch
Region V
230 South Dearborn Street
Chicago, Illinois 60604

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EPA CONTRACT NUMBER: 68-W8-0093
WORK ASSIGNMENT NUMBER: 13-5N45
DONOHUE & ASSOCIATES, INC.

FINAL QUALITY ASSURANCE PROJECT PLAN FOR DESIGN INVESTIGATION ACTIVITIES

SOUTH ANDOVER
ANDOVER, MINNESOTA
SEPTEMBER, 1989

Prepared by: Marcia A. Kuehl /LF Date: 9/15/89
Marcia A. Kuehl
Site QC Officer, Donohue & Associates

Approved by: David S Voight Date: 9/15/89
David S. Voight
Site Manager, Donohue & Associates

Approved by: Michael L Crosser Date: 9/15/89
Michael L. Crosser
ARCS V Technical Services/Quality Assurance Manager,
Donohue & Associates

Reviewed by: James W. Garvin Date: 9/25/89
James W. Garvin, P.E.
ARCS Project Manager, Donohue & Associates

Reviewed by:________________ Date:________________
Curtis Ross
Central Regional Laboratory Director, U.S. EPA Region V

Approved by:________________ Date:________________
____
Quality Assurance Officer, U.S. EPA Region V

Approved by:________________ Date:________________
James R. Van der Kloot
Remedial Project Manager, U.S. EPA Region V

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FICHE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
			Sample Summaries			
	1	80/02/26	Site Inspection Andover City Investment	TCohn - USEPA	JGoldstein - USEPA	Memorandum
	1	80/04/01	Site Inspection Musket Ranch and Trading Post	TCohn - USEPA	JGoldstein - USEPA	Memorandum
	2	80/04/17	Planned meeting on Musket Ranch	NToepfer - USEPA	MKanner - MPCA	Memorandum
	8	80/05/08	Purge and Trap Analysis Lab No. 2-1070	Twin City Testing	Anoka Cty Health Dept.	Sampling/Data
	3	80/05/19	Field Investigation Report concerning presence of PCBs at Pumpkin City Investments	RJGraedinger		Other
	2	80/05/23	Placement and drilling of wells	NToepfer - USEPA	JBrossman	Memorandum
	6	80/05/30	Trip Report to determine point locations for well placement	NToepfer - USEPA	File	Memorandum
	70	80/06/27	Subsurface exploration and observation well installations at the Andover, MN site	Soil Testing Services of Minnesota	PEDCO Environmental, Inc.	Reports/Studies
	3	80/07/22	Letter to Misteiske of Commercial Auto Parts and Schernell of Wilber Auto Parts informing them of potential responsibility	Clark, MPCA	see title field	Correspondence
	18	80/08/04	Certified Letter to PRPs informing them of their potential responsibility	Clark, MPCA	PRPs	Correspondence
	36	80/10/13	MPCA Agenda Item Control Sheet Meeting Date 10/28/80	MKanner - MPCA		Other
	14	81/01/00	Transcript of Statement by Carl Ray Barker			Other

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FICHE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
	157	81/01/00	Technical Assistance to Andover, MN Preliminary Hydrogeologic Report on the Heidelberger site	RMT		Reports/Studies
	4	81/01/11	MPCA Agenda Item Control Sheet	MKanner - MPCA		Other
	4	81/01/23	Final Strategy Determination Musket Ranch	MToepfer - USEPA		Other
	1	81/02/03	RMT Findings to date	GHMadany	MELynch	Memorandum
	5	81/02/23	Summary of 2/2/81 meeting and requests for past records etc and position on cleanup	MKanner - MPCA	Attys for PRPs	Correspondence
	14	81/03/09	Letter forwarding "Andover Groundwater Monitoring Plan" with attachments	Vanderboom, Pace Labs	MKanner	Correspondence
	4	81/03/19	Enclosing statements of three (3) transporters of hazardous waste	BLSims - Minn Ofc of Atty Gen'l	CBenedict - USEPA	Correspondence
	37	81/03/30	Andover Drum Inventory	WAO'Connor - Pace Labs	Bemis Co and MPCA	Reports/Studies
	44	81/04/06	Report entitled:Andover Groundwater Monitoring	Pace Labs	Bemis Co.Inc.	Reports/Studies
	31	81/04/26	Andover Groundwater Monitoring 3/9-16/81	Pace Labs	Bemis Co	Reports/Studies
	4	81/05/01	Emergency Action Plan	MKanner, MPCA	Braun, USEPA	Reports/Studies
	3	81/09/08	Interim Report re recent activities	JDOskvarek - Ecology & Environment	File	Memorandum
	1	81/09/30	Withdrawal of offer made in letter of 7/17/81	CLBader - Bemis Co	MKanner - MPCA	Correspondence
	8	81/09/30	Interim Report	JDOskarek - Ecology & Environment	File	Memorandum

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	17	81/10/23	Mitre Model Scoring of Andover, MN	Ecology & Environment		Other
	1	81/12/09	Andover sites Fact Sheet			Fact Sheet
	7	81/12/03	Appendix E, Model Worksheets from HRS Scoring Package	USEPA		Report/Study
	2	82/03/14	Letter to USEPA from Standard Solvents Atty. informing USEPA that they are working with Kanner to resolve "the problems at Andover"	Standard Solvents Atty.	Summerlee, USEPA	Correspondence
	28	82/03/15	Demand Letters to PRPs: Parmak Inc. Carl Ray Barker Cyrle Link William Baston Charles Mistelske Standard Solvents Irving Schernell Shirley Heidelberger David Heidelberger Marion Heidelberger Cecil Heidelberger Color-Ad Packaging ACME Tag Bemis Co	WASullivan - USEPA		Correspondence
	1	82/03/22	Response to demand letter	CCHeidelberger	WLSummerlee - USEPA	Correspondence

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	2	82/03/29	Response to demand letter	CBarker	EPA	Correspondence
	2	82/03/31	Response to demand letter	BOLudcke - Atty for Color-Ad	KLSummerlee - USEPA	Correspondence
	2	82/03/31	Response to demand letter	KWRouse for Parmak	KLSummerlee - USEPA	Correspondence
	1	82/04/02	Response to demand letter	RILang - Atty for Acme Tag	KLSummerlee - USEPA	Correspondence
	2	82/04/14	Response to demand letter	WHull, Standard Solvents	KLSummerlee	Correspondence
	3	82/04/28	Log of Site Inspection			Log Books
	1	82/06/07	Response to Congressional Inquiry	Adamkus, USEPA	Strangeland	Correspondence
	25	82/06/28	HRS Scoring Package		-	Other
	15	82/09/00	Andover Sites Data Review Mead Case 809, 775, 792	AFHaeberer - USEPA	BWright - USEPA	Memorandum
	20	83/01/03	Demand Letters to PRPs	LJBreimhurst - MPCA		Correspondence
			Color-Ad Packaging			
			Acme Tag			
			Bemis Co			
			Vapors Steam Bath			
			David Heidelberger			
			Cyril Link			
			Marion Heidelberger			
			Cecil Heidelberger			
			Parmak Inc			
			Standard Solvents			
	1	83/01/03	Memo re: Groundwater Contamination in the area of S. Andover	G.Englund, Water Supply, MDPH	Water Well Contractors	Memorandum
	1	83/01/10	Response to MPCA Demand Letter	DHeidelberger	MPCA	Correspondence

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	1	83/01/10	Response to MPCA demand letter	RILang - Atty for Acme Tag	MPCA	Correspondence
	1	83/01/11	Response to MPCA demand letter	WDHull - Atty for Std Solvents	MPCA	Correspondence
	1	83/01/17	Response to MPCA demand letter	CLBader - Bemis Co	MPCA	Correspondence
	3	83/01/24	Response to letter of 1/10/83	MKanner - MPCA	RILang-Atty for Acme Tag	Correspondence
	2	83/01/25	Response to MPCA demand letter	KWRouse - Atty for Parmak	MPCA	Correspondence
	2	83/01/25	Response to MPCA demand letter	WDHull - Atty for Std Solvents	MPCA	Correspondence
	5	83/04/07	MPCA Agenda Item Control Sheet	DDay - MPCA		Other
	10	83/04/18	Notice of MPCA Bd. meeting to authorize to negotiate a Superfund cooperative agreement with USEPA	Kanner, MPCA	PRPs	Correspondence
	2	83/05/24	Site Tour with Consultants on 5/12/83	DDay - USEPA	File	Memorandum
	3	83/05/25	Notes of phone conversation with RBoice re review of site conditions	DDay - MPCA		Communication Record
	1	83/07/00	South Andover Conditions at listing and status	USEPA		Other
	8	83/08/04	Letter to USEPA from Brustman, MPCA forwarding Community Relations Plan for Waste Disposal Engineering, Inc.	Brustman, MPCA	Marcia Carlson, USEPA	Correspondence
	3	83/08/12	Review of 8/3/83 meeting re hazardous waste containers encountered during tire moving activities	DDay - MPCA	RSlaback & CHeidelberger	Correspondence

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	3	84/03/08	Notification of Superfund project and start of 60 day comment period	BGConstantelos - USEPA	TNWarren - MSPA	Correspondence
	52	84/06/05	MPCA Agenda Item Control Sheet Meeting Date 84/06/26	MVennewitz - MPCA		Other
	3	84/08/16	Follow-up and response to 7/25/84 meeting	MKVennewitz - MPCA	EShernell	Correspondence
	2	84/08/20	Letter informing Hull, atty. for Standard Solvents outlining Consent Order to be drafted	MKVennewitz,MPCA	W.Hull,Standard Solv.Atty	Correspondence
	54	84/09/04	Draft Consent Order	M.K. Vennewitz	Attys for PRPs	Pleadings/Orders
	75	84/09/14	Work Plan for Removal of Drums and Contaminated Soils	Pace Labs		Reports/Studies
	25	84/09/21	Action Memo: Authorization to Proceed with a Remedial Investigation and Feasibility Study at South Andover site	BGConstantelos - USEPA	VVAdamkus - USEPA	Memorandum
	2	84/10/03	Letter to USEPA and MPCA from Bemis & Co. Attys. notifying them of intention to proceed with remedial action at the site	McDonald, Bemis Co. Inc.Atty.	USEPA,MPCA	Correspondence
	2	84/10/03	Notice on behalf of Bemis Co., Standard Solvents, Color-Ac Packaging and Acme Tag of intent to proceed with remedial actions	DCMcDonald - Briggs and Moran	USEPA and MPCA	Correspondence
	2	84/10/09	Follow-up to 10/2/84 inspection/meeting at Commercial Auto Parts	MKVennewitz - MPCA	EShernell	Correspondence
	2	84/11/28	Final Drum Inventory			Other
	1	85/00/00	Article from the Coon Rapids Challenge,Winter	Coon Rapids Challenge paper		Newspaper Article

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			85/86:"Superfund Project Begins..."			
	48	85/01/16	Prescreening Results	WAO'Connor - Pace Labs	MVennewitz - MPCA	Sampling/Data
	5	85/01/28	Review of PCB test results	WAO'Connor - Pace Labs	MVennewitz - M,PCA	Correspondence
	3	85/03/25	Response to 3/7/85 letters re barrels uncovered	MKVennewitz - MPCA	CHeidelberger	Correspondence
	17	85/06/25	Site Safety Plan South Andover	JBDalgleish		Other
	4	85/07/30	Demand Letters and list of addressees	BGConstantelos - USEPA	Attached list	Correspondence
	2	85/08/00	Notes of phone conversation with various PRPs	KStreet - USEPA		Communication Record
	21	85/08/00	PRP replies to notice letters			Correspondence
	49	85/08/14	Final Work Plan RI/FS	CH2M Hill and Ecology & Envrnmnt		Reports/Studies
	4	85/09/00	Superfund Program Fact Sheet South Andover Site	USEPA AND MPCA		Fact Sheet
	15	85/09/00	Community Relations Plan	MPCA		Reports/Studies
	1	85/09/19	USEPA News Release: EPA To Brief Residents on S. Andover Superfund Site	USEPA		Press Release
	16	85/10/22	Request to sign access agreement Letters sent to: CMisteiske RSlaback (Signed) Cyrle Link CHeidelberger DHeidelberger	RGrimes - USEPA		Correspondence

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			WBaston			
			HHaluptzok (Signed)			
	6	85/10/31	Proposal for Technical and Operationing Procedures for Remediation of South Andover site	Rollins Environmental Services	MPCA	Reports/Studies
	2	85/11/22	Summary of Events which occurred between Nov 14 - 21 re CHeidelberger	GWong - USEPA		Handwritten Notes
	17	86/01/16	Site Safety Plan South Andover	JBDalgleish		Other
	6	86/02/14	Data Summary	JBDalgleish - Barr Engr	PSmith - CH2M Hill	Correspondence
	2	86/05/20	Action Memo: Authorization for Supplemental Funding of the RI/FS	BEConstantelos - USEPA	VVAdamkus - USEPA	Memorandum
	1	86/08/18	Request for advice on wells when grading housing development area	RWNelson	GWong - USEPA	Correspondence
	1	86/08/27	Notes of phone conversation with RGrimes re Offsite monitoring wells 2 new developments in the S. Andover area	GWong - USEPA		Communication Record
	1	86/08/27	Notes of phone conversation with DRobohm-MPCA and PSmith-CH2M Hill re potential developers near S. Andover site	GWong - USEPA		Communication Record
	2	86/08/29	Response to inquiries re new housing development	DJRobohm - MPCA	RPacker	Correspondence
	1	86/09/11	Response to inquiry about wells when grading	RGrimes - USEPA	RWNelson	Correspondence
	1	86/09/30	Notes of phone conversation with JPeterson re	GWong - USEPA		Communication Record

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	2	87/06/10	High Court strengthens landowners rights	Minneapolis Star and Tribune		Newspaper Article
	1	87/06/13	Landowner rights ruling sets stage for lawsuits	Minneapolis Star and Tribune		Newspaper Article
	2	87/08/19	Status memo for the S. Andover site	G. Wong, USEPA	see listing	Memorandum
	500	88/01/29	Remedial Investigation Report, Final, South Andover Site Andover, Mn			Reports/Studies
	250	88/01/29	Public Review Draft Feasibility Study Report South Andover, Andover, Mn			Reports/Studies
	4	88/02/00	Superfund Fact Sheet summarizing S. Andover site Feasibility Study	USEPA together with MPCA		Fact Sheet
	132	88/02/08	Transcript of proceedings from Feb. 8, Public Hearing in Andover	Hintz, Court Reporter	USEPA	Meeting Notes
	1	88/02/12	Newspaper Article: "Alternative for Andover's Chemical Waste Site Cleanup Recommended"	J. Yelle, Analin County Union		Newspaper Article
	4	88/02/14	Letter to USEPA from Heidelberger re: his comments on "the proposed pumping, treating and dumping..."	Heidelberger	Hall, USEPA	Correspondence
	42	88/02/14	Letter to USEPA from Andover landowner Sonsteby with attachments re: her opinion of how poorly State and local govt. dealt with site	Sonsteby, Andover landowner	Hall, USEPA	Correspondence
	1	88/02/17	Memo to interested persons re: FS comment period	Hall, Brustean, USEPA	interested persons	Fact Sheet

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			extension			
	2	88/02/18	Trip Report on TCAAP Meeting with Army and MPCA	USEPA		Meeting Notes
	2	88/02/22	Letter to USEPA from the Anoka County Health & Social Services Dept. forwarding their comments on the RI/FS dated 1-29-88	Anoka County Health & Soc.Serv.Dept	Dagnell, USEPA	Correspondence
	4	88/02/26	Certified Letter to PRPs re: their potential responsibility	Mary Gade, USEPA	PRPs, see listing	Correspondence
	2	88/03/04	Letter to USEPA from the City of Andover forwarding comments to the RI/FS	Elling, Andover City Councilman	Hall, USEPA	Correspondence
	2	88/03/04	Letter to USEPA from the City of Andover forwarding their comments to the RI/FS	Orttel, acting mayor of Andover	Hall, USEPA	Correspondence
	35	88/03/30	ROD	USEPA		Reports/Studies

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			CERCLA			Guidance
			SARA			Guidance
			RCRA			Guidance
			NCP			Guidance
			Superfund brochure: The New Superfund, What It Is, How It Works			Guidance
		87/01/00	Superfund brochure: EPA Journal- The New Superfund Jan/Feb 87			Guidance
		87/05/00	Superfund brochure: Your Guide to the USEPA			Guidance
			Superfund brochure: Toxic Chemicals, What They Are, How They Affect You			Guidance
			Superfund brochure: Superfund Glossary			Guidance
		85/06/00	Guidance on Feasibility Studies Under CERCLA			Guidance
		85/06/00	Guidance on Remedial Investigations Under CERCLA			Guidance

SUMMARY OF REMEDIAL ALTERNATIVE SELECTION
SOUTH ANDOVER SITE
GROUNDWATER OPERABLE UNIT

SITE LOCATION AND DESCRIPTION

The South Andover site is located in the southern portion of Andover, Minnesota, approximately 16 miles north - northeast of Minneapolis. The site is located in the southern half of Section 34 of Grow Township (T.32N., R.24W.). The South Andover site vicinity is shown in Figure 1.

A residential neighborhood exists 1/4 mile north of the site. Development is currently planned to the west and the south of the site. Bunker Lake Boulevard borders the site on the north, and Jay Street on the east. Small businesses along both roads deal in used cars, auto parts, and auto salvage. Several pieces of property within the site are auto salvage yards, and a large portion of the site is buried under a pile of tires and miscellaneous junk. The Waste Disposal Engineering landfill (WDE), which previously accepted hazardous waste, is located 3,000 feet northeast of the site. WDE is a National Priorities List site which is undergoing remedial design.

The site is comprised of several separate parcels of land totaling approximately 50 acres. Various independent storage and disposal activities took place on the site. The parcels of land are shown in Figure 2. The waste storage and disposal activities are detailed in Table 1.

SITE HISTORY

Industrial waste handling activities at the South Andover site are reported to have begun in 1954 with the storage of solvents and inks on the Cecil Heidelberger property. Open pit burning of liquid wastes began on the Batson property in 1970. Chemical waste storage began at the Mistelske property in 1973.

Actions to limit the waste handlers at the various properties began in 1973 when Anoka County officials instructed Cecil Heidelberger to remove and dispose of the chemical wastes stored on the property. Citizen complaints of well contamination prompted investigations by the Minnesota Pollution Control Agency (MPCA). MPCA issued a Citation of Violation to Cecil and Marion Heidelberger in 1976 for the storage of chemical waste. The Heidelbergers discontinued processing waste in early 1977 and stopped accepting waste in 1978.

Actions to regulate other waste handlers at the site occurred in 1980. Notices of Violation were issued by the MPCA to Shirley Heidelberger, Cyril Link, and Charles Mistelske for improper disposal of industrial wastes.

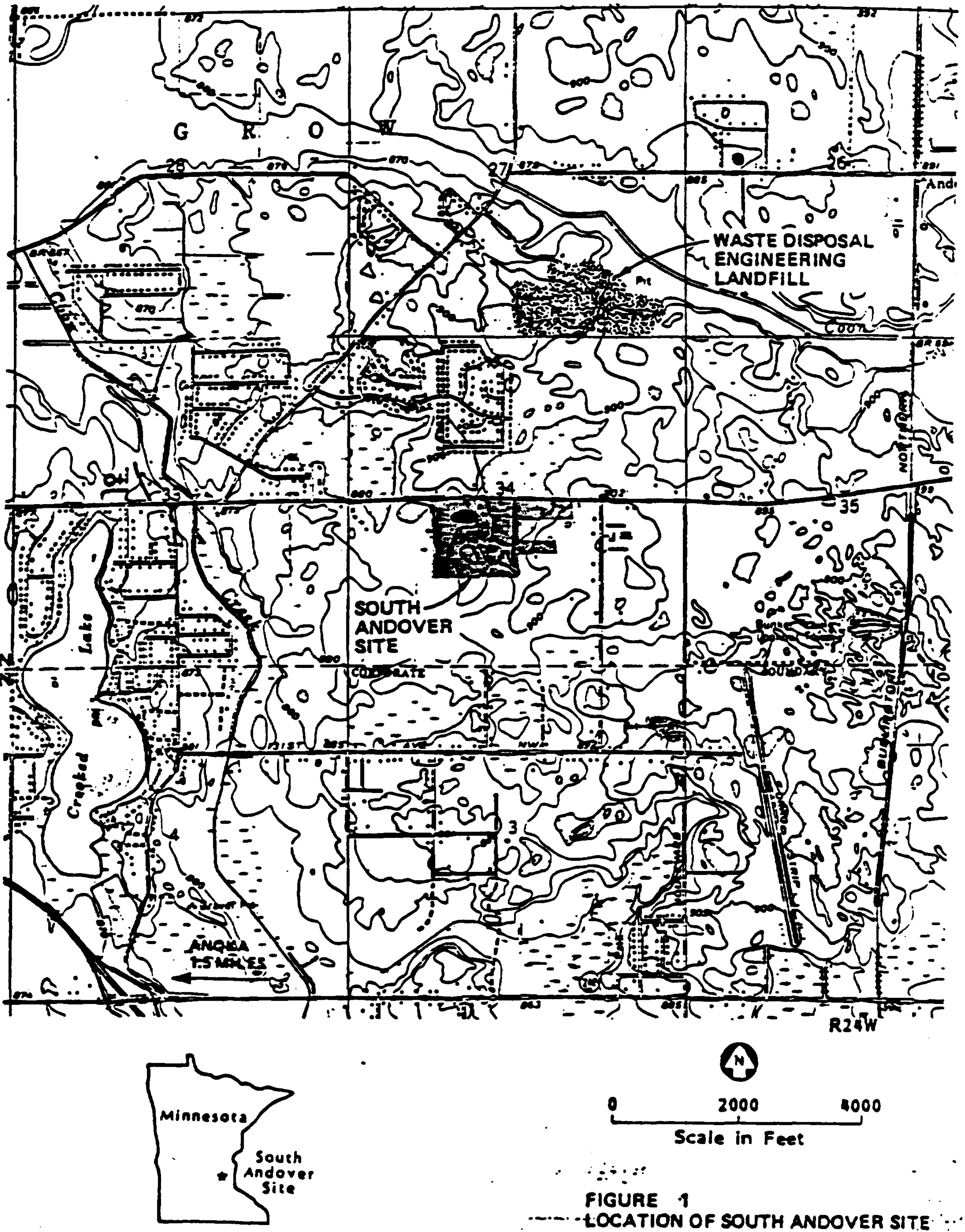
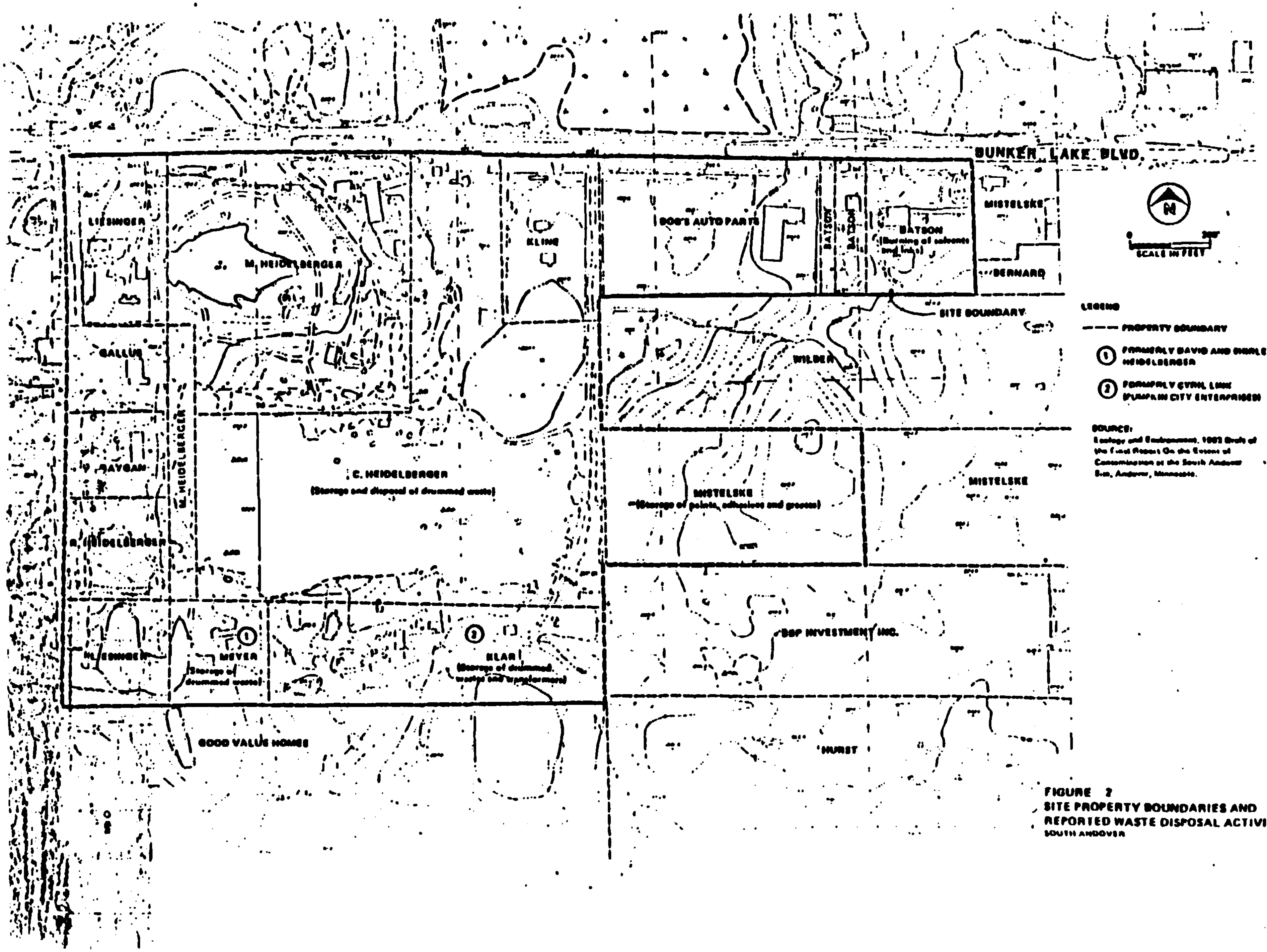


FIGURE 1
LOCATION OF SOUTH ANDOVER SITE
SOUTH ANDOVER



SOURCE:
Ecology and Environment, 1983 Draft of the Final Report On the Extent of Contamination at the South Andover Site, Andover, Minnesota.

FIGURE 2
SITE PROPERTY BOUNDARIES AND REPORTED WASTE DISPOSAL ACTIVITI
SOUTH ANDOVER

TABLE 1

WASTE LOCATION AND DISPOSAL ACTIVITY

LOCATION	DISPOSAL ACTIVITY
Cecil Heidelberger Property	Chemical wastes were stored and disposed of on the property. A majority of the property is covered with tires and other debris.
Batson Property	Thousands of barrels of solvents and inks were allegedly burned in open pits. A wetland on the property was used as a disposal area prior to filling.
Charles Mistelske Property	The property was used to store approximately 8,300 gallons of paints, adhesives and greases in 1-,2-, and 55-gallon containers.
Meyer Property	The property was used to store approximately 200 drums of chemical waste. Spillage of chemical waste is known to have occurred.
Klar Property	Storage of drummed waste and transformers occurred on the property. An inactive smelting plant, empty drums and miscellaneous debris are present on the site.

Cecil Heidelberger disposed of the contents of approximately 700 drums in 1981 by mixing the contents with waste oil and using the mixture as fuel in an asphalt plant. Approximately 500 additional drums were removed in 1986 by a group of potentially responsible parties (PRPs). Some drums remain onsite.

Several site investigations have been performed at the site. An initial appraisal was performed by Residual Management Technologies (RMT) and PEDCo Environmental in 1979 at the request of U.S. EPA. A follow-up investigation by RMT/PEDCo in 1981 included the installation of 22 monitoring wells. Ecology & Environment, Inc. (E&E) installed 26 additional wells and 22 piezometers in 1981 as part of an expanded FIT groundwater investigation.

An initial remedial investigation (RI), completed January 29, 1988, was performed at the site to characterize the nature and extent of contamination. Soil investigations were limited by the presence of a large volume of tires piled onsite and piles of junked automobiles at various auto salvage yards onsite. The tires on the Cecil Heidelberger property, the majority of the tires, are currently being shredded and removed from the site under a grant from the Minnesota Waste Management Board. The tire removal is scheduled to be completed by Spring 1989. A subsequent RI, looking at contamination of site soils and possible contamination of the lower sand aquifer, is planned for the site following the tire removal.

A feasibility study (FS), completed January 29, 1988, was developed in conjunction with the RI. The FS looked at a variety of alternatives for dealing with the groundwater problem. The alternatives ranged from no action to complete lateral containment of the surficial aquifer with groundwater extraction.

ENFORCEMENT HISTORY

Sixteen parties were notified, by a March 15, 1982 letter from U.S.EPA's Office of Enforcement and Compliance Monitoring (OECM) in Washington, that the U.S. EPA was considering spending public funds at the South Andover site and that they may be liable for money expended by the government. These parties included site owners, site operators and waste generators.

In a July 30, 1985 letter from U.S. EPA Region V, 21 PRPs were notified that U.S. EPA planned to conduct an RI/FS at the site, and that the U.S. EPA would consider an offer by the PRPs to conduct the RI/FS. None of the PRPs indicated that they had the desire and ability to conduct the RI/FS. Negotiations were terminated in an August 29, 1985 memorandum, and the Superfund was used to conduct the RI/FS.

Copies of the Proposed Plan for this operable unit were sent to the PRPs on February 1, 1988. In a February 26, 1988 letter from U.S. EPA Region V, 21 PRPs were notified that the U.S. EPA intended to conduct a remedial action at the site and that the PRPs had 60 days to submit a good faith proposal. No response has been received as of this date.

COMMUNITY RELATIONS HISTORY

Community relations activities at the South Andover site have been handled with direct involvement from the U.S. EPA and the MPCA. The initial contact with the public was in the form of interviews with representatives of the City of Andover, City of Coon Rapids and property owners on or near the site.

Two public meetings have been held for the site. The first meeting was held on September 25, 1985 prior to initiating field activities. The second meeting was held on February 8, 1988 to answer questions and receive comments on this initial groundwater operable unit.

Public involvement and participation on the site has been limited to date. Representatives of the City of Andover and Anoka County have asked for greater involvement. There is a strong interest from these local bodies to facilitate development of the site and the surrounding area. Concern has also been expressed regarding the impact of this site when combined with the presence and remedial actions planned for the WDE site.

SCOPE OF OPERABLE UNIT

This response action is an initial groundwater operable unit and is consistent with Section 300.68(c) of the National Contingency Plan (NCP). This initial groundwater operable unit is being implemented to protect public health and the environment by controlling the migration of contaminated groundwater. The operable unit addresses known areas of groundwater contamination in the surficial aquifer. The U.S. EPA and MPCA feel the possible migration of contaminants from the surficial aquifer off the site or into the lower aquifer are the major concern posed by the site. This operable unit was initiated to deal with these concerns.

The operable unit is fully consistent with all future site work, including the subsequent RI/FS planned for Spring 1989. In addition, it is believed that the gradients established by the extraction well system may be beneficial to the subsequent RI by aiding in the location of "hot spots" which have not been detected. The extraction well system will be incorporated into any subsequent remedial action decisions at the site.

It was determined that the soils do not pose a risk which needs to be addressed as part of the present operable unit. A subsequent RI/FS is planned for the site following the tire removal presently scheduled to be completed by Spring 1989. Because the soil investigation has not been completed, it was determined that soil removal or capping at the present time could interfere with the subsequent RI/FS, may not be consistent with the final remedy and may not be cost effective. For these reasons, an interim soil remedy was determined to be unnecessary and inappropriate at the present time.

SITE CHARACTERISTICS

The initial RI focused on the surficial aquifer and portions of the site which were clear of tires and other debris. The results of the RI can be broken down into three areas: 1) groundwater, 2) soils, and 3) surface water and sediments.

Multiple waste handling operations occurred between 1954 and 1981 on several different properties within the general site boundaries. Because of this, there is not one source area, but multiple source areas which include locations where drums were stored, where wastes were discharged to the ground, and where wastes were allegedly burned.

As a part of the initial RI, potential risks from contaminated groundwater and exposed soil locations on the site were calculated based on present site use conditions and on possible future residential or commercial development conditions. Both carcinogenic and noncarcinogenic risks were calculated. Risks were not calculated for surface water and sediment locations at this time, but will be included in the subsequent RI.

The carcinogenic risks are theoretical quantifications, and are reported as excess lifetime cancer risks. Excess lifetime cancer risk is defined as the incremental increase in the probability of getting cancer compared to the probability if no exposure occurred. For example, a $1x10^{-6}$ excess lifetime cancer risk represents an exposure that could result in one extra cancer case per million people exposed. Noncarcinogenic risks are determined by comparing potential doses of contaminants by site visitors to contaminant specific reference doses. The reference dose is an estimate of an exposure level that would not be expected to cause adverse effects when exposure occurs.

The analytical results from the remedial investigation and the risk assessment can be found in the RI Report for the South Andover site completed January 29, 1988. A brief summary of the results is presented below.

Groundwater Contamination

The site is underlain by a surficial sand aquifer, a middle aquitard, a lower sand aquifer, a till unit and a bedrock aquifer. The lateral flow in the surficial aquifer was found to radiate in a generally westwardly direction from the eastern portion of the site. Water level measurements in the well nests indicate a dominant downward component of flow in both the surficial aquifer and the middle aquitard. Residence time of groundwater in the surficial aquifer and the aquitard are less than 10 years and 28 to 70 years respectively. The potentiometric surface of the lower sand aquifer indicates lateral flow southwest across the site.

Groundwater samples were collected from 50 monitoring wells and 8 residential wells on or near the site. Elevated levels of a number of organic and inorganic compounds were detected in shallow monitor wells on site. The highest detected contaminant concentrations are shown in Table 2. Only one contaminant was detected in the lower sand aquifer, and it was only detected in one well which contained 97 ppb methylene chloride. The methylene chloride may be a lab contaminant as opposed to actually being present in the well. Additional RI work is planned for the lower sand aquifer. Residential well sampling by Anoka County and the MPCA indicated that one residential well on-site, which was drawing from the surficial aquifer, was found to be contaminated. This well was ordered to be abandoned by the MPCA.

The contaminants are found in zones of discrete contamination rather than in a continuous plume. This is indicative of the multiple waste handling and disposal operations which occurred on the site.

The contaminated surficial aquifer exceeds a number of maximum contaminant levels as set by the Safe Drinking Water Act and pose incremental cancer risks of greater than 1×10^{-6}. The groundwater does not pose an imminent risk to the population because the upper aquifer is not currently used as a source of drinking water on or near the site. However, because there is a downward gradient through the aquifer separating the upper and lower sand aquifers, the upper sand aquifer is a possible source of contamination to the lower sand aquifer which serves as a regional drinking water source. There is a potential for an increase in the incremental cancer risk of greater than 1×10^{-6} if wells are set in the upper aquifer as a result of future development of the site or if the lower aquifer becomes contaminated. In addition to the cancer risk, use of the contaminated groundwater would exceed the reference dose for bis(2-ethylhexyl)phthalate and acetone.

Soil Contamination

A complete surface and subsurface soil characterization could not be performed at the site due to the presence of the large volume of tires and three active auto junk yards. A limited soil sampling was performed during the RI concentrating on suspected waste storage and disposal areas which were not buried under tires or automobiles.

The soil samples indicated elevated levels of organics and inorganics. For the most part, each contaminant was found at low levels and in a limited number of locations. Under current land use the incremental

TABLE 2

CONTAMINANT LEVELS AND STANDARDS

COMPOUND	HIGHEST DETECTED GROUNDWATER CONCENTRATION (ug/l)	COON CREEK 30-DAY AV. DISCHARGE LIMITS (ug/l) (e)	GROUNDWATER DRINKING WATER STANDARDS (ug/l)	POTW DISCHARGE LIMITS (ug/l)
1,1,1-Trichloroethane	330	830	200 (a)	5000 (f)
1,1,2-Trichloroethane	37	900	6.11 (b)	5000 (f)
1,1-Dichloroethane	12	-	-	10,000 (f)
1,2-Dichloroethane	2	2140	3.8 (b)	15,000 (f)
1,1-Dichloroethene	20	-	-	10,000 (f)
1,2-Dichloroethylene	9	1880	70 (a,b)	10,000 (f)
2-Hexanone	75	-	-	15,000 (e)
4-Methyl-2-Pentanone	18	16,970	-	15,000 (e)
Acetone	170,000	1,270,000	-	15,000 (e)
Chlorobenzene	4	200	60 (b)	1000 (f)
Ethylbenzene	18	2410	680 (a,b)	10,000 (f)
Methylene Chloride	1600	6430	350 (c)	15,000 (e)
Tetrachloroethylene	20	150	6.9 (b)	10,000 (f)
Toluene	3200	1010	2000 (a,b)	15,000 (e)
Trichloroethylene	3	1360	5 (a)	10,000 (f)
Vinyl Chloride	12	86	0.15 (b)	15,000 (e)
Xylenes	22	320	440 (a,b)	15,000 (e)
Benzoic Acid	7	-	-	15,000 (e)
Bis(2-Ethylhexyl)Phthalate	2200	10	21,000 (d)	10,000 (f)
Diethyl Phthalate	1	4340	434,000 (d)	10,000 (f)
Di-n-butyl Phthalate	24	-	-	10,000 (f)
Di-n-octyl Phthalate	3	-	-	15,000 (e)
Isophorone	25	9750	5200 (d)	15,000 (e)
2-Methyl Phenol	21	-	-	15,000 (e)
4-Methyl Phenol	56	-	-	15,000 (e)
N-Nitrosodiphenylamine	6	10	71.1 (b)	10,000 (f)
Phenol	6	2550	280 (c)	15,000 (e)
Arsenic	17	400	50 (a,b)	100 (f)
Cadmium	256	-	5 (b)	1000 (f)
Chromium	127	-	120 (b)	10,000 (f)
Copper	673	-	1300 (b)	8000 (f)
Lead	23	220	20 (a,b)	100 (f)
Nickel	168	2720	150 (b)	1000 (f)
Zinc	8120	3060	-	30 (f)

(a) Based on Federal Safe Drinking Water Act Primary Maximum Contaminant Level

(b) Based on State of Minnesota Recommended Allowable Drinking Water Limits

(c) Based on Federal Office of Drinking Water Health Advisories (Relative Source Contribution) for long-term exposure (to be considered only)

(d) Based on Federal Clean Water Act Water Quality Criteria for Human Health adjusted for Toxicity Protection (to be considered only)

(e) Based on MPCA Division of Water Quality proposed effluent limitation

(f) Based on Threshold in inhibitory effect for activated sludge plants U.S.EPA/530-SW-86-004 (to be considered only) cancer risk posed by the soils is less than $1x10^{-6}$. The levels of lead in three of the soil samples could result in lead intakes which exceed the reference dose. Under future residential or commercial development, the cancer risk would exceed $1x10^{-6}$. Future use scenarios of light commercial/industrial development and residential development had incremental cancer risks of $4x10^{-5}$ and $1x10^{-4}$ respectively. Under both of these development scenarios, three soil samples had lead levels which could result in intakes of lead greater than the reference dose.

Surface Water and Sediment Contamination

Six surface water and sediment samples were collected from ponded water locations on the site. No pesticides or volatile organic compounds were found in any of the samples. Phenol phthalates and benzoic acid were detected in the samples. Naphthalene was detected in one sample. Elevated levels of inorganics were also detected.

The surface water bodies are not used for drinking water or recreation. Therefore, the surface water and sediments were not dealt with at this time. They will be considered during the overall site RI/FS.

ALTERNATIVES EVALUATION

The major objective of the feasibility study (FS) was to evaluate the need for an initial groundwater measure and possible actions which could be undertaken. As discussed above, this operable unit will not address soil remediation. This will be addressed in the subsequent RI/FS. Due to the limited scope of the RI/FS, which examined the threat to public health and the environment posed by the contaminated surficial aquifer, alternatives were formulated to achieve the following four goals:

- Minimize the potential for direct contaminant consumption;
- Control contaminant migration to the lower sand aquifer;
- Control contaminant migration to surface water; and
- Provide measures that will be consistent with the final site recommendations.

A comprehensive list of appropriate remedial technologies was identified for groundwater control. These technologies were screened based on the characteristics of the site and the characteristics of the contaminants. The technologies which survived the initial screening were further screened based on effectiveness, implementability and cost. Cost was only used between alternative technologies providing similar degrees of protection and treatment.

Technologies which satisfied the screening requirements were combined to form remedial action alternatives. Alternatives which could not guarantee consistency with future site work were dropped from consideration at this point in the evaluation process. The remaining alternatives ranged in scope from no action through complete lateral containment of the surficial aquifer with groundwater extraction. The four alternatives developed are detailed below.

Alternative 1 - No Action

The no-action alternative is required by the National Contingency Plan (NCP) to be considered through the detailed analysis. It provides a baseline for comparison of other alternatives. Under the no-action alternative, no remedial measures would be undertaken at the South Andover site at the present time. The choice of the no action alternative at this time would not affect the U.S. EPA's and the MPCA's plans to perform a subsequent RI/FS at the South Andover site and is completely consistent with all future site work.

Alternative 2 - Alternative Water Supply

The alternative water supply alternative has the following three major components:

- Provide municipal water to private well users on or near the site;
- Monitor groundwater movement at the site; and
- Place restrictions on new wells on or near the site.

Connection to the municipal water supply would provide uncontaminated water to residences currently using their own private wells. Municipal water hookups would be provided to the eight residences sampled during the RI. Residential wells in both the surficial and lower aquifers will be properly abandoned to eliminate conduits for future migration of contaminants into the lower aquifer. This alternative would not affect future site work.

Groundwater monitoring will be used to detect lateral and vertical migration of contaminants. The monitoring will be coordinated with future site investigations. The well restrictions would eliminate the chance of new wells being installed in a contaminated aquifer.

Alternative 3 - Groundwater Extraction

The groundwater extraction alternative has the following four major components:

- Extract groundwater from the surficial aquifer;
- Provide municipal water to private well users on or near the site;
- Monitor groundwater movement at the site; and
- Place restrictions on new wells on or near the site.

The extraction wells would be located in or slightly downgradient of known contaminated groundwater areas. The wells would pump approximately 20 to 50 gpm (total). The extraction well system would control the horizontal migration of groundwater offsite and limit the vertical migration of contaminants into the lower aquifer by withdrawing the contaminated groundwater found in the surficial aquifer. The exact number and location of the wells will be determined during the remedial design process. Effects on the WDE extraction well system will be taken into consideration at this time.

The municipal water supply, groundwater monitoring, and restrictions on wells are the same as described in Alternative 2.

This alternative will not interfere with future site work. In addition, the gradients imposed by the extraction well system may be helpful in locating unknown areas of contamination.

Alternative 4 - Lateral Containment

The lateral containment option has the following five major components:

- Install a slurry wall around the site;
- Extract groundwater from the surficial aquifer;
- Provide municipal water to private well users on or near the site;
- Monitor groundwater movement at the site; and
- Place restrictions on new wells on or near the site.

This alternative incorporates all aspects of Alternative 3 with the addition of a circumferential slurry wall. The slurry wall will further limit horizontal groundwater contaminant migration and exclude clean water recharge from the surrounding aquifer. The entire site would be surrounded by the slurry wall which would average 30 feet in depth, 3 feet in width, and be approximately 5,800 feet long.

With a reasonable amount of coordination between the development of the workplan for the subsequent field work and the design of the slurry wall, this alternative should not affect future site work. This alternative, however, may limit future development to some extent.

Groundwater Discharge Options

Alternatives 3 and 4 involve groundwater extraction. It is necessary to provide for a discharge option for the extracted groundwater for both of these alternatives. Three possible discharge options were developed. The discharge options are as follows:

- Direct discharge to Coon Creek;
- Onsite treatment of groundwater with discharge to Coon Creek; and

- Discharge to the Metropolitan Waste Control Commission (MWCC) publically-owned treatment works (POTW).

The choice of groundwater discharge option will depend on preliminary work performed during the remedial design (RD) process. Information needed to make the final decision would include actual flow rates from the extraction wells, confirmation of the levels of acetone, methylene chloride and bis (2-ethylhexyl) phthalate present in the surficial aquifer, the National Pollution Discharge Elimination System (NPDES) permit requirements and possible interactions with the remedial action at the WDE site.

Direct discharge of the extracted groundwater to Coon Creek would require an NPDES permit. The NPDES permit sets specific contaminant discharge limits for the discharged waters. The discharge limits would be established by the State of Minnesota and would take into consideration the size and flow rate of Coon Creek, contaminant levels in Coon Creek from other sources and the uses of Coon Creek.

The levels of contaminants found in the surficial aquifer onsite currently exceed two of the proposed discharge limitations to Coon Creek provided by the MPCA. These compounds are toluene and bis (2-ethylhexyl) phthalate. The toluene level only exceeds the proposed discharge limitations in one monitoring well. The actual discharge level of toluene, when the discharge of all the extraction wells are combined, is expected to be below the discharge limitations. In this case, no treatment prior to discharging may be needed. The level of bis (2-ethylhexyl) phthalate significantly exceeds the proposed limitations, but has not been confirmed and may be a laboratory or sampling contaminant. The presence of this compound will be checked prior to determining the discharge option. The cost of the direct discharge is $160,000. A detailed breakdown of the cost is shown in Table 3.

If the NPDES discharge limits are exceeded by the extracted groundwater, onsite treatment of groundwater prior to discharging to Coon Creek would be provided as needed to meet proposed NPDES discharge limits established by the MPCA. A possible system was analyzed in the FS which would remove inorganic, volatile organic and base/neutral organic contamination through the use of an inorganic metal precipitator, an anthracite-greensand filter, an air stripper, and a granulated activated carbon system. This system is anticipated to meet a "best available technology economically achievable" criteria for the treatment of groundwater. Additional sample results during the remedial design may indicate parts of the system are unnecessary. This option would require significant operation and maintenance. Therefore, the maximum present worth cost of an onsite treatment system is $1,700,000. A detailed breakdown of the cost is shown in Table 3.

TABLE 3

COST SUMMARY

ASSEMBLED ALTERNATIVE	CAPITAL COST	REPLACEMENT COST	OPERATION & MAINT.	PRESENT WORTH
Alternative 1 NO ACTION	$0	$0	$0	$0
Alternative 2 ALTERNATIVE WATER SUPPLY	$65,000	$0	$48,000	$520,000
Alternative 3 GROUNDWATER EXTRACTION	$290,000	$50,100	$48,000	$760,000
Alternative 4 LATERAL CONTAINMENT	$3,000,000	$50,100	$48,000	$3,500,000

DISCHARGE OPTIONS	CAPITAL COST	REPLACEMENT COST	OPERATION & MAINT.	PRESENT WORTH
DISCHARGE TO COON CREEK	$160,000	$0	$0	$160,000
ON-SITE TREATMENT - DISCHARGE TO COON CREEK	$430,000	$32,000	$140,000	$1,700,000
DISCHARGE TO POTW	$26,000	$0	$31,000	$320,000

The discharge to a POTW option would entail sending the extracted groundwater to the MWCC wastewater treatment system. The onsite sanitary sewer lines could be used for this purpose. The MWCC POTW has adequate capacity and is in compliance with all of its discharge permits. The highest level for each of contaminants found in the surficial aquifer onsite meet the pretreatment limits for the POTW with the exception of acetone and zinc. The levels of acetone and zinc that will be present in the combined discharge of the extraction wells are expected to meet the pretreatment standards. The addition of the discharge stream is expected to have little if any effect on the MWCC treatment system due to the low contaminant levels and flow rates. The present worth cost for this option is $320,000. A detailed breakdown of the cost is presented in Table 3.

SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The four alternatives assembled were evaluated based on the following nine criteria:

- Overall protection of human health and the environment;
- Compliance with all federal and state applicable or relevant and appropriate requirements (ARARs);
- Reduction of toxicity, mobility or volume;
- Short term effectiveness;
- Long term effectiveness;
- Implementability;
- Cost;
- Community acceptance; and
- State acceptance.

A summary of the relative performance of the alternatives with respect to each of the nine criteria is provided in this section.

Alternatives 2, 3 and 4 would all be effective in protecting public health from ingestion and inhalation of the contaminants detected in the upper aquifer and possibly present in the lower aquifer. By providing municipal water to homes in the vicinity of the site, potential exposure to contaminated groundwater is eliminated. Additionally, Alternatives 3 and 4 provide a level of current and future protection to the environment by limiting contaminant migration offsite or into the lower aquifer through extraction of contaminated groundwater from the surficial aquifer. Alternative 2 does not provide protection to environmental receptors. Alternative 1 does not provide protection to human health or the environment.

Compliance with ARARs dealing with cleanup levels are not necessary for operable units. However, while the operable unit does not have to meet these ARARs, the final remedy will. Therefore, it is desirable that this remedy meet all ARARs.

The primary ARARs for this initial groundwater operable unit are the maximum concentration limits (MCLs) under the Safe Drinking Water Act (SDWA). MCLs are applicable where the water will be provided directly to 25 or more people or will be supplied to 15 or more service connections. MCLs are relevant and appropriate where surface water or groundwater is or may otherwise be used for drinking water. Alternatives 1 and 2 do not address the contaminated groundwater and, therefore, do not meet the SDWA ARARs. No reasonable grounds exist at the present time to justify a waiver of this requirement at the present time for Alternatives 1 and 2. Alternatives 3 and 4 meet the SDWA's MCLs by removing the contaminated groundwater in the surficial aquifer which has been found to exceed the MCLs. Also considered ARARs for the groundwater operable unit are the RCRA groundwater protection standards. These use background, MCLs or alternate concentration limits (ACLs) as the cleanup level. The criteria for choosing between background, MCLs and ACLs are detailed In 40 CFR Part 264.94.

Because the operable unit is being implemented for the purpose of controlling contaminant migration as opposed to restoring the surficial aquifer, the extraction well system will operate until the completion of the subsequent RI/FS regardless of future contaminant levels. Final cleanup levels will be established as a part of the subsequent RI/FS.

Additional ARARs, which are related to discharge options, would need to be met if either Alternatives 3 or 4 were chosen. These include the Clean Water Act, which covers discharges to surface water bodies, the Clean Air Act, which covers air emissions and POTW pretreatment requirements, which cover contaminant levels being discharged to a POTW. The relevant ARARs will be met by the discharge option chosen.

The criterion dealing with the reduction of toxicity, mobility or volume of contaminants only considers reductions due to treatment. Alternatives 1 and 2 do not incorporate any treatment. These alternatives, therefore, do not reduce toxicity, mobility or volume. Alternatives 3 and 4 would involve treatment if either the discharge to POTW option or the onsite treatment with discharge to Coon Creek option is chosen. Both of these discharge options involve treatment which would significantly reduce mobility and volume. If direct discharge to Coon Creek is chosen, neither Alternative 3 nor 4 would involve treatment.

Alternatives 2, 3 and 4 provide a high degree of effectiveness in the short term in achieving prompt protection of human health with no significant adverse effects resulting from the implementation of the remedy. The hook-up to municipal water supplies would not require any significant time delays and is very effective in protecting the public from any potential risks due to consumption of contaminated groundwater.

Alternatives 3 and 4 are protective of the environment in the short term. The anticipated implementation timeframe may be somewhat longer for Alternative 4 due to the time required to design and construct a slurry wall. The no action alternative is not adequately protective of human health or the environment.

Alternatives 2, 3 and 4 are effective in providing long term protection of human health. The hook-up to municipal water eliminates the need to use groundwater on or near the site, but does not address the contamination present in the shallow aquifer or the threat to the lower aquifer. Alternatives 3 and 4 provide a moderate level of long term effectiveness with regard to protection of the environment by controlling contaminant migration. Neither Alternative 3 or 4 eliminates the downward flow gradient through the aquitard or removes contaminants already present in the aquitard, but both decrease the volume of downward flow from the surficial aquifer and the volume of contaminants present in the upper aquifer that pose a threat to the lower aquifer. Long term issues will be addressed more fully in the a subsequent RI/FS. The no action alternative is not adequately protective of human health and the environment.

The implementability of each alternative is based on the technical feasibility, administrative feasibility and the availability of services and materials for the alternative. All of the alternatives are technically feasible. They all involve technologies which have been used regularly in the past and have a demonstrated performance record. All of the alternatives are administratively feasible. Alternatives 3 and 4 would require obtaining a NPDES permit if a surface water discharge is used. Approval of the MWCC would be necessary if the POTW discharge is chosen for Alternative 3 or 4. Alternative 4 may require additional steps and time delays during design and in obtaining access and clearing junk automobiles from around the site prior to the construction of a slurry wall. The services and materials required for each alternative are expected to be readily available.

There are no costs associated with Alternative 1, the no action alternative. Alternative 2 has a total present worth cost of $520,000. Alternative 3 has a total present worth cost of $760,000. Alternative 4 has a total present worth cost of $3,500,000. Alternatives 3 and 4 would have the additional costs associated with the chosen discharge option. A summary of the costs for each alternative is provided in Table 3. Alternative 4 is not felt to offer significant increases in protectiveness to public health and the environment, short term effectiveness or long term effectiveness for the extra cost.

Limited comments were received from the community regarding the various alternatives considered. The comments received indicated the communities concern regarding the discharge options which were considered in the event a groundwater extraction alternative was chosen. These comments indicated a general opposition from the community, including representatives from Anoka County, to a discharge to Coon Creek. Representatives from the City of Andover expressed concern regarding any discharge to the City's sewer system due to the volume limits set by the MWCC for the City and the resulting displacement of potential future development.

The State of Minnesota, through the MPCA, has been actively involved in the RI/FS process for the South Andover site. The MPCA concurs with the U.S. EPA's selected alternative. The selected alternative must be presented to Minnesota's Citizen Review Board prior to the State's commitment to fund 10 percent of the remedial action.

SELECTED ALTERNATIVE

Based on available data and analysis conducted to date, the U.S. EPA selects Alternative 3 as the most appropriate solution for meeting the goals of the initial groundwater operable unit at the South Andover site. The characteristics of Alternative 3 that are considered most important are:

- The alternative provides immediate protection to human health from the potential threats associated with consumption of groundwater from the site.
- The alternative limits migration of groundwater offsite and controls migration of contaminants into the aquitard and lower aquifers.
- The alternative provides for management of surface water quality through monitoring of contaminant levels in the surficial aquifer and possible surface water discharges.
- The alternative is consistent with additional site actions and will be compatible with the final site remedy.

Clean-up Levels

The initial groundwater operable unit is being implemented for the purpose of controlling contaminant migration not restoration of the surficial aquifer to drinking water standards. Therefore, no cleanup levels are being established at this time. The extraction system will operate until the completion of the subsequent RI/FS. At that time, the groundwater operable unit will be incorporated into the overall site remedy and clean-up levels will be set. The levels to be set are expected to meet all Federal and State ARARs.

Due to the discontinuous and possibly intermittent nature of the contamination, continuous extraction of the groundwater would provide a more reliable migration control system than one which would pump only when analytical data indicates a contaminant specific or risk specific action level was exceeded. The continuous extraction is also supported by the predominately downward gradient which exists through the aquitard. By increasing the horizontal gradient through the remainder of the study, the chances of capturing contaminants, prior to them entering the aquitard, is increased.

A second important advantage of continuous extraction is that extraction could significantly aid the subsequent RI in locating potential sources of contamination. Previous efforts, using monitor wells and soil gas analysis, did not locate any source areas of high concentration in groundwater or soil. The gradients caused by the extraction wells will potentially draw in pockets of high contamination and facilitate the pinpointing of the source areas.

Operation and Maintenance

The recommended alternative requires a certain degree of annual operation and maintenance (O&M) activity to ensure that groundwater will be extracted and treated to meet the clean-up levels. The degree of O&M cannot be determined until the discharge option is selected. Direct discharge to Coon Creek and discharge to the POTW would both require monitoring of the discharge contaminant levels. An O&M plan will need to be developed during remedial design after the groundwater discharge option has been chosen.

A groundwater monitoring plan will also need to be developed and implemented to determine if contaminants have migrated offsite or into the lower aquifer. This can be incorporated into the subsequent RI/FS work planned for the site.

All O&M responsibilities will be covered as specified in Section 104(c) of SARA. The O&M plan will be reviewed at the completion of the subsequent RI/FS and be incorporated into the final remedy.

STATUTORY DETERMINATIONS

The U.S. EPA and MPCA believe that this remedy will satisfy the statutory requirements of providing protection of human health and the environment, attaining applicable or relevant and appropriate requirements of other environmental statutes, will be cost-effective, and will utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. The choice of discharge option for the extracted groundwater will determine whether this operable unit will satisfy the preference for treatment as a principal element.

Protection of Human Health and the Environment

The selected remedy provides adequate protection of human health and the environment by preventing consumption of contaminated groundwater through the provision of an alternate water supply, limiting offsite migration if contaminated groundwater and protecting the deeper aquifer from becoming contaminated by the implementation of a groundwater extraction system.

Additional controls on exposure are achieved through restrictions on new wells on or near the site and through monitoring of groundwater at the site.

Attainment of Applicable or Relevant and Appropriate Requirements

This remedy will ensure that drinking water to be supplied to current private well users will attain MCLs under the SDWA and that the discharge from the groundwater extraction system will meet NPDES limitations under the Clean Water Act if discharged to Coon Creek.

Cost-Effectiveness

This alternative affords a high degree of overall effectiveness in not only protecting existing well users against exposure to contaminated groundwater through the provision of an alternate water supply, but also in halting further migration of the contaminated groundwater offsite and into the lower drinking water aquifer through the extraction system. The present worth cost of this action will range from $920,000 to $2,460,000 depending on the discharge option selected during design. This compares with the $3,500,000 required to construct a slurry wall around the site. U.S. EPA believes the costs of the selected remedy are proportionate to the overall effectiveness it affords such that it represents a reasonable value for the money.

Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

U.S. EPA believes this remedy is the most appropriate solution for meeting the goals of the initial groundwater operable unit at the South Andover site providing the best balance among the evaluation criteria for the alternatives evaluated. This remedy provides effective protection in both the short- and long-term to potential human and environmental receptors, protects the deeper aquifer from becoming contaminated, is readily implemented, is cost effective and is consistent with future response actions that may be undertaken at the site.

Preference for Treatment as a Principal Element

Due to the limited scope of this remedy, which is not the final response action for any of the principal threats posed by the site, the statutory preference for treatment may not be met. The choice of discharge option during design will determine if the preference is achieved. Subsequent actions are planned, however, that will definitively address the principal threats.

SCHEDULE

The remedial action start is one of the 175 sites comprising a statutory goal for remedial action starts by October 1989. The following are the key milestones for implementation of the remedial action in the event that RD/RA negotiations are not successful.

Approve Remedial Action (execute ROD)	March 1988
Initiate Remedial Design	June 1988
Complete Remedial Design	June 1989
Initiate Remedial Action (Award Contract)	September 1989

FUTURE ACTION

A detailed study of a large portion of the site was impossible due to the large volume of tires and junk automobiles present onsite. The tires are currently being shredded onsite and sent offsite. The operation is taking place under a grant from the Minnesota Waste Management Board and is scheduled to be completed by Spring 1989.

A subsequent RI/FS is planned for the site following the tire removal. The subsequent RI/FS will study and determine appropriate final groundwater remediation and source control measures.

APPENDIX A

DQO SUMMARY SHEETS

DATA USES

SITE
NAME SOUTH ANDOVER
LOCATION ANDOVER, MINNESOTA
NUMBER ______
PHASE ______
RI1 RI2 RI3 ERA FS [✓ RD] RA

EPA REGION
5

DATE JULY 1989
CONTRACTOR DONOHUE
SITE MANAGER DAVID VOIGHT

DATA USE / MEDIA	SITE CHARACTERIZATION (INCLUDING HEALTH & SAFETY)	RISK ASSESSMENT	EVALUATION OF ALTERNATIVES	ENGINEERING DESIGN OF ALTERNATIVES	MONITORING DURING REMEDIAL ACTION	PRP DETERMINATION	OTHER ______
SOURCE SAMPLING TYPE ______							
SOIL SAMPLING							
GROUND WATER SAMPLING	☒	☒	☒	☒			
SURFACE WATER/SEDIMENT SAMPLING							
AIR SAMPLING							
BIOLOGICAL SAMPLING							
OTHER RESIDENTIAL WELLS	☒	☒					

NOTE: CHECK APPROPRIATE BOX (ES)

CDM SF DQO 1.001

DQO SUMMARY FORM

1. SITE

NAME South Andover
LOCATION Andover, Minnesota
NUMBER

EPA REGION 5
PHASE
RI 1 RI 2 RI 3 ERA FS [✓ RD] RA
(CIRCLE ONE)

2. MEDIA (CIRCLE ONE)
SOIL [✓ GW] SW/SED AIR BIO OTHER

3. USE (CIRCLE ALL THAT APPLY)
[✓ SITE CHARAC. (H&S)] [✓ RISK ASSESS.] [✓ EVAL. ALTS.] [✓ ENG'G DESIGN] PRP DETER. MONITORING REMEDIAL ACTION OTHER

4. OBJECTIVE determine current nature + extent of gw contamination to support either implementation of 3/30/88 ROD or modification + provide data for remedial design contractor for design + selection of proper discharge option

[redacted]

AREA 50 acres, irregular square, max dimensions 1400' x 2100'
DEPTH TO GROUND WATER Average ~10 ft (4-17')
GROUND WATER USE Groundwater within surficial aquifer (Operable Unit) is used locally on-site & near th on
SOIL TYPES 10-50' thick glacial outwash (sand) underlain by 50-70' of silt & clay & 35' sand
SENSITIVE RECEPTORS On-site residences, other private water supplies located w-SC of site.

6. DATA TYPES (CIRCLE APPROPRIATE DATA TYPES)

A. ANALYTICAL DATA

[✓ pH] [✓ PESTICIDES] TOX [✓ TP]
[✓ CONDUCTIVITY] [✓ PCB] TOC [✓ TSS]
[✓ VOA] [✓ METALS] BTX [✓ TDS]
[✓ ABN] [✓ CYANIDE] [✓ COD]
TCLP

B. PHYSICAL DATA

[✓ PERMEABILITY] [✓ HYDRAULIC HEAD] By WATER LEVEL
POROSITY PENETRATION TEST
GRAIN SIZE HARDNESS
BULK DENSITY WATER LEVEL

7. SAMPLING METHOD (CIRCLE METHOD(S) TO BE USED)
[✓ ENVIRONMENTAL] BIASED [✓ GRAB] NON-INTRUSIVE PHASED
SOURCE GRID COMPOSITE INTRUSIVE

8. ANALYTICAL LEVELS (INDICATE LEVEL(S) AND EQUIPMENT & METHODS)

LEVEL 1 FIELD SCREENING - EQUIPMENT pH, CONDUCTIVITY METER, THERMOMETER
LEVEL 2 FIELD ANALYSIS - EQUIPMENT
LEVEL 3 NON-CLP LABORATORY - METHODS
LEVEL 4 CLP/RAS - METHODS RAS INORGANICS, ORGANICS
LEVEL 5 NON STANDARD SAS: COD, TP, TSS, TDS

9. SAMPLING PROCEDURES

BACKGROUND - 2 PER EVENT OR NONE, ALREADY ESTABLISHED BY RI STUDY
CRITICAL (LIST)
PROCEDURES PURGING UNTIL STABILIZED (pH, COND, TEMP), BAILER FOR COLLECTION

10. QUALITY CONTROL SAMPLES (CONFIRM OR SET STANDARD)

A. FIELD
COLLOCATED - 5% OR
REPLICATE - 5% OR 10%
FIELD BLANK - 5% OR 10%
TRIP BLANK - 1 PER DAY OR 10%

B. LABORATORY

	RAS	SAS
REAGENT BLANK - 1 PER ANALYSIS BATCH OR	5%	10%
REPLICATE - 1 PER ANALYSIS BATCH OR	5%	10%
MATRIX SPIKE - 1 PER ANALYSIS BATCH OR	5%	10%

OTHER see SAS requirements

[redacted]

BUDGET unknown
SCHEDULE 17 calendar days field work
61 calendar days – lab + data validation
STAFF 2 field technicians

CONTRACTOR DONOHUE
PRIME CONTRACTOR DONOHUE
[redacted] David S. Vaught
[redacted] 2/5/89

DQO SUMMARY FORM

1. SITE

NAME South Andover

LOCATION Andover, Minnesota

NUMBER

EPA REGION 5

PHASE

RI 1 RI 2 RI 3 ERA FS [✓ RD] RA

(CIRCLE ONE)

2. MEDIA (CIRCLE ONE)

SOIL [✓ GW RESIDENTIAL WELLS] SW/SED AIR BIO OTHER

3. USE (CIRCLE ALL THAT APPLY)

[✓ SITE CHARAC. (H&S)] [✓ RISK ASSESS.] EVAL. ALTS. ENG'G DESIGN PRP DETER. MONITORING REMEDIAL ACTION OTHER

4. OBJECTIVE determine current nature + extent of gw contamination to assess if any health risks exist + if plume is affecting residental wells

[redacted]

AREA 50 acres, irregular square max dimensions 1400' x 2100'

DEPTH TO GROUND WATER Average ~10 ft (4-17')

GROUND WATER USE gw within surficial aquifer (Operable Unit) is used locally onsite + near the site

SOIL TYPES 20-50' thick glacial outwash (sand) underlain by 50-70' silt + clay + 35' sand

SENSITIVE RECEPTORS Onsite residences, other private water supplies located west of site

6. DATA TYPES (CIRCLE APPROPRIATE DATA TYPES)

A. ANALYTICAL DATA

[✓ pH] [✓ PESTICIDES] TOX

[✓ CONDUCTIVITY] [✓ PCB] TOC

[✓ VOA] [✓ METALS] BTX

[✓ ABN] [✓ CYANIDE] COD

TCLP

B. PHYSICAL DATA

PERMEABILITY HYDRAULIC HEAD

POROSITY PENETRATION TEST

GRAIN SIZE HARDNESS

BULK DENSITY

7. SAMPLING METHOD (CIRCLE METHOD(S) TO BE USED)

[✓ ENVIRONMENTAL] BIASED [✓ GRAB] NON-INTRUSIVE PHASED

SOURCE GRID COMPOSITE INTRUSIVE

8. ANALYTICAL LEVELS (INDICATE LEVEL(S) AND EQUIPMENT & METHODS)

LEVEL 1 FIELD SCREENING - EQUIPMENT pH, CONDUCTIVITY METER, THERMOMETER

LEVEL 2 FIELD ANALYSIS - EQUIPMENT

LEVEL 3 NON-CLP LABORATORY - METHODS

LEVEL 4 CLP/RAS - METHODS

LEVEL 5 NON STANDARD SAS CLP/CRL residential well analysis < metals/CN organics

9. SAMPLING PROCEDURES

BACKGROUND - 2 PER EVENT OR NONE, ALREADY ESTABLISHED IN RI STUDY

CRITICAL (LIST)

PROCEDURES COLLECTED AFTER 15 MINUTES (COLD WATER) OF PUMPING CLOSEST TO WELL HEAD, RW6 - PURGE 5 WELL VOLUMES FIRST SAMPLE WITH BAILER

10. QUALITY CONTROL SAMPLES (CONFIRM OR SET STANDARD)

A. FIELD

COLLOCATED - 5% OR

REPLICATE - 5% OR 10%

FIELD BLANK - 5% OR 10%

TRIP BLANK - 1 PER DAY OR 10%

B. LABORATORY

	INORGANIC	ORGANIC
REAGENT BLANK - 1 PER ANALYSIS BATCH OR	10%	5%
REPLICATE - 1 PER ANALYSIS BATCH OR	10%	5%
MATRIX SPIKE - 1 PER ANALYSIS BATCH OR	10%	5%

OTHER see SAS requirements

[redacted]

BUDGET unknown

SCHEDULE 17 calendar days field work
61 calendar days - lab + data validation

STAFF 2 field technicians

CONTRACTOR DONOHUE

PRIME CONTRACTOR DONOHUE

[redacted] Max for David Voight

[redacted] 7/5/89

APPENDIX B

SAS REQUEST FORMS

5/016	Total Phosphorous
5/018	Chemical Oxygen Demand
5/024	Total Dissolved Solids
5/025	Total Suspended Solids
5/029	Drinking Water and Residential Wells - Organics with Low Quantitation Limits Rev. 8.0, 6/89
5/030	Drinking Water and Residential Wells - Metals, CN Rev. 5.0, 4/88 or Rev. 6.0.

5/016__-0-6/87 Total Phosphorus in H_2O 6/29/87

U.S. Environmental Protection Agency
CLP Sample Management Office
P . Box 818, Alexandria, Virginia 22313
Phone: (703)/557-2490 or FTS/557-2490

SAS Number

SPECIAL ANALYTICAL SERVICES
Client Request

Approved For Scheduling

☒ Regional Transmittal ☐ Telephone Request

A. EPA Region/Client: Region V

B. RSCC Representative: Jan Pels

C. Telephone Number: (312) 353-2720

D. Date of Request:

E. Site Name: South Andover, Andover Minnesota

Please provide below a description of your request for Special Analytical Services under the Contract Laboratory Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Analysis for total phosphorous in waters (surface waters, ground waters, drinking waters, leachate, etc.). Most samples will be unfiltered although certain aliquots can be filtered and preserved at time of collection. Results will be reported as mg/l P.

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration):
29 low level groundwater (aqueous) samples

3. Purpose of analysis (specify whether Superfund (Remedial or Enforcement), RCRA, NPDES, etc.):
Superfund Design Investigation (Remedial)

4. Estimated date(s) of collection: [October, 1989 ?]

5 Estimated date(s) and method of shipment:

6. Number of days analysis and data required after laboratory receipt of samples:

Laboratory should report results within 30 days after receipt of samples.

7. Analytical protocol required (attach copy if other than a protocol currently used in this program):

Total Phosphorus EPA Method 365.1 (Automated, Colorimetric, Ascorbic Acid)

Total Phosphorus EPA Method 365.2 (Automated, Colorimetric, Single Reagent)

Total Phosphorus EPA Method 365.4 (Block Digestor)

Samples will be preserved in the field with 1 ml/l H_2SO_4 to pH <2 and stored at 4°C until analysis and validation of results.

8. Special technical instruction (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.) Check sample pH using wide-range pH paper. If the pH>2, contact CPMS, CRL for instructions: Dilute and redigest samples with absorbances or peak heights higher than the highest standard. All standards, blanks, audits, etc. must be digested. The holding time is not to exceed 28 days from sample collection. Use only the method(s) specified above. The calibration curve must include at least 5 standards. (One of the standards must be zero concentration).

9. Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.). If not completed, format of results will be left to program discretion: The test procedure used will be clearly identified. Bench records and all records of analysis and calculations for samples, blanks, duplicates, spikes and all control checks with peak height or response and concentrations will be provided with copies of worksheets. Results will be reported as mg/l P. Any digestion log will be provided showing sample aliquots and concentrations of all samples tested. Records must be legible and sufficient to recalculate all concentrations. A photocopy of the instrument readout i.e. stripcharts, printer tapes, etc. must be included. EPA QC reference samples, or any other reference sample or initial calibration verification, will be identified as to source, lot number, and sample number. Corresponding "true" or target values and associated 95% confidence limits for analysis results will be provided for all reference samples used.

10. Other (use additional sheets or attach supplementary information, as needed):

11 Name of sampling/shipping contact: Marcia Kuehl/Mike Whittington

Phone: (414) 458-8711

I. DATA REQUIREMENTS

Parameter:	Detection Limit	Precision Desired (±% or Conc.)
Total P	0.05 mg/l	Duplicate results must agree to within 10% for concentrations > 0.5 mg/l or within 0.05 mg/l for concentrations < 0.5 mg/l
NOTE: These are minimum requirements. Report actual detection limits used based on specified methodologies.		

II. QC REQUIREMENTS - Do not use designated field blanks for QA audits

Audits Required	Frequency of Audits	Limits* (% or Conc.)
Matrix Spike*	at least 1 per group of 10 or fewer samples	85% - 115%
Lab Duplicate	at least 1 per group of 10 or fewer samples	± (10% or 0.05 mg/l)
Lab Blank (Also serves as a calibration blank).	at least 1 per group of 10 or fewer samples	<0.05 mg/l
Calibration verification standard	1 per group of 10 samples and end of sample set	90% - 110%
1 set of EPA nutrient QC reference samples conc. 3&4	1 per sample set	85% - 115%

*The matrix spike concentrations will be approximately 30% or larger of sample concentrations, but spiked samples shall not exceed the working range of the standard curve.

III. ACTION REQUIRED IF LIMITS ARE EXCEEDED:

Take corrective action and reanalyze samples.

Contact Jay Thakkar (312) 886-1972 or Chuck Elly (312) 353-9087.

Please return this request to the Sample Management Office as soon as possible to expedite processing of your request for special analytical services. Should you have any questions or need any assistance, please call the Sample Management Office.

U.S. Environmental Protection Agency
CLP Sample Management Office
P. O. Box 818, Alexandria, Virginia 22313
PHONE: (703)/557-2490 or FTS/557-2490

SAS Number

SPECIAL ANALYTICAL SERVICES
Client Request

Approved for Scheduling

☒ Regional Transmittal ☐ Telephone Request

A. EPA Region/Client: Region V

B. RSCC Representative: Jan Pels

C. Telephone Number: 312/ 353-2720

D. Date of Request:

E. Site Name: South Andover, Andover Minnesota

Please provide below a description of your request for Special Analytical Services under the Contract Laboratory Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Analysis of chemical oxygen demand (COD) (Hi-level) (50 - 800 mg/l) and COD (Lo-level) (5 - 50 mg/l) in water (surface water, groundwater, leachate, wastewater, drinking water, etc.). Samples will be unfiltered. Any sample with COD values less than 50 mg/l will be determined and reported as COD (Lo-level). Samples with COD values greater than or equal to 50 mg/l will be determined and reported as COD (Hi-level). The COD (Lo-level) method is used for optimum precision and accuracy of measurement of low concentration COD values.

   If field specific conductance values are greater than or equal to 5000 umhos/cm, field personnel will indicate this on the SAS Packing Lists or any future RAS/SAS Traffic Report Forms, the field conductance values and the instruction "Check for Possible Chloride Interference in COD Test" for any such samples. If this is the case or if there is other definite knowledge of chlorides exceeding 2000 mg/l, the laboratory will determine the chloride content and inhibit chloride interference pursuant to Section 7.1 of EPA Method 410.3.

   NOTE: It is expected that few waters from Region V (<3%), will have chloride concentrations in excess of 2000 mg/l, however, it is the responsibility of field personnel to first identify any samples having a chloride interference for COD so that the COD test can be modified to compensate for any chloride interference.

   Results are reported as mg/l COD.

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration): 29 low level groundwater (aqueous) samples

3. rpose of analysis (specify whether Superfund (Remedial or Enforcement), RCRA, DES, etc.): Superfund Design Investigation - Remedial

4. Estimated date(s) of collection: [October, 1989?]

5. Estimated date(s) and method of shipment:

6. Number of days analysis and data required after laboratory receipt of samples:
   Laboratory should report results within 30 days after receipt

7. Analytical protocol required (attach copy if other than a protocol currently used in this program):

   EPA Method 410.1 (Titrimetric, Mid-level) for COD $\geq$ 50 mg/l.
   EPA Method 410.2 (Titrimetric, Low-level) for COD $<$ 50 mg/l.

   Use Section 7.1 of Method 410.3 if chloride concentration exceeds 2000 mg/l in a sample. If titration blank is necessary for each different amount of mercuric sulfate used for inhibition of chloride interference, SAS Packing Lists will note the samples requiring assessment of chloride interferences. Measurement of chloride will be done using any method of "Standard Methods",16th ed., or "EPA Methods for Chemical Analysis of Water and Wastes", 1983 ed., whenever possible chloride interference is noted.

   Samples will be preserved with 1 ml of H_2SO_4 to pH less than 2 and kept at 4°C until sample analysis and validation of results are completed. Holding time is not to exceed 28 days from date of sample collection.

8. Special technical instruction (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.):

   1. Check sample pH (wide range pH paper). If pH>2, contact CPMS, CRL for further instructions.
   2. Use a) 50 ml sample aliquots for both methods, b) 0.250 N $K_2Cr_2O_7$ reagent and 0.25 N ferrous ammonium sulfate titrant for Method 410.1, and c) 0.0250 N $K_2Cr_2O_7$ reagent and 0.025 N ferrous ammonium sulfate titrant for Method 410.2.
   3. Dilute and reanalyze (by Method 410.1) any samples with COD values > 800 mg/l or titrant volumes < 5.0 ml. Reanalyze samples (by Method 410.1) if initial sample values are > 50 mg/l COD by Method 410.2. Reanalyze samples (by Method 410.2) if initial sample values are < 50 mg/l COD by Method 410.1.
   4. Any sample aliquots < 50 mls will be diluted to 50 mls so that the COD reaction mixture will be 50% H_2SO_4/ 50% water by volume.
   5. Titration blanks will be determined, at least in duplicate each day of analysis and will not differ more than ± 0.1 ml titrant for Method 410.1 and ± 1.0 ml titrant for Method 410.2.
   6. Separate sets of QA Audits will be performed for each method, if both methods are used.
   7. Use potassium hydrogen phthalate as a matrix spike compound. Use 20 mg/l matrix spike concentration for Method 410.2.
   8. Samples will be refluxed for at least 2 hours.
   9. Homogenize sample aliquots, as necessary, to obtain sample aliquots of representative suspended solids.
   10. Use only the method specified.

9. Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.). If not completed, format of results will be left to program discretion.

Bench records, tabulating titrant standardization, titration volumes for titration or sample blanks (2 or more in number), samples, and QA Audits will be provided for each method used. All records of analysis and calculations must be legible and sufficient to recalculate all sample concentrations and QA Audit results. Records of chloride analysis will be provided for any samples so specified on the RAS/SAS Traffic Report or SAS Packing List. Separate bench records will be provided for any COD determinations of high chloride samples (>2000 mg/l Cl) including weight of mercuric sulfate used, sample titration volume and titration blank volume for each sample type. EPA QC Reference samples, or any other reference samples, will be identified as to source, lot number, and sample number. Corresponding "true" or target values and associated 95% confidence limits for analysis results will be provided for all reference samples used.

10. Other (use additional sheets or attach supplementary information, as needed):

11. Name of sampling/shipping contact: Marcia Kuehl / Mike Whittington
Phone: (414) 458-8711

I. DATA REQUIREMENTS

Parameter:	Detection Limit	Precision Desired (±% or Conc.)
COD (Method 410.1)	50 mg/l	Method 410.1: Differences in sample duplicates are to be < or = to 0.2 ml titrant or ≤ 8 mg/l for concentrations ≤ 80 mg/l and < 10% for COD concentrations exceeding 80 mg/l.
COD (Method 410.2)	5 mg/l	Method 410.2: Differences in sample duplicate results are t be ≤ 1.0 ml titrant or ≤ 4 mg/ for concentrations less than 40 mg/l and are to be ≤ 5 mg/l for concentrations between 40 50 mg/l.

NOTE: These are minimum requirements. Report actual detection limits used based on specified methodologies.

II. QC REQUIREMENTS

Audits Required	Frequency of Audits	Limits* (% or Conc.)
Matrix spike (KHP) Method 410.1* Method 410.2(Use 20 mg/l spike)	at least 1 per group of 10 or fewer samples	85 - 115% Recovery (410.1) 75 - 125% Recovery (410.2)
Lab duplicate	" " " "	Diff ≤ (8 mg/l or 10%) (410.1) Diff ≤ (4 mg/l - 5 mg/l) (410.2)
Titration blank (used for calculation of results)	at least 2 per sample set for each method used	Diff in titrant volumes shall not exceed 0.1 ml for 410.1 and 1.0 ml for 410.2
1 set of EPA QC Demand Reference samples - 2 concentration levels	1 per sample set for each method used	90 - 110% Recovery or ≤ 8 mg/l error for 410.1 and ≤ 5 mg/l error for 410.2 in aliquot tested

* - Matrix spike will be greater than 30% of the sample concentration, but spiked sample shall not exceed 800 mg/l for Method 410.1.

III. ACTION REQUIRED IF LIMITS ARE EXCEEDED:

Take corrective action and reanalyze samples. Contact Jay Thakkar (312) 886-1972 or Chuck Elly (312) 353-9087.

Contact Region V RSCC Dennis Wesolowski (312) 886-1971 concerning questions on chloride interferences and modifications of COD test.

Please return this request to the Sample Management Office as soon as possible to expedite processing of your request for special analytical services. Should you have any questions or need any assistance, please call the Sample Management Office.

5/024__-0-6/87 Total Dissolved Solids 6/29/87

U.S. Environmental Protection Agency
HWI Sample Management Office
P.O. Box 818, Alexandria, Virginia 22313
Phone: (703) 557-2490 or FTS-557-2490

SAS Number

Special Analytical Services
Regional Request

☒ Regional Transmittal ☐ Telephone Request

A. EPA Region and Site Name: Region V
B. Regional Representative: Jan Pels
C. Telephone Number: (312) 353-2720
D. Data request:
E. Site Name: South Andover, Andover Minnesota

Please provide below a description of your request for Special Analytical Services under the Uncontrolled Hazardous Waste Dumpsite Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Analysis of total dissolved solids (180°C) in water (surface waters, wastes, groundwaters, drinking water, leachate, etc.) Results are reported as mg/l dissolved solids.

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration):
29 low level groundwater (aqueous) samples

3. Purpose of analysis (specify whether Superfund (Remedial or Enforcement), RCRA, NPDES, etc.):
Superfund Design Investigation (Remedial)

4. Estimated date(s) of collection: [October, 1989?]

5. Estimated date(s) and method of shipment:

6. Approximate number of days results required after lab receipt of samples: ________

Laboratory should report results within 30 days after receipt of samples

7. Analytical protocol required (attach copy if other than a protocol currently used in this program):

1. EPA Method 160.1, 1983 ed., or

2. Method 209B, "Standard Methods", 16th ed. Samples will be kept at 4°C until sample analysis and validation of results. Holding time is 7 days from date of sample collection.

8. Specail technical instructionns (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.):

1) Use standard aliquots of 100ml; however do not use sample aliquots yielding more than 200 mg residue. If residue is greater than 200 mg, repeat the analysis using a smaller sample aliquot. 2) If the pH value is less than 4.0, raise the pH of the aliquot (using NaOH titrant) to between pH 4 and 8 and subtract the weight of sodium added from the weigth of the residue. 3) Residue will be weighed either to constant weight pursuant to Section 7.6 of Method 160.1 the final weight is to be used for calculations. Constant weight is defined as a) less than 0.5 mg or less than 4% weight loss from the previous weight, whichever is smaller, or b) dried overnight (12 hours drying time) with a single weight used for calculations.

9. Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.). If not completed, format of results will be left to program discretion.

Identify the QC reference sample lot numbers used and their true values with 95% confidence intervals. Bench records of tare weights, final weights, additional weights to determine constant weights, volumes filtered, blanks, duplicate samples, and reference samples will be provided with copies of work sheets used to calculate results . Dates and time of 1) determination of tare weights, 2) sample filtration, and 3) determination of residue weights and constant residue weights will be part of bench records. All records of analysis must be legible and sufficient to recalculate all sample concentrations and QA results.

10. Other (use additional sheets or attach supplementary information, as needed):

11. Name of sampling/shipping contact: Marcia Kuehl/Mike Whittington

Phone: (414) 458-8711

Please return this request to the Sample Management Office as soon as possible to expedite processing of your request for special analytical services. Should you have any questions or need any assistance, please call the Sample Management Office.

I. DATA REQUIREMENTS

Parameter	Detection Limit	Precision Desired (±% or Conc.)
TDS	20 mg/l	Difference in duplicate sample aliquots shall not exceed 2 mg for residues. Duplicate differences shall not exceed 10% for sample values greater than 200 mg/l.
Note: These are minimum requirements. Report the actual detection limits used based on allowable methodology options.		

II. QUALITY CONTROL REQUIREMENTS

Do not use any designated field blanks for QA Audits.

Audits Required	Frequency of Audits	Limits* (±% or Conc.)
1. 1 set of EPA QC Mineral Reference Samples*- 2 concentration levels.	1 per sample set	85-115% Recovery
2. Lab Duplicate	At least 1 per group of 10 or fewer samples	± (10% or 2 mg of residue)
3. Lab Blanks (100 ml of filtered reagent water)	At least 1 per group of 10 or fewer samples	- 20 mg/l to + 20 mg/l

* Alternate reference samples must be approved by Region V RSCC prior to analysis.

III. *Action Required if Limits are Exceeded:

Take corrective action and retest samples. Contant Charles T. Elly (312/353-9087) or Jay Thakkar at (312/886-1972).

5/025__-[illegible]-[illegible]/87

Total suspended solids in water 6/29/87

U.S. Environmental Protection Agency
HWI Sample Management Office
P.O. Box 818, Alexandria, Virginia 22313
Phone: (703) 557-2490 or FTS-557-2490

SAS Number

Approved for Scheduling

Special Analytical Services
Regional Request

☒ Regional Transmittal

☐ Telephone Request

A. EPA Region and Site Name: Region V
B. Regional Representative: Jan Pels
C. Telephone Number: (312) 353-2720
D. Data request:
E. Site Name: South Andover, Andover Minnesota

Please provide below a description of your request for Special Analytical Services under the Uncontrolled Hazardous Waste Dumpsite Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Analysis for total suspended solids (103-105°C) in water (surface waters, groundwater, drinking water, leachate, etc.) Results are reported as mg/l total suspended solids.

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration):
29 low level groundwater (aqueous) samples

3. Purpose of analysis (specify whether Superfund (Remedial or Enforcement), RCRA, NPDES, etc.):
Superfund Design Investigation (Remedial)

4. Estimated date(s) of collection: [October, 1989?]

5. Estimated date(s) and method of shipment: Daily by overnight carrier.

6. Approximate number of days results required after lab receipt of samples: 30

7. Analytical protocol required (attach copy if other than a protocol currently used in this program):

1. EPA Method 160.2, 1983 ed., (Gravimetric, Dried at 103° - 105° C) using glass fiber filter discs without organic binder such as: Millipore AP-40, Reeve Angel 934-AH, Gelman A/E, or equivalent. Use only membrane filter apparatus with 47 mm diameter glass fiber filter and a coarse (40-60 micron) fritted disc filter support. The filter and support specifications are mandatory. Samples will be held at 4°C until sample analysis and validation of results are completed. Holding time is 7 days from date of sample collection.

8. Specail technical instructionns (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.):

1. Sample aliquot volumes are selected on the basis of the following factors. a) During initial sample filtratrion, filtration rate should not drop rapidly, or require more than 5 minutes of filtratrion time. (Increase the filter area or decrease the sample volume as needed for sample reanalysis), b) The sample aliquot filtered should provide a residue with greater than 1.0 mg for aliquots less than 200ml in volume, and c) Sample aliquots should not exceed 200ml in volume. 2. Duplicate sample aliquots will be filtered with 2 or more intervening samples. 3. Final residues are to be weighed either to constant weight pursuant to Section 7.6 of Method 160.1 (The final weight is to be used for calculations), or dried overnight (12 hours of drying time) with the single weight used for calculations. Constant weight is defined as less than 0.5 mg or less than 4% weight loss from the previous weight, whichever is smaller. 4. Use only the method specified above in items 7 and 8.

9. Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.). If not completed, format of results will be left to program discretion.

Identify EPA QC reference sample lot numbers used and their true values and 95% confidence intervals. Bench records of tare weights, final weights, volumes filtered, blanks, duplicate samples, and reference samples (all in the order filtered) will be provided along with copies of worksheets used to calculate results. Dates and time of a) filtration of initial 100ml volume, b) determination of tare weights, c) sample filtration, and d) determination of constant residue weights will be part of bench records. All records of analysis must be legible and sufficient to recalculate all sample concentrations and QA results.

10. Other (use additional sheets or attach supplementary information, as needed):

11. Name of sampling/shipping contact: Marcia Kuehl/Mike Whittington

Phone: (414) 458-8711

Please return this request to the Sample Management Office as soon as possible to expedite processing of your request for special analytical services. Should you have any questions or need any assistance, please call the Sample Management Office.

I. DATA REQUIREMENTS

Parameter	Detection Limit	Precision Desired (±% or Conc.)
Suspended Solids	2-3 mg/l for 200 ml sample aliquot	Difference in duplicate results shall not exceed 0.5 mg for duplicate aliquots filtered.
Note: These are minimum requirements. Report the actual detection limits used based on allowable methodology options.		

II. QUALITY CONTROL REQUIREMENTS Do not use designated field blanks for QA Audits.

Audits Required	Frequency of Audits	Limits* (±% or Conc.)
1) Lab Duplicates (See item 8.3 on Page 2)	1 per group of 10 or fewer samples	less than 0.5 mg for residue. less than 10% for sample. ≥ 5 mg
2) Lab Blanks (200 ml aliquots)	1 per group or 10 or fewer samples	-0.5 to +0.5 mg.
3) 1 set of 2 EPA QC Residue Reference Samples-2 concentration levels	1 per sample set	< 5 mg/l error for concentrations ≤ to 50 mg/l or < or = to 10% for nominal concentrations > than 50 mg/l

* Alternate reference samples must be approbed by Region V RSCC prior to analysis.

III. *Action Required if Limits are Exceeded:

Take corrective action and reanalyze samples.

Contact Jay Thakkar (312) 886-1972 or Chuck Elly (312) 353-9087.

U.S. Environmental Protection Agency
Sample Management Office
P. O. Box 818, Alexandria, Virginia 22313
PHONE: (703)/557-2490 or FTS/557-2490

SAS Number

SPECIAL ANALYTICAL SERVICES
Client Request

☐ Regional Transmittal ☐ Telephone Request

A. EPA Region/Client: V/

B. RSCC Representative: Jan Pels

Telephone Number: (312) 353-2720

D. Date of Request:

E. Site Name:

Please provide below a description of your request for Special Analytical Services under the Contract Laboratory Program. In order to most efficiently obtain laboratory capability for request, please address the following considerations, if applicable. Incomplete or erroneous information may result in delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Analysis of drinking water/ residential wells for volatiles, semi-volatiles, and pesticides/PCBs with low quantitation limits.

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration):

6 low level residential well samples for semi-volatiles
7 low level residential well samples for volatiles
3 low level residential well samples for PCB/Pests

3. Purpose of analysis (specify whether Superfund (Remedial or Enforcement), RCRA, NPDES, etc.):

Superfund Design Investigation (Remedial)

Rev. 8.0 6/89

4. Estimated date(s) of collection: [October, 1989?]

5. Estimated date(s) and method of shipment:

6. Number of days analysis and data required after laboratory receipt of samples:

7 days for analysis. Final report and data due within 15 days.

7. Analytical protocol required (attach copy if other than a protocol currently used in this program):

CLP SOW for Organic Analysis (Multi-Media, Multi-concentration) [illegible] 2/88

8. Special technical instruction (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.):

1. Modifications to the CLP Organic SOW 2/88 [illegible] in Attachment I.
2. Required low level quantitation limits in Attachment II.

9. Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.). If not completed, format of results will be left to program discretion.

As per CLP Organics SOW 2/88 [illegible] with modifications as outlined in Attachment I.

10. Other (use additional sheets or attach supplementary information, as needed):

11. Name of sampling/shipping contact: Marcia Kuehl/Mike Whittington

Phone: (414) 458-8711

I. DATA REQUIREMENTS

Parameter:	Detection Limit	Precision Desired (±% or Conc.)
See attachment II	See attachment II	± 20%

II. QC REQUIREMENTS

Audits Required	Frequency of Audits	Limits* (% or Conc.)
As per CLP Organic SOW 2/88	As per CLP Organic SOW 2/88	Exceptions to CLP Organic SOW 2/88: See attachment I

III. ACTION REQUIRED IF LIMITS ARE EXCEEDED:

Contact Region V RSCC Jan Pels (312) 353-2720
Chuck Elly (312) 353-9087

ease return this equest to the S anagement Off as soon as possible expedite Re
Should you have a estions

ATTACHMENT 1 (page 1 of 2)

MODIFICATIONS TO THE CLP ORGANICS SOW 8/87
FOR THE REGION V RESIDENTIAL WELL SAS

1. Special Technical Instructions.

Volatile Analysis

a) Sample volume is increased from 5 ml to 20 or 25 ml to achieve lower detection limits. Lab must use the same volume of sample that is used for the MDL study.

b) Acrolein and acrylonitrile are additional target compounds. These compounds will be added to both initial and continuing calibration mixes. Acrolein and acrylonitrile will use bromochloromethane as internal standard. The primary and secondary quantitation ions to be used for these compounds are:

Compound	Primary Ion	Secondary Ion(s)
Acrolein	56	55
Acrylonitrile	53	52

c) Initial calibration: Five point initial calibration - 5, 10, 20, 40 and 60 ug/L for all compounds except for acrolein and acrylonitrile, which should be analyzed at 25,50,75,100 and 125 ug/L.

d) Continuing calibration: Performed at 20 ug/L for all compounds except acrolein and acrylonitrile, which should be analyzed at 50 ug/L.

e) Surrogate standards: SOW standards spiked at 20 ppb.

f) Matrix spike/matrix spike duplicate: Matrix spike compounds at 20 ppb.

Semivolatiles Analysis

a) Extraction/blowdown: Extract the entire one liter bottle, rinsing the cap & bottle and add to sample. Final blowdown volume may be decreased to 0.5 ml to achieve required detection limits.

b) Initial Calibration: Five points at 5,10,20,50, and 100 total nanograms except for benzoic acid, 2,4-dinitrophenol, 2,4,5-trichlorophenol, all three nitroaniline isomers, 4-nitrophenol, 4,6-dinitro-2-methylphenol and pentachlorophenol which should be analyzed at 20,50,80,100 and 120 total nanograms. The laboratory should notify the Region if this calibration range is not possible.

c) Continuing calibration: 20 total nanograms except for benzoic acic, 2,4-dinitrophenol, 2,4,5-trichlorophenol, all three nitroaniline isomers, 4-nitrophenol, 4,6-dinitro-2-methylphenol and pentachlorophenol which should be analyzed at 50 total nanograms.

d) Surrogate standards: SOW standards spiked as 20ppb for base-neutral standards and 40ppb for the acid standards.

e) Matrix spike/matrix spike duplicate: Matrix spike compounds as per the SOW spiked at 20ppb for baseneutrals and 40ppb for the acids.

ATTACHMENT 1 (page 2 of 2)

Pesticides/PCBs Analysis

a) Extraction/blowdown: Extract the entire one liter bottle; rinse cap & bottle and add to sample. Final blowdown volume may be decreased up to 0.5mL to achieve required detection limits.
b) Surrogate standard: Spiked at 0.2 ppb.
c) Matrix spike/matrix spike duplicate: SOW Matrix spike compounds spiked at 1/5 the SOW concentration.

2. Analytical Results Required.
   a. Quantitation Limits: Organic Analysis Data Sheets, Form 1 will reflect method detection limits experimentally determined and verified previously by the contractor.
   b. Additional volatile parameters: Results will include all data for acrolein/acrylonitrile analogous to the other volatile target compounds in the SOW. Form is may be appended to include these parameters.
   c. Dilutions: The contractor will request permission of the Region to dilute any sample exceeding the initial calibration range for any parameter. Diluted and undiluted sample data will be included in the results as per the SOW.

3. QC Requirements:
   a. Initial Calibration (Volatiles/Semivolatiles):
      SPCC criteria apply.
      The %RSD for the RFs for all compounds must be ≤ 35%.
      The RFs for all other (non SPCC) compounds must be ≥ 0.05.
   b. Continuing Calibration:
      SPCC criteria apply.
      The %D for the RFs for all compounds must be ≤ 25%.
      The RFs for all other (non SPCC) compounds must be ≥ 0.05.
   c. Matrix Spike/ Matrix Spike Duplicates:
      SOW criteria apply for %R and %RPDs.

   d. Surrogates:
      Sow criteria apply for %R and corrective action.

   e. Blanks:
      Sow criteria apply, however, the calculated MDLs must be used instead of RAS CRQLs.

ATTACHMENT II

(ALL UNITS ARE MICROGRAMS/LITER)

ANALYTE	CAS #	QUANTITATION LIMIT
BENZENE	71-43-2	1.5
BROMODICHLOROMETHANE	75-27-4	1.5
BROMOFORM	75-25-2	1.5
BROMOMETHANE	74-83-9	1.5
CARBON TETRACHLORIDE	56-23-5	1.5
CHLOROBENZENE	108-90-7	1.5
CHLOROETHANE	75-00-3	1.5
CHLOROFORM	67-66-3	1.5
CHLOROMETHANE	74-87-3	1.5
DIBROMOCHLOROMETHANE	124-48-1	1.5
1,1-DICHLOROETHANE	75-34-3	1.5
1,2-DICHLOROETHANE	107-06-2	1.5
1.1-DICHLOROETHENE	75-35-4	1.5
total -1.2-DICHLOROETHENE		1.5
1,2-DICHLOROPROPANE	78-87-5	1.5
cis-1,3-DICHLOROPROPENE	10061-01-5	2
trans-1,3-DICHLOROPROPENE	10061-02-6	1
ETHYL BENZENE	100-41-4	1.5
METHYLENE CHLORIDE (*)	75-09-2	1
1.1.2.2-TETRACHLOROETHANE	79-34-5	1.5
TETRACHLOROETHENE	127-18-4	1.5
TOLUENE (*)	108-88-3	1.5
1,1,1-TRICHLOROETHANE	71-55-6	1.5
1,1.2-TRICHLOROETHANE	79-00-5	1.5
TRICHLOROETHENE	79-01-6	1.5
VINYL CHLORIDE	75-01-4	1.5
ACROLEIN	107-02-8	25
ACETONE (*)	67-64-1	5
ACRYLONITRILE	107-13-1	25
CARBON DISULFIDE *	75-15-0	3
2-BUTANONE (*)	78-93-3	5
VINYL ACETATE	108-05-4	5
4-METHYL-2-PENTANONE	108-10-1	1.5
2-HEXANONE	519-78-6	5
STYRENE	100-42-5	1
m-XYLENE **	108-38-3	1.5
o-XYLENE **	95-47-6	
p-XYLENE **	106-42-3	

* COMMON LABORATORY SOLVENT
BLANK LIMIT IS 5x METHOD DETECTION LIMIT

** THE m-xylene o-XYLENE AND p-XYLENE ARE REPORTED AS A TOTAL OF THE [illegible]

Rev. [illegible]

ATTACHMENT II

(ALL UNITS ARE MICROGRAMS/LITER)

ANALYTE	CAS #	QUANTITATION LIMIT
BIS(2-CHLOROETHYL)ETHER	111-44-4	1.5
PHENOL	108-95-2	2
2-CHLOROPHENOL	95-57-8	2
1,3-DICHLOROBENZENE	541-73-1	2
1,4-DICHLOROBENZENE	106-46-7	2
1,2-DICHLOROBENZENE	95-50-1	2.5
BENZYL ALCOHOL	100-51-6	2
BIS(2-CHLOROISOPROPYL) ETHER	39638-32-9	2.5
2-METHYLPHENOL	95-48-7	1
HEXACHLOROETHANE	67-72-1	2
N-NITROSODIPROPYLAMINE	621-64-7	1.5
NITROBENZENE	98-95-3	2.5
4-METHYLPHENOL	106-44-5	1
ISOPHORONE	78-59-1	2.5
2-NITROPHENOL	88-75-5	2
2,4-DIMETHYLPHENOL	105-67-9	2
BIS(2-CHLOROETHOXY)METHANE	111-91-1	2.5
2,4-DICHLOROPHENOL	120-83-2	2
1,2,4-TRICHLOROBENZENE	120-82-1	2
NAPHTHALENE	91-20-3	2
4-CHLOROANILINE	106-47-8	2
HEXACHLOROBUTADIENE	87-68-3	2.5
BENZOIC ACID	65-85-0	20
2-METHYLNAPTHALENE	91-57-6	2
4-CHLORO-3-METHYLPHENOL	59-50-7	1.5
HEXACHLOROCYCLOPENTADIENE	77-47-4	2
2,4,6-TRICHLOROPHENOL	88-06-2	1.5
2,4,5-TRICHLOROPHENOL	95-95-4	1.5
2-CHLORONAPTHALENE	91-58-7	1.5
ACENAPTHYLENE	208-96-8	1.5
DIMETHYL PHTHALATE	131-11-3	1.5
2,6-DINITROTOLUENE	606-20-2	1
ACENAPHTHENE	83-32-9	1.5
3-NITROANILINE	99-09-2	2.5
DIBENZOFURAN	132-64-9	1
2,4-DINITROPHENOL	51-28-5	(15)
2,4-DINITROTOLUENE	121-14-2	1

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ATTACHMENT II

(CONTINUED) (ALL UNITS ARE MICROGRAMS/LITER)

ANALYTE	CAS *	QUANTITATION LIMIT
FLUORENE	86-73-7	1
4-NITROPHENOL	100-02-7	1.5
4-CHLOROPHENYL PHENYL ETHER	7005-72-3	1
DIETHYL PHTHALATE	84-66-2	1
4,6-DINITRO-2-METHYLPHENOL	534-52-1	(15)
N-NITROSODIPHENYLAMINE *	86-30-6	
DIPHENYLAMINE *	122-39-4	1.5
4-NITROANILINE	100-01-6	3
4-BROMOPHENYL PHENYL ETHER	101-55-3	1.5
HEXACHLOROBENZENE	118-74-1	1.5
PENTACHLOROPHENOL	87-86-5	2
PHENANTHRENE	85-01-8	1
ANTHRACENE	120-12-7	2.5
DI-n-BUTYL PHTHALATE	84-74-2	2
FLUORANTHENE	206-44-0	1.5
PYRENE	129-00-0	1.5
BUTYL BENZYL PHTHALATE	85-68-7	3.5
CHRYSENE **	218-01-9	
BENZO(a)ANTHRACENE **	56-55-3	1.5
BIS(2-ETHYLHEXYL) PHTHALATE	117-81-7	1
DI-n-OCTYL PHTHALATE	117-84-0	1.5
BENZO(b)FLUORANTHENE ***	205-99-2	
BENZO(k)FLUORANTHENE ***	207-08-9	1.5
BENZO(a)PYRENE	50-32-8	2
INDENO(1,2,3-cd)PYRENE	193-39-5	3.5
DIBENZO(a,h)ANTHRACENE	53-70-3	2.5
BENZO(g,h,i)PERYLENE	191-24-2	4
2-NITROANILINE *	88-74-4	1

* THESE TWO PARAMETERS ARE REPORTED AS A TOTAL
** THESE TWO PARAMETERS ARE REPORTED AS A TOTAL
*** THESE TWO PARAMETERS ARE REPORTED AS A TOTAL

VALUES IN PARENTHESES ARE ESTIMATES. ACTUAL VALUES ARE BEING DETERMINED AT THIS TIME.

6/8

Attachment II

Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL)*

		Quantitation Limits**
Pesticides/PCBs	CAS Number	Water ug/L
alpha-BHC	319-84-6	0.010
beta-BHC	319-85-7	0.005
delta-BHC	319-86-8	0.005
gamma-BHC (Lindane)	58-89-9	0.005
Heptachlor	76-44-8	0.030
Aldrin	309-00-2	0.005
Heptachlor epoxide	1024-57-3	0.005
Endosulfan I	959-98-8	0.010
Dieldrin	60-57-1	0.010
4,4'-DDE	72-55-9	0.005
Endrin	72-20-8	0.010
Endosulfan II	33213-65-9	0.010
4,4'-DDD	72-54-8	0.020
Endosulfan sulfate	1031-07-8	0.10
4,4'-DDT	50-29-3	0.020
Methoxychlor	72-43-5	0.020
Endrin ketone	53494-70-5	0.030
alpha-Chlordane	5103-71-9	0.020
gamma-Chlordane	5103-74-2	0.020
Toxaphene	8001-35-2	0.25
Aroclor-1016	12674-11-2	0.10
Aroclor-1221	11104-28-2	0.10
Aroclor-1232	11141-16-5	0.10
Aroclor-1242	53469-21-9	0.10
Aroclor-1248	12672-29-6	0.10
Aroclor-1254	11097-69-1	0.10
Aroclor-1260	11096-82-5	0.10

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Drinking Water (Inorganics)

.S. Environmental Protection Agency
CLP Sample Management Office
P. O. Box 818, Alexandria, Virginia 22313
PHONE: (703)/557-2490 or FTS/557-2490

SAS Number

Approved for Scheduling

________________ ________

Approved For Scheduling
APR 25 1988

SPECIAL ANALYTICAL SERVICES
Client Request

☒ Regional Transmittal ☐ Telephone Request

A. EPA Region/Client: V

B. RSCC Representative: Jan Pels

C. Telephone Number: (312) 353-2720

D. Date of Request:

E. Site Name: South Andover, Andover Minnesota

Please provide below a description of your request for Special Analytical Services under the Contract Laboratory Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Analysis of Drinking Water and/or residential well water for metals and cyanide using detection limits lower than SOW [illegible] SOW787 (See Attachment II) Six elements are to be determined by GFAA using the method of standard additions. GFAA analysis of samples free of particulates may be conducted on the undigested sample.

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration):

6 low-level residential well samples

3. Purpose of analysis (specify whether Superfund (Remedial or Enforcement), RCRA, NPDES, etc.):

Superfund Design Investigation (Remedial)

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~~5/87~~ 4/88

4. Estimated date(s) of collection: [October 1989?]

5. Estimated date(s) and method of shipment:

6. Number of days analysis and data required after laboratory receipt of samples: Laboratory should report results within 30 days after receipt of sample

7. Analytical protocol required (attach copy if other than a protocol currently used in this program): Inorganic analysis as per SOW 785, IFB WA-85-J838, with the exceptions listed in Attachments II & III. ICP emission spectroscopy, mercury, and cyanide analyses follow the SOW mentioned above for sample preparation and analysis protocol with the instrument detection limits and matrix spike levels given in Attachment II and the QC audits as described in Attachment III. GFAA analyses may be run undigested if the samples are free of particulates. If particulates are present the samples are to be digested as per SOW mentioned above. The ICP digest is to be used for Sb analyses, if digestion is required. A detailed set of instructions for conducting the GFAA analyses are included in Attachment III. Special instrument detection limits and matrix spike levels are listed on Attachment II.

8. Special technical instruction (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.): 1) Check the pH of each sample (wide range pH paper is acceptable). If the pH values are outside of the specified limits of SOW785, contact Region V for instructions.
2) Instrument Detection limits(IDL) of Attachment II are to be met prior to any sample analysis. 3) Spike Ca, Mg, Na and K and all other parameters as per Attachment II. The Spikes for these four analytes shall be to a separate aliquot unless documentation is provided that no contamination results for the other analytes.

The GFAA protocol is specified in Attachment III. The frequency and limits of certain audits are changed from that given in SOW 785 for all analyses as per Attachment III.

9. Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.). If not completed, format of results will be left to program discretion.

All of the deliverables included in SOW785 of CURRENT SOW are required. Also, provide current quarterly XI, XII, XIII for each case. Submit Form VIII separate for each separate parameter analyzed by MSA. Form VIII must be modified to include the slope of each addition as well as the correlation coefficient. Use footnotes on Form I for reporting results, except use IDL of Attachment II for detection limit. MAKE CHANGES ON FORMS V, VI, VII to Reflect SAS CONTRACT LIMITS AND IDL Where Appropriate.

10. Other (use additional sheets or attach supplementary information, as needed):

Name of sampling/shipping contact: Marcia Kuehl/Mike Whittington

Phone: (414) 458-8711

Please return this request to the Sample Management Office as soon as possible to expedite processing of your request for special analytical services. Should you have any questions or need any assistance please call the Sample Management Office.

I. DATA REQUIREMENTS

Parameter:	Detection Limit	Precision Desired (±% or Conc.)
ICP Metals	See Attachment II	10% RPD or Duplicate Differences ≤ SAS IDL of - Attachment II
Furnace Metals	" "	
Mercury, Cyanide	See Attachment II as per	SOW 785

II. QC REQUIREMENTS

Audits Required	Frequency of Audits	Limits* (% or Conc.)
For ICP -AES, Hg, and CN	See 9.A of Attachment III	
GFAA (undigested) As,Cd, Pb,Sb,Se,Tl	See 9.B of Attachment III	
GFAA (digested) As,Cd,Pb, Sb,Se,Tl	See 9.C of Attachment III	

III. ACTION REQUIRED IF LIMITS ARE EXCEEDED:

Take corrective action and repeat analysis

Contact Jay Thakkar
(312)886-1972

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ATTACHMENT II

Instrument Detection Limit and Spiking Level for Drinking Water

Compound	Required Instrument Detection Limit[1] ug/L			Required Matrix Spike Concentrations ug/L		
	GFAA	ICP	Other	GFAA	ICP	Other
Metal:						
1. Aluminum		100			2000	
2. Antimony [2]	5			20	500	
3. Arsenic	5			20		
4. Barium		50			2000	
5. Beryllium		5			50	
6. Cadmium [2]	0.5			2	50	
7. Calcium [3]		1000			50,000	
8. Chromium		10			200	
9. Cobalt		10			500	
10. Copper		10			250	
Iron		100			1000	
Lead [2]	2			20	500	
13. Magnesium [3]		1000			25,000	
14. Manganese		10			200	
15. Mercury			0.2			1.0
16. Nickel		20			400	
17. Potassium [3]		2000			20,000	
18. Selenium	2			10		
19. Silver		5			50	
20. Sodium [3]		1000			50,000	
21. Thallium	2			20		
22. Vanadium		10			500	
23. Zinc		20			200	
24. Cyanide			10			100

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[1] Instrument Detection Limits (IDL) must be met before any samples are analyzed. The Lab may submit their quarterly Form XI with each case if all IDLs meet the detection limits. IF Detectn LIMITS can not be met by USING ICP, USE OF GFAA REQUIRED.

[2] ICP analysis results may only be reported for Sb, Cd and Pb, if the concentration is ≥ 10 times the IDL of instrument used. If ICP results are reported, all ICP audits are required including matrix spike.

[3] port Ca, Mg, Na and K on separate Form V for Matrix Spike if a separate aliquot is
ed for this spike.

ATTACHMENT III

Special instructions for GFAA and QC requirements for all analyses.

1. Sample aliquots are preserved in the field as follows:
   a) One liter preserved with 5ml/l of 50% HNO_3 to pH<2 for all metals (excluding Hg).
   b) One liter sample preserved with 0.5% HNO_3 V/V and 0.05% $K_2Cr_2O_7$ W/V for Mercury.
   c) One liter of sample preserved with 5ml/l of 6N NaOH to pH $\geq$ 12 for cyanide determination.
2. Analysis of the six metals (specified in Attachment II) by graphite furnace atomic absorption (GFAA) must use the method of standard additions for quantitation.
3. All of the samples for GFAA metals can be analyzed without digestion if the samples are clean and without any particulates. In this case, a calibration blank, duplicate, ICVS, and CCVS shall be analyzed without digestion. if CCV is out, Rerun Previous 10 Samples and CCV
4. If any of the samples contain particulate or significant suspended solids, sample aliquots, preparation blank, duplicate, matrix spikes and lab control samples are to be digested per page D-2 of SOW785. The samples digested for ICP analysis are to be used for antimony determination.
5. No identified field blank may be used as a laboratory duplicate or matrix spike sample

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ATTACHMENT III

6.1 Zeeman, Smith/Hieftje background correction or equivalent (not D_2) is required for Arsenic, Selenium and Antimony or any element with structured background interferences.

6.2 The matrix modifiers of SOW785 are mandatory for As & Se.

6.3 L'vov platform is allowed.

6.4 Any matrix modifers for Sb, Cd, Pb and Tl must be approved by the Region V Central Regional Laboratory's Contract Project Management Section prior to use and documented with the raw data.

6.5 Each sample or QC audit is to be determined by the MSA using the sample or QC audit and then three consecutive spikes.

6.6 Each calibration blank and QC audit solution must contain the same nitric acid concentration as the sample (or diluted samples). All solutions analyzed must have their matrix concentrations fully documented in the raw data.

6.7 Each analytical determination must have the resulting absorbance clearly recorded and documented in the order of determined.

6.8 The data for each MSA determination must show; slope (signal/conc.), intercept and correlation coefficent (r). The results must be reported on Form VIII for all samples and QC audits in order of analysis. Form VIII must be modified to include the above mentioned slope.

6.9 Samples and QC audits will be tested in the following order for the method of standard addition quantitation.

a) calibration blank and + 3 spikes
b) ICVS (provided by EMSL-LV) +3 spikes
c) 5 samples, each with 3 spikes
d) calibration blank + 3 spikes
e) CCVS + 3 spikes
f) succeeding sets of 5 samples, cal. blank, and CCVS.

7. Report the correlation coefficient for all MSA analyses. r> 0.995 is required for all sample and audit analyses. A correlation coefficent (r) ≥ 0.998 is recommended for the calibration blank or problems will occur with the sample analysis. If r<0.995 or the slope is <35% of the initial calibration blank, reanalyze the sample once. If the standard addition again fails these criteria, Dilute sample 1:1 or minimum [illegible] and reanalyze. If the standard addition again fails, flag the data with a "+".

8. Care must be taken to avoid exceeding the linear range for all GFAA analyses. This problem is especially severe with Cd and Pb. Dilution of the samples may be necessary to avoid this problem. //

9 if Sample concentration Higher than the Highest spike Added Dilute Sample 1:1 and Reanalysed

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10 FOR MSA, use 10, 20, and 30 ug/L calibration standard, and FOR Cd, use 1, 2 and 3 ug/L calibration standards for 3 Spikes Addition

Q.C. REQUIREMENTS

. A ICP Metals, Mercury and Cyanide

Audits Required	Frequency of Audits	Limits
ICVS, CCVS, ICP serial dilution, ICP ICS, Distilled CN standard	as per SOW 785	as per SOW 785
Calibration Blank	Beginning of Run and 1 in 10 thereafter	≤ IDL
Preparation Blank	1 in 10 samples	< SAS IDL of Attachment II
Duplicate	1 in 10 samples	10% RPD or Difference is ≤ SAS IDL, 15% For Hg & CN
Matrix Spike (ICP)	1 in 10 samples	85 - 115% Recovery
Matrix Spike(ICP-Ca,Mg, Na, K)*	1 in 10 samples	85 - 115% Recovery
Matrix spike (Hg & CN)	1 in 10 samples	80 - 120%
Digested Lab Control Sample	1 per sample set	85 - 115%

*May be combined with other spike (cf item 8 of SAS)

B G.F.A.A. Undigested Samples

Audits Required	Frequency of Audits	Limits
1) Duplicate	1 in 10 samples	Difference of < SAS IDL of Attachment II or ≤ 10% RPD
2) Calibration Blank	Initially and after every 5 samples	≤ IDL
3) ICVS and CCVS	Initially ICVS,and CCVS after every 5 samples	90% - 110%

9.C GFAA Digested Samples

Audits Required	Frequency of Audits	Limits
1) Calibration Blank	Initially and after every 5 samples	≤ IDL
2) Preparation Blank (Digested)	1 in 10 samples	< SAS IDL of Attachment II
3) Duplicates (Digested)	1 in 10 samples	Difference of < SAS IDL or 10% RPD
4) Matrix Spike (Digested)	1 in 10 samples	85 - 115% Recovery
5) Lab Control Sample (Digested)	1 per set of samples	85 - 115% Recovery
6) ICVS, CCVS	Initially ICVS, and CCVS after every 5 samples	90 - 110% Recovery

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APPENDIX C

PHYSICAL SOIL TESTING ANALYTICAL METHODS

Particle Size
Atterberg Limits

W-20-50

Designation: D 422 – 63 (Reapproved 1972)$^{\epsilon 1}$

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race St., Philadelphia, Pa. 19103
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If not listed in the current combined index, will appear in the next edition

Standard Method for
PARTICLE-SIZE ANALYSIS OF SOILS[1]

This standard is issued under the fixed designation D 422; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

$^{\epsilon 1}$ Note—Section 2 was added editorially and subsequent sections renumbered in July 1984.

1. Scope

1.1 This method covers the quantitative determination of the distribution of particle sizes in soils. The distribution of particle sizes larger than 75 µm (retained on the No. 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 75 µm is determined by a sedimentation process, using a hydrometer to secure the necessary data (Notes 1 and 2).

NOTE 1—Separation may be made on the No. 4 (4.75-mm), No. 40 (425-µm), or No. 200 (75-µm) sieve instead of the No. 10. For whatever sieve used, the size shall be indicated in the report.

NOTE 2—Two types of dispersion devices are provided: (*1*) a high-speed mechanical stirrer, and (*2*) air dispersion. Extensive investigations indicate that air-dispersion devices produce a more positive dispersion of plastic soils below the 20-µm size and appreciably less degradation on all sizes when used with sandy soils. Because of the definite advantages favoring air dispersion, its use is recommended. The results from the two types of devices differ in magnitude, depending upon soil type, leading to marked differences in particle size distribution, especially for sizes finer than 20 µm.

2. Applicable Documents

2.1 *ASTM Standards:*

D421 Method for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[2]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[3]

E 100 Specification for ASTM Hydrometers[4]

3. Apparatus

3.1 *Balances*—A balance sensitive to 0.01 g for weighing the material passing a No. 10 (2.00-mm) sieve, and a balance sensitive to 0.1 % of the mass of the sample to be weighed for weighing the material retained on a No. 10 sieve.

3.2 *Stirring Apparatus*—Either apparatus A or B may be used.

3.2.1 Apparatus A shall consist of a mechanically operated stirring device in which a suitably mounted electric motor turns a vertical shaft at a speed of not less than 10 000 rpm without load. The shaft shall be equipped with a replaceable stirring paddle made of metal, plastic, or hard rubber, as shown in Fig. 1. The shaft shall be of such length that the stirring paddle will operate not less than ¾ in. (19.0 mm) nor more than 1½ in. (38.1 mm) above the bottom of the dispersion cup. A special dispersion cup conforming to either of the designs shown in Fig. 2 shall be provided to hold the sample while it is being dispersed.

3.2.2 Apparatus B shall consist of an air-jet dispersion cup[5] (Note 3) conforming to the general details shown in Fig. 3 (Notes 4 and 5).

NOTE 3—The amount of air required by an air-jet dispersion cup is of the order of 2 ft³/min; some small air compressors are not capable of supplying sufficient air to operate a cup.

NOTE 4—Another air-type dispersion device, known as a dispersion tube, developed by Chu and Davidson at Iowa State College, has been shown to give

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[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity, and Density Characteristics of Soils.

Current edition approved Nov. 21, 1963. Originally published 1935. Replaces D 422 – 62.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] *Annual Book of ASTM Standards*, Vol 14.01.

[5] Detailed working drawings for this cup are available at a nominal cost from the American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103. Order Adjunct No. 12-404220-00.

results equivalent to those secured by the air-jet dispersion cups. When it is used, soaking of the sample can be done in the sedimentation cylinder, thus eliminating the need for transferring the slurry. When the air-dispersion tube is used, it shall be so indicated in the report.

NOTE 5—Water may condense in air lines when not in use. This water must be removed, either by using a water trap on the air line, or by blowing the water out of the line before using any of the air for dispersion purposes.

3.3 *Hydrometer*—An ASTM hydrometer, graduated to read in either specific gravity of the suspension or grams per litre of suspension, and conforming to the requirements for hydrometers 151H or 152H in Specifications E 100. Dimensions of both hydrometers are the same, the scale being the only item of difference.

3.4 *Sedimentation Cylinder*—A glass cylinder essentially 18 in. (457 mm) in height and 2½ in. (63.5 mm) in diameter, and marked for a volume of 1000 mL. The inside diameter shall be such that the 1000-mL mark is 36 ± 2 cm from the bottom on the inside.

3.5 *Thermometer*—A thermometer accurate to 1°F (0.5°C).

3.6 *Sieves*—A series of sieves, of square-mesh woven-wire cloth, conforming to the requirements of Specification E 11. A full set of sieves includes the following (Note 6):

3-in. (75-mm)
2-in. (50-mm)
1½-in. (37.5-mm)
1-in. (25.0-mm)
¾-in. (19.0-mm)
⅜-in. (9.5-mm)
No. 4 (4.75-mm)
No. 10 (2.00-mm)
No. 20 (850-µm)
No. 40 (425-µm)
No. 60 (250-µm)
No. 140 (106-µm)
No. 200 (75-µm)

NOTE 6—A set of sieves giving uniform spacing of points for the graph, as required in Section 17, may be used if desired. This set consists of the following sieves:

3-in. (75-mm)
1½-in. (37.5-mm)
¾-in. (19.0-mm)
⅜-in. (9.5-mm)
No. 4 (4.75-mm)
No. 8 (2.36-mm)
No. 16 (1.18-mm)
No. 30 (600-µm)
No. 50 (300-µm)
No. 100 (150-µm)
No. 200 (75-µm)

3.7 *Water Bath or Constant-Temperature Room*—A water bath or constant-temperature room for maintaining the soil suspension at a constant temperature during the hydrometer analysis. A satisfactory water tank is an insulated tank that maintains the temperature of the suspension at a convenient constant temperature at or near 68°F (20°C). Such a device is illustrated in Fig. 4. In cases where the work is performed in a room at an automatically controlled constant temperature, the water bath is not necessar

3.8 *Beaker*—A beaker of 250-mL capaci

3.9 *Timing Device*—A watch or clock wi second hand

4. Dispersing Agent

4.1 A solution of sodium hexametaphosp (sometimes called sodium metaphosphate) s be used in distilled or demineralized water at rate of 40 g of sodium hexametaphosphate of solution (Note 7)

NOTE 7—Solutions of this salt, if acidic, slowl vert or hydrolyze back to the orthophosphate form w a resultant decrease in dispersive action. Soluti should be prepared frequently (at least once a mon or adjusted to pH of 8 or 9 by means of sodi carbonate. Bottles containing solutions should have date of preparation marked on them.

4.2 All water used shall be either distilled demineralized water. The water for a hydrome test shall be brought to the temperature that expected to prevail during the hydrometer te For example, if the sedimentation cylinder is be placed in the water bath, the distilled or d mineralized water to be used shall be brought the temperature of the controlled water bath, if the sedimentation cylinder is used in a roo with controlled temperature, the water for t test shall be at the temperature of the room. T basic temperature for the hydrometer test is 68 (20°C). Small variations of temperature do n introduce differences that are of practical sign icance and do not prevent the use of correctio derived as prescribed.

5. Test Sample

5.1 Prepare the test sample for mechanic analysis as outlined in Method D 421. Durir the preparation procedure the sample is divide into two portions. One portion contains onl particles retained on the No. 10 (2.00-mm) siev while the other portion contains only particle passing the No. 10 sieve. The mass of air-drie soil selected for purpose of tests, as prescribed i Method D 421, shall be sufficient to yield quantities for mechanical analysis as follows:

5.1.1 The size of the portion retained on th No. 10 sieve shall depend on the maximum siz of particle, according to the following schedule:

Nominal Diameter of Largest Particles, in. (mm)	Approximate Minimum Mass of Portion, g
⅜ (9.5)	500
¾ (19.0)	1000

Nominal Diameter of Largest Particles, in. (mm)	Approximate Minimum Mass of Portion, g
1 (25.4)	2000
1½ (38.1)	3000
2 (50.8)	4000
3 (76.2)	5000

5.1.2 The size of the portion passing the No. 10 sieve shall be approximately 115 g for sandy soils and approximately 65 g for silt and clay soils.

5.2 Provision is made in Section 5 of Method D 421 for weighing of the air-dry soil selected for purpose of tests, the separation of the soil on the No. 10 sieve by dry-sieving and washing, and the weighing of the washed and dried fraction retained on the No. 10 sieve. From these two masses the percentages retained and passing the No. 10 sieve can be calculated in accordance with 12.1.

NOTE 8—A check on the mass values and the thoroughness of pulverization of the clods may be secured by weighing the portion passing the No. 10 sieve and adding this value to the mass of the washed and oven-dried portion retained on the No. 10 sieve.

SIEVE ANALYSIS OF PORTION RETAINED ON NO. 10 (2.00-mm) SIEVE

6. Procedure

6.1 Separate the portion retained on the No. 10 (2.00-mm) sieve into a series of fractions using the 3-in. (75-mm), 2-in. (50-mm), 1½-in. (37.5-mm), 1-in. (25.0-mm), ¾-in. (19.0-mm), ⅜-in. (9.5-mm), No. 4 (4.75-mm), and No. 10 sieves, or as many as may be needed depending on the sample, or upon the specifications for the material under test.

6.2 Conduct the sieving operation by means of a lateral and vertical motion of the sieve, accompanied by a jarring action in order to keep the sample moving continuously over the surface of the sieve. In no case turn or manipulate fragments in the sample through the sieve by hand. Continue sieving until not more than 1 mass % of the residue on a sieve passes that sieve during 1 min of sieving. When mechanical sieving is used, test the thoroughness of sieving by using the hand method of sieving as described above.

6.3 Determine the mass of each fraction on a balance conforming to the requirements of 3.1. At the end of weighing, the sum of the masses retained on all the sieves used should equal closely the original mass of the quantity sieved.

HYDROMETER AND SIEVE ANALYSIS OF PORTION PASSING THE NO. 10 (2.00-mm) SIEVE

7. Determination of Composite Correction f Hydrometer Reading

7.1 Equations for percentages of soil remai
ing in suspension, as given in 14.3, are based o
the use of distilled or demineralized water
dispersing agent is used in the water, howeve
and the specific gravity of the resulting liquid
appreciably greater than that of distilled or d
mineralized water

7.1.1 Both soil hydrometers are calibrated
68°F (20°C), and variations in temperature fro
this standard temperature produce inaccurac
in the actual hydrometer readings. The amou
of the inaccuracy increases as the variation fro
the standard temperature increases.

7.1.2 Hydrometers are graduated by the ma
ufacturer to be read at the bottom of the meni
cus formed by the liquid on the stem. Since it
not possible to secure readings of soil suspensio
at the bottom of the meniscus, readings must
taken at the top and a correction applied.

7.1.3 The net amount of the corrections f
the three items enumerated is designated as t
composite correction, and may be determin
experimentally.

7.2 For convenience, a graph or table of com
posite corrections for a series of 1° temperatu
differences for the range of expected test temp
atures may be prepared and used as neede
Measurement of the composite corrections m
be made at two temperatures spanning the ran
of expected test temperatures, and corrections f
the intermediate temperatures calculated assu
ing a straight-line relationship between the t
observed values.

7.3 Prepare 1000 mL of liquid composed
distilled or demineralized water and dispersi
agent in the same proportion as will prevail
the sedimentation (hydrometer) test. Place t
liquid in a sedimentation cylinder and the c
inder in the constant-temperature water bath,
for one of the two temperatures to be used. Wh
the temperature of the liquid becomes consta
insert the hydrometer, and, after a short inter
to permit the hydrometer to come to the temp
ature of the liquid, read the hydrometer at t
top of the meniscus formed on the stem. F
hydrometer 151H the composite correction is t
difference between this reading and one; for h

drometer 152H it is the difference between the reading and zero. Bring the liquid and the hydrometer to the other temperature to be used, and secure the composite correction as before.

8. Hygroscopic Moisture

8.1 When the sample is weighed for the hydrometer test, weigh out an auxiliary portion of from 10 to 15 g in a small metal or glass container, dry the sample to a constant mass in an oven at 230 ± 9°F (110 ± 5°C), and weigh again. Record the masses.

9. Dispersion of Soil Sample

9.1 When the soil is mostly of the clay and silt sizes, weigh out a sample of air-dry soil of approximately 50 g. When the soil is mostly sand the sample should be approximately 100 g.

9.2 Place the sample in the 250-mL beaker and cover with 125 mL of sodium hexametaphosphate solution (40 g/l). Stir until the soil is thoroughly wetted. Allow to soak for at least 16 h.

9.3 At the end of the soaking period, disperse the sample further, using either stirring apparatus A or B. If stirring apparatus A is used, transfer the soil - water slurry from the beaker into the special dispersion cup shown in Fig. 2, washing any residue from the beaker into the cup with distilled or demineralized water (Note 9). Add distilled or demineralized water, if necessary, so that the cup is more than half full. Stir for a period of 1 min.

NOTE 9—A large size syringe is a convenient device for handling the water in the washing operation. Other devices include the wash-water bottle and a hose with nozzle connected to a pressurized distilled water tank.

9.4 If stirring apparatus B (Fig. 3) is used, remove the cover cap and connect the cup to a compressed air supply by means of a rubber hose. A air gage must be on the line between the cup and the control valve. Open the control valve so that the gage indicates 1 psi (7 kPa) pressure (Note 10). Transfer the soil - water slurry from the beaker to the air-jet dispersion cup by washing with distilled or demineralized water. Add distilled or demineralized water, if necessary, so that the total volume in the cup is 250 mL, but no more.

NOTE 10—The initial air pressure of 1 psi is required to prevent the soil - water mixture from entering the air-jet chamber when the mixture is transferred to the dispersion cup.

9.5 Place the cover cap on the cup and c
the air control valve until the gage pressure i
psi (140 kPa). Dispense the soil according to
following schedule:

Plasticity Index	Dispersion Period, min
Under 5	[illegible]
6 to 20	[illegible]
Over 20	[illegible]

Soils containing large percentages of mica r
be dispersed for only 1 min. After the disper
period, reduce the gage pressure to 1 psi pre
atory to transfer of soil - water slurry to the
imentation cylinder.

10. Hydrometer Test

10.1 Immediately after dispersion, transfer
soil - water slurry to the glass sedimentation
inder, and add distilled or demineralized w
until the total volume is 1000 mL.

10.2 Using the palm of the hand over the o
end of the cylinder (or a rubber stopper in
open end), turn the cylinder upside down
back for a period of 1 min to complete
agitation of the slurry (Note 11). At the end
min set the cylinder in a convenient location
take hydrometer readings at the following in
vals of time (measured from the beginning
sedimentation), or as many as may be nee
depending on the sample or the specification
the material under test: 2, 5, 15, 30, 60, 250,
1440 min. If the controlled water bath is u
the sedimentation cylinder should be place
the bath between the 2- and 5-min readings.

NOTE 11—The number of turns during this mi
should be approximately 60, counting the turn up
down and back as two turns. Any soil remaining in
bottom of the cylinder during the first few turns sh
be loosened by vigorous shaking of the cylinder w
it is in the inverted position.

10.3 When it is desired to take a hydrom
reading, carefully insert the hydrometer about
to 25 s before the reading is due to approxima
the depth it will have when the reading is tak
As soon as the reading is taken, carefully rem
the hydrometer and place it with a spinn
motion in a graduate of clean distilled or dem
eralized water.

NOTE 12—It is important to remove the hydrom
immediately after each reading. Readings shall be ta
at the top of the meniscus formed by the suspens
around the stem, since it is not possible to se
readings at the bottom of the meniscus.

10.4 After each reading, take the temperature of the suspension by inserting the thermometer into the suspension.

11. Sieve Analysis

11.1 After taking the final hydrometer reading, transfer the suspension to a No. 200 (75-μm) sieve and wash with tap water until the wash water is clear. Transfer the material on the No. 200 sieve to a suitable container, dry in an oven at 230 ± 9°F (110 ± 5°C) and make a sieve analysis of the portion retained, using as many sieves as desired, or required for the material, or upon the specification of the material under test.

CALCULATIONS AND REPORT

12. Sieve Analysis Values for the Portion Coarser than the No. 10 (2.00-mm) Sieve

12.1 Calculate the percentage passing the No. 10 sieve by dividing the mass passing the No. 10 sieve by the mass of soil originally split on the No. 10 sieve, and multiplying the result by 100. To obtain the mass passing the No. 10 sieve, subtract the mass retained on the No. 10 sieve from the original mass.

12.2 To secure the total mass of soil passing the No. 4 (4.75-mm) sieve, add to the mass of the material passing the No. 10 sieve the mass of the fraction passing the No. 4 sieve and retained on the No. 10 sieve. To secure the total mass of soil passing the ⅜-in. (9.5-mm) sieve, add to the total mass of soil passing the No. 4 sieve, the mass of the fraction passing the ⅜-in. sieve and retained on the No. 4 sieve. For the remaining sieves, continued the calculations in the same manner.

12.3 To determine the total percentage passing for each sieve, divide the total mass passing (see 12.2) by the total mass of sample and multiply the result by 100.

13. Hygroscopic Moisture Correction Factor

13.1 The hydroscopic moisture correction factor is the ratio between the mass of the oven-dried sample and the air-dry mass before drying. It is a number less than one, except when there is no hygroscopic moisture.

14. Percentages of Soil in Suspension

14.1 Calculate the oven-dry mass of soil used in the hydrometer analysis by multiplying the air-dry mass by the hygroscopic moisture correction factor.

14.2 Calculate the mass of a total sample represented by the mass of soil used in the hydrometer test, by dividing the oven-dry mass used by the percentage passing the No. 10 (2.00-mm) sieve, and multiplying the result by 100. This value is the weight W in the equation for percentage remaining in suspension.

14.3 The percentage of soil remaining in suspension at the level at which the hydrometer is measuring the density of the suspension may be calculated as follows (Note 13). For hydrometer 151H:

$$P = [(100\,000/W) \times G/(G - G_1)](R - G_1)$$

Note 13—The bracketed portion of the equation for hydrometer 151H is constant for a series of readings and may be calculated first and then multiplied by the portion in the parentheses.

For hydrometer 152H:

$$P = (Ra/W) \times 100$$

where:

a = correction faction to be applied to the reading of hydrometer 152H. (Values shown on the scale are computed using a specific gravity of 2.65. Correction factors are given in Table 1),

P = percentage of soil remaining in suspension at the level at which the hydrometer measures the density of the suspension,

R = hydrometer reading with composite correction applied (Section 7),

W = oven-dry mass of soil in a total test sample represented by mass of soil dispersed (see 14.2), g,

G = specific gravity of the soil particles, and

G_1 = specific gravity of the liquid in which soil particles are suspended. Use numerical value of one in both instances in the equation. In the first instance any possible variation produces no significant effect, and in the second instance, the composite correction for R is based on a value of one for G_1.

15. Diameter of Soil Particles

15.1 The diameter of a particle corresponding to the percentage indicated by a given hydrometer reading shall be calculated according to Stokes' law (Note 14), on the basis that a particle of this diameter was at the surface of the suspension at the beginning of sedimentation and had settled to the level at which the hydrometer is measuring the density of the suspension. According to Stokes' law:

$$D = \sqrt{[30n/980(G - G_1)] \times L/T}$$

where:

D = diameter of particle, mm,

n = coefficient of viscosity of the suspending medium (in this case water) in poises (varies with changes in temperature of the suspending medium),

L = distance from the surface of the suspension to the level at which the density of the suspension is being measured, cm. (For a given hydrometer and sedimentation cylinder, values vary according to the hydrometer readings. This distance is known as effective depth (Table 2)),

T = interval of time from beginning of sedimentation to the taking of the reading, min,

G = specific gravity of soil particles, and

G_1 = specific gravity (relative density) of suspending medium (value may be used as 1.000 for all practical purposes).

NOTE 14—Since Stokes' law considers the terminal velocity of a single sphere falling in an infinity of liquid, the sizes calculated represent the diameter of spheres that would fall at the same rate as the soil particles.

15.2 For convenience in calculations the above equation may be written as follows:

$$D = K\sqrt{L/T}$$

where:

K = constant depending on the temperature of the suspension and the specific gravity of the soil particles. Values of K for a range of temperatures and specific gravities are given in Table 3. The value of K does not change for a series of readings constituting a test, while values of L and T do vary.

15.3 Values of D may be computed with sufficient accuracy, using an ordinary 10-in. slide rule.

NOTE 15—The value of L is divided by T using the *A*- and *B*-scales, the square root being indicated on the *D*-scale. Without ascertaining the value of the square root it may be multiplied by K, using either the *C*- or *CI*-scale.

16. Sieve Analysis Values for Portion Finer than No. 10 (2.00-mm) Sieve

16.1 Calculation of percentages passing the various sieves used in sieving the portion of the sample from the hydrometer test involves several steps. The first step is to calculate the mass of the fraction that would have been retained on No. 10 sieve had it not been removed. This m is equal to the total percentage retained on No. 10 sieve (100 minus total percentage passi times the mass of the total sample represen by the mass of soil used (as calculated in 14 and the result divided by 100.

16.2 Calculate next the total mass passing No. 200 sieve. Add together the fractional mas retained on all the sieves, including the No sieve, and subtract this sum from the mass of t total sample (as calculated in 14.2).

16.3 Calculate next the total masses passi each of the other sieves, in a manner simila that given in 12.2.

16.4 Calculate last the total percentages pas ing by dividing the total mass passing (as calcu lated in 16.3) by the total mass of sample (a calculated in 14.2), and multiply the result b 100.

17. Graph

17.1 When the hydrometer analysis is per formed, a graph of the test results shall be made plotting the diameters of the particles on a loga rithmic scale as the abscissa and the percentage smaller than the corresponding diameters to ar arithmetic scale as the ordinate. When the hy drometer analysis is not made on a portion o the soil, the preparation of the graph is optional since values may be secured directly from tabulated data.

18. Report

18.1 The report shall include the following:

18.1.1 Maximum size of particles,

18.1.2 Percentage passing (or retained on) each sieve, which may be tabulated or presented by plotting on a graph (Note 16),

18.1.3 Description of sand and gravel particles:

18.1.3.1 Shape—rounded or angular,

18.1.3.2 Hardness—hard and durable, soft, or weathered and friable,

18.1.4 Specific gravity, if unusually high or low,

18.1.5 Any difficulty in dispersing the fraction passing the No. 10 (2.00-mm) sieve, indicating any change in type and amount of dispersing agent, and

18.1.6 The dispersion device used and the length of the dispersion period.

NOTE 16—This tabulation of graph represents the gradation of the sample tested. If particles larger than those contained in the sample were removed before testing, the report shall so state giving the amount and maximum size.

18.2 For materials tested for compliance with definite specifications, the fractions called for in such specifications shall be reported. The fractions smaller than the No. 10 sieve shall be read from the graph.

18.3 For materials for which compliance with definite specifications is not indicated and when the soil is composed almost entirely of particles passing the No. 4 (4.75-mm) sieve, the results read from the graph may be reported as follows:

(1) Gravel, passing 3-in. and retained on No. 4 sieve %
(2) Sand, passing No. 4 sieve and retained on No. 200 sieve %
  (a) Coarse sand, passing No. 4 sieve and retained on No. 10 sieve %
  (b) Medium sand, passing No. 10 sieve and retained on No. 40 sieve %
  (c) Fine sand, passing No. 40 sieve and retained on No. 200 sieve %
(3) Silt size, 0.074 to 0.005 mm %
(4) Clay size, smaller than 0.005 mm %
  Colloids, smaller than 0.001 mm %

18.4 For materials for which compliance with definite specifications is not indicated and when the soil contains material retained on the No. 4 sieve sufficient to require a sieve analysis on that portion, the results may be reported as follows (Note 17):

SIEVE ANALYSIS

Sieve Size	Percentage Passing
3-in	
2-in	
1½-in	
1-in	
¾-in	
⅜-in	
No. 4 (4.75-mm)	
No. 10 (2.00-mm)	
No. 40 (425-μm)	
No. 200 (75-μm)	

HYDROMETER ANALYSIS

0.074 mm	
0.005 mm	
0.001 mm	

NOTE 17—No. 8 (2.36-mm) and No. 50 (300-μm) sieves may be substituted for No. 10 and No. 40 sieves.

TABLE 1 Values of Correction Factor, a, for Different Specific Gravities of Soil Particles[A]

Specific Gravity	Correction Factor[A]
2.95	0.94
2.90	0.95
2.85	0.96
2.80	0.97
2.75	0.98
2.70	0.99
2.65	1.00
2.60	1.01
2.55	1.02
2.50	1.03
2.45	1.05

[A] For use in equation for percentage of soil remaining in suspension when using Hydrometer 152H.

TABLE 2 Values of Effective Depth Based on Hydrometer and Sedimentation Cylinder of Specified Sizes[A]

Hydrometer 151H		Hydrometer 152H			
Actual Hydrometer Reading	Effective Depth, L, cm	Actual Hydrometer Reading	Effective Depth, L, cm	Actual Hydrometer Reading	Effective Depth, L, cm
1.000	16.3	0	16.3	31	11.2
1.001	16.0	1	16.1	32	11.1
1.002	15.8	2	16.0	33	10.9
1.003	15.5	3	15.8	34	10.7
1.004	15.2	4	15.6	35	10.6
1.005	15.0	5	15.5		
1.006	14.7	6	15.3	36	10.4
1.007	14.4	7	15.2	37	10.2
1.008	14.2	8	15.0	38	10.1
1.009	13.9	9	14.8	39	9.9
1.010	13.7	10	14.7	40	9.7
1.011	13.4	11	14.5	41	9.6
1.012	13.1	12	14.3	42	9.4
1.013	12.9	13	14.2	43	9.2
1.014	12.6	14	14.0	44	9.1
1.015	12.3	15	13.8	45	8.9
1.016	12.1	16	13.7	46	8.8
1.017	11.8	17	13.5	47	8.6
1.018	11.5	18	13.3	48	8.4
1.019	11.3	19	13.2	49	8.3
1.020	11.0	20	13.0	50	8.1
1.021	10.7	21	12.9	51	7.9
1.022	10.5	22	12.7	52	7.8
1.023	10.2	23	12.5	53	7.6
1.024	10.0	24	12.4	54	7.4
1.025	9.7	25	12.2	55	7.3
1.026	9.4	26	12.0	56	7.1
1.027	9.2	27	11.9	57	7.0
1.028	8.9	28	11.7	58	6.8
1.029	8.6	29	11.5	59	6.6
1.030	8.4	30	11.4	60	6.5
1.031	8.1				
1.032	7.8				
1.033	7.6				
1.034	7.3				
1.035	7.0				
1.036	6.8				
1.037	6.5				
1.038	6.2				

[A] Values of effective depth are calculated from the equation:

$$L = L_1 + \frac{1}{2}\left(L_2 - \frac{V_B}{A}\right)$$

where

L = effective depth, cm

L_1 = distance along the stem of the hydrometer from the top of the bulb to the mark for a hydrometer reading, cm

L_2 = overall length of the hydrometer bulb, cm,

V_B = volume of hydrometer bulb, cm^3, and

A = cross-sectional area of sedimentation cylinder, cm^2

Values used in calculating the values in Table 2 are as follows:

For both hydrometers, 151H and 152H:

L_2 = 14.0 cm

V_B = 67.0 cm^3

A = 27.8 cm^2

For hydrometer 151H:

L_1 = 10.5 cm for a reading of 1.000

= 2.3 cm for a reading of 1.031

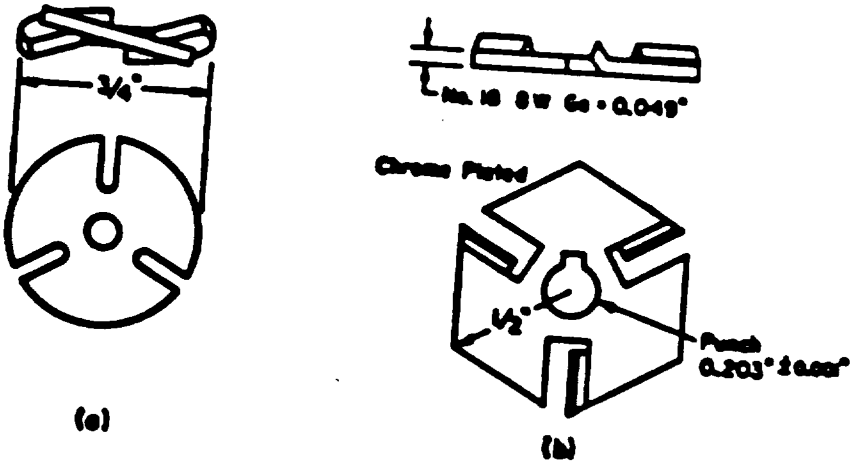
For hydrometer 152H:

L_1 = 10.5 cm for a reading of 0 g/litre

= 2.3 cm for a reading of 50 g/litre

TABLE 3 Values of K for Use in Equation for Computing Diameter of Particle in Hydrometer Analysis

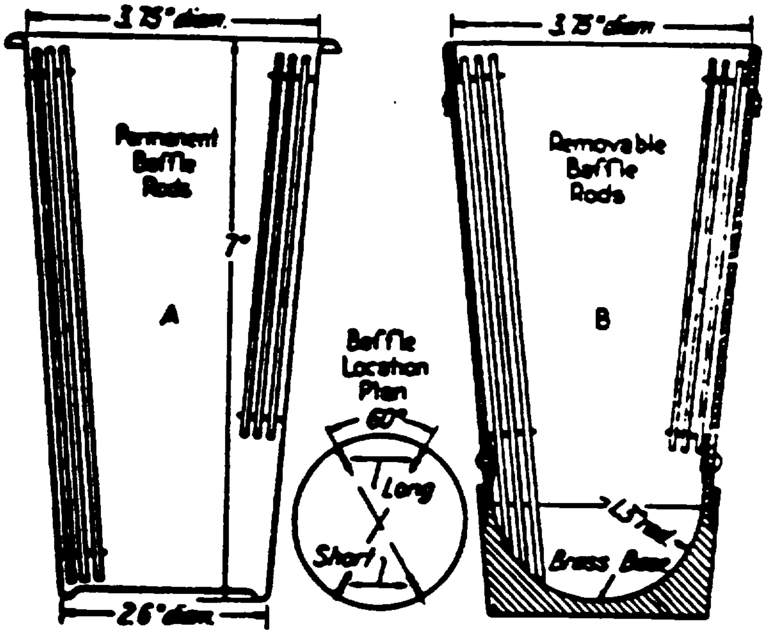
Temperature, °C	Specific Gravity of Soil Particles								
	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
16	0.01510	0.01505	0.01481	0.01457	0.01435	0.01414	0.01394	0.01374	0.01356
17	0.01511	0.01486	0.01462	0.01439	0.01417	0.01396	0.01376	0.01356	0.01338
18	0.01492	0.01467	0.01443	0.01421	0.01399	0.01378	0.01359	0.01339	0.01321
19	0.01474	0.01449	0.01425	0.01403	0.01382	0.01361	0.01342	0.01323	0.01305
20	0.01456	0.01431	0.01408	0.01386	0.01365	0.01344	0.01325	0.01307	0.01289
21	0.01438	0.01414	0.01391	0.01369	0.01348	0.01328	0.01309	0.01291	0.01273
22	0.01421	0.01397	0.01374	0.01353	0.01332	0.01312	0.01294	0.01276	0.01258
23	0.01404	0.01381	0.01358	0.01337	0.01317	0.01297	0.01279	0.01261	0.01243
24	0.01388	0.01365	0.01342	0.01321	0.01301	0.01282	0.01264	0.01246	0.01229
25	0.01372	0.01349	0.01327	0.01306	0.01286	0.01267	0.01249	0.01232	0.01215
26	0.01357	0.01334	0.01312	0.01291	0.01272	0.01253	0.01235	0.01218	0.01201
27	0.01342	0.01319	0.01297	0.01277	0.01258	0.01239	0.01221	0.01204	0.01188
28	0.01327	0.01304	0.01283	0.01264	0.01244	0.01225	0.01208	0.01191	0.01175
29	0.01312	0.01290	0.01269	0.01249	0.01230	0.01212	0.01195	0.01178	0.01162
30	0.01298	0.01276	0.01256	0.01236	0.01217	0.01199	0.01182	0.01165	0.01149



Metric Equivalents

in.	0.001	0.049	0.203	½	¾
mm	0.03	1.24	5.16	12.7	19.0

FIG. 1 Detail of Stirring Paddles



Metric Equivalents

in.	1.3	2.6	3.75
mm	33	66	95.2

FIG. 2 Dispersion Cups of Apparatus

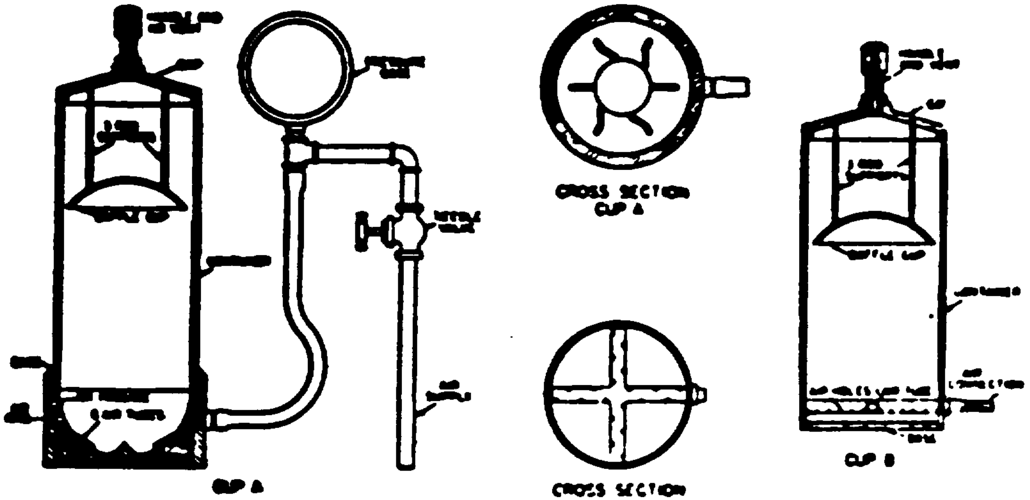
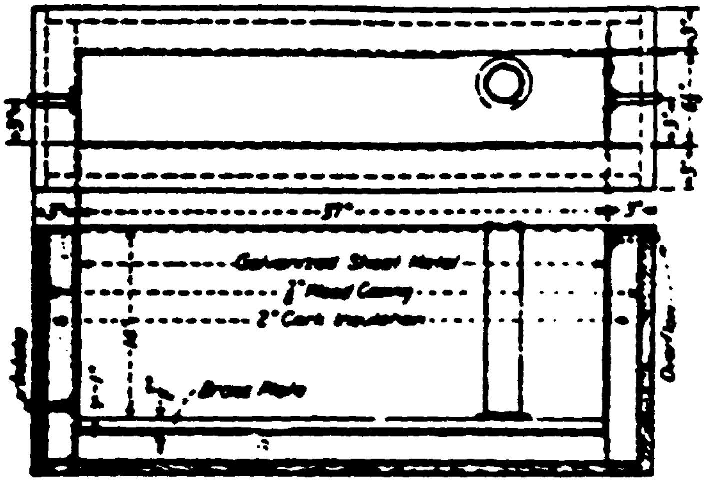


FIG. 3 Air-Jet Dispersion Cups of Apparatus B



Metric Equivalents

in	⅞	1	3	6¼	14	37
mm	22.2	25.4	76.2	158.7	356	940

FIG. 4 Insulated Water Bath

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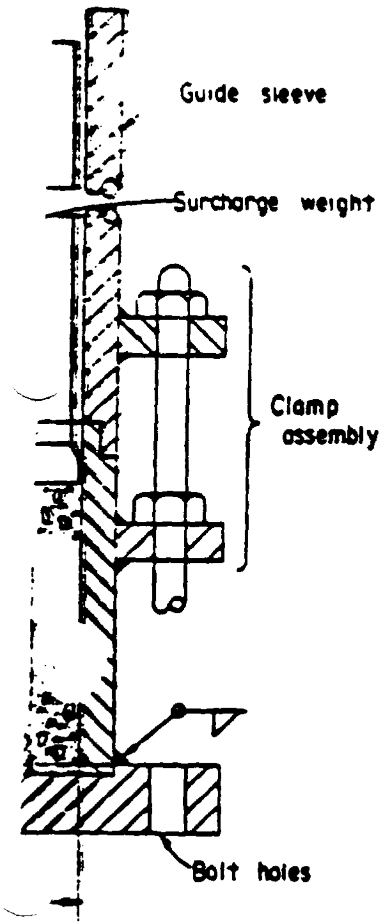

ameter

Designation: D 4318 – 84

Standard Test Method for
LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS[1]

This standard is issued under the fixed designation D 4318; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the liquid limit, plastic limit, and the plasticity index of soils as defined in Section 3.

1.1.1 Two procedures for preparing test specimens and two procedures for performing the liquid limit are provided as follows:

- *A* Multipoint test using a wet preparation procedure, described in Sections 10.1, 11, and 12.
- *B* Multipoint test using a dry preparation procedure, described in Sections 10.2, 11, and 12.
- *C* One-point test using a wet preparation procedure, described in Sections 13, 14, and 15.
- *D* One-point test using a dry preparation procedure, described in Sections 13, 14, and 15.

The procedure to be used shall be specified by the requesting authority. If no procedure is specified, Procedure A shall be used.

NOTE 1—Prior to the adoption of this test method, a curved grooving tool was specified as part of the apparatus for performing the liquid limit test. The curved tool is not considered to be as accurate as the flat tool described in 6.2 since it does not control the depth of the soil in the liquid limit cup. However, there are some data which indicate that typically the liquid limit is slightly increased when the flat tool is used instead of the curved tool.

1.1.2 The plastic limit test procedure is described in Sections 16, 17, and 18. The plastic limit test is performed on material prepared for the liquid limit test. In effect, there are two procedures for preparing test specimens for the plastic limit test.

1.1.3 The procedure for calculating the plasticity index is given in Section 19.

1.2 The liquid limit and plastic limit of soils (along with the shrinkage limit) are often collectively referred to as the Atterberg limits in recognition of their formation by Swedish soil scientist, A. Atterberg. These limits distinguish the boundaries of the several consistency states of plastic soils.

1.3 As used in this test method, soil is any natural aggregation of mineral or organic materials, mixtures of such materials, or artificial mixtures of aggregates and natural mineral and organic particles.

1.4 The multipoint liquid limit procedure is somewhat more time consuming than the one-point procedure when both are performed by experienced operators. However, the one-point procedure requires the operator to judge when the test specimen is approximately at its liquid limit. In cases where this is not done reliably, the multipoint procedure is as fast as the one-point procedure and provides additional precision due to the information obtained from additional trials. It is particularly recommended that the multipoint procedure be used by inexperienced operators.

1.5 The correlations on which the calculations of the one-point procedure are based may not be valid for certain soils, such as organic soils or soils from a marine environment. The liquid

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[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity and Density Characteristics of Soils.

Current edition approved Oct. 26, 1984. Published December 1984. Originally published as D 4318 – 83. Last previous edition D 4318 – 83$^{\epsilon 1}$.

limit of these soils should therefore be determined by the multipoint procedure (Procedure A).

1.6 The liquid and plastic limits of many soils that have been allowed to dry before testing may be considerably different from values obtained on undried samples. If the liquid and plastic limits of soils are used to correlate or estimate the engineering behavior of soils in their natural moist state, samples should not be permitted to dry before testing unless data on dried samples are specifically desired.

1.7 The composition and concentration of soluble salts in a soil affect the values of the liquid and plastic limits as well as the water content values of soils (see Method D 2216). Special consideration should therefore be given to soils from a marine environment or other sources where high soluble salt concentrations may be present. The degree to which the salts present in these soils are diluted or concentrated must be given consideration if meaningful results are to be obtained.

1.8 Since the tests described herein are performed only on that portion of a soil which passes the 425-μm (No. 40) sieve, the relative contribution of this portion of the soil to the properties of the sample as a whole must be considered when using these tests to evaluate the properties of a soil.

1.9 The values stated in acceptable metric units are to be regarded as the standard. The values given in parentheses are for information only.

1.10 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Applicable Documents

2.1 *ASTM Standards*

C 702 Methods for Reducing Field Samples of Aggregate to Testing Size[2]

D 75 Practice for Sampling Aggregates[3]

D 420 Recommended Practice for Investigating and Sampling Soil and Rock for Engineering Purposes[4]

D 653 Terms and Symbols Relating to Soil and Rock Mechanics[4]

D 1241 Specification for Materials for Soil-Aggregate Subbase, Base, and Surface Courses[4]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[4]

D 2240 Test Method for Rubber Property—Durometer Hardness[5]

D 2487 Test Method for Classification of Soils for Engineering Purposes[4]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[4]

D 3282 Practice for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes[4]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[6]

E 319 Methods of Testing Single-Arm Balances[6]

E 898 Method of Testing Top-Loading, Direct-Reading Laboratory Scales and Balances[6]

3. Definitions

3.1 *Atterberg limits*—originally, seven "limits of consistency" of fine-grained soils were defined by Albert Atterberg. In current engineering usage, the term usually refers only to the liquid limit, plastic limit, and in some references, the shrinkage limit.

3.2 *consistency*—the relative ease with which a soil can be deformed.

3.3 *liquid limit (LL)*—the water content, in percent, of a soil at the arbitrarily defined boundary between the liquid and plastic states. This water content is defined as the water content at which a pat of soil placed in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove for a distance of 13 mm (½ in.) when subjected to 25 shocks from the cup being dropped 10 mm in a standard liquid limit apparatus operated at a rate of 2 shocks per second.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vols 04.02, 04.03, and 04.08.

[4] *Annual Book of ASTM Standards*, Vol 04.08.

[5] *Annual Book of ASTM Standards*, Vol 09.01.

[6] *Annual Book of ASTM Standards*, Vol 14.02.

NOTE 2—The undrained s
liquid limit is considered to b

3.4 *plastic limit (PL)*—
percent, of a soil at the b
plastic and brittle states
this boundary is the water
can no longer be deform
mm (⅛ in.) in diameter t
bling.

3.5 *plastic soil*—a soil
water content over which
and which will retain its s

3.6 *plasticity index (PI*
content over which a so
Numerically, it is the diffe
uid limit and the plastic li

3.7 *liquidity index*—th
percentage, of (*1*) the natu
soil minus its plastic lim
index.

3.8 *activity number (A*
plasticity index of a soil
weight of particles having
smaller than 0.002 mm.

4. Summary of Method

4.1 The sample is pro
material retained on a 4
The liquid limit is deter
trials in which a portion c
in a brass cup, divided in
and then allowed to fl
shocks caused by repeated
a standard mechanical d
liquid limit. Procedures A
or more trials over a rang
be performed and the dat
or calculated to make a re
the liquid limit is deter
liquid limit. Procedures C
from two trials at one wa
by a correction factor to
limit.

4.2 The plastic limit i
nately pressing together
mm (⅛ in.) diameter thr
plastic soil until its water
point at which the threa
longer able to be pressed
The water content of th
reported as the plastic lim

Note 2—The undrained shear strength of soil at the liquid limit is considered to be 2 ±0.2 kPa (0.28 psi).

3.4 *plastic limit (PL)*—the water content, in percent, of a soil at the boundary between the plastic and brittle states. The water content at this boundary is the water content at which a soil can no longer be deformed by rolling into 3.2 mm (⅛ in.) in diameter threads without crumbling.

3.5 *plastic soil*—a soil which has a range of water content over which it exhibits plasticity and which will retain its shape on drying.

3.6 *plasticity index (PI)*—the range of water content over which a soil behaves plastically. Numerically, it is the difference between the liquid limit and the plastic limit.

3.7 *liquidity index*—the ratio, expressed as a percentage, of (*1*) the natural water content of a soil minus its plastic limit, to (*2*) its plasticity index.

3.8 *activity number (A)*—the ratio of (*1*) the plasticity index of a soil to (*2*) the percent by weight of particles having an equivalent diameter smaller than 0.002 mm.

4. Summary of Method

4.1 The sample is processed to remove any material retained on a 425-µm (No. 40) sieve. The liquid limit is determined by performing trials in which a portion of the sample is spread in a brass cup, divided in two by a grooving tool, and then allowed to flow together from the shocks caused by repeatedly dropping the cup in a standard mechanical device. The multipoint liquid limit, Procedures A and B, requires three or more trials over a range of water contents to be performed and the data from the trials plotted or calculated to make a relationship from which the liquid limit is determined. The one-point liquid limit, Procedures C and D, uses the data from two trials at one water content multiplied by a correction factor to determine the liquid limit.

4.2 The plastic limit is determined by alternately pressing together and rolling into a 3.2 mm (⅛ in.) diameter thread a small portion of plastic soil until its water content is reduced to a point at which the thread crumbles and is no longer able to be pressed together and rerolled. The water content of the soil at this stage is reported as the plastic limit.

4.3 The plasticity index is calculated as the difference between the liquid limit and the plastic limit.

5. Significance and Use

5.1 This test method is used as an integral part of several engineering classification systems to characterize the fine-grained fractions of soils (see Test Method D 2487 and Practice D 3282) and to specify the fine-grained fraction of construction materials (see Specification D 1241). The liquid limit, plastic limit, and plasticity index of soils are also used extensively, either individually or together with other soil properties to correlate with engineering behavior such as compressibility, permeability, compactibility, shrink-swell, and shear strength.

5.2 The liquid and plastic limits of a soil can be used with the natural water content of the soil to express its relative consistency or liquidity index and can be used with the percentage finer than 2-µm size to determine its activity number.

5.3 The one-point liquid limit procedure is frequently used for routine classification purposes. When greater precision is required, as when used for the acceptance of a material or for correlation with other test data, the multipoint procedure should be used.

5.4 These methods are sometimes used to evaluate the weathering characteristics of clay-shale materials. When subjected to repeated wetting and drying cycles, the liquid limits of these materials tend to increase. The amount of increase is considered to be a measure of a shale's susceptibility to weathering.

5.5 The liquid limit of a soil containing substantial amounts of organic matter decreases dramatically when the soil is oven-dried before testing. Comparison of the liquid limit of a sample before and after oven-drying can therefore be used as a qualitative measure of organic matter content of a soil.

6. Apparatus

6.1 *Liquid Limit Device*—A mechanical device consisting of a brass cup suspended from a carriage designed to control its drop onto a hard rubber base. A drawing showing the essential features of the device and the critical dimensions is given in Fig. 1. The design of the device may vary provided that the essential functions are of the tip of the grooving tool must be 7.9 to 8.1 mm.

NOTE 6—The width of the tip of grooving tools is conveniently checked using a pocket-sized measuring magnifier equipped with a millimetre scale. Magnifiers of this type are available from most laboratory supply companies. The depth of the tip of grooving tools can be checked using the depth measuring feature of vernier calipers.

9.2 *Adjustment of Height of Drop*—Adjust the height of drop of the cup so that the point on the cup that comes in contact with the base rises to a height of 10 ±0.2 mm. See Fig. 4 for proper location of the gage relative to the cup during adjustment.

NOTE 7—A convenient procedure for adjusting the height of drop is as follows: place a piece of masking tape across the outside bottom of the cup parallel with the axis of the cup hanger pivot. The edge of the tape away from the cup hanger should bisect the spot on the cup that contacts the base. For new cups, placing a piece of carbon paper on the base and allowing the cup to drop several times will mark the contact spot. Attach the cup to the device and turn the crank until the cup is raised to its maximum height. Slide the height gage under the cup from the front, and observe whether the gage contacts the cup or the tape. See Fig. 4. If the tape and cup are both contacted, the height of drop is approximately correct. If not, adjust the cup until simultaneous contact is made. Check adjustment by turning the crank at 2 revolutions per second while holding the gage in position against the tape and cup. If a ringing or clicking sound is heard without the cup rising from the gage, the adjustment is correct. If no ringing is heard or if the cup rises from the gage, readjust the height of drop. If the cup rocks on the gage during this checking operation, the cam follower pivot is excessively worn and the worn parts should be replaced. Always remove tape after completion of adjustment operation.

MULTIPOINT LIQUID LIMIT—PROCEDURES A AND B

10. Preparation of Test Specimens

10.1 *Wet Preparation*—Except where the dry method of specimen preparation is specified (10.2), prepare specimens for test as described in the following sections.

10.1.1 *Samples Passing the 425-µm (No. 40) Sieve*—When by visual and manual procedures it is determined that the sample has little or no material retained on a 425-µm (No. 40) sieve, prepare a specimen of 150 to 200 g by mixing thoroughly with distilled or demineralized water on the glass plate using the spatula. If desired, soak soil in a storage dish with small amount of water to soften the soil before the start of mixing. Adjust the water content of the soil to bring it to a consistency that would require 25 to 35 blows of the liquid limit device to close the groove (Note 8). If, during mixing, a small percentage of material is encountered that would be retained on a 425-µm (No. 40) sieve, remove these particles by hand, if possible. If it is impractical to remove the coarser material by hand, remove small percentages (less than about 15 %) of coarser material by working the specimen through a 425-µm (No. 40) sieve using a piece of rubber sheeting, rubber stopper, or other convenient device provided the operation does not distort the sieve or degrade material that would be retained if the washing method described in 10.1.2 were used. If larger percentages of coarse material are encountered during mixing, or it is considered impractical to remove the coarser material by the methods just described, wash the sample as described in 10.1.2. When the coarse particles found during mixing are concretions, shells, or other fragile particles, do not crush these particles to make them pass a 425-µm (No. 40) sieve, but remove by hand or by washing. Place the mixed soil in the storage dish, cover to prevent loss of moisture, and allow to stand for at least 16 h (overnight). After the standing period and immediately before starting the test, thoroughly remix the soil.

NOTE 8—The time taken to adequately mix a soil will vary greatly, depending on the plasticity and initial water content. Initial mixing times of more than 30 min may be needed for stiff, fat clays.

10.1.2 *Samples Containing Material Retained on a 425-µm (No. 40) Sieve:*

10.1.2.1 Select a sufficient quantity of soil at natural water content to provide 150 to 200 g of material passing the 425-µm (No. 40) sieve. Place in a pan or dish and add sufficient water to cover the soil. Allow to soak until all lumps have softened and the fines no longer adhere to the surfaces of the corase particles (Note 9).

NOTE 9—In some cases, the cations of salts present in tap water will exchange with the natural cations in the soil and significantly alter the test results should tap water be used in the soaking and washing operations. Unless it is known that such cations are not present in the tap water, distilled or demineralized water should be used. As a general rule, water containing more than 100 mg/L of dissolved solids should not be used for washing operations.

10.1.2.2 When the sample contains a large percentage of material retained on the 425-µm

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(No. 40) sieve, perform the
operation in increments, wa
0.5 kg (1 lb) of material at o
425-µm (No. 40) sieve in the
pan. Pour the soil water mixt
If gravel or coarse sand particl
as many of these as possible w
of water from a wash bottle.
natively, pour the soil water
mm (No. 10) sieve nested a
40) sieve, rinse the fine ma
remove the 2-mm (No. 10) s
and removing as much of the
possible, add sufficient water
the level to about 13 mm (½ in
of the 425-µm (No. 40) sieve
by stirring with the fingers
lowering the sieve in the pa
suspension so that fine mate
the coarser particles. Disaggre
that have not slaked by gently
the sieve with the fingertips. (
ing operation by raising the si
surface and rinsing the mate
small amount of clean wate
retained on the 425-µm (No.

10.1.2.3 Reduce the water
terial passing the 425-µm (N
approaches the liquid limit.
content may be accomplishe
bination of the following me
the air currents at ordinary
(*b*) exposing to warm air cur
such as an electric hair drye
Buckner funnel or using fil
canting clear water from sur
or (*e*) draining in a colande
dish lined with high retentivi
filter paper.[7] *If a plast* *of pa*
care that the dish never b
saturated that it fails to active
its surface. Thoroughl dry c
During evaporation and coo
often enough to prevent over
and soil pinnacles on the sur
For soil samples containing
method of water reduction
will not eliminate the w
specimen

10.1.2.4 Thoroughly mix
the 425-µm (No. 40) siev on
the spatula. Adjust the water
ture, if necessary, by adding

(No. 40) sieve, perform the following washing operation in increments, washing no more than 0.5 kg (1 lb) of material at one time. Place the 425-μm (No. 40) sieve in the bottom of the clean pan. Pour the soil water mixture onto the sieve. If gravel or coarse sand particles are present, rinse as many of these as possible with small quantities of water from a wash bottle, and discard. Alternatively, pour the soil water mixture over a 2-mm (No. 10) sieve nested atop the 425-μm (No. 40) sieve, rinse the fine material through and remove the 2-mm (No. 10) sieve. After washing and removing as much of the coarser material as possible, add sufficient water to the pan to bring the level to about 13 mm (½ in.) above the surface of the 425-μm (No. 40) sieve. Agitate the slurry by stirring with the fingers while raising and lowering the sieve in the pan and swirling the suspension so that fine material is washed from the coarser particles. Disaggregate fine soil lumps that have not slaked by gently rubbing them over the sieve with the fingertips. Complete the washing operation by raising the sieve above the water surface and rinsing the material retained with a small amount of clean water. Discard material retained on the 425-μm (No. 40) sieve.

10.1.2.3 Reduce the water content of the material passing the 425-μm (No. 40) sieve until it approaches the liquid limit. Reduction of water content may be accomplished by one or a combination of the following methods: (*a*) exposing the air currents at ordinary room temperature, (*b*) exposing to warm air currents from a source such as an electric hair dryer, (*c*) filtering in a Buckner funnel or using filter candles, (*d*) decanting clear water from surface of suspension, or (*e*) draining in a colander or plaster of paris dish lined with high retentivity, high wet-strength filter paper.[7] If a plaster of paris dish is used, take care that the dish never becomes sufficiently saturated that it fails to actively absorb water into its surface. Thoroughly dry dishes between uses. During evaporation and cooling, stir the sample often enough to prevent overdrying of the fringes and soil pinnacles on the surface of the mixture. For soil samples containing soluble salts, use a method of water reduction such as *a* or *b* that will not eliminate the soluble salts from the test specimen.

10.1.2.4 Thoroughly mix the material passing the 425-μm (No. 40) sieve on the glass plate using the spatula. Adjust the water content of the mixture, if necessary, by adding small increments of distilled or demineralized water or by allowing the mixture to dry at room temperature while mixing on the glass plate. The soil should be at a water content that will result in closure of the groove in 25 to 35 blows. Return the mixed soil to the mixing dish, cover to prevent loss of moisture, and allow to stand for at least 16 h. After the standing period, and immediately before starting the test, remix the soil thoroughly.

10.2 *Dry Preparation*

10.2.1 Select sufficient soil to provide 150 to 200 g of material passing the 425-μm (No. 40) sieve after processing. Dry the sample at room temperature or in an oven at a temperature not exceeding 60°C until the soil clods will pulverize readily. Disaggregation is expedited if the sample is not allowed to completely dry. However, the soil should have a dry appearance when pulverized. Pulverize the sample in a mortar with a rubber tipped pestal or in some other way that does not cause breakdown of individual grains. When the coarse particles found during pulverization are concretions, shells, or other fragile particles, do not crush these particles to make them pass a 425-μm (No. 40) sieve, but remove by hand or other suitable means, such as washing.

10.2.2 Separate the sample on a 425-μm (No. 40) sieve, shaking the sieve by hand to assure thorough separation of the finer fraction. Return the material retained on the 425-μm (No. 40) sieve to the pulverizing apparatus and repeat the pulverizing and sieving operations as many times as necessary to assure that all finer material has been disaggregated and material retained on the 425-μm (No. 40) sieve consists only of individual sand or gravel grains.

10.2.3 Place material remaining on the 425-μm (No. 40) sieve after the final pulverizing operations in a dish and soak in a small amount of water. Stir the soil water mixture and pour over the 425-μm (No. 40) sieve, catching the water and any suspended fines in the washing pan. Pour this suspension into a dish containing the dry soil previously sieved through the 425-μm (No. 40) sieve. Discard material retained on the 425-μm (No. 40) sieve.

10.2.4 Adjust the water content as necessary by drying as described in 10.1.2.3 or by mixing on the glass plate, using the spatula while adding increments of distilled or demineralized water.

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[7] S and S 595 filter paper, available in 32-cm circles, has proven satisfactory.

until the soil is at a water content that will result in closure of the groove in 25 to 35 blows.

10.2.5 Put soil in the storage dish, cover to prevent loss of moisture and allow to stand for at least 16 h. After the standing period, and immediately before starting the test, thoroughly remix the soil (Note 8).

11. Procedure

11.1 Place a portion of the prepared soil in the cup of the liquid limit device at the point where the cup rests on the base, squeeze it down, and spread it into the cup to a depth of about 10 mm at its deepest point, tapering to form an approximately horizontal surface. Take care to eliminate air bubbles from the soil pat but form the pat with as few strokes as possible. Heap the unused soil on the glass plate and cover with the inverted storage dish or a wet towel.

11.2 Form a groove in the soil pat by drawing the tool, beveled edge forward, through the soil on a line joining the highest point to the lowest point on the rim of the cup. When cutting the groove, hold the grooving tool against the surface of the cup and draw in an arc, maintaining the tool perpendicular to the surface of the cup throughout its movement. See Fig. 5. In soils where a groove cannot be made in one stroke without tearing the soil, cut the groove with several strokes of the grooving tool. Alternatively, cut the groove to slightly less than required dimensions with a spatula and use the grooving tool to bring the groove to final dimensions. Exercise extreme care to prevent sliding the soil pat relative to the surface of the cup.

11.3 Verify that no crumbs of soil are present on the base or the underside of the cup. Lift and drop the cup by turning the crank at a rate of 1.9 to 2.1 drops per second until the two halves of the soil pat come in contact at the bottom of the groove along a distance of 13 mm (½ in.). See Fig. 6.

NOTE 10—Use the end of the grooving tool, Fig. 2, or a scale to verify that the groove has closed 13 mm (½ in.).

11.4 Verify that an air bubble has not caused premature closing of the groove by observing that both sides of the groove have flowed together with approximately the same shape. If a bubble has caused premature closing of the groove, reform the soil in the cup, adding a small amount of soil to make up for that lost in the grooving operation and repeat 11.1 to 11.3. If the soil slides on the surface of the cup, repeat 11.1 through 11.3 at a higher water content. If, after several trials at successively higher water contents, the soil pat continues to slide in the cup or if the number of blows required to close the groove is always less than 25, record that the liquid limit could not be determined, and report the soil as nonplastic without performing the plastic limit test.

11.5 Record the number of drops, N, required to close the groove. Remove a slice of soil approximately the width of the spatula, extending from edge to edge of the soil cake at right angles to the groove and including that portion of the groove in which the soil flowed together, place in a weighed container, and cover.

11.6 Return the soil remaining in the cup to the glass plate. Wash and dry the cup and grooving tool and reattach the cup to the carriage in preparation for the next trial.

11.7 Remix the entire soil specimen on the glass plate adding distilled water to increase the water content of the soil and decrease the number of blows required to close the groove. Repeat 11.1 through 11.6 for at least two additional trials producing successively lower numbers of blows to close the groove. One of the trials shall be for a closure requiring 25 to 35 blows, one for closure between 20 and 30 blows, and one trial for a closure requiring 15 to 25 blows.

11.8 Determine the water content, W_N, of the soil specimen from each trial in accordance with Method D 2216. Make all weighings on the same balance. Initial weighings should be performed immediately after completion of the test. If the test is to be interrupted for more than about 15 min, the specimens already obtained should be weighed at the time of the interruption.

12. Calculations

12.1 Plot the relationship between the water content, W_N, and the corresponding number of drops, N, of the cup on a semilogarithmic graph with the water content as ordinates on the arithmetical scale, and the number of drops as abscissas on the logarithmic scale. Draw the best straight line through the three or more plotted points.

12.2 Take the water content corresponding to the intersection of the line with the 25-drop abscissa as the liquid limit of the soil. Computa-

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tional methods may be subst
ical method for fitting a stra
and determining the liquid li

ONE-POINT LIQUID LIMI
C AND D

13. Preparation of Test Spec

13.1 Prepare the specimen
ner as described in Section
mixing, adjust the water cont
requiring 20 to 30 drops of t
to close the groove.

14. Procedure

14.1 Proceed as describe
11.5 except that the number
close the groove shall be 20 t
or more than 30 blows are r
water content of the soil an
dure.

14.2 Immediately after r
content specimen as describ
the soil in the cup, adding
soil to make up for that lost
water content sampling oper
through 11.5, and, if the sec
groove requires the same num
more than two drops differen
water content specimen. Ot
entire specimen and repeat.

NOTE 11—Excessive drying o
will cause the number of blows to

14.3 Determine water con
as described in 11.8.

15. Calculations

15.1 Determine the liquid l
content specimen using one
equations:

$$LL = W_N\left(\frac{N}{25}\right)$$

$$LL = KW_N$$

where:

N = the number of blows ca
groove at water conten
W_N = water content, and
K = a factor given in Table

The liquid limit is the aver
liquid limit values.

15.2 If the difference betw

tional methods may be substituted for the graphical method for fitting a straight line to the data and determining the liquid limit.

ONE-POINT LIQUID LIMIT—PROCEDURES C AND D

13. Preparation of Test Specimens

13.1 Prepare the specimen in the same manner as described in Section 10, except that at mixing, adjust the water content to a consistency requiring 20 to 30 drops of the liquid limit cup to close the groove.

14. Procedure

14.1 Proceed as described in 11.1 through 11.5 except that the number of blows required to close the groove shall be 20 to 30. If less than 20 or more than 30 blows are required, adjust the water content of the soil and repeat the procedure.

14.2 Immediately after removing a water content specimen as described in 11.5, reform the soil in the cup, adding a small amount of soil to make up for that lost in the grooving and water content sampling operations. Repeat 11.2 through 11.5, and, if the second closing of the groove requires the same number of drops or no more than two drops difference, secure another water content specimen. Otherwise, remix the entire specimen and repeat.

NOTE 11—Excessive drying or inadequate mixing will cause the number of blows to vary.

14.3 Determine water contents of specimens as described in 11.8.

15. Calculations

15.1 Determine the liquid limit for each water content specimen using one of the following equations:

$$LL = W^N \left(\frac{N}{25}\right)^{0.121} \quad \text{or}$$

$$LL = k(W^N)$$

where:

N = the number of blows causing closure of the groove at water content,

W^N = water content, and

k = a factor given in Table 1

The liquid limit is the average of the two trial liquid limit values.

15.2 If the difference between the two trial liquid limit values is greater than one percentage point, repeat the test.

PLASTIC LIMIT

16. Preparation of Test Specimen

16.1 Select a 20-g portion of soil from the material prepared for the liquid limit test, either after the second mixing before the test, or from the soil remaining after completion of the test. Reduce the water content of the soil to a consistency at which it can be rolled without sticking to the hands by spreading and mixing continuously on the glass plate. The drying process may be accelerated by exposing the soil to the air current from an electric fan, or by blotting with paper that does not add any fiber to the soil, such as hard surface paper toweling or high wet strength filter paper.

17. Procedure

17.1 From the 20-g mass, select a portion of 1.5 to 2.0 g. Form the test specimen into an ellipsoidal mass. Roll this mass between the palm or fingers and the ground-glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length (Note 12). The thread shall be further deformed on each stroke so that its diameter is continuously reduced and its length extended until the diameter reaches 3.2 ±0.5 mm (0.125 ±.020 in.), taking no more than 2 min (Note 13). The amount of hand or finger pressure required will vary greatly, according to the soil. Fragile soils of low plasticity are best rolled under the outer edge of the palm or at the base of the thumb.

NOTE 12—A normal rate of rolling for most soils should be 80 to 90 strokes per minute, counting a stroke as one complete motion of the hand forward and back to the starting position. This rate of rolling may have to be decreased for very fragile soils.

NOTE 13—A 3.2-mm (⅛-in.) diameter rod or tube is useful for frequent comparison with the soil thread to ascertain when the thread has reached the proper diameter, especially for inexperienced operators.

17.1.1 When the diameter of the thread becomes 3.2 mm, break the thread into several pieces. Squeeze the pieces together, knead between the thumb and first finger of each hand, reform into an ellipsoidal mass, and reroll. Continue this alternate rolling to a thread 3.2 mm in diameter, gathering together, kneading and rerolling, until the thread crumbles under the pressure required for rolling and the soil can no longer be rolled into a 3.2-mm diameter thread (See Fig. 7). It has no significance if the thread breaks into threads of shorter length. Roll each of these shorter threads to 3.2 mm in diameter. The only requirement for continuing the test is that they are able to be reformed into an ellipsoidal mass and rolled out again. The operator shall at no time attempt to produce failure at exactly 3.2 mm diameter by allowing the thread to reach 3.2 mm, then reducing the rate of rolling or the hand pressure, or both, while continuing the rolling without further deformation until the thread falls apart. It is permissible, however, to reduce the total amount of deformation for feebly plastic soils by making the initial diameter of the ellipsoidal mass nearer to the required 3.2-mm final diameter. If crumbling occurs when the thread has a diameter greater than 3.2 mm, this shall be considered a satisfactory end point, provided the soil has been previously rolled into a thread 3.2 mm in diameter. Crumbling of the thread will manifest itself differently with the various types of soil. Some soils fall apart in numerous small aggregations of particles, others may form an outside tubular layer that starts splitting at both ends. The splitting progresses toward the middle, and finally, the thread falls apart in many small platy particles. Fat clay soils require much pressure to deform the thread, particularly as they approach the plastic limit. With these soils, the thread breaks into a series of barrel-shaped segments about 3.2 to 9.5 mm (⅛ to ⅜ in.) in length.

17.2 Gather the portions of the crumbled thread together and place in a weighed container. Immediately cover the container.

17.3 Select another 1.5 to 2.0 g portion of soil from the original 20-g specimen and repeat the operations described in 17.1 and 17.2 until the container has at least 6 g of soil.

17.4 Repeat 17.1 through 17.3 to make another container holding at least 6 g of soil. Determine the water content, in percent, of the soil contained in the containers in accordance with Method D 2216. Make all weighings on the same balance.

NOTE 14—The intent of performing two plastic limit trials is to verify the consistency of the test results. It is acceptable practice to perform only one plastic limit trial when the consistency in the test results can be confirmed by other means.

18. Calculations

18.1 Compute the average of the two water contents. If the difference between the two water contents is greater than two percentage points, repeat the test. The plastic limit is the average of the two water contents.

PLASTICITY INDEX

19. Calculations

19.1 Calculate the plasticity index as follows:

$$PI = LL - PL$$

where:

LL = the liquid limit,
PL = the plastic limit.

Both LL and PL are whole numbers. If either the liquid limit or plastic limit could not be determined, or if the plastic limit is equal to or greater than the liquid limit, report the soil as nonplastic, NP.

20. Report

20.1 Report the following information:

20.1.1 Sample identifying information,

20.1.2 Any special specimen selection process used, such as removal of sand lenses from undisturbed sample,

20.1.3 Report sample as airdried if the sample was airdried before or during preparation,

20.1.4 Liquid limit, plastic limit, and plasticity index to the nearest whole number and omitting the percent designation. If the liquid limit or plastic limit tests could not be performed, or if the plastic limit is equal to or greater than the liquid limit, report the soil as nonplastic, NP,

20.1.5 An estimate of the percentage of sample retained on the 425-μm (No. 40) sieve, and

20.1.6 Procedure by which liquid limit was performed, if it differs from the multipoint method.

21. Precision and Bias

21.1 No interlaboratory testing program has as yet been conducted using this test method to determine multilaboratory precision.

21.2 The within laboratory precision of the results of tests performed by different operators at one laboratory on two soils using Procedure A for the liquid limit is shown in Table 2.

TABLE 1 Factors for Obtaining
Content and Number of Drops

N (Number of Drops)	(F
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	

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centage points.
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could not be
is equal to or
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ber and omit-
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uid limit was
e multipoint

program has
st method to
n.
cision of the
ent operators
Procedure A
e 2.

TABLE 1 Factors for Obtaining Liquid Limit from Water Content and Number of Drops Causing Closure of Groove

N (Number of Drops)	k (Factor for Liquid Limit)
20	0.974
21	0.979
22	0.985
23	0.990
24	0.995
25	1.000
26	1.005
27	1.009
28	1.014
29	1.018
30	1.022

TABLE 2 Within Laboratory Precision for Liquid Limit

	Average Value, (	Standard Deviation, *s*
Soil A:		
PL	21.9	1.07
LL	27.9	1.07
Soil B:		
PL	20.1	1.21
LL	32.6	0.98

DIMENSIONS

LETTER	A▲	B▲	C▲	E▲	F	G	H	J▲	K▲	L▲	M▲
MM	54 ± 0.5	2 ± 0.1	27 ± 0.5	56 ± 2.0	32	10	16	60 ± 1.0	50 ± 2.0	150 ± 2.0	125 ± 2.0

LETTER	N	P	R	T	U▲	V	W	Z
MM	24	28	24	45	47 ± 1.0	3.8	13	6.5

▲ ESSENTIAL DIMENSIONS

CAM ANGLE DEGREES	CAM RADIUS
0	0.742 R
30	0.753 R
60	0.764 R
90	0.773 R
120	0.784 R
150	0.796 R
180	0.818 R
210	0.854 R
240	0.901 R
270	0.945 R
300	0.974 R
330	0.99[illegible] R
360	1.000 R

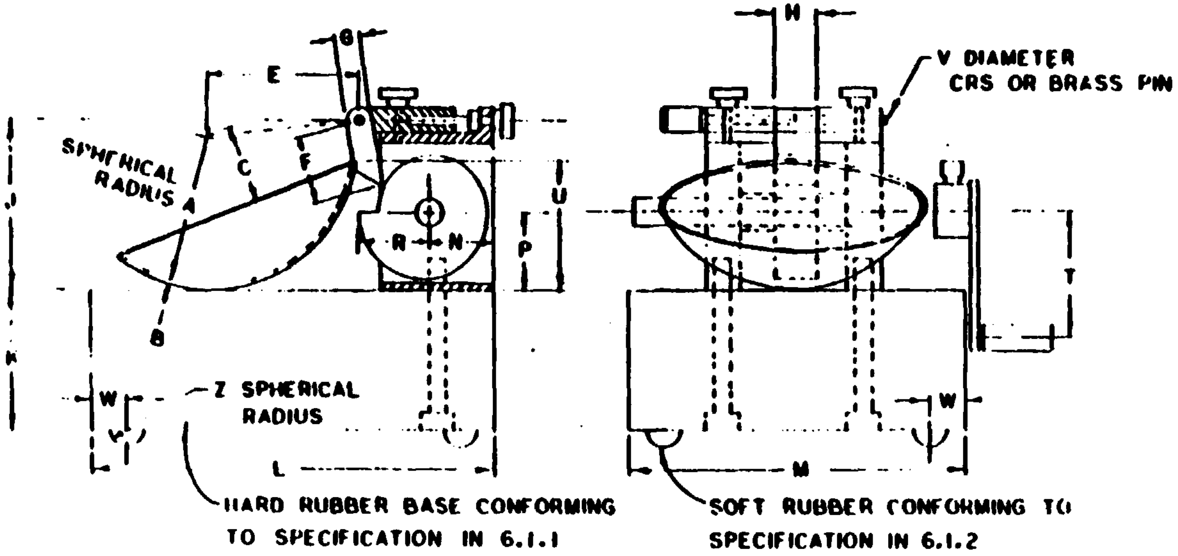
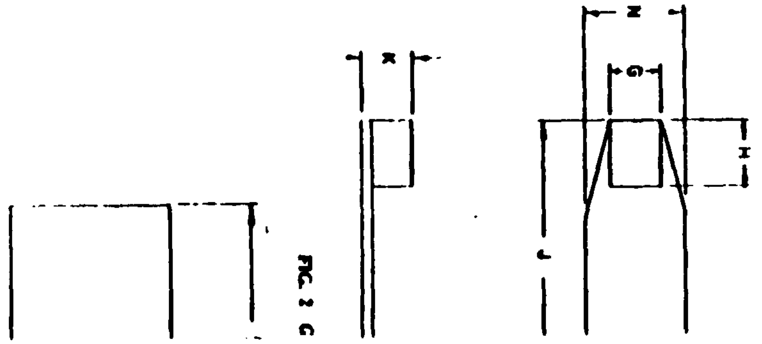


FIG. 1 Hand-Operated Liquid Limit Device



DIMENSIONS

LETTER	A▲	B▲	C▲	D▲	E▲	F▲
MM	2 ± 0.1	11 ± 0.2	40 ± 0.5	8 ± 0.1	50 ± 0.5	2 ± 0.1
LETTER	G	H	J	K▲	L▲	N
MM	10 MINIMUM	13	60	10 ±0.05	60 DEG ± 1 DEG	20

▲ *ESSENTIAL DIMENSIONS*

B *BACK AT LEAST 15 MM FROM TIP*

NOTE : DIMENSION A SHOULD BE 1.9–2.0 AND DIMENSION D SHOULD BE 8.0–8.1 WHEN NEW TO ALLOW FOR ADEQUATE SERVICE LIFE

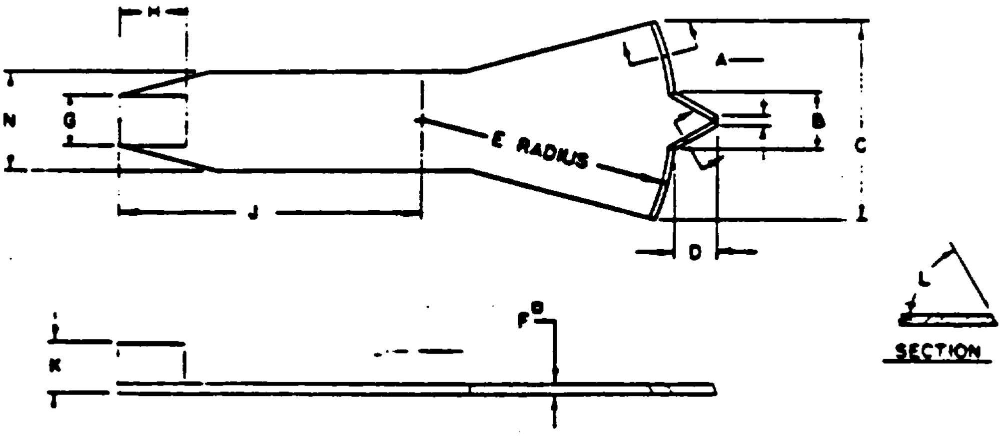
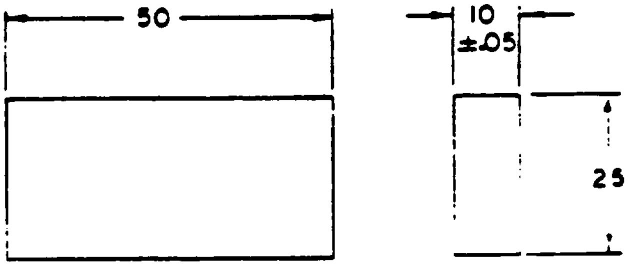


FIG. 2 Grooving Tool (Optional Height-of-Drop Gage Attached)



DIMENSIONS IN MILLIMETRES

FIG. 3 Height of Drop Gage

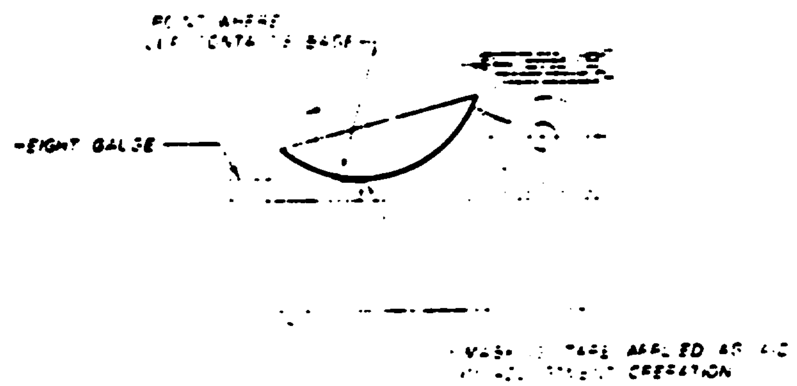


FIG. 4 Calibration for Height of Drop

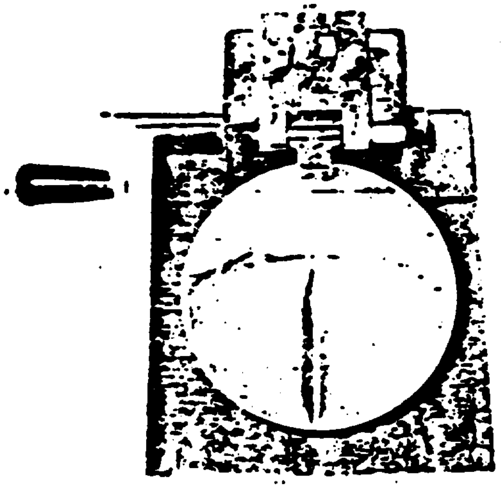


FIG. 5 Grooved Soil Pat in Liquid Limit Device

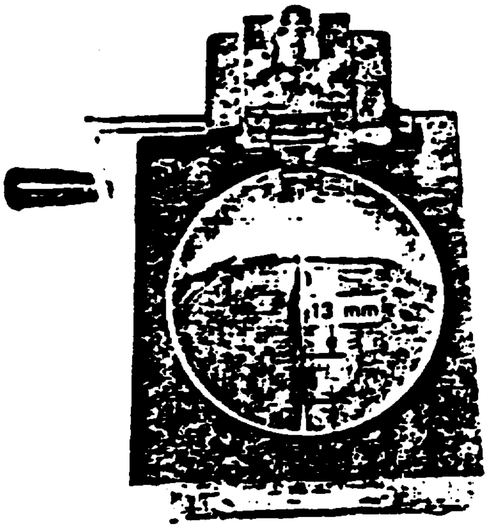


FIG. 6 Soil Pat After Groove Has Closed

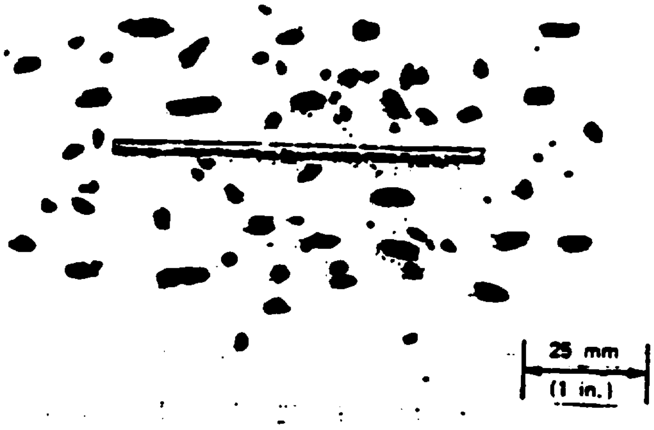


FIG. 7 Lean Clay Soil at the Plastic Limit

Standard Tes
DISTRIBUTIC
METHOD[1]

This standard is issued under the
original adoption or, in the case of
A superscript epsilon (ε) indicates a

As an aqueous
dependent upon
of other fluids a
interactions deter
(such as ions) tra
importance in ret
species at velociti
complex formati
precipitating as t
test method appl
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It is difficult to
in the geological
(K_d) has been us
modeling (usually
used to assess the
fluid migrates thr
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[1] This method is under the ju
Subcommittee D18.14 on
Current edition approved