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October 23 1998

Mr John T Cook P L S
Remedial Project Manager
U S Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City Kansas 66101

Subject Response to U S EPA Comment Letter Supplemental Data Collection & Evaluation Report McGraw Edison Superfund Site Centerville Iowa

Dear Mr Cook

Woodward Clyde International Americas is submitting the enclosed response to the U S EPA September 23 1998 comment letter on behalf of Cooper Industries The U S EPA letter provided comments on the Report on Supplemental Data Collection and Evaluation of Alternative Groundwater Remedy July 1998 by Golder Sierra Responses to the specific comments are provided in a response letter by Golder Sierra followed by a revised report

Please call Chris Smith (Cooper Industries) at (713) 209 8638 if you have any questions

Very truly yours

John Seymour P E
Project Coordinator

JPS mr

Enclosures

cc C Smith
H David Sanders (Black & Veatch)

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SUPERFUND RECORDS

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GOLDER
SIERRA

REVISED
REPORT ON

SUPPLEMENTAL DATA COLLECTION AND EVALUATION OF ALTERNATIVE GROUNDWATER REMEDY (IRON REACTIVE PERMEABLE BARRIER AND NATURAL ATTENUATION)

FOR

McGRAW-EDISON SUPERFUND SITE
CENTERVILLE, IOWA

PREPARED BY

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October 1998

986 1083

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770 496 1893
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GOLDER
SIERRA

October 23 1998

Cooper Industries Inc
600 Travis Suite 5800
Houston Texas 77002

Our Ref 986 1083

Attention Mr Christopher L Smith
Senior Project Manager Environmental Affairs

RE REVISED REPORT ON SUPPLEMENTAL DATA COLLECTION AND
EVALUATION OF ALTERNATIVE GROUNDWATER REMEDY
(IRON REACTIVE PERMEABLE BARRIER AND NATURAL ATTENUATION)
McGRAW EDISON SUPERFUND SITE
CENTERVILLE IOWA

Dear Chris

Golder Sierra LLC (Golder) is pleased to submit this Revised Report on Supplemental Data Collection and Evaluation of Alternative Groundwater Remedy (Iron Reactive Permeable Barrier and Natural Attenuation) for the McGraw Edison Superfund Site (Site) This report has been revised in response to USEPA letter dated September 23 1998 with comments on the July 30 1998 Supplemental Data Collection and Evaluation of Alternative Groundwater Remedy Report A separate letter responding to the individual USEPA comments in the September 23 1998 letter has been included in this report following this cover letter

Golder appreciates the opportunity of assisting Cooper Industries Inc on this project If you have any questions please do not hesitate to contact Rafael Ospina or Grant Hocking at (770) 496 1893 in our Atlanta office

Very truly yours

GOLDER SIERRA LLC

Rafael Ospina

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Senior Project Manager

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October 23 1998

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Our Ref 986 1083

Attention Mr Christopher L Smith
Senior Project Manager Environmental Affairs

RE RESPONSE TO EPA COMMENTS ON REPORT ON SUPPLEMENTAL DATA COLLECTION AND EVALUATION OF ALTERNATIVE GROUNDWATER REMEDY (IRON REACTIVE PERMEABLE BARRIER AND NATURAL ATTENUATION)
McGRAW EDISON SUPERFUND SITE
CENTERVILLE, IOWA
UAO No VII 94 F0008

Dear Mr Smith

Golder Sierra LLC (Golder) is pleased to submit this letter responding to the EPA Region VII (EPA) comments on the Report on Supplemental Data Collection and Evaluation of Alternative Groundwater Remedy (Iron Reactive Permeable Barrier and Natural Attenuation) by Golder dated July 30 1998 This letter presents the response to comments submitted by EPA in a letter dated September 23 1998

The format of this letter includes the comments by EPA (indicated in bold and italics) followed with the respective answer The comments and answers are detailed below

COMMENTS AND ANSWERS

1 *Page 7, Section 2 2 2* ***The analytical results for the 16 duplicate samples and the 7 rinsate blank samples that were sent to RECRA LabNet do not appear to be included in the report These sample results should be included***

The results are included in a separate data transmittal dated October 19 1998 to U S EPA The sample identification number the date sampled description and lab data package where the analytical results can be found are identified on the attached Table B 1 The sample ID number for the soil laboratory analyses that duplicated the field gas chromatograph (GC) analyses are shown on the attached Table B 1 QA/QC

Tables B 1 and B 1 QA/QC will be included in Appendix B 3 of the Revised Supplemental Data Collection and Evaluation of Alternative Groundwater Remedy Report (Revised Supplemental Data Collection Report)

2 <u>Page 8, Section 2 3</u> *The paragraph indicates that most of the wells experienced at least a 50 percent drop in TCE concentrations over the past four years This statement should be re phased to better state the data results*

The statement has been rephrased in the Revised Supplemental Data Collection Report to better state the data results

3 <u>Page 13, Section 2 3 3</u> *The QC results should be included in the report*

The QC results are included in the complete data package transmittal dated October 19 1998 The sample identification number the date sampled description and lab data package where the analytical results can be found are identified on the attached Table B 1

4 <u>Page 20, Section 3 3 2</u> *The first line of the second paragraph refers to Figure 5 The reference should be to Figure 10*

The figure number has been changed in the Revised Supplemental Data Collection Report

5 <u>Page 26, Section 3 5 3</u> *The last paragraph indicates that a comparison of the UW/EIT laboratory data and the RECRA LabNet laboratory data in Appendix E 1 Show good agreement for the influent data Since the detection limits for the RECRA LabNet data are 50 micrograms per liter and the contaminant concentrations if present appear to be below these detection limits state how this data agrees*

For high VOC concentrations RECRA LabNet have a reported detection limit of 50 µg/L and UW/ETI have a reported detection limit of 5 10 µg/L at low VOC concentrations RECRA LabNet have a reported detection limit of 0 1 to 1 µg/L and UW/ETI have a reported detection limit of 5 10 µg/L In the influent sample i e high VOC loading and high VOC concentration there is reasonable agreement and in the effluent i e low VOC loading and low VOC concentrations both laboratories reported virtually all VOC compounds to be non detect for their respective detection limits

The first sentence of the last paragraph in page 26 Section 3 5 3 will be replaced with the above sentence in the Revised Supplemental Data Collection Report The method detection limits (MDLs) by UW/ETI laboratory which were not included in the July 30 1998 submittal will be included in Appendix E 1

6 <u>Page 27, Section 3 6 2</u> *The reference to Figure 12 in the second paragraph should be to Figure 17*

The figure number has been changed in the Revised Supplemental Data Collection Report

7 <u>Page 29, Section 4 1</u> *The TCE concentration of 1 100 000 ug/L identified in MW 2 should be included on Figure 7*

The TCE concentration of 1 100 000 ug/L identified in MW 2 will be included on Figure 7 of the Revised Supplemental Data Collection Report

8 <u>Page 30, Section 4 3</u> *The second paragraph indicates that the majority of the low Eh values are located in the TCE plume as shown in Figure 7 However the majority of the low Eh values actually appear to be located outside the 10 microgram per liter contour line This statement should be revised accordingly*

The Eh values have been shown as contours on a new Figure and Section 4 3 has been edited in the Revised Supplemental Data Collection Report to reflect the actual data collected in the field

9 <u>Page 31, Section 4 3</u> *MW 2 in the first line at the top of the page should be MW 3*

The third paragraph in Section 4 3 has been edited The reference to the monitoring wells has been removed in the third paragraph of Section 4 3

10 <u>Page 32, Section 4 4</u> *The first paragraph indicates that increasing TCE concentrations were reported only at two wells MW 2 and WT 18 This appears to be an incorrect statement According to the data in Table 1 TCE concentrations also appear to be increasing in MW 6 (5 to 9 2) MW 7 (nd to 31) and WT 14 (0 5 to 0 8)*

The first paragraph of Section 4 4 has been edited and an additional paragraph added in the Revised Supplemental Data Collection Report to reflect all the wells that showed an increase in TCE concentrations in the 1998 sampling event and the spatial change in groundwater TCE concentrations between the 1994 and 1998 sampling events

11 <u>Page 32, Section 4 4</u> *The fifth sentence of the second paragraph states that such reductions in cis 1 2 DCE are seen across the site The data in Table 2 indicates the cis 1 2 DCE increased What data indicates the cis 1 2 DCE concentrations are decreasing?*

The statement *such reductions in cis 1 2 DCE are seen across the site* has been removed from the second paragraph in Section 4 4 and the statement *For example in MW 8A the TCE concentration decreased from 240 ppb to 7 ppb(1994 to 1998) and cis 1 2 DCE decreased from 0 8 ppb to non detect over the same period"* was added in the second paragraph of Section 4 4 in the Revised Supplemental Data Collection Report

12 *Page 33, Section 4 5 This section indicates the total number of points accumulated in scoring this site for NA is 1 9 Some of the scoring in Table 8 may be overly generous For example the maximum score of 2 is given for nitrate even though one data point is above 1 mg/L and one data point is below 1 mg/L The maximum score of 2 is given for sulfate even though only one data point is below 20 mg/L The maximum score of 1 is given to carbon dioxide and alkalinity even though only one data point is greater than two times background Finally the maximum score of 3 is given to ethene/ethane even though no ethane concentrations are greater that 100 micrograms per liter Using scores for carbon dioxide alkalinity and chloride is questionable since there is no representative background sample that can be used as a basis of comparison This rating requires further explanation and possible adjustment Additional sampling may provide more conclusive evidence to support NA as a viable remedial option*

The total number of points assigned in the Scoring System has been re evaluated providing a new total score of 16 Table 8 in the Revised Supplemental Data Collection Report shows the new scoring assigned to the different parameters considered in the evaluation Additional explanation has been provided in the second paragraph of Section 4 5 of the Supplemental Data Collection Report

The score of 16 would mark the Site as having adequate evidence of Natural Attenuation The evaluation of Natural Attenuation at the Site is determined in order of importance from the following

1 Groundwater TCE Concentrations
    - Spatial distribution and Time Trends of Concentration Data

2 Presence of Daughter Products
    - cis 1 2 DCE
    - ethene and ethane

3 Natural Attenuation Indicators
    - presence of electron donors
    - reduction of computing electron acceptors
    - evidence of Cometabolic Degradation
    - availability of growth substrates
    - evidence of mineralization

4 Site Ranking of Parameters

Considering the significant reduction in TCE concentrations in the groundwater and the presence of daughter products it is concluded that there is adequate to strong evidence of Natural Attenuation mechanisms being active at the Site

Natural Attenuation (USEPA 1996b) is those processes being biodegradation dispersion dilution adsorption or other natural processes that will attain required cleanup levels within a reasonable time frame

13 *Page 39, Section 5 2* ***Explain how was the injection well spacing of 15 feet determined?***

The spacing of 15 feet provided in the July 30 1998 submittal is a typical value The actual spacing between hydrofracturing wells will be determined during the design phase of the IRPB

14 *Appendix B 3* ***Because the QA/QC analytical results are not included in the report it is difficult to review the data validation discussion All QA/QC work sheets should be included with the data results***

All of the QA/QC analytical results are included in the complete data transmittal dated October 19 1998 The sample identification number the date sampled description and lab data package where the analytical results can be found are identified on the attached table

In addition the attached Table B 1 1 QA/QC (soil results) and Table B 2 2 QA/QC (groundwater) have the data qualifiers that were omitted from the tables in the original report dated July 30 1998

15 *Section 4 32, Page 30, Third Paragraph* ***Why are only the 1994 data discussed? According to page 12 iron analyses were performed in 1998 also The 1998 iron data should be presented and discussed***

Testing for ferrous iron (II) in the field was not performed during the 1998 sampling event and due to sample aeration would not have yielded representative values This statement will be included in the discussion in section 4 3 2 in the Revised Supplemental Data Collection Report

Data reported by the laboratory on iron is not representative of ferrous iron (II) but is the total iron since nitric acid is added to the sample during sampling Therefore the data reported by the laboratory have not been included in the Report

The following comments may be addressed in this resubmitted report or must be addressed in the supplement to the FS

1 *Page 43, Section 5 5* ***The first bullet at the top of the page indicates the down gradient TCE concentrations from the IRPB should decline with time to less than MCL levels within a moderate time frame of 10 to 15 years How many years will be required to determine if the IRPB is working satisfactorily? What steps will be taken if it is determined that the IRPB is not reducing the TCE concentrations to MCLs?***

Two years will be required to determine if the IRPB is performing satisfactorily Contingency measures will be discussed in the Supplemental FS Such contingency measures may involve additional iron injections or the installation of a second IRPB

2 ***Page 48, Section 5 6 5 Performance monitoring to determine if NA is occurring should be discussed***

Performance monitoring for NA will be discussed in detail in the Supplemental FS

3 ***Page 51, Section 5 7 The first bullet at the top of the page indicates that both systems are judged to be limited in the short term. Why is the VGR system limited in the short term?***

The VGR system is limited in the short term due to its low imposed groundwater gradient thus low groundwater flow velocities and long flow path ways in the upper/intermediate sands to the VGR extraction wells ETG (1994) concluded that the VGR was limited in the short term for the same above reasons

4 ***Page 51, Section 5 7 The second bullet indicates the IRPB is assessed to be more effective and more reliable than a pump and treat system Why is this true when the IRPB is more of an innovative treatment system?***

The IRPB is targeted at remediating contaminated groundwater while the VGR is not selective and would extract both contaminated and non contaminated groundwater IRPB technology has shown to be effective over the past five (5) years without any impact on performance and with the high degree of confidence that IRPBs will be effective for fifteen (15) years IRPBs have only been in place for five (5) years and thus are considered a new innovative technology

5 ***Page 53 and 54, Section 6 2 The text indicates that the TCE groundwater concentrations down gradient of the IRPB and in the remnant plume down gradient of the IRPB will be degraded to MCLs in ten years A backup or contingency remedy that will be implemented if the TCE concentrations are not degraded to MCLs should be discussed At this time the contingency remedy will be the selected remedy as presented in the Record of Decision***

The contingency remedy will be presented in the Supplemental FS

6 ***Page 30, Section 4 3 The reported concentrations of iron in Table 1 should not be used as iron (II) concentrations in assessing the site Using filtered total iron results to determine the iron (II) concentrations is too qualitative The iron (II) concentrations should be measured in the field immediately after collection***

Agreed the iron (II) concentrations should be measured in the field immediately after collection

The concentrations of dissolved iron in Table 1 will not be used as iron (II) for scoring the site for Natural Attenuation activity and therefore these values have been removed from the table A score of 0 will be given to iron (II) in Table 8

7 ***Groundwater modeling was performed to support the conclusion that biodegradation is actively decreasing the concentration of TCE in the groundwater The models used are very limited in their ability to actually simulate site conditions Based on the limited data presented in this report (Figure 28) the geologic strata in the aquifer are not at all conducive to using a simplistic analytical model The modeling effort presented is not supported by a complete discussion and the conclusions of the modeling are not fully supported***

Further discussion and a back analysis and forward prediction parameter sensitivity analyses were conducted to evaluate the expected range of outcomes The parameter sensitivities were first evaluated for back calculation best fit to the current Site TCE concentrations i e 30 years since plant operation began From these back calculated parameter values a 10 year forward projection was computed which calculated only a small variation in times to achieve groundwater remediation goals for the range of parameters considered

The 1D and 2D transient models used for fate and transport analysis were in close agreement Sensitivity analysis of input variability demonstrated the robustness of model back analysis calibration from site historic data

The sensitivity analyses are presented on two new Tables 9 and 10 and model description and sample output are included in a new Appendix F It has been demonstrated that these models are sufficient to forecast the expected conditions in ten (10) years based on calibration from site data over the past 30 years

8 ***Section 4 3, Page 31, First full paragraph, Sentence 4*** ***This sentence indicates that MW 8 is near the plume source In fact MW 8 appears to exist on the edge of the plume downgradient of the source The sulfate data appears to be inconclusive at best Data from MW 2 and MW 8A which are both near the source are have sulfate concentrations greater than the sulfate concentration in MW 23WT The sulfate data from these wells is contradictory***

The sulfate data should be presented on a contour map like the other parameters

Sulfate data has been presented as contours on a figure in the Revised Supplemental Data Collection Report and the spatial variability is discussed in Section 4 3 of the Revised Supplemental Data Collection Report

9 ***Section 4 3, Page 31, Second full paragraph*** ***No true background samples were collected to show that ethane and ethene are only present because of the degradation of TCE If ethane and ethene are present in background samples their presence is meaningless***

Elevated ethane and ethene concentrations were only detected in the high TCE concentration source wells along with other TCE daughter products The correlation of high ethane and ethene values with high TCE concentrations is supportive evidence that NA is occurring at the site Only low ethene and ethane concentrations were detected in the remaining wells

10 ***Section 4 6 1, Page 34*** ***A porosity of 35% seems excessively high Why was this value used? Values ranging from 20% to 25% are more commonly accepted What impact does changes in this value have in the modeling results?***

A value of 35% porosity was determined from soil classification and a widely used reference text book From our experience this value is reasonable for the type of soils at the Site Recompacted Site soil samples subjected to the leak off tests were determined to have a porosity of 0 33 to 0 34 see Table 5 However if the porosity of the upper and intermediate sands ranged from 0 25 to 0 35 the conclusions of the report would stand un changed For example sensitivity analyses were conducted using a range of porosity of 0 25 to 0 35 to back calculate other parameters to best fit current Site TCE concentrations and then forward predict the time to achieve groundwater remediation goals

The results from these analyses are given below

Porosity (n)	Retardation Coefficient (D) (ft /day	Dispersion Coefficient (D) (ft /day)	Degradation Half Life for TCE (t_0) (days)	Computed Groundwater TCE Concentration (ppb) at 30 Yrs Along Plume Major Flow Axis			Time to Achieve Remediation Goals TCE <5ppb (yrs)
				200 ft	400 ft	600 ft	
0 25	1 4	13 7	600	1291	249	48	11 4
0 3	1 4	13 4	600	1292	249	48	11 1
0 35	1 4	16 6	600	1291	249	48	10 9

Notes (1) Parameter D was computed to fit current site TCE groundwater concentrations and be within the acceptable parameter range

The conclusions on the performance of the IRPB are not impacted by considering a range of porosity from 0 25 to 0 35 because the barrier is significantly over designed

The distribution coefficient (K_d) is generally corrected to account for the amount of organic carbon in the aquifer by the following equation

$$K_d = K \quad {}^{*}f$$

Where K is the organic carbon distribution coefficient of the contaminant and f is the fraction of organic carbon in the aquifer Is the fraction of organic carbon known for the aquifer? If it is known it should be accounted for in the retardation factor If the amount of organic carbon is unknown then a significant data gap exists Sensitivity analyses should be performed to evaluate the impact of uncertainty n the retardation factor The uncertainty of the retardation factor is a significant data gap and can have a significant impact on model results

A more detailed discussion of the concept which was applied in using the model should be provided The discussion must be present to support the conclusions The discussion should include assumptions of the model model input parameters (these have been discussed except a more detailed discussion regarding the contaminant source in the model should be more fully discussed) model calibration sensitivity analysis evaluations and all significant simulations

Model output should be discussed and supported with additional graphs or maps A discussion on the limitations of the model should also be included

The evaluation of K_d for TCE is discussed further in Section 4 6 1 of the Revised Supplemental Data Collection Report The f for the sands at this site has been determined and it has been documented (reference cited in Section 4 6 1) that K_d = K *f under estimates K_d A sensitivity analysis has been conducted on K_d D and t_{50} and has confirmed the robustness of the back calculation procedure and provides greater confidence in the 10 year forward prediction of TCE groundwater concentrations The time to achieve groundwater remediation goals was computed for a range of inputs and concluded that the time to achieve such goals ranges from a low of 9 years to a high of 15 years Detailed discussion of those additional analyses is provided in Sections 4 6 1 and 4 6 2

The dispersion factor can have an significant impact on concentrations downgradient of the source area A sensitivity analysis should be run to evaluate the impact of uncertainty of this value

Sensitivity analysis has been conducted and reported in Section 4 6 1 of the Revised Supplemental Data Collection Report

Please provide additional discussion regarding Figure 23 Discuss the simulations which support the data on this figure Was the simulation steady state or transient?

The simulation was transient and further discussion supporting the data on this figure is provided in Section 4 6 1 of the Revised Supplemental Data Collection Report

11 <u>Section 4 6 2, page 36</u> One paragraph of discussion is insufficient supporting documentation to support the conclusions presented The second paragraph of Section 4 6 2 should be significantly expanded to discuss the conceptual model the assumptions of the model the calibration of the model the sensitivity analysis the simulations and the limitations of the model Model output should be presented to support the conclusions the calibration and the sensitivity analysis of the model

Additional discussion has been included in Section 4 6 2 in the Revised Supplemental Data Collection Report along with further analysis and model output to support the conclusions calibration and sensitivity analysis of the model Output has been presented in Appendix G 1 for the 1D transient model used for the analysis in Section 4 6 1 and in Appendix G 2 for the 2D transient model used for the analysis in Section 4 6 2 in the Revised Supplemental Data Collection Report

Golder believes the above answers to the EPA comments on the Supplemental Data Collection and Evaluation of Alternative Groundwater Remedy Report are appropriate If you have any questions please do not hesitate to contact us

Very truly yours

GOLDER SIERRA LLC

Rafael Ospina

Rafael I Ospina P E
Senior Project Manager

Grant Hocking Ph D
President

RIO/GH/rio

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Table B 1
QUALITY ASSURANCE/QUALITY CONTROL
FIELD SUMMARY
MAY 1998
McGraw Edison Site
Centerville, Iowa

I D #	Sample Date	Description	Data Package
MW 7	5/13/98	GW Duplicate	CC
MW 23WT	5/6/98	GW Duplicate	AA
EW 1	5/12/98	GW Duplicate	CC
BR 10	5/8/98	GW Duplicate	DD
MW 7A	5/13/98	GW Matrix Spike	CC
MW 7A	5/13/98	GW MS Duplicate	CC
MW 24	5/26/98	GW Field Blank	BB
MW 30	5/6/98	GW Field Blank	AA
MW 31	5/6/98	GW Field Blank	AA
MW 32	5/7/98	GW Field Blank	DD
MW 33	5/8/98	GW Field Blank	DD
MW 34	5/13/98	GW Field Blank	CC
Rinsate 2	4/29/98	Soil Field Blank	FF
Rinsate 3	4/30/98	Soil Field Blank	FF
Rinsate 4	5/1/98	Soil Field Blank	EE
Rinsate 5	5/2/98	Soil Field Blank	EE
Rinsate 6	5/2/98	Soil Field Blank	EE
P 2	4/30/98	GW Duplicate of Field GC Analysis	EE
P 6	5/2/98	GW Duplicate of Field GC Analysis	EE

<u>Notes/Legend</u>
GW = Groundwater
QC duplicates for soil samples collected and analyzed by field GC are shown on the attached B 1 1QA/QC

Table B 1 1 QA/QC
TCE Concentrations of Soil Samples
McGraw Edison Site Centerville Iowa

Borehole ID	Sample Date	Depth (feet)	Lab TCE (ug/kg)	Field TCE (ug/kg)	Borehole ID	Sample Date	Depth (feet)	Lab TCE (ug/kg)	Field TCE (ug/kg)
P 01	27 Apr 98	1 3	ns	2 2	P 05	30-Ap 98	9 11	nd	d
P 01	27 Ap 98	3-5	ns	d	P-05	30-Apr 98	11 13	ns	nd
P 01	27 Apr 98	5-7	ns	d	P 05	30-Ap 98	13-15	ns	d
P 01	27 Apr 98	7 9	ns	nd	P 05	30-Apr 98	15-17	ns	d
P 01	27 Apr 98	9-11	nd	nd	P 05	30 Apr 98	17 19		nd
P 01	27 Apr 98	11 13	ns	nd	P 05	30 Ap 98	19-21	s	d
P 01	27 Apr 98	13-15	ns	nd	P 05 (2)	1 M y 98	5-7 5	ns	d
P 01	27 Apr 98	17 19	ns	nd	P 05 (2)	1 May 98	7 5-10	nd	d
P 01	27 Apr 98	19 21	ns	nd	P 05 (2)	1 May 98	10-12 5	s	d
P-01	27 Apr 98	21 23	ns	nd	P-05 (2)	1 May 98	12 5-15	ns	nd
P 01	27 Ap 98	23 25	ns	d	P 05 (2)	1 M y 98	15-17 5		d
P-01	27 Apr 98	25-27	ns	nd	P 05 (2)	1 May 98	17 5-20	ns	1 5
P-01	28-Ap 98	27 29	s	d	P 05 (2)	1 M y 98	20 22 5		4
P-01	28-Apr 98	29-31	ns	nd	P-05 (2)	1 May 98	22 5-25	ns	26 8
P 01	28-Ap 98	31 33		d	P 05 (2)	1 May 98	25-27 5	ns	88
P-01	28-Apr 98	33-35	nd	nd	P-05 (2)	1 May 98	27 5-30	ns	83 6
P 01	29 Apr 98	35-37	ns	d	P 05 (2)	1 May 98	30-32 5	ns	52 3
P 01	28-Ap 98	39-41	s	nd	P-05 (2)	1 May 98	32 5-35	ns	8 1
P 02	29-Ap 98	1 3	d	d	P 05 (2)	1 M y 98	35 37 5	ns	3 3
P-02	29-Ap 98	3-5	n	d	P 05 (2)	1 May 98	37 5-40	nd	d
P 02	29-Ap 98	5-7	ns	nd	P 06	2 May 98	0-2 5	ns	nd
P 02	29-Apr 98	7 9	ns	nd	P 06	2 May 98	2 5-5	ns	d
P 02	29-Ap 98	9 11	ns	nd	P 06	2 M y 98	5-7 5		nd
P 02	29-Apr 98	11 13	s	nd	P 06	2 May 98	7 5-10	ns	3 2
P 02	29 Ap 98	13-15		d	P 06	2 May 98	10-12 5		7 7
P-02	29 Apr 98	15-17	ns	nd	P 06	2 May 98	12 5-15	nd (UJ)	nd
P 02	29 Ap 98	17 19		d	P 06	2 May 98	15-17 5	ns	d
P-02	29-Apr 98	19-21	ns	nd	P 06	2 May 98	17 5-20	ns	nd
P 02	29-Ap 98	21 23	ns	nd	P 06	2 M y 98	20-22 5		d
P 02	29-Ap 98	23-25	n	nd	P 06	2 M y 98	22 5-25	ns	nd
P 02	29 Ap 98	25 27	ns	nd	P 06	2 May 98	25 27 5	ns	9 3
P 02	29-Apr 98	27 29	ns	nd	P-06	2 May 98	27 5-30	ns	23 4
P 02	29 Apr 98	29 31	ns	d	P 06	2 May 98	30-32 5	ns	14 6
P-02	29-Apr 98	31 33	s	nd	P-06	2 May 98	32 5-35	ns	1 2
P 02	29 Ap 98	33 35	s	nd	P 06	2 M y 98	35-37 5		d
P 02	29-Apr 98	35-37	ns	nd	P 06	2-May 98	37 5-40	nd	nd
P 02	29 Apr 98	37 39	ns	d	P 07	2 May 98	0-2 5	ns	d
P 02	29-Apr 98	39-41	nd	nd	P-07	2 May 98	2 5-5	nd	nd
P 03	3-M y 98	0-2 5	s	nd	P 07	2 M y 98	5-7 5		1 3
P 03	3-May 98	2 5-5	s	nd	P-07	2 May 98	7 5-10	ns	9 8
P 03	3-May 98	5-7 5	ns	nd	P 07	2 May 98	10-12 5	ns	nd
P-03	3 May 98	7 5-10	ns	nd	P-07	2 May 98	12 5-15	ns	nd
P 03	3 M y 98	10 12 5	nd	nd	P 07	2 M y 98	15-17 5	ns	nd
P-03	3-May 98	12 5-15	ns	nd	P 07	2 May 98	17 5-20	ns	nd
P 03	3-May 98	15-17 5	ns	1 6	P 07	2 May 98	20-22 5	ns	d
P 03	3-May 98	17 5-20	ns	4 4	P 07	2 May 98	22 5-25	nd	nd
P 03	3-May 98	20-22 5	s	nd	P 07	2 May 98	25-27 5	ns	5 8
P 03	3-May 98	22 5-25	ns	nd	P-07	2 May 98	27 5-30	ns	nd
P 03	3-May 98	25-27 5	ns	nd	P 07	2 M y 98	30-32 5	ns	d
P-03	3-May-98	27 5-30	ns	nd	P 07	2 May 98	32 5-35	ns	nd
P 03	3 M y 98	30 32 5		d	P 07	2 M y 98	35-37 5		d
P 03	3-May 98	32 5-35	ns	nd	P 07	2 May 98	37 5-40		nd
P 03	3 May 98	35-37 5	ns	d	P 07	2 May 98	40-42		d
P 03	3-May 98	37 5-40	nd	nd	P-08	3-May 98	0-2 5	ns	nd
P 04	30-Ap 98	1 3	s	nd	P 08	3-May 98	2 5-5	ns	64 4
P 04	30-Apr 98	3-5	ns	d	P-08	3-M y 98	5-7 5	ns	48 4
P 04	30 Apr 98	5-7	ns	nd	P 08	3-May 98	7 5-10	ns	104 9
P-04	30-Apr 98	7 9	ns	nd	P-08	3-May 98	10-12 5	ns	49 5
P 04	30 Ap 98	9-11	ns	nd	P 08	3-May 98	12 5-15	s	8 8
P-04	30-Ap 98	11 13	ns	d	P 08	3-May 98	15-17 5	ns	d
P-04	30-Apr 98	13 15	ns	9 9	P 08	3-May 98	17 5-20	ns	d
P 04	30-Apr 98	15-17	ns	nd	P 08	3-May 98	20-22 5	nd	nd
P 04	30-Ap 98	17 19	nd	nd	P 08	3-May 98	22 5-25	s	nd
P-04	30-Apr 98	19-21	ns	nd	P-08	3-May 98	25-27 5	ns	6 4
P 04	1 May 98	0-32	ns	11 9	P 08	3-May 98	27 5-30	ns	1 8
P-04	1-May 98	32 5-35	ns	nd	P 08	3-May 98	30-32 5	nd	nd
P 04	1 May 98	35-37 5	ns	nd	P 08	3-May 98	32 5-35	ns	d
P-04	1 May-98	37 5-39	ns	nd	P 08	3-May 98	35-37 5	ns	nd
P 04	1 May 98	39-40	ns	nd	P-08	3-May 98	37 5-40	ns	nd
P-04 (2)	3-May 98	20-22 5	ns	nd	P-08	3-May 98	40-42	ns	nd
P 04 (2)	3-May 98	22 5-25	ns	nd	P-09 (SB SC2)	13-May 98	6-8	130	ns
P-04 (2)	3-May 98	25-27 5	ns	nd	P-09 (SB-SC2)	13-May 98	8-10	120 (J)	ns
P 04 (2)	3-May 98	27 5-30	ns	nd	P 09 (SB SC2)	13-May 98	10-12	80 (J)	
P-05	30-Apr 98	1 3	ns	nd	P-09 (SB-SC2)	13-May 98	12 14	4 (J)	ns
P 05	30-Ap 98	3-5	ns	nd	P 09 (SB SC2)	13-May 98	18-20	nd (UJ)	ns
P-05	30-Apr 98	5-7	ns	nd	P-09 (SB SC2)	13-May 98	28-30	8	ns
P 05	30-Apr 98	7 9	ns	nd					

d compo nd d t cted lys J- E t m t d co ce t t f d cted lyt W C d t valid t m m f J ly 1998

t mpl d f l b lys

(2) B ri g ft ed d re mp ed

Table B 2 2 QA/QC
Summary of May 1998 Groundwater TCE Analyses
McGraw Edison Site
Centerville Iowa

Well ID	1998 TCE (µg/L)
MW 1	nd
MW 2	1 100 000 J
MW 3	nd
MW 3A	6 400J 7 000dupJ
MW-4	nd
MW 5	nd
MW 6	9 2J
MW 7	31J 1dupJ
MW 7A	2J
MW 8	1J
MW 8A	7J
MW 9	
MW 19WT	70J
MW 20WT	20J
MW 21	nd
MW 22WT	nd
MW 23WT	nd
ALLEN WELL	51 J
WT 11	nd
WT 12	nd
WT 13	nd
WT 14	0 8J
WT 16	nd
WT 18	45J
EW 1	14J 12dupJ
BD 11	nd
BD 12	nd
BD 13	nd
BD 14	nd
BD 16	nd
BD 18	4J
BR 10	nd

NOTES

* Grab Sample
dup Duplicate Sample
nd Constituent not detected during analysis of sample
Not Obtained

J= Estimated concentration for detected analytes
see W C July 30 1998 memo

MOnitoring well MW 9 was not analyzed in May 1998 because a dead animal was stuck in the well

EXECUTIVE SUMMARY

A soil and groundwater field sampling program plus a feasibility assessment of a Permeable (Reactive) Barrier and quantification of natural attenuation processes at the McGraw Edison Superfund Site are contained in this report This effort was conducted as per the Soil and Groundwater Field Sampling Plan submitted to the USEPA on June 13 1997 and with response to comments on November 5 1997 and was subsequently approved by the agency on December 11 1997 with response to final comments provided to the agency on January 30 1998

The objectives of the work plan were as follows

☐ to assess current Site conditions to finalize the remedial design

☐ to further delineate the soil contamination in the South Culvert Area

☐ to assess the feasibility of implementing an alternative groundwater remedy utilizing an Iron Reactive Permeable Barrier (IRPB) and

☐ to evaluate and quantify any Natural Attenuation mechanisms active at the Site

The field work consisted of nine (9) soil borings to depths of 40 feet in the South Culvert Area with continuous soil samples collected for TCE contamination analysis Groundwater samples were taken at the bottom of eight (8) of these borings and analyzed for TCE The thirty two (32) existing monitoring wells were sampled and analyzed for TCE contamination and five (5) of these wells were further sampled and analyzed for Natural Attenuation parameters Two soil borings were completed near the TCE Storage Area for collection of samples for the IRPB assessment Groundwater was collected from monitoring well MW 3A for a laboratory column reactivity test to assess the suitability of the Site groundwater for an iron reactive barrier

The iron reactivity column test quantified the degradation half lives for TCE and cis 1 2 DCE in the presence of zero valent granular iron and also completed inorganic analyses to determine whether any precipitation or clogging might occur Laboratory studies were conducted on the Site soils to quantify the feasibility of constructing an IRPB using the orientated vertical hydraulic fracturing technology Natural Attenuation processes at the Site were quantified from the bioparameter analysis of the Site groundwater Numerical model simulations back calculated Natural Attenuation processes from historical and current data The results of the modeling were used to predict future impacts of Natural Attenuation processes on Site wide contamination in the groundwater The degradation ability of the IRPB was quantified for all of the potential organic constituents of concern at the Site using Site data and the degradation half lives from the column test

The soils in the South Culvert Area were found to have TCE concentrations less than 150 µg/kg with 98% of the soil volume sampled having TCE concentrations less than 100 µg/kg and 65% of the soil volume sampled having TCE concentrations below detection limits TCE concentrations in the groundwater were found to be generally lower than those values reported in the last sampling round of 1994 The assessment of the Natural Attenuation bioparameters indicated significant Natural Attenuation occurring at the Site with a complete degradation pathway evident due to the presence of end products of the degradation cycle ethane and ethene The reactivity of the zero valent granular iron was capable of completely degrading the volatile organics in the Site groundwater From the iron reactive column test a half life for TCE was calculated as being less than 0 5 hour

The conclusions from this field work and feasibility assessment are as follows

- ☐ the South Culvert Area soils are below the contamination level of 750 µg/kg and therefore do not require or warrant active remediation by soil vapor extraction
- ☐ groundwater concentrations of TCE are generally declining across the entire Site
- ☐ there is adequate to strong evidence that natural attenuation is occurring at the Site
- ☐ an IRPB can be constructed at the Site by the vertical hydraulic fracturing technology
- ☐ the IRPB will degrade all of the VOCs of concern to below MCLs and is considered to have sufficient longevity for the Site groundwater to be remediated to below MCLs
- ☐ the remnant plume down gradient of the IRPB will be degraded by Natural Attenuation mechanisms to below MCLs in approximately ten (10) years and
- ☐ the alternative groundwater remedy of an IRPB and Natural Attenuation was determined to be equivalent or superior to the current groundwater remedy utilizing the NCP criteria The alternative groundwater remedy was determined to be superior to the current remedy in respect to effectiveness implementability and cost

The recommendations from this work are as follow

- ☐ to implement the soil remedy using soil vapor extraction in the areas of the TCE Storage Area and inside of the Manufacturing Building of the upper till #3 unit down to depths of 20 and 30 feet respectively
- ☐ to eliminate the South Culvert Area for active remediation and
- ☐ to modify the groundwater remedy to construct an IRPB Barrier and to rely on natural attenuation at the Site to achieve remediation levels in the remnant down gradient plume

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1 0 INTRODUCTION

A Soil and Groundwater Field Sampling Plan Addendum (Addendum) was submitted to the USEPA (Agency) by MWR/Envirogen Inc (MWR/Envirogen) on June 13 1997 This document described additional field activities to be performed at the McGraw Edison Superfund Site (Site) located in Centerville Iowa Figure 1 Response to initial review comments on the Addendum were submitted to the Agency on November 5 1997 The agency approved the work plan on December 11 1997 subject to a satisfactory response to final review comments A response to final review comments was submitted to the USEPA on January 30 1998

The objectives of the work plan were as follow

- to assess current site conditions to finalize the remedial design
- to further delineate the soil contamination in the South Culvert Area
- to assess the feasibility of implementing an alternative groundwater remedy utilizing an Iron Reactive Permeable Barrier (IRPB) and
- to evaluate and quantify any Natural Attenuation mechanisms active at the Site

Groundwater sampling at existing monitoring wells and soil boring sampling in the South Culvert Area was performed by Envirogen Golder Sierra LLC (Golder) was retained by MWR/Envirogen to conduct the IRPB feasibility evaluation for an alternative groundwater remedial system for the Site and to quantify Natural Attenuation activity (biodegradation dispersion dilution and/or adsorption) at the Site The IRPB would be a passive in situ treatment of groundwater at the Site contaminated mainly with trichloroethene (TCE) This alternative groundwater remedial system is to be complemented by a Soil Vapor Extraction (SVE) system being evaluated by MWR/Envirogen for source control of the unsaturated zone

The field activities were conducted in May 1998 MWR/Envirogen retained ERM North Central of St Charles Missouri and Aquadrill Drilling Services (Aquadrill) of Coralville Iowa to perform Geoprobe® and drilling work respectively for soil and groundwater sampling activities in the South Culvert Area and in the TCE Storage Area for the IRPB subsurface drilling program The South Culvert Area work and monitoring well sampling activities were supervised by MWR/Envirogen personnel The IRPB drilling and sampling program was supervised by a Golder geologist Analytical laboratory testing was conducted by RECRA LabNet of University Park Illinois and Monroeville Pennsylvania Envirogen Inc Laboratory of Lawrenceville New Jersey and MICROSEEPS of Pittsburgh Pennsylvania

The field work consisted of nine (9) soil borings to depths of 40 feet in the South Culvert Area with continuous soil samples collected for TCE contamination analysis Groundwater samples were taken at the bottom of eight (8) of these borings and analyzed for TCE The thirty two (32) existing monitoring wells were sampled and analyzed for TCE contamination and five (5) of these wells were further sampled and analyzed for Natural Attenuation parameters Two soil borings were completed near the TCE Storage Area for collection of samples for the IRPB assessment Groundwater was collected from monitoring well MW 3A for a laboratory column reactivity test to assess the suitability of the Site groundwater for an iron reactive barrier

As part of the evaluation of an alternative groundwater remedy Golder designed and implemented a limited subsurface investigation program at the Site to collect samples for laboratory testing in support of the IRPB feasibility evaluation Soil and groundwater samples were collected by Golder s field personnel and sent to University of Waterloo/EnviroMetal Technologies Inc (UW/ETI) in Canada under Contract to Golder for iron bench scale column and soil desorption testing and to Golder geotechnical laboratory in Atlanta Georgia for soil classification testing soil resistivity testing and leak off testing

This report is divided into the following key elements

- ☐ Section 1 provides an introduction to the report objectives and background
- ☐ Section 2 presents the field program and results
- ☐ Section 3 presents the reactive barrier laboratory testing program and results
- ☐ Section 4 presents the Natural Attenuation evaluation and results
- ☐ Section 5 presents the Iron Reactive Permeable Barrier evaluation and results and the Alternative Groundwater Remedial Plan

- ☐ Section 6 presents the proposed soil remedy implementation and the alternative groundwater remedy and

- ☐ Section 7 presents the summary and conclusions

1 1 Background

Toasters and toaster ovens were manufactured at the McGraw Edison site (Site) in Centerville Iowa between 1965 and 1978 Operations were housed in a 194 800 square foot manufacturing building McGraw Edison sold the facility to Peabody International Corp (Peabody) in 1980 Cooper acquired the stock of McGraw Edison in 1985 and McGraw Edison became a wholly owned subsidiary of Cooper Cooper purchased the facility from Peabody in 1990

The Iowa Department of Natural Resources (IDNR) performed an assessment of the Site in June 1986 Hazardous substances identified at the Site by the IDNR included plating sludges trichloroethene (TCE) sodium hydroxide and sulfuric acid The USEPA conducted sampling at the Site in January 1987 Analysis of sludges and sediments indicated elevated concentrations of chromium arsenic nickel and cobalt

Cooper and Peabody conducted a site investigation and removed the plating solids in compliance with an Administrative Order on Consent (AOC) signed with the USEPA on October 3 1988 During the site investigation several areas of the site were found to contain metal concentrations significantly higher than background levels volatile organic compounds (VOCs) were detected in surface water and soil samples from the south property perimeter and TCE was detected above drinking water standards in the groundwater A residential well adjacent to the site was also sampled and found to contain TCE Cooper provided a permanent water supply by connecting the residence well to the public water supply in the winter of 1988

A Remedial Investigation (RI) was conducted by Cooper between October 1991 and May 1992 This work addressed the soil groundwater surface water and sediment at the Site A Supplemental RI was conducted by Cooper during October and November 1995 which included field work for the definition of the extent of the soil and groundwater contamination at the Site and characterization of the water bearing units

2 0 FIELD SOIL AND GROUNDWATER SAMPLING PROGRAM AND RESULTS

2 1 General

A Soil and Groundwater Field Sampling Plan Addendum (Addendum) was submitted to the USEPA by MWR/Envirogen on June 13 1997 that described additional field activities to be performed at the Site The purpose of this work was to

- ☐ assess current site conditions to finalize the remedial design
- ☐ further delineate the soil contamination in the South Culvert Area
- ☐ assess the feasibility of implementing an alternative groundwater remedy utilizing an Iron Reactive Permeable Barrier (IRPB) and
- ☐ evaluate and quantify any Natural Attenuation mechanisms active at the Site

The following activities were specified in the Addendum and performed in May 1998

1 Groundwater sampling and analysis at thirty two (32) existing monitoring wells
2 Natural Attenuation groundwater sampling at select monitoring wells and evaluation
3 Soil and groundwater sampling in the South Culvert Area and evaluation and
4 Iron Reactive Permeable Barrier preliminary data collection activities and feasibility evaluation

Groundwater sampling at existing monitoring wells and soil boring sampling in the South Culvert Area were performed by MWR/Envirogen Golder designed and implemented a limited subsurface investigation to collect samples to be used in various tests to provide data to determine the feasibility of installing an IRPB for groundwater remediation at the Site The subsurface investigation consisted of a subsurface soil drilling program soil sample collection and groundwater sample collection The monitoring wells and soil borings completed at the Site are detailed on Figures 3 and 4

The following sections document the methodology and results of the soil and groundwater field sampling activities and results

2 2 South Culvert Soil Sampling Program and Results

The primary goal of this sampling was to assess current site conditions in the South Culvert Area in order to finalize the soil remedial design Nine (9) additional soil borings (P 01 to P 09) were completed in the South Culvert Area at the locations shown on Figures 4 and 5 Soil borings P 01 to P 08 were located approximately 20 feet in the northerly southerly easterly and westerly directions from existing boring SB SC 1 (MW 19WT) and SB SC 2 Any deviation from the 20 foot intervals was due to landscape obstructions Soil boring P 09 (field labeled SB SC2) was completed to verify the presence or absence of high TCE soil concentrations at SB SC 2 reported in the Supplemental RI/FS Investigation Report (Woodward Clyde Consultants 1994) This borehole was located centrally between P 05 P 06 P 07 and P 08 as close to the location of SB SC 2 sampled in October 1995

2 2 1 Soil Sampling

The soil borings were sampled by Geoprobe® technology drill rig or Hydropunch® and analyzed for TCE using a field gas chromatograph (GC) Continuous soil samples were collected in soil borings P 01 to P 08 in 2 or 2 5 foot vertical intervals starting at one foot below ground surface (BGS) and continued until approximately 35 to 40 feet BGS Soil boring P 09 was sampled at 2 foot intervals at the same discrete intervals that were sampled during the installation of the original SB SC 2 in October 1993 and the samples were analyzed by EPA Method 8260 for TCE by RECRA Lab Net University Park Illinois The soil samples were logged by a MWR/Envirogen geologist noting color texture moisture content odor and grain size using the United Soil Classification System (USCS) The soil boring logs for the borings drilled in the South Culvert Area are included in Appendix A The results of the soil TCE concentrations in the South Culvert Area are shown on Figure 5 and summarized in tables in Appendix B

ERM North Central of St Charles Missouri was subcontracted by MWR/Envirogen to perform Geoprobe® work Soil samples from P 01 and P 02 were collected in a 1 5 inch outer diameter drive point sampler with an acetate liner two feet in length However due to the presence of consolidated soils in the South Culvert Area the acetate liner was consistently being compressed causing a loss of soil in the sampler Instead a two inch outer diameter drive point Macro sampler with an acetate liner four feet in length was used at P 04 and P 05

At P 04 and P 05 sloughing occurred at approximately 21 feet BGS Aquadrill Drilling Services of Iowa City Iowa was contracted by MWR/Envirogen to complete P 04 resample P 05 and complete the remaining soil borings (including P 09) with a drill rig and Laskey samplers with copolyester liners 2 5 inches in diameter and five feet in length

The liner was removed from the sampler and split open onto a clean surface New latex gloves were worn and changed between each sample to prevent cross contamination The two foot section of soil was screened using a PID HNu model PI 101 equipped with a 11 7 eV lamp for soil borings P 01 through P 08 Once screening was complete a composite soil sample of each two foot interval was placed in a four ounce wide mouth glass jar and packed with minimal headspace Each sample was analyzed on site with a field GC for TCE The field GC analysis results for TCE are shown on Figure 5 for soil borings P 02 through P 08 and laboratory analysis results for soil boring P 09 Chain of custody protocol was used for all samples The soil samples were logged by a MWR/Envirogen geologist noting color texture moisture content odor and grain size using the United Soil Classification System (USCS) The soil boring logs for the South Culvert Area are included in Appendix A

The TCE concentrations determined in the nine (9) soil borings are detailed on Figure 5 The locations of these nine (9) borings are given on Figure 4 and in the insert on Figure 5 As can be seen on Figure 5 the maximum TCE concentration measured in the soil was 130 µg/kg Ninety eight (98%) percent of the soil volume sampled had TCE concentrations less than 100 µg/kg and sixty five (65%) percent of the soil volume sampled had TCE concentrations below detection limits

2 2 2 Field Quality Assurance and Quality Control

Sixteen (16) of 148 soil samples were duplicated and sent to RECRA LabNet to be analyzed by EPA Method 8260 for TCE to verify mobile laboratory accuracy Duplicate samples were chosen based on suspected regions of contamination and covered a variety of depths In addition a rinsate blank was taken during each day of soil and groundwater sampling (7 total) These samples consisted of distilled drinking water which was used to rinse the sampler after decontamination

Analytical chemistry data validation for laboratory analyses are contain in Appendix B

2 3 Groundwater and Natural Attenuation Sampling Program and Results

The groundwater sampling program involved the collection of groundwater samples from the soil borings completed in the South Culvert Area and from the Site groundwater monitoring wells The objective of the groundwater sampling program was to evaluate the distribution of TCE in the groundwater and to evaluate the degree of Natural Attenuation of VOCs at the Site

Groundwater samples were collected within the first two feet of the saturated unit in soil borings P 01 through P 08 completed in the South Culvert Area see Figure 4 The samples were analyzed for TCE with the field GC

Thirty two (32) existing monitoring wells (Figure 3) were sampled for field parameters (temperature dissolved oxygen specific conductance pH and redox potential) and for laboratory analysis of TCE Five of the existing monitoring wells (MW 2 MW 3A MW 8 MW 8A and MW 23WT) were sampled for laboratory analysis of biochemical parameters and VOCs to evaluate the existence of Natural Attenuation of VOCs at the Site Prior to sampling a static water level was measured and recorded for each well The May 1998 sampling event groundwater level data is presented in the form of potentiometric contours on Figure 6 and summarized in tabular form in Appendix B The distribution of groundwater TCE concentration levels obtained after the May 1998 sampling event is shown on Figure 7 The chemistry data are summarized in Tables 1 to 3 and in Appendix B

The TCE concentrations in the majority of the groundwater monitoring wells in this latest round of sampling were lower than the previous 1994 sampling event see Table 1 except for monitoring wells MW 6 and WT 18 which rose from 5 ppb to 9 ppb and 12 ppb to 45 ppb respectively The monitoring well in the unsaturated zone MW 2 located in a localized perched water table rose in 1998 and its high concentration and fluctuations are indicative of a source area TCE concentrations in monitoring well MW 3A dropped from 14 000 ppb in 1994 to 7 000 ppb in 1998 MW 8A dropped from 240 ppb to 7 ppb and the Allen Well from 120 ppb to 51 ppb The TCE groundwater plume shown on Figure 7 has reduced in concentration and in the overall TCE mass contained in the plume over the past four (4) years The dissolved phase mass of TCE in the groundwater plume delineated in the Supplemental RI/FS Investigation Report (Woodward Clyde Consultants 1994) is estimated to be >90 lbs while in 1998 Figure 7 the dissolved phase mass of TCE is estimated to be 35 lbs based on the TCE concentration contours shown on Figure 7 this represents approximately a 60% reduction in TCE dissolved mass in the groundwater plume over the past four (4) years

2 3 1 Groundwater Sampling in South Culvert Area

Groundwater samples were collected in soil borings P 01 through P 08 drilled during the soil sampling program in the South Culvert Area Groundwater sampling was performed using Geoprobe® or HydroPunch® techniques The samples were collected within the first two feet of the saturated unit Groundwater from soil boring P 01 was collected using the Geoprobe® technique A one inch inner diameter hollow rod was driven into the ground creating a separate pilot hole four foot deep (38 42 ft BGS) Groundwater samples were obtained using bottom check valve sampling technique using a 5/8 inch diameter Teflon® tube A tubing check valve was located at the bottom end of the roll of tubing The tubing check valve end first was pushed down the bore of the probe rod until it reached the top of the screen point sampler The tubing was then lifted approximately 4 inches off the bottom (top of the screen point sampler) and oscillated up and down in 8 to 12 inch strokes The pumping rate was adjusted to minimize air intrusion during sampling The groundwater was placed into 40 mL sample containers with a Teflon® lined septum lid and preserved with hydrochloric acid After sample collection the tubing was removed and properly disposed

Groundwater samples from borings P 02 through P 08 were taken using the HydroPunch® sampler Check valves a stainless steel screen and O rings were inserted in the tool body and the point was attached The tool was driven three feet below the last soil sample interval (below the static water level) After filling the sample chamber with groundwater (for no longer than one hour) the tool was withdrawn a clean piece of tygon tubing with a valve was attached and the sample was collected in 40 mL vials with a Teflon® lined septum lid and preserved with hydrochloric acid

2 3 2 Groundwater Sampling at Monitoring Wells

Groundwater samples were collected by MWR/Envirogen field personnel between May 3 and May 26 1998 Thirty two (32) existing monitoring wells (Figure 3) were sampled for field parameters (temperature dissolved oxygen specific conductance pH and redox potential) and for laboratory analysis of TCE Five of the existing monitoring wells (MW 2 MW 3A MW 8 MW 8A and MW 23WT) were sampled for laboratory analysis of biochemical parameters and VOCs to evaluate the existence of Natural Attenuation of VOCs at the Site

Prior to sampling groundwater levels were measured on May 3 1998 The static water levels were measured using a Solinst Water Level Meter The height of the water column and the standing volume of water in the well was calculated based on well installation records included in the Groundwater Operable Unit Feasibility Study (Woodward Clyde Consultants 1993) and Supplemental RI/FS Investigation Report (Woodward Clyde Consultants 1994) A groundwater potentiometric contour map for the May 3 1998 measurements is shown on Figure 6 The estimated well water volumes and water level data are summarized in Appendix B The tape and probe were decontaminated with soap (alconox) and water followed by a distilled water rinse between each monitoring well

Groundwater Sample Collection for TCE Analysis

In order to prevent cross contamination between wells new latex gloves were worn while sampling and a new disposable bailer was used at each well The bailer was slowly lowered and raised to minimize disturbance to the water column minimizing the loss of VOCs during bailing and sampling Water removed from the wells was containerized in a 3 000 gallon plastic agricultural tank and stored on site behind the manufacturing building for future disposal

Groundwater from the wells was purged by removing at least three well volumes or until dry prior to sampling using a disposable polyethylene bailer Field parameters were measured by inserting a low flow sampling tip at the end of the bailer and the water was allowed to enter a YSI 3560 Water Quality Monitor flow cell Purging continued until three consecutive stabilized (within 10 percent) field parameter measurements of pH temperature specific conductance and reduction oxidation potential (redox) were obtained on samples no closer than one well volume apart If the well was bailed dry prior to removing three well volumes field parameters were measured and the samples were subsequently taken Wells that bailed dry included MW 7 MW 7A EW 1 BD 13 BD 16 BD 18 BR 10 WT 13 and WT 16 A Keck Model SP 84 Groundwater Sampling Pump was used to purge wells BR 10 EW 1 MW 3 and MW 7 based on the large quantity of water that was expected to be purged from these wells

After sampling was complete the dissolved oxygen (DO) was measured down hole with a YSI 51B Dissolved Oxygen Meter and allowed to stabilize before recording measurements In cases where the well was too deep groundwater was collected in a bucket and DO was subsequently measured For several wells DO was not measured due to a lack of water from bailing the wells dry and such measurements would not be representative of groundwater conditions due to aeration of the sample All instruments were decontaminated between each well with an alconox/distilled water rinse followed by two distilled water rinses

Water samples from each well were placed into two 40 mL glass vials with a Teflon® lined septum lid and preserved with hydrochloric acid using the low flow sampling tip The bottle was labeled recorded on the chain of custody and placed on ice in a cooler prior to transport to RECRA LabNet Each well was analyzed for TCE using EPA Method 8260

Samples collected between May 5 through 8 1998 were shipped to RECRA LabNet in Illinois A large workload at the Illinois laboratory resulted in the need for the samples to be shipped to the RECRA LabNet in Pittsburgh The samples arrived in Pittsburgh on May 15 1998 A number of vials (samples WT 12 BD 12 WT 11 MW 6 MW 4 MW 22WT MW 23WT dup

WT 14 and BD 14) were broken during transportation As a result samples WT 12 and BD 12 were re sampled and re analyzed

Groundwater Sample Collection for Natural Attenuation

Monitoring wells MW 25WT MW 8 MW 8A MW 3 and MW 2 were sampled in order of increasing chemical concentrations (as written) to evaluate the degree of Natural Attenuation of VOCs at the Site MW 25WT was purged and sampled using a QED Model 407 Bladder Pump and Model 465 Controller attached to a gas powered oil less air compressor The pump was lowered into the well slowly to minimize disturbance and to a depth such that the intake was at least two feet above the bottom of the well The pump was started at the lowest speed setting and slowly increased until discharge occurred During purging field parameters were measured in the flow cell every three to five minutes and continued until all parameters were stabilized In order to take water samples from the pump the flow cell was disconnected from the pump tubing After sampling was complete DO was allowed to stabilize and was recorded

At wells MW 8 MW 8A MW 3A and MW 2 problems with the bladder pump were encountered The pumping procedure followed the same method used for MW 25WT however no water could be withdrawn from any of these wells Thus monitoring wells MW 8 MW 3A and MW 2 were purged using a bailer MW 8 and MW 2 were purged dry before three well volumes were removed At MW 8A a Keck pump was used to purge the well and was also dry prior to removing three well volumes Field parameters were measured and samples were taken using a bailer and a low flow sampling tip After sampling was complete DO was allowed to stabilize and was recorded

All samples were collected in specified containers with the required preservative and chain of custody procedures were followed The samples collected for dissolved metals analysis were filtered using a Solinst 0 45 um filter and preserved with nitric acid The samples were shipped on ice via overnight courier to Envirogen Inc Analytical and Treatability Laboratories for analysis

Groundwater samples for VOCs and iron were submitted to RECRA LabNet and all other samples were submitted to the Envirogen Inc Laboratory for analysis The samples were tested for those parameters listed in the soil and groundwater sampling plan using the associated EPA test methods

The minimum detection limit for methane ethene and ethane analyzed by EPA Method 8015 (Envirogen Laboratory) is 300 ppt In the event that concentrations fell below this detection limit samples were also sent to Microseeps Inc laboratories of Pittsburgh Pennsylvania which uses Method AM 18 (Microseeps Method) with minimum detection limits between 5 to 15 ppt

2 3 3 Field Quality Assurance and Quality Control

Two (2) of eight (8) groundwater samples collected during the soil sampling program in the South Culvert Area were duplicated and sent to RECRA LabNet to be analyzed by EPA Method 8260 for TCE to verify mobile laboratory accuracy In addition one rinsate blank was taken during each day of groundwater and soil sampling (7 total) These samples consisted of distilled drinking water which was used to rinse the sampler after decontamination

During sampling of the monitoring wells six bailer field blanks were collected using bottled distilled drinking water and labeled MW 24 MW 30 through MW 34 Distilled water was poured into a clean bailer a low flow sampling tip was attached to the bailer and the water was collected in 40 mL glass vials with a Teflon® lined septum lid and preserved with hydrochloric acid These samples were sent to the laboratory with the other groundwater samples to check for possible contamination due to sample collection techniques or laboratory error

Three duplicates were also collected at MW 23WT BR 10 and MW 7 to ensure that the sampling procedure was precise Analytical chemistry data validation for laboratory analyses are contained in Appendix B

2 4 Reactive Barrier Field Sampling Program and Results

2 4 1 General

Golder designed and implemented a limited subsurface investigation at the Site in order to collect samples to be used in various tests to provide data to determine the feasibility of installing an Iron Reactive Permeable Barrier for groundwater remediation at the Site The subsurface investigation consisted of a subsurface soil drilling program soil sample collection and ground water sample collection The monitoring wells and soil borings completed at the Site are detailed in Figures 2 3 and 4 respectively

2 4 2 IRPB Subsurface Drilling Program

MWR/Envirogen retained Aquadrill Drilling Services (Aquadrill) to perform the subsurface drilling program A Golder geologist supervised the subsurface drilling program which was conducted on May 4 5 1998 Aquadrill advanced and continuously sampled two soil borings GB 1 and GB 1A near the vicinity of the suspected source area of the chlorinated solvents at the facility (Figure 8) GB 1 was advanced to auger refusal encountered at 72 5 ft BGS and GB 1A was advanced to 55 ft BGS The drilling equipment consisted of a truck mounted CME 75 drilling rig 4 25 inch inner diameter hollow stem auger (HSA) flights and Laskey 5 feet continuous samplers with acetate liners All heavy equipment that could possibly contact the samples including the back of the drilling rig were decontaminated with a steam cleaner and potable water prior to each soil boring The soil borings were abandoned by pumping Benseal 100% bentonite slurry through tremie pipe from the bottom of the borings Soil cuttings were placed in steel 55 gallon drums provided by MWR/Envirogen and stored within the former manufacturing building at the facility

2 4 3 Soil Units Encountered

Golder visually classified the soils encountered during the investigation according to the Unified Soil Classification System (USCS) and recorded the depths and thicknesses of the various soil units on soil boring logs as detailed in Appendix C The soil types consisted of stiff to very stiff clays silts and sands that were deposited by glacial meltwater streams Using the 5 feet continuous Laskey samplers and acetate liners sample recovery ranged from 0% to 100% and the overall recovery in GB 1 was 70 % (50 6 feet/70 feet) Auger refusal was encountered at 72 5 ft BGS in GB 1 and an angular fragment of fresh yellowish brown medium grained fossiliferous limestone was recovered in the end of the last sample tube indicating that bedrock was encountered The soil stratigraphy recorded on the soil boring logs is consistent with subsurface geologic cross sections presented in earlier investigations at the facility (Woodward Clyde Consultants 1994)

As shown on the boring logs two sandy aquifers were encountered in the soil borings The upper sand consisted of moist wet medium gray to dark yellowish orange fine to coarse SAND with little to some clayey silt and trace amounts of well rounded gravel (SM) The depth and thickness of the upper sand ranged from 30 3 31 3 to 28 5 31 9 ft BGS and 1 1 to 3 4 ft in GB 1A and GB 1 respectively Moist firm to very stiff to hard mottled/streaked medium gray to dark yellowish orange SILTY CLAY (CL) occurred stratigraphically above and below the upper sand unit

Approximately 9 feet of silty clay separates the upper sand and the intermediate/channel sand which is referred to as the intermediate sand because previous investigations have encountered a lower sand unit The intermediate/channel sand consists of wet dark yellowish orange fine SAND with trace to little clayey silt (SM) This unit tended to flow several feet into the augers and sample recovery within this unit was generally poor As such the exact depth and thickness of this unit is somewhat uncertain being estimated as 41 to 68 ft BGS and 27 ft respectively A lower sandy unit was encountered between 70 72 5 ft BGS but this material may have flowed into the augers from the overlying intermediate/channel sand

2 4 4 IRPB Soil Desorption Sample Collection

Golder placed representative soil samples from each soil unit except the soils in the upper sand unit in clean sealable plastic bags and shipped to Golder soil testing laboratory in Atlanta Georgia Sampling personnel donned clean latex gloves when handling the soil samples

The soils in the upper sand were placed in clean glass jars and stored in an iced cooler These soils were re saturated with groundwater containing the highest TCE concentrations collected from monitoring well MW 3A MW 3A is located approximately 12 feet and 17 feet west of GB 1 and GB 1A respectively and MW 3A is screened across the uppermost sand unit These soil samples were shipped via an overnight courier to University of Waterloo/EnviroMetal Technologies Inc (UW/ETI) in Waterloo Ontario for column desorption testing (see Section 3 6)

2 4 5 IRPB Groundwater Column Reactivity Sample Collection

On May 3 6 1998 Golder collected groundwater samples from MW 3A to be used for iron permeable barriers reactivity testing by UW/ETI and Golder Monitoring well MW 3A was selected since it has been historically the highest groundwater TCE concentration Prior to sample collection MW 3A was purged with a clean disposable teflon bailer and clean nylon cord The field parameters pH specific conductance temperature and reduction oxidation potential were measured with a calibrated YSI flow through cell by MWR/Envirogen Sampling personnel donned clean latex gloves during purging and sample collection After purging a total of 43 1 quart (13 gallons) amber glass sampling bottles were filled with ground water from MW 3A stored in an iced cooler and shipped via an overnight courier to UW/ETI Furthermore 4 1 quart bottles (1 gallon) were shipped to Golder soil testing laboratory in Atlanta Georgia

3 0 REACTIVE BARRIER LABORATORY TESTING PROGRAM AND RESULTS

3 1 General

A laboratory testing program was conducted to provide data for the Iron Reactive Permeable Barrier feasibility evaluation (see Section 5 0) for the Site Soil classification tests soil resistivity and leak off tests were conducted by Golder soils laboratory in Atlanta Georgia Iron reactivity bench scale column testing and soil desorption testing was conducted by UW/ETI in Canada Soil Total Organic Content (TOC) testing was conducted by Advanced Chemistry Labs Inc in Atlanta Georgia The laboratory testing program included

- ☐ Seven (7) soil classification tests (grain size distribution Atterberg limits of clays and specific gravity tests) conducted on soil samples collected from soil boring GB 1 and a sample of Master Builders granular iron used for the iron reactivity bench scale column test See Appendix D 1 for the laboratory test results
- ☐ Three (3) leak off tests using Site soils from soil boring GB 1 and Golder s standard fracturing gel See Appendix D 2 for laboratory tests results
- ☐ Three (3) soil resistivity tests (saturated condition) using soil samples collected from soil boring GB 1 and groundwater collected from groundwater monitoring well MW 3A See Appendix D 3 for laboratory test results
- ☐ One (1) iron reactivity bench scale column test using Master Builders granular iron and Site groundwater collected from groundwater monitoring well MW 3A See Appendix E 1 for laboratory test results and
- ☐ One (1) soil desorption test using a soil sample collected from soil boring GB 1 saturated at the Site with groundwater collected from groundwater monitoring well MW 3A See Appendix E 2 for laboratory test results
- ☐ Two (2) soil TOC analytical tests on samples collected from soil boring GB 1 See Appendix E 3 for laboratory test results

The following sections provide a background on hydraulic fracturing fluids and reactivity of iron followed with a description of the tests conducted including test methodologies and test results

3 2 Hydraulic Fracturing Fluids

The purpose of a fracturing fluid is to wedge open and propagate a hydraulic fracture and to transport and distribute the proppant (granular iron) throughout the fracture Fluid properties strongly govern fracture propagation behavior and the distribution and placement of the propping agent Fluids that leak off rapidly into the formation have a low efficiency in hydraulic wedging and extending of the fracture Fluid leak off may result in undesirable levels of residue remaining in the fracture The effective viscosity of the fluid controls the internal fracturing pressure and proppant transporting characteristics Following are some of the desirable characteristics of a fracturing fluid for the emplacement of Iron Reactive Permeable Barriers

- ☐ Chemical compatibility of gel fluids with iron proppant
- ☐ Acceptable leak off characteristics
- ☐ Sufficient viscosity to suspend proppant and produce necessary fracture width
- ☐ Good temperature stability for the formation being treated
- ☐ Low friction loss in pumping equipment and pipe
- ☐ Minimal damaging effects to the formation hydraulic conductivity
- ☐ Good post treatment breaking characteristics and
- ☐ Environmental sensitivity of fracturing fluid chemistry (Gidley et al 1989)

For commercial granular iron the Golder standard fracturing gel has been investigated in both the laboratory and field trials for the above features The fracturing fluid has been tested in the laboratory for gel and iron chemical compatibility leak off viscosity temperature stability hydraulic conductivity breaking and environmental sensitivity of fluid chemistry

3 2 1 Fracturing Fluid Design

The Golder standard fracturing fluid is a water based cross link gel hydroxypropylguar (HPG) a natural polymer used in the food industry as a thickener HPG is chosen for it s minimal impact on the iron s reactivity and it s extremely low residue The gel is water soluble in the uncross linked state and water insoluble in the cross linked state Cross linked the gel can be extremely viscous ensuring the granular iron remains suspended An enzyme breaker is added to controllably degrade the viscous cross linked gel down to water and sugars MSDS sheets are available on all of the constituents and extensive chemical analyses of the gel are available including priority pollutant scans The gel does not exceed drinking water standard MCLs for any compound

The gel is mixed and blended with the granular iron in the uncross linked state Sufficient mechanical agitation is necessary to ensure the granular iron remains evenly distributed in the mix The gel and granular iron are then fed to a pumping unit and cross linked in line to form a highly viscous cross linked gel The Golder standard fracturing gel design used for the iron/gel reactivity bench scale column test is shown on Table 4 The gel design products form a cross linked gel with high viscosity that will suspend the iron proppant in solution The cross link gels take typically three to four weeks to break depending on groundwater temperature conditions The average groundwater temperature at the Site is approximately 14° C the cross link and enzyme loadings have been increased from the normal loading at 25 C to allow for the lower reactivity at lower Site temperatures

3 2 2 Granular Iron Proppant

The U S patent number 5226213 dated November 30 1993 entitled Cleaning Halogenated Contaminants from Groundwater for the zero valent metal technology is assigned to the University of Waterloo The University of Waterloo has granted certain rights to this patent to EnviroMetal Technologies Inc Guelph Ontario Canada Three commercial granular irons approved by ETI have been tested by Golder during the developmental stage of the hydrofracturing technology for installation of Iron Reactive Permeable Barriers including Master Builders Peerless and Connelly granular irons Some of the iron samples raised the pH of the mixture outside the pH range of operation for borate cross linking agents The iron that has the least chemical interference with the guar enzyme and cross linkers and is compatible with the Site soils (see Section 5 0) is the medium to fine Master Builders granular iron

3 3 Leak Off Testing of Soils

3 3 1 General

During the injection of a fracturing fluid into the formation fluid is lost (leaked off) from the fracturing gel mix to the formation This leak off characteristic is dependent on both fracture fluid constituents and formation characteristics The volume of fluid lost during fracturing determines the fracturing fluid efficiency or the ratio of fracture volume to volume of fluid pumped It is important to know this efficiency to prevent early fracture termination caused by premature deposition of the granular component of the fracturing fluid

The rate of leak off to the formation is governed by the fracturing fluid leak off coefficient C which is a combination of three types of linear flow mechanisms (Gidley et al 1989) The three types of flow mechanisms are fracturing fluid viscosity and relative permeability effects *Cv* reservoir fluid viscosity/compressibility effects *Cc* and wall building effects *Cw* *Cv* and *Cc* can be estimated theoretically from aquifer data and fracture fluid viscosity data while *Cw* must be investigated experimentally

3 3 2 Laboratory Method

A laboratory leak off test procedure for soils was developed by Golder for the estimation of the leak off coefficient *Cw* The test method is an adaptation of leak off testing on core used in the petroleum industry Essentially the method utilizes a pressure cell containing a piston as shown on Figure 9 The apparatus has an inlet at the top of the cell (above the piston) and an outlet at the base of the cell A site soil sample is placed in the cell with enough water to saturate the sample The sample is consolidated at a normal pressure equivalent to the estimated in situ effective vertical stress at the approximate depth where the hydrofracture will be initiated (typically within the lower 10 feet of the barrier) by applying pressure above the piston to compact the soil During consolidation the excess water is allowed to exit through the outlet at the base of the pressure cell The dry unit weight and porosity of the sample are calculated and recorded Fracturing fluid is placed between the soil sample and the piston The fracturing fluid is then pressurized against the soil sample by the piston using a pressure in the vicinity of the expected down hole fracturing fluid pressure for a particular treatment The volume of fluid expelled from the base of the cell is monitored and is equivalent to the volume of fracturing fluid which leaked off to the sample

Leak off test data are plotted as filtrate volume vs the square root of time as shown on Figure 10 The test shows two phases of the leak off phenomenon The first stage is the wall building stage of leak off where the fracturing fluid penetrates the formation causing a filter cake to build up on the formation fluid interface The volume of fluid lost in the wall building stage of fracturing is called spurt loss The first stage of leak off can be recognized on Figure 10 as the early time curvature of filtrate volume versus time During the second stage after the filter cake has built up the rate of fluid loss is resisted by viscosity and compressibility effects only This stage is represented by the later time straight line of the test results The slope of this line is used in the following equation to determine *Cw*

$$Cw = (m/2Ac) \qquad (1)$$

Where *Cw* is the wall building coefficient (cm/min^{1}) m is the slope of the best fit straight line (cm / min$^{1/}$) and Ac is the cross sectional area of the soil sample in the test cell (cm)

The volume loss determined at the intercept of the line used to determine the *Cw* coefficient at time zero is used to determine the Spurt value of the leak off test The Spurt is obtained using the following expression

$$\text{Spurt value} = (\text{Fluid loss}/2Ac) \qquad (\;)$$

3 3 3 Results

Tests were carried out on three samples collected from soil boring GB 1 at 25 50 and 100 psi pressures Prior to testing the samples were consolidated at an effective stress of 30 psi The confining stress was applied at increments of 5 psi to minimize excessive pore water pressure during the consolidation process The remolded dry unit weight and porosity of the samples ranged from 110 5 to 114 1 pounds per cubic foot (PCF) and 0 33 to 0 34 respectively corresponding to a medium dense sand (Holtz and Kovacs 1981) The test results are summarized in Table 5 and the test data are included in Appendix D 2

3 4 Soil Electrical Resistivity

3 4 1 General

Active resistivity is used to monitor the geometry of Iron Reactive Permeable Barriers during installation The fracture fluid is made conductive and is electrically energized by a 100Hz signal so the fracture location can be detected by the receivers in boreholes adjacent to the barrier Induced 100 Hz voltages are monitored and recorded during fracture growth From these induced voltages the wall geometry is calculated using incremental inversion algorithms to provide a high resolution image of the permeable barrier This imaging provides a real time feed back of the fracture geometry during injection and thus enables quantifying the continuity of the permeable barrier system

For the active resistivity technique to be efficient there must be a significant contrast between the resistivity of the formation (soil and groundwater) and the fracturing fluid of at least 30 times Laboratory testing was performed using Site soil samples collected from soil boring GB 1 saturated with Site groundwater collected from groundwater monitoring well MW 3A The conductivity of the gel/iron fracturing fluid is adjusted by the addition of sodium chloride (NaCl) to the fracturing fluid The Golder standard fracturing fluid design resistivity ranges from 160 to 240 ohm cm with a mean of 190 ohm cm The final gel design should consider the Site soil resistivity in the area where the permeable barrier is to be installed

3 4 2 Laboratory Method

The soil electrical resistance was estimated in the laboratory following the Standard Method for Field Measurement of Soil Resistivity Using the Wenner Four Electrode Method (ASTM G 57) Samples were placed in a soil box with two plate electrodes and two pin electrodes as shown on Figure 11 The soil sample was saturated with groundwater collected from groundwater monitoring well MW 3A Using a Nillson Model 400 four pin soil resistance meter a voltage potential was applied to the plate electrodes in the soil tray causing a current flow through the sample The voltage drop and current was measured between the two pin electrodes using the same meter The geometry of the box is such that a correction factor of 1 is used for the Wenner array and hence electrical resistance measurements are in effect direct

Electrical resistivity testing of soils required the soil box to be filled with the sample The source and detector electrodes in the soils box were connected to the meter A known current was passed between the two source electrodes and a voltage drop measured between the two detector electrodes providing an estimate of resistance Resistivity values are normalized (ASTM G 57) at 15 5 °C using the following expression

$$\text{Resistivity @ 15 5 °C} = [(24\ 5 + \text{Temperature})/40] \times \text{Resistivity} \tag{5}$$

3 4 3 Results

The resistivity results for the soil samples are summarized in Table 6 Based on the laboratory soil resistivity tests the gel/iron mix should have a maximum resistivity of 250 ohms cm for contrast purposes with the existing soils during hydrofracturing active resistivity monitoring

3 5 *Iron Reactivity Column Test*

3 5 1 General

In order to determine the reactivity of the granular iron considered for construction of Iron Reactive Permeable Barriers at the Site a reactive bench scale column test was conducted on a medium to fine Master Builders granular iron The column test was flushed with contaminated Site groundwater The bench scale iron reactivity column test was conducted by EnviroMetal Technologies Inc (ETI) working in association with the Institute for Groundwater Research University of Waterloo Waterloo Ontario Canada

The selection of the iron type for construction of the wall system considers not only the hydraulic conductivity and reactivity characteristics but also the ability of the iron filings to cross link with the hydrofracturing gel used to transport the granular iron into the ground

3 5 2 Laboratory Method

The laboratory bench scale column test was conducted using the EnviroMetal Process (Gillham 1996 Gillham and O Hannesin 1992 1994) to determine the rates of degradation of the chlorinated organic compounds that are present in the groundwater at the Site A groundwater sample from monitoring well MW 3A was collected by Golder field personnel and sent to the University of Waterloo for iron reactivity column testing

In general the column consists of a Plexiglass™ cylinder with a length of 1 6 ft and an internal diameter of 1 5 in Seven sampling ports are positioned along the length of the column as shown on Figure 12 The column was carefully loaded with iron initially flushed with carbon dioxide then distilled water before the Site groundwater was introduced The Site groundwater was fed into the column at a constant rate of 2 ft/day from a collapsible Teflon® bag Based on ETI s laboratory experience a flow velocity of about 2 ft/day is the maximum that can be used for the type of iron tested to minimize piping/channeling conditions in the sample Samples for organic analyses Eh and pH were collected periodically from the sample ports along the column Samples for both organic and inorganic tests Eh and pH were collected from the influent and effluent

The concentration of a particular species was quantified along the column length at a particular time i e after the column was swept by a certain number of pore volumes of the Site groundwater Concentrations of VOCs were monitored along the column until the values at each point in the column reached a relatively steady state condition Steady state condition is reached when the column test shows a constant (i e unchanging) concentration profile along its length The flow rate used in the test was used to calculate the residence time of groundwater relative to the influent end of the column at each sample point The residence time was used to determine concentration versus time plots for each of the VOCs The degradation rates by zero valent iron for each compound were closely matched by a first order kinetic model

First order rate constants are quantified that best fit the data (Figure 13) The first order kinetic degradation model is given in equation (4) the first order rate constant in equation (5) and the half life in equation (6)

$$C = C_0 e^{-\lambda t} \qquad (4)$$

where C is the organic concentration in solution at time t C_O is the organic concentration in solution at the initial or influent condition i e at t=0 λ_I is the first order rate constant for the species and t is the residence time in the column

$$\lambda = -\frac{\ln\left(\frac{C}{C_0}\right)}{t} \qquad (\ )$$

The half life $t_{0\ 5}$ is the time for the organic concentration to be reduced to one half of it s initial or influent concentration i e rearranging equation (4) gives

$$t_{0\ 5} = {}^{0\ 693}\!/\!_{\lambda} \qquad (6)$$

Master Builders Column Test

The Master Builders granular iron used in the column test was obtained from Master Builders Inc Cleveland Ohio Geotechnical laboratory testing was conducted on the Masters Builders granular iron to determine its physical properties The medium to fine Master Builders iron filings tested had a grain size ranging from 0 07 to 2 mm (ASTM D 421) and a specific gravity of 6 95 (particle density of 6 95 g/cm) (ASTM D 854) Grain size distribution and specific gravity test results are included in Appendix D 1

Prior to column testing a sample of the medium to fine Master Builders iron was mixed with Golder s standard cross linked gel to be used for emplacement of the granular iron in the hydrofracturing process The column sample was prepared with the iron/gel mix in a cross link state The cross link and guar were degraded by the aid of an enzyme added to the initial mix Once the iron column was ready for testing groundwater collected from monitoring well MW 3A was flushed through the column The column experiment was conducted at room temperature (23 C) The iron column sample had a pore volume of 260 ml with a porosity of 0 46 and a density of 157 lb/ft^3 (2 52 g/cm^3)

A representative sample (dry) of the medium to fine Master Builders granular iron used fo column testing was sent to Golder soils laboratory in Atlanta Georgia for soil classification (grain size distribution and specific gravity) testing

3 5 3 Results

Groundwater from well MW 3A as received in the laboratory contained about 7 800 ppb of TCE and 10 ppb of cDCE No other VOCs were detected in the Site groundwater sample The retention time vs concentration for the species TCE and cDCE detected along the column are shown on Figure 14 The semi log plots used for determination of the half lives for the VOCs encountered in the Site groundwