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FMC NORTHERN ORDNANCE DIVISION
MINNEAPOLIS

MONITORING WELLS
Installation and Sampling
Northern Ordnance Plant
Fridley, Minnesota

NORTHERN ORDNANCE DIVISION
MINNEAPOLIS

MONITORING WELLS
Installation and Sampling
Northern Ordnance Plant
Fridley, Minnesota

March, 1983
Ref. No. 1085

CONESTOGA-ROVERS & ASSOCIATES LIMITED

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	WELL LOCATIONS	2
3.0	WELL INSTALLATION	3
3.1	SPLIT SPOON SAMPLING	3
3.2	MONITORING WELL INSTALLATION	4
3.2.1	GENERAL	4
3.2.2	METHOD OF INSTALLATION	5
3.3	WELL DEVELOPMENT	6
3.4	SURVEY	6
4.0	GROUNDWATER SAMPLING	7
4.1	SAMPLE COLLECTION	7
4.2	SAMPLE HANDLING AND SHIPMENT	8
5.0	CHEMICAL ANALYSIS	9

APPENDIX A - BOREHOLE LOGS - SPLIT SPOON SAMPLING
APPENDIX B - CHAIN OF CUSTODY

LIST OF FIGURES

		Page
FIGURE 1	WELL LOCATIONS	2a
FIGURE 2	TYPICAL WELL DETAIL	6a
FIGURE 3	WELL DEVELOPMENT DETAIL	6d

LIST OF TABLES

TABLE 1	MONITORING WELL DETAILS	6b
TABLE 2	WELL DEVELOPMENT DETAILS	6c
TABLE 3	SAMPLE CONTAINERIZATION AND STABILIZATION	8a
TABLE 4	PRIORITY POLLUTANT ANALYSIS	9a

1.0 INTRODUCTION

During 1981-1982 FMC Corporation retained E.A. Hickok and Associates to install 18 groundwater monitoring wells on property south and southwest of the Northern Ordnance plant in Fridley, Minnesota. Chemical analysis of samples collected from these wells and from plant production wells revealed low concentrations of organic materials, primarily 1,1,2-Trichloroethene (TCE), in the groundwater system.

In January 1983, FMC retained Conestoga-Rovers & Associates Limited (CRA) to install and sample three additional ground monitoring wells. In late January, FMC submitted to, and received approval from, the Minnesota Department of Health for well installation specifications prior to commencing well construction. This report details the installation and sampling of the three wells.

2.0 WELL LOCATIONS

A total of three 4-inch diameter groundwater monitoring wells were installed at locations as detailed in Figure 1. Well 33 was installed north of the Northern Ordnance plant on property owned by the United States Navy. Well 34 was installed north and west of the Northern Ordnance plant on property owned by FMC Corporation. Well 35 was installed west of the South Study Area on property owned by the Minneapolis Water Department.

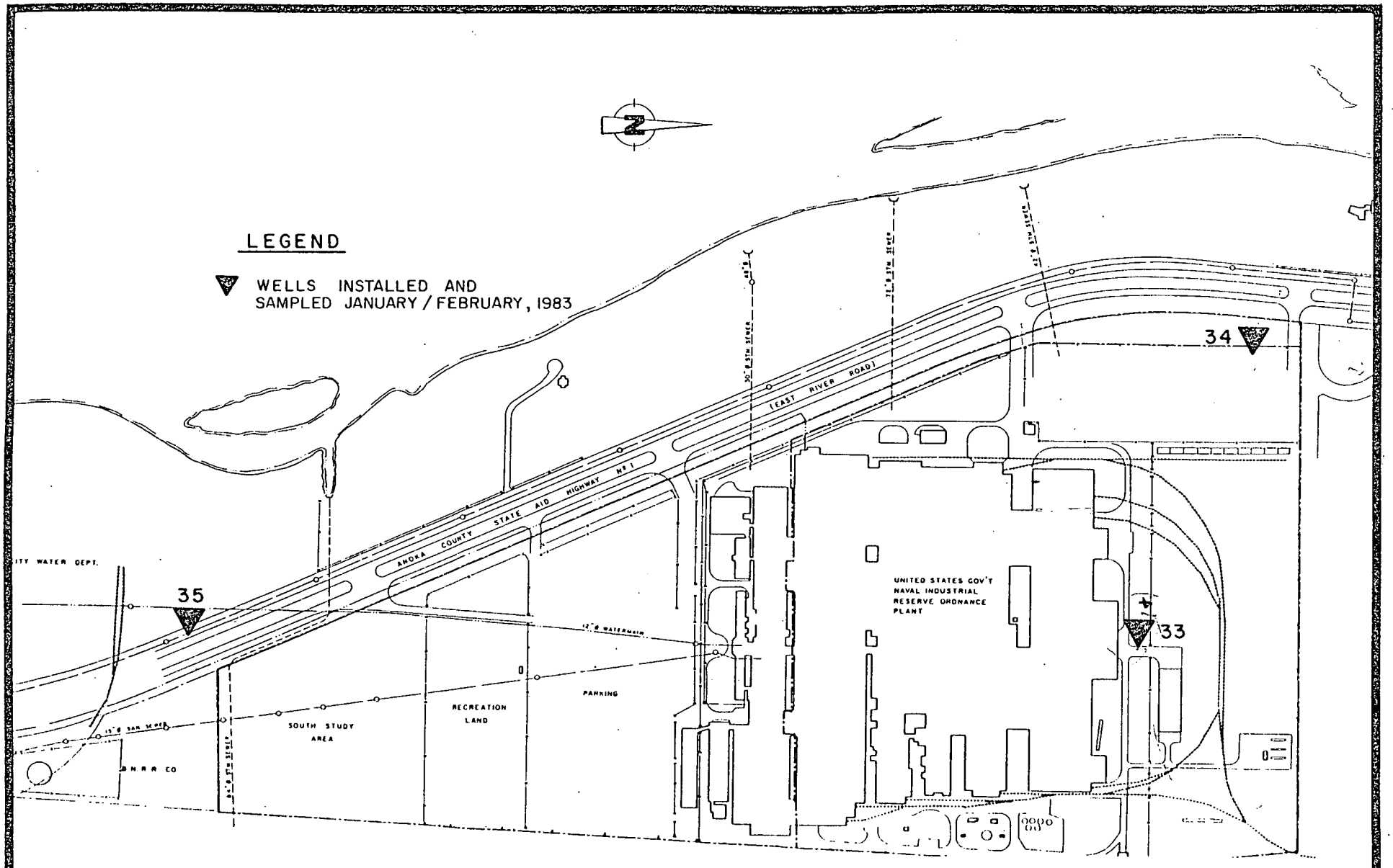

figure 1

WELL LOCATIONS

FMC Northern Ordnance Plant

CRA

CONESTOGA-ROVERS & ASSOCIATES LIMITED

1085-14/03/83

3.0 WELL INSTALLATION

3.1 SPLIT SPOON SAMPLING

Split spoon sampling was conducted at each well location prior to well installation. Samples were collected at 5-foot intervals from the ground surface to bedrock at Well 34 and Well 35, and to a depth of 100 feet at Well 33.

A CME 75 truck mounted drill rig equipped with rotary head and 8-inch diameter hollow stem augers was used to advance the boreholes to the desired sampling depths. Three-inch diameter, stainless steel split spoon sampling tools, driven with a 140-pound hammer dropped through a distance of 30 inches were used to obtain soil samples through the saturated zone. Two-inch diameter stainless steel split spoon sampling tools were used to obtain samples between the top of the water table and existing ground.

A bentonite slurry drilling fluid was used to maintain the borehole through the saturated zone.

Geologic record samples were retained for the full depth of each borehole at 5-foot intervals. Grain size analysis was performed on soil samples collected

from the saturated zone in order to determine the appropriate slot size for the well screen.

Upon completion of sampling, boreholes were left open pending well installation.

Mr. R. Karls of the MPCA was present and observed all split spoon sampling and installation of monitoring wells.

Borehole logs for the split spoon sampling are contained in Appendix A.

3.2 MONITORING WELL INSTALLATION

3.2.1 General

All wells were installed using a Midway 1500 rotary air-mud drilling rig equipped with an 8-inch diameter tri-cone rotary drilling bit. Wells were installed in the boreholes from which split spoon samples were collected.

3.2.2 Method of Installation

Four-inch diameter schedule 40 iron pipe, threaded and coupled with reamed and drifted couplings was used as a riser. Johnson 4-inch diameter x 0.010 inch slot galvanized low carbon steel screens were installed between the top of the water table and the first encountered clay soil strata as determined from the split spoon sampling logs.

The screens were packed at the bottom of the casing using neoprene K packers and the native granular soils allowed to collapse around the screen.

The annular space between the riser casing and the borehole wall was backfilled with drill cuttings for a distance of 10 feet above the screen. The remaining annular void was backfilled to ground surface with a neat portland cement grout.

The upper end of the well casing was fitted with a lockable cap. All keys were given to Mr. D. Hildre (FMC NOD) at the completion of the sampling program.

Details of a typical well installation are illustrated on Figure 2. Physical details of the three installed wells are presented in Table 1.

3.3 WELL DEVELOPMENT

All wells were developed using compressed air. A 1-inch galvanized iron pipe was installed to the bottom of the well screen and compressed air at a pressure of 30 psi was pumped into the screen. The wells were developed until the effluent stream appeared to be clear.

Well development times and volumes are presented on Table 2. Well development details are presented on Figure 3.

3.4 SURVEY

All wells were field surveyed for location and elevation during the second week of February.

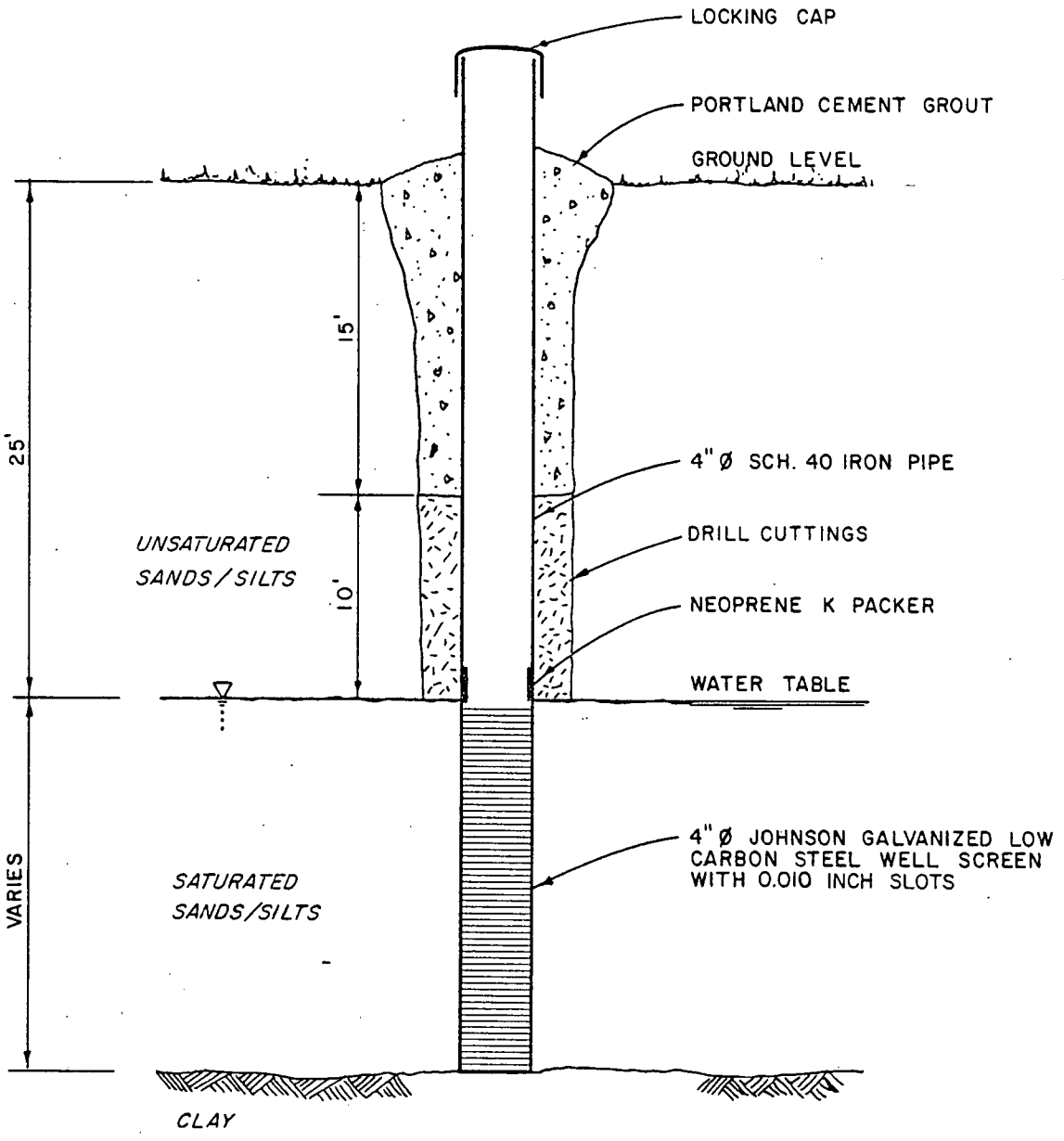

figure 2

TYPICAL WELL DETAIL

FMC Northern Ordnance Plant

CRA

1085-14/03/83

CONESTOGA-ROVERS & ASSOCIATES LIMITED

TABLE 1

MONITORING WELLS DETAILS

Well No.	Elevation of Top of Casing	Elevation of Top of Screen		Elevation of Base of Screen	Groundwater(1) Elevation
33	837.1	810.6	46'	764.6	813.60
34	835.8	809.3	25'	784.3	813.77 5.5"
35	832.1	805.6	35'	770.6	808.22

(1) Water elevations were recorded February 7, 1983

TABLE 2

WELL DEVELOPMENT DETAILS

Well No.	Screen Length (ft.)	Well Volume (gal.)	Pumping Rate (g.p.m.)	Pumping Duration (min.)	Volume Pumped (gal.)
33	46	34.6	30	60	1,800
34	25	20.8	30	87	2,610
35	35	26.6	4	140	560

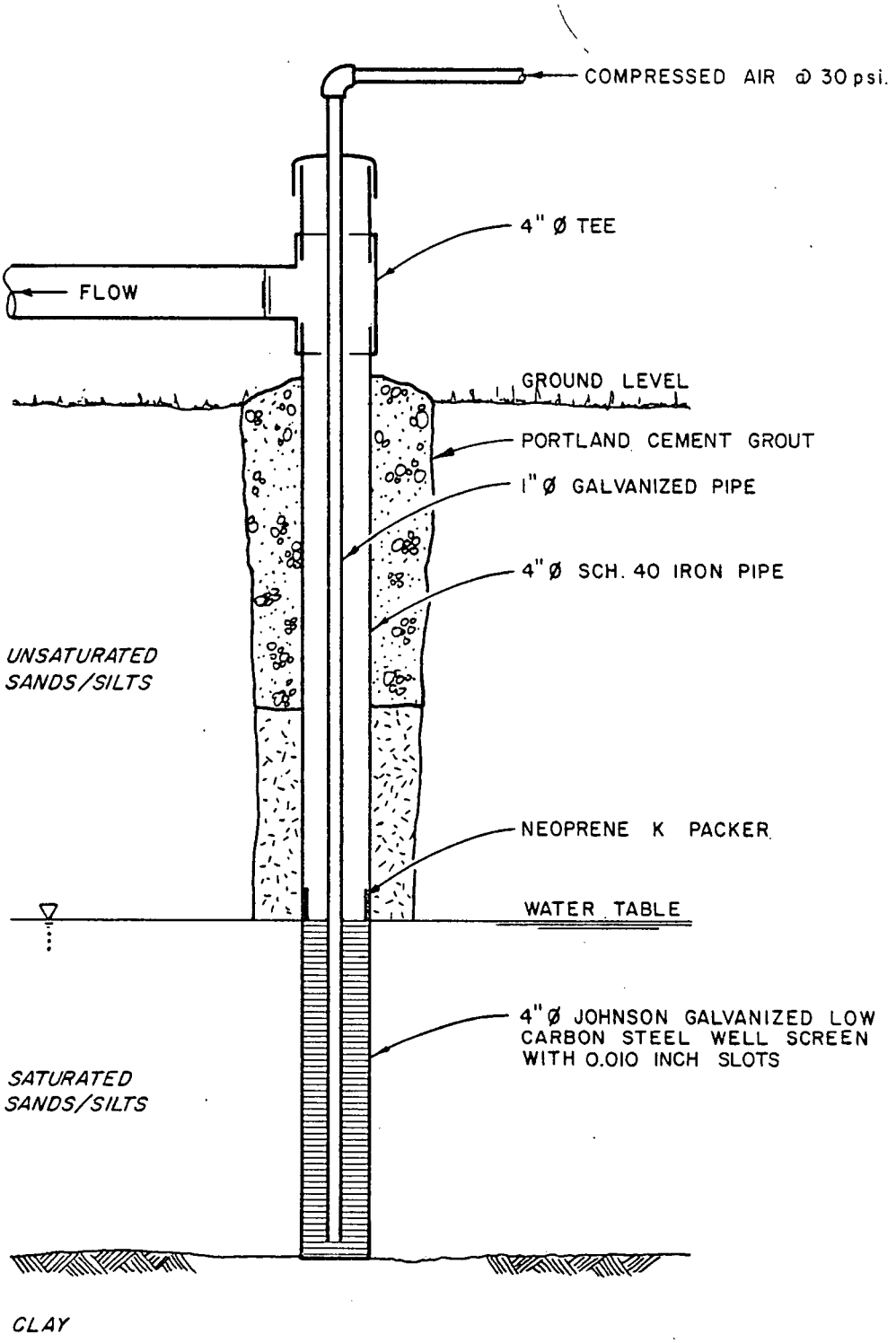

figure 3

WELL DEVELOPMENT DETAIL

FMC Northern Ordnance Plant

CRA

1085 - 14/03/83

CONESTOGA-ROVERS & ASSOCIATES LIMITED

4.0 GROUNDWATER SAMPLING

4.1 SAMPLE COLLECTION

Well 34, well 35 and production well 2 were sampled on January 28, 1983. Well 33 and production well 1 were sampled on January 31, 1983. Well 33 and production well 2 were resampled on February 4, 1983.

Production well 1 was sampled by drawing the sample directly from a tap ahead of the well head pump into the sample containers while Well 2 was sampled with a submersible pump. All other wells were sampled using a 2-inch diameter, 4-foot long copper bailer. The bailer was cleansed with an acetone-hexane-acetone-distilled water rinse prior to sample collection.

Wells 33, 34 and 35 were purged by bailing four to five well volumes prior to sample collection. Production well 2 had approximately one well volume purged by stainless steel submersible pump prior to the January 28 1983 sampling, and approximately three well volumes purged by submersible pump prior to the February 4 1983 sampling. The tap at production well 1 was allowed to flow fully open for approximately ten minutes prior to sample collection.

Mr. M. Ayers of the MPCA was present on January 31, 1983 and collected four 40-ml replicate samples from each of production well 1 and well 33. Ms. L. Thorvig of the MPCA was present on February 4, 1983 and collected four 40-ml replicate samples from production well 2.

4.2 SAMPLE HANDLING AND SHIPMENT

Samples were collected in prepared containers provided by the FMC Princeton, New Jersey, analytical laboratory. Each sample was containerized and stabilized as detailed in Table 3.

In addition, for each sample a field blank was collected by running 1 gallon of "Super Q" de-ionized water through the bailer and collecting the water in a precleaned glass jar.

After collection, sample container lids and caps were taped securely. The containers were then placed in coolers with ice and ice packs and shipped under a chain of custody protocol to the Princeton laboratory by a commercial courier service.

Chain of custody records are presented within Appendix C.

TABLE 3

SAMPLE CONTAINERIZATION AND STABILIZATION

PARAMETER	SAMPLE CONTAINER	COOLED TO	STABILIZATION	VOLUME
Volatiles	Clear glass with teflon lined cap	4°C	-	4 to 6 x 40ml
Semi-Volatiles	Amber glass with teflon lined cap	4°C	-	1 gallon
Pesticides	Amber glass with teflon lined cap	4°C	-	2 x 1 quart
Total Phenol	Wide mouth clear glass with teflon lined cap	4°C	H_2SO_4,pH<2	1 quart
Total Cyanide	Plastic bottle	4°C	NaOH,pH>12	1 quart
Metals	Plastic bottle	4°C		1 quart
Field Blank	Clear glass with teflon lined cap	4°C	-	1 gallon

5.0 CHEMICAL ANALYSIS

All well samples were analysed for the Priority Pollutants and selected conventional parameters. Analytical results are presented in Table 4.

For the priority pollutant analysis, the semi-volatile organic fraction was not reported as detectable in any well sample with the exception of total phenol which was reported as present in wells 2, 33, and 34 at concentrations between 5 and 10 parts per billion (ppb).

For all wells excepting well 33, methylene chloride, TCE, 1-1-dichloroethane and 1,2-dichloroethylene were reported present in low ppb concentrations.

TCE concentrations were reported as 300,000 ppb and 45,000 ppb and xylene isomer concentrations were reported as 1000 ppb and 100 ppb for the two samples collected at well 33. Detection of other volatile organic compounds was not possible due to interferences resulting from the elevated TCE concentrations.

TABLE 4

PRIORITY POLLUTANT ANALYSIS

MONITORING WELL SAMPLES

HEAVY METALS (mg/L)

Sampling Date	Well Site	Ag (0.0008)	Be (0.0005)	Cd (0.01)	Cr (0.001)	Cu (0.03)	Ni (0.05)	Zn (0.009)	As (0.002)	Hg (0.0004)	Pb (0.002)	Se (0.005)	Sb (0.004)	Tl (0.003)
Jan. 28/83	35	ND	ND	0.0388	ND	0.09	ND	7.11	ND	ND	0.002	ND	ND	ND
	34	ND	ND	0.0444	ND	0.11	ND	7.99	ND	ND	ND	ND	ND	ND
	2	ND	ND	0.0004	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Jan. 31/83	33	ND	ND	0.307	0.002	ND	ND	4.05	ND	ND	ND	ND	ND	ND
	1	ND	ND	0.0004	0.002	ND	ND	ND	ND	ND	0.002	ND	ND	ND
Feb. 4/83	33	ND	ND	ND	ND	0.01	ND(1)	0.227	ND	ND	0.011	ND	ND(1)	ND
	2	ND	ND	ND	0.002	0.01	ND(1)	0.091	ND	ND	0.011	ND	ND(2)	ND

ND - Not detected
( ) Detection limit in parenthesis
(1) Detection limit at 0.07 ug/L
(2) Detection limit at 0.01 ug/L

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TABLE 4 (Cont'd)

PRIORITY POLLUTANT ANALYSIS

MONITORING WELL SAMPLES

		VOLATILE ORGANIC COMPOUNDS (ug/L)									SEMI-VOLATILE ORGANIC COMPOUNDS	
Sampling Date	Well Site	Methylene Chloride (1)	T.C.E. (10)	1,1-Dichloro-ethane (1)	1,2-Dichloro-ethylene (1)	Tetra-chloroethylene (1)	Xylene Isomers[1] (1)	Acetone[1] (1)	Hexane Isomers[1] (1)	Hexene Isomers[1] (1)	Base/Neutral Compounds (1)	Acid Compounds (1)
Jan. 28/83	35	50	15	D	D	ND	ND	>300	500	D	ND	ND
	34	D	ND	ND	ND	ND	ND	> 80	130	D	ND	ND
	2	D	25	ND	ND	ND	ND	ND	ND	ND	ND	ND
Jan. 31/83	33	*	300,000	*	*	*	1,000	*	*	*	ND	ND
	1	ND	60	D	ND	ND	ND	ND	ND	ND	ND	ND
Feb. 4/83	33	*	45,000	*	*	*	100	*	*	*	*	*
	2	D	30	ND	ND	ND	ND	ND	ND	ND	ND	ND

1 Estimated values
( ) Detection limits in parenthesis
ND - Not detected at detection limits
D - Detected at 1 to 10 ug/l
* - Elevated concentrations of TCE precluded detection of compound

TABLE 4 (Cont'd)

PRIORITY POLLUTANT ANALYSIS

MONITORING WELL SAMPLES

CONVENTIONAL PARAMETERS (ug/L)

Sampling Date	Well Site	Total Phenol (5)	Total Cyanide (20)	NO_3N (50)
Jan. 28/83	35	ND	ND	50
	34	7	ND	50
	2	ND	ND	ND
Jan. 31/83	33	10	ND	ND
	1	ND	ND	50
Feb. 4/83	33	5	ND	50
	2	5	ND	50

ND - Not detected
( ) Detection limits in parenthesis

CONESTOGA-ROVERS & ASSOCIATES LIMITED

Reported concentrations of heavy metals were within the range of normal groundwater values for all samples collected and analyzed.

All of Which is Respectfully Submitted,

CONESTOGA-ROVERS & ASSOCIATES LIMITED

Richard G. Shepherd, P. Eng.

Frank A. Rovers, P. Eng.

APPENDIX A

SPLIT SPOON SAMPLING

BOREHOLE LOGS

STATE OF MINNESOTA
DEPARTMENT OF HEALTH

WATER WELL RECORD

Minnesota Statutes 156A.01-.08

MINNESOTA UNIQUE WELL for Water Sample

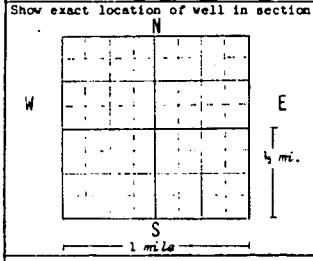
127362

1. LOCATION OF WELL

County Name	Fraction	Section Number	Township Number	Range Number
	¼ ¼ ¼		N. or S.	E. or W.

Distance and Direction from Road Intersections or Street Address and City of Well Location

Show exact location of well in section grid with "X." Sketch map of well location.



2. FORMATION LOG

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO
Sand			0	50

Use a second sheet, if needed.

15. REMARKS, ELEVATION, SOURCE OF DATA, etc.

IMPORTANT: FILE WITH DEED - WELL OWNER COPY

3. PROPERTY OWNER'S NAME
FMC (Braun Engineering & Testing Inc.)
Address
4800 N. E. River Road
Minneapolis, Minn.

4. WELL DEPTH (completed) 50 ft. **Date of Completion** 1-29-83

5. 1☐ Cable tool 4☐ Reverse 7☐ Driven 10☐ Dug
2☐ Hollow rod 5☐ Air 8☐ Bored 11☐ _____
3☒ Rotary 6☐ Jetted 9☐ Power Auger

6. USE
1☐ Domestic 4☐ Public Supply 7☐ Industry
2☐ Irrigation 5☐ Air Conditioning 8☐ Commercial
3☐ Test Well 6☒ Monitoring Wells

7. CASING DIAM.
Threaded ☒1 Welded ☐3
Black ☒2 Galv. ☐4
0 in. to 25 ft. depth
____ in. to ____ ft. depth
____ in. to ____ ft. depth

HEIGHT: Above/Below
Surface ____ ft.
Weight 10:86 lbs./ft.
Drive Shoe? Yes ____ No ____

8. SCREEN
Make Johnson
Type Galvanized Dia. 4"
Slot/Gauze 10 Length 25'
Set between 25' ft. and 50' ft.
____ ft. and ____ ft.
____ ft. and ____ ft.
FITTINGS:

Or open hole from ____ ft. to ____ ft.

9. STATIC WATER LEVEL
____ ft. ☐ below ☐ above land surface Date Measured ____

10. PUMPING LEVEL (below land surface)
____ ft. after ____ hrs. pumping ____ g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

11. WELL HEAD COMPLETION None
1☐ Pitless adapter 2☐ Basement offset 3☐ At least 12" above grade

12. Well grouted?
☒ Yes ☐ No Cu. Yds. ____
1☒ Neat cement 2☐ Bentonite 3☐ ____
Depth: from ____ ft. to ____ ft.
from ____ ft. to ____ ft.

13. Nearest source of possible contamination
____ feet ____ direction ____ type
Well disinfected upon completion? Yes ☐ No ☐

14. PUMP None
Date Installed ____
☐ Not installed
Manufacturer's Name ____
Model Number ____ HP ____ Volts ____
Length of drop pipe ____ ft. Capacity ____ g.p.m.
Material of drop pipe ____
Type: 1☐ Submersible 3☐ Turbine 5☐ Reciprocating
2☐ Jet 4☐ Centrifugal 6☐ ____

16. WATER WELL CONTRACTOR'S CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

DON STODOLA WELL DRILLING CO., INC. 172
Licensee Business Name License No.

Address 15306 Highway 7, Minka, Minn. 55343

Signed Donald L. Stodola Date 2-16-83
Authorized Representative

Mark Stodola
Name of Driller

7/74 30M

STATE OF MINNESOTA
DEPARTMENT OF HEALTH

WATER WELL RECORD

Minnesota Statutes 156A.01-.08

MINNESOTA UNIQUE WELL NO.
for Water Sample

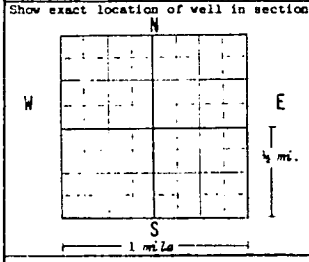
127363

1. LOCATION OF WELL

County Name	Fraction	Section Number	Township Number	Range Number
	¼ ¼ ¼		N. or S.	E. or W.

Distance and Direction from Road Intersections or Street Address and City of Well Location

Show exact location of well in section grid with "X." Sketch map of well location.



2.

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO
Sand			0	60

Use a second sheet, if needed.

15. REMARKS, ELEVATION, SOURCE OF DATA, etc.

IMPORTANT: FILE WITH DEED - WELL OWNER COPY

3. PROPERTY OWNER'S NAME
FMC (Braun Engineering & Testing Inc.)
Address 4800 N. E. River Road
Minneapolis, Minn.

4. WELL DEPTH (completed) 60' ft.
Date of Completion 1-29-83

5.
1 ☐ Cable tool 4 ☐ Reverse 7 ☐ Driven 10 ☐ Dug
2 ☐ Hollow rod 5 ☐ Air 8 ☐ Bored 11 ☐ _____
3 ☒ Rotary 6 ☐ Jetted 9 ☐ Power Auger

6. USE
1 ☐ Domestic 4 ☐ Public Supply 7 ☐ Industry
2 ☐ Irrigation 5 ☐ Air Conditioning 8 ☐ Commercial
3 ☐ Test Well 6 ☒ Monitoring Wells

7. CASING DIAM.
Threaded ☒ 1 Welded ☐ 3
Black ☒ 2 Galv. ☐ 4
4 in. to 25 ft. depth
_____ in. to _____ ft. depth
_____ in. to _____ ft. depth

HEIGHT: Above/Below
Surface _____ ft.
Weight 10.86 lbs./ft.
Drive Shoe? Yes ___ No ___

8. SCREEN
Make Johnson
Type Galvanized Dia. 4"
Slot/Gauze 10 Length 35'
Set between 25 ft. and 60 ft.
_____ ft. and _____ ft.
_____ ft. and _____ ft.

Or open hole from _____ ft. to _____ ft.

FITTINGS:

9. STATIC WATER LEVEL
_____ ft. ☐ below ☐ above land surface Date Measured _____

10. PUMPING LEVEL (below land surface)
_____ ft. after _____ hrs. pumping _____ g.p.m.
_____ ft. after _____ hrs. pumping _____ g.p.m.

11. WELL HEAD COMPLETION None
1 ☐ Pitless adapter 2 ☐ Basement offset 3 ☐ At least 12" above grade

12. Well grouted?
☒ Yes ☐ No Cu. Yds. _____
1 ☒ Neat cement 2 ☐ Bentonite 3 ☐ _____
Depth: from _____ ft. to _____ ft.
from _____ ft. to _____ ft.

13. Nearest source of possible contamination
_____ feet _____ direction _____ type
Well disinfected upon completion? Yes ☐ No ☐

14. PUMP None
Date installed _____
☐ Not installed
Manufacturer's Name _____
Model Number _____ HP _____ Volts _____
Length of drop pipe _____ ft. capacity _____ g.p.m.
Material of drop pipe _____
Type: 1 ☐ Submersible 3 ☐ Turbine 5 ☐ Reciprocating
2 ☐ Jet 4 ☐ Centrifugal 6 ☐ _____

16. WATER WELL CONTRACTOR'S CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

DON STODOLA WELL DRILLING CO., INC. 172
License Number *License No.*

Address 15306 Highway # 7, Minka, Minn. 55343

Signed Arnold F. Stodola, Pres. Date 2-16-83
Authorized Representative

Mark Stodola
Name of Driller

7/74 30M

STATE OF MINNESOTA
DEPARTMENT OF HEALTH

WATER WELL RECORD

Minnesota Statutes 156A.01-.08

MINNESOTA UNIQUE ... for Water Sample

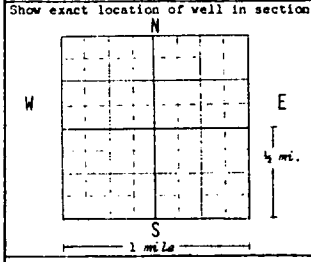
127364

1. LOCATION OF WELL

County Name	Fraction	Section Number	Township Number	Range Number
	¼ ¼ ¼		N. or S.	E. or W.

Distance and Direction from Road Intersections *or* Street Address and City of Well Location

Show exact location of well in section grid with "X." Sketch map of well location.



2.

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO
Sand			0	77

Use a second sheet, if needed.

15. REMARKS, ELEVATION, SOURCE OF DATA, etc.

IMPORTANT: FILE WITH DEED - WELL OWNER COPY

3. PROPERTY OWNER'S NAME

FMC (Braun Engineering & Testing Inc.)

Address 4800 N. E. River Road
Minneapolis, Minn. 55343

4. WELL DEPTH (completed) 77' ft.

Date of Completion 1-29-83

5.
1 [ ] Cable tool 4 [ ] Reverse 7 [ ] Driven 10 [ ] Dug
2 [ ] Hollow rod 5 [ ] Air 8 [ ] Bored 11 [ ] _____
3 [X] Rotary 6 [ ] Jetted 9 [ ] Power Auger

6. USE
1 [ ] Domestic 4 [ ] Public Supply 7 [ ] Industry
2 [ ] Irrigation 5 [ ] Air Conditioning 8 [ ] Commercial
3 [ ] Test Well 6 [X] Monitoring Wells

7. CASING DIAM.
Threaded [X] 1 Welded [ ] 3
Black [X] 2 Galv. [ ] 4
4 in. to 31 ft. depth
____ in. to ____ ft. depth
____ in. to ____ ft. depth

HEIGHT: Above/Below
Surface ____ ft.
Weight 10.86 lbs./ft.
Drive Shoe? Yes ____ No ____

8. SCREEN
Make Johnson
Type Galvanized Dia. 4"
Slot/Gauze 10 Length 46'
Set between ____ ft. and ____ ft.
____ ft. and ____ ft.
____ ft. and ____ ft.

Or open hole from ____ ft. to ____ ft.

FITTINGS:

9. STATIC WATER LEVEL
____ ft. [ ] below [ ] above land surface Date Measured ____

10. PUMPING LEVEL (below land surface)
____ ft. after ____ hrs. pumping ____ g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

11. WELL HEAD COMPLETION None
1 [ ] Pitless adapter 2 [ ] Basement offset 3 [ ] At least 12" above grade

12. Well grouted?
[X] Yes [ ] No Cu. Yds. ____
1 [X] Neat cement 2 [ ] Bentonite 3 [ ] ____
Depth: from ____ ft. to ____ ft.
from ____ ft. to ____ ft.

13. Nearest source of possible contamination
____ feet ____ direction ____ type
Well disinfected upon completion? Yes [ ] No [ ]

14. PUMP None
Date installed ____
[ ] Not installed
Manufacturer's Name ____
Model Number ____ HP ____ Volts ____
Length of drop pipe ____ ft. Capacity ____ g.p.m.
Material of drop pipe ____
Type: 1 [ ] Submersible 3 [ ] Jet Surface 5 [ ] Reciprocating
2 [ ] Jet 4 [ ] Centrifugal 6 [ ] ____

16. WATER WELL CONTRACTOR'S CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

DON STODOLA WELL DRILLING CO., INC. 172
Licensee Name License No.

Address 15306 Highway # 7, Mtka, Minn. 55343

Signed [signature] Date 2-16-83
Authorized Representative

Mark Stodola
Name of Driller

7/74 30M

STRATIGRAPHIC AND INSTRUMENTATION LOG

PROJECT NAME: FMC Northern Ordnance Division
HOLE Nº: Well 33
JOB Nº: 1085
DATE COMPLETED: January 24, 1983
CLIENT: FMC Corporation
GEOLOGIST/ENGINEER: D. Robinson
HOLE TYPE: 4" Ø Well
GROUND ELEVATION:
LOCATION: U.S. Navy Property
TOP OF PIPE ELEVATION: 837.1 feet

PROFILE			MONITOR INSTALLATION	SAMPLE			PENETRATION TEST BLOWS/FOOT
DEPTH (ELEVATION)	STRATIGRAPHY DESCRIPTION & REMARKS	STRATIGRAPHY		NUMBER	TYPE	BLOWS/FOOT	20 40 60 80
0-5	Dark Brown Sandy Fill			1	R		
5-6	Medium Brown Sand			1	R		
10-11	Medium Brown Sand - Dry			1	R		
15-16	Medium Brown Sand - Dry			1	R		
20-21	Medium Brown Sand - Dry			1	R		
25-26	Coarse Brown Sand - Wet			1	R		
30-31	Medium Brown Silty Sand			1	R		
35-36	Medium Brown Silty Sand			1	R		
40-41	Gray Brown Wet Silty Sand			1	R		
45-46	Gray Brown Wet Silty Sand			1	R		
50-51	Gray Brown Wet Silty Sand			1	R		
55-56	Coarse Brown Sand			1	R		
60-61	Medium Brown Sand			1	R		
65-66	Medium Brown Sand			1	R		
70-71	Coarse Sand with Gravel			1	R		
75-76	Stiff Brown Clay			1	R		
80-81	Stiff Brown Clay			1	R		
85-86	Stiff Brown Clay			1	R		
90-91	Stiff Brown Clay			1	R		
95-96	Brown Silt			1	R		
100-101	Brown Sandy Silt			1	R		

○ GRAIN SIZE ANALYSIS ▼ WATER FOUND ▽ STATIC WATER LEVEL

CONESTOGA-ROVERS & ASSOCIATES LIMITED

STRATIGRAPHIC AND INSTRUMENTATION LOG

PROJECT NAME: FMC Northern Ordnance Division
HOLE Nº: Well 34
JOB Nº: 1085
DATE COMPLETED: January 21, 1983
CLIENT: FMC Corporation
GEOLOGIST/ENGINEER: D. Robinson
HOLE TYPE: 4"Ø Well- 8" Hollow 3" S.S.
GROUND ELEVATION:
LOCATION: N.W. Corner Plant Site
TOP OF PIPE ELEVATION: 835.8

PROFILE			MONITOR INSTALLATION	SAMPLE			PENETRATION TEST BLOWS / FOOT
DEPTH (ELEVATION)	STRATIGRAPHY DESCRIPTION & REMARKS	STRATIGRAPHY		NUMBER	TYPE	BLOWS / FOOT	20 40 60 80
0-1	Topsoil & Cinders						
5-7	Medium Brown Sand - Dry			1	R		
10-12	Medium Brown Sand - Dry			1	R		
15-17	Medium Brown Sand - Damp			1	R		
20-22	Medium Brown Sand - Damp			1	R		
25-27	Med. Brown Sand-Wet Silt @26.5			1	R		
30-32	Medium to Coarse Sand			1	R		
35-37	Coarse Sand & Gravel-Some Cobbles			1	R		
40-42	Silt with Gravel			1	R		
45-47	Coarse Gravel-1' Clay Layer			1	R		
50-52	Medium Stiff Gray Clay			1	R		
55-57	Medium Stiff Gray Clay			1	R		
60-62	Sandy Gray Clay			1	R		
65-67	Sandy Gray Clay			1	R		
70-72	Sandy Gray Clay			1	R		
75-77	Fine Silty Sand			1	R		
80-82	Wet Silt			1	R		
85-87	Gravel with Silt			1	R		
90-92	Brown Medium Sand			1	R		
95-97	Brown Medium Sand			1	R		
100-101	Brown Medium Sand						
101	Yellow Sandstone			1	R		
105-106	Yellow & Red Sandstone			1	R		

○ GRAIN SIZE ANALYSIS ▼ WATER FOUND ▽ STATIC WATER LEVEL

CONESTOGA-ROVERS & ASSOCIATES LIMITED

STRATIGRAPHIC AND INSTRUMENTATION LOG

PROJECT NAME : FMC Northern Ordnance Division
HOLE Nº: Well 35
JOB Nº : 1085
DATE COMPLETED: January 22, 1983
CLIENT : FMC Corporation
GEOLOGIST/ENGINEER: D. Robinson
HOLE TYPE : 4" Ø Well
GROUND ELEVATION:
LOCATION : Minnesota Water Works Property
TOP OF PIPE ELEVATION: 832.1

PROFILE			MONITOR INSTALLATION	SAMPLE			PENETRATION TEST BLOWS / FOOT
DEPTH (ELEVATION)	STRATIGRAPHY DESCRIPTION & REMARKS	STRATIGRAPHY		NUMBER	TYPE	BLOWS / FOOT	20 40 60 80
0-5	Brown Medium Sand			1	R		
5-7	Brown Medium Sand			1	R		
10-12	Brown Medium Sand			1	R		
15-17	Brown Medium Coarse Sand			1	R		
20-22	Brown Medium Coarse Sand			1	R		
25-27	Coarse Brown Sand			1	R		
30-32	Moist Sand with Clay			1	R		
35-37	Moist Sand with Clay			1	R		
40-42	Moist Sand with Clay			1	R		
45-46	Gray Medium Sand, Moist			1	R		
50-51	Silt with Gravel			1	R		
55-56	Coarse Brown Sand			1	R		
60-61	Stiff Brown Clay			1	R		
65-66	Stiff Brown Clay			1	R		
70-71	Coarse Brown Sand			1	R		
75-76	Medium Brown Silty Sand			1	R		
80-81	Medium Brown Silty Sand			1	R		
85-86	Coarse Brown Sand with Silt			1	R		
90-91	Medium Brown Sand			1	R		
95-96	Medium Brown Sand			1	R		
100-101	Medium Brown Sand			1	R		
105-106	Brown Silty Sand			1	R		
110-111	Coarse Gravel with Stones			1	R		
115-116	Medium Brown Sand			1	R		
120-121	Yellow Sandstone 120.3'			1	R		

○ GRAIN SIZE ANALYSIS ▼ WATER FOUND ▽ STATIC WATER LEVEL

CONESTOGA-ROVERS & ASSOCIATES LIMITED

APPENDIX B

CHAIN OF CUSTODY

CHAIN OF CUSTODY RECORD & ANALYTICAL REPORT

REQUESTER: _____ DATE: 1/28/83

PLANT LOCATION: Minneapolis Minn

SITE DESCRIPTION: Sampling Wells 35, 34 & Reference Well 2

FMC Corporation
Environmental Analytical Services
Center Technical Department
Route 1 at Plainsboro Road
Princeton, New Jersey 08540

I. FIELD DATA

Sampler	Weather Wet/Dry	Temp. °C	pH	Flow (GPD)	Other	Notebook	Initials
D. Robinson	Dry	0					

II. SAMPLING

Sample Code	Description	Sample Size	Begin Date·Time	Analyses Requested	Field Stab./Storage
Well 35	Water	Varies	1/28/83 1530	Per Labels	Per Instr
Well 34	"	"	1650		on ice
B.H 19	Soil	500 ml	1/28/83 1300		"
Snow	Snow	3x500 ml	1/28/83 1400		"

III. CHAIN OF CUSTODY

	Name	Date	Time
Field	D. Robinson	1/28/83	19.35
Transportation	L. Willie	1/28/83	1940
Transportation			
Laboratory			

SAMPLE QUALIFICATION

Sample	Reason

IV. LABORATORY CONTROL & ANALYSIS

Sample #	Analyses	Sample Certification Accept/Qualify	Lab Stab./ Storage	Analyst Notification Initials·Date	Analysis Begun Date·Time	Data $mg \cdot L^{-1}$	Notebook

V. Copies to: _____ VI. Lab. Supervisor _____ Date _____

DISTRIBUTION: White - Return to Requester - Canary - Retained by Analytical - Pink - Retained by Requester

CHAIN OF CUSTODY RECORD

PROJECT Nº. 1085

PROJECT NAME: F.M.C Minneapolis

FMC Corporation
Northern Ordnance Division
4800 East River Road
Minneapolis Minnesota 55421
(612) 571 9201 Telex 29 0432

SAMPLER'S SIGNATURE (SIGN)

SAMPLE Nº.	SEQ. Nº.	DATE	TIME	SAMPLE LOCATION	SAMPLE TYPE	Nº. OF CONTAINERS	REMARKS
WELL 34		1/29/83		WELL 34	WATER GRABS 1 GAL BLANK	1	
WELL 35		1/29/83		" 35	" " 1 GAL BLANK	1	
					TOTAL Nº. OF CONTAINERS	2	

RELINQUISHED BY:	DATE/TIME	RECEIVED BY:	RELINQUISHED BY:	DATE/TIME	RECEIVED BY:
1 (SIGN)	1/31/83 19:37	2 (SIGN)	2 (SIGN)		3 (SIGN)
RELINQUISHED BY:	DATE/TIME	RECEIVED BY:	RELINQUISHED BY:	DATE/TIME	RECEIVED BY:
3 (SIGN)		4 (SIGN)	4 (SIGN)		5 (SIGN)
RELINQUISHED BY:	DATE/TIME	RECEIVED BY:	RELINQUISHED BY:	DATE/TIME	RECEIVED BY:
5 (SIGN)		6 (SIGN)	6 (SIGN)		7 (SIGN)

METHOD OF SHIPMENT:	SHIPPED BY:	RECEIVED FOR LABORATORY:	DATE/TIME
		(SIGN)	

CHAIN OF CUSTODY RECORD

PROJECT Nº.	PROJECT NAME:
1085	F.M.C MINNEAPOLIS.

FMC Corporation
Northern Ordnance Division
4800 East River Road
Minneapolis Minnesota 55421
(612) 571 9201 Telex 29 0432

SAMPLER'S SIGNATURE _____ (SIGN)

SAMPLE Nº.	SEQ. Nº.	DATE	TIME	SAMPLE LOCATION	SAMPLE TYPE	Nº. OF CONTAINERS	REMARKS
433	1	1/31/83		WELL 33	WATER - GROUND 6-40 ml VIALS	6	
					1-GAL JAR AMBER	1	
					2-QT JARS AMBER	2	
					1-WIDE MOUTH CLEAR	1	
					2-PLASTIC QUARTS	2	
					1-GAL BLACK	1	
442	1	1/31/83		WELL 1	" " 6-40 ml VIALS	6	
					1 GAL AMBER	1	
					2 QT JARS AMBER	2	
					1 WIDE MOUTH AMBER	1	
					2 PLASTIC QUARTS	2	
					TOTAL Nº. OF CONTAINERS	25	

RELINQUISHED BY:	DATE/TIME	RECEIVED BY:	RELINQUISHED BY:	DATE/TIME	RECEIVED BY:
1 (SIGN)	1/31, 1985	2 (SIGN)	2 (SIGN)	/	3 (SIGN)
RELINQUISHED BY:	DATE/TIME	RECEIVED BY:	RELINQUISHED BY:	DATE/TIME	RECEIVED BY:
3 (SIGN)	/	4 (SIGN)	4 (SIGN)	/	5 (SIGN)
RELINQUISHED BY:	DATE/TIME	RECEIVED BY:	RELINQUISHED BY:	DATE/TIME	RECEIVED BY:
5 (SIGN)	/	6 (SIGN)	6 (SIGN)	/	7 (SIGN)

METHOD OF SHIPMENT:	SHIPPED BY:	RECEIVED FOR LABORATORY:	DATE/TIME
		(SIGN)	/

CHAIN OF CUSTODY RECORD & ANALYTICAL REPORT

REQUESTER: _____ DATE: 1/31/83

PLANT LOCATION: Minneapolis Minn

SITE DESCRIPTION: Production Well #2, Sampling Wells 33, 34, 35

FMC Corporation
Environmental Analytical Services
Center Technical Department
Route 1 at Plainsboro Road
Princeton, New Jersey 08540

I. FIELD DATA

Sampler	Weather Wet/Dry	Temp. °C	pH	Flow (GPD)	Other	Notebook	Initials
D. Robinson	Dry	-05					

II. SAMPLING

Sample Code	Description	Sample Size	Begin Date·Time	Analyses Requested	Field Stab./Storage
Wells 2, 33, 34, 35	PER ATTACHED	VARIES			

III. CHAIN OF CUSTODY

	Name	Date	Time
Field	[signature]	1/31/83	7.41
Transportation			
Transportation			
Laboratory			

SAMPLE QUALIFICATION

Sample	Reason

IV. LABORATORY CONTROL & ANALYSIS

Sample #	Analyses	Sample Certification Accept/Qualify	Lab Stab./ Storage	Analyst Notification Initials·Date	Analysis Begun Date·Time	Data $mg \cdot L^{-1}$	Notebook

V. Copies to: _____ VI. Lab. Supervisor _____ Date _____

DISTRIBUTION: White - Return to Requester - Canary - Retained by Analytical - Pink - Retained by Requester

CHAIN OF CUSTODY RECORD

PROJECT Nº.

PROJECT NAME: F.M.C MPLS

FMC Corporation
Northern Ordnance Division
4800 East River Road
Minneapolis Minnesota 55421
(612) 571 9201 Telex 29 0432

SAMPLER'S SIGNATURE (SIGN)

SAMPLE Nº.	SEQ. Nº.	DATE	TIME	SAMPLE LOCATION	SAMPLE TYPE	Nº. OF CONTAINERS	REMARKS
WELL 33	1	2/4/83			WATER-GRAB 1 GAL, 2 AMBER 2 PLASTIC 1 WIDEMOUTH, 4 VIALS 1 PUMP BLANK	11	
						11	
WELL 2	2	2/4/83			AS ABOVE		
						22	
					TOTAL Nº. OF CONTAINERS		

RELINQUISHED BY:	DATE/TIME	RECEIVED BY:	RELINQUISHED BY:	DATE/TIME	RECEIVED BY:
1 (SIGN)	2/4/83	2 (SIGN)	2 (SIGN)		3 (SIGN)
RELINQUISHED BY: 3 (SIGN)	DATE/TIME	RECEIVED BY: 4 (SIGN)	RELINQUISHED BY: 4 (SIGN)	DATE/TIME	RECEIVED BY: 5 (SIGN)
RELINQUISHED BY: 5 (SIGN)	DATE/TIME	RECEIVED BY: 6 (SIGN)	RELINQUISHED BY: 6 (SIGN)	DATE/TIME	RECEIVED BY: 7 (SIGN)

METHOD OF SHIPMENT:	SHIPPED BY:	RECEIVED FOR LABORATORY:	DATE/TIME
T-E		(SIGN)	

CHAIN OF CUSTODY RECORD & ANALYTICAL REPORT

REQUESTER: C&A DATE: 2/4/83

PLANT LOCATION: F.M.C Mpls Mn

SITE DESCRIPTION: Well 33, 2

FMC Corporation
Environmental Analytical Services
Center Technical Department
Route 1 at Plainsboro Road
Princeton, New Jersey 08540

I. FIELD DATA

Sampler	Weather Wet/Dry	Temp. °C	pH	Flow (GPD)	Other	Notebook	Initials
D. Robinson	Dry	-10					

II. SAMPLING

Sample Code	Description	Sample Size	Begin Date·Time	Analyses Requested	Field Stab./Storage
Well 33	Water - Grab	1 liter	2/4/83 1330		
Well 2	Water - Grab		2/4/83 1400		

III. CHAIN OF CUSTODY

	Name	Date	Time
Field	D. Robinson	2/4/83	
Transportation	X		
Transportation			
Laboratory			

SAMPLE QUALIFICATION

Sample	Reason

IV. LABORATORY CONTROL & ANALYSIS

Sample #	Analyses	Sample Certification Accept/Qualify	Lab Stab./ Storage	Analyst Notification Initials·Date	Analysis Begun Date·Time	Data $mg \cdot L^{-1}$	Notebook

V. Copies to: _____ VI. Lab. Supervisor _____ Date _____

DISTRIBUTION: White - Return to Requester - Canary - Retained by Analytical - Pink - Retained by Requester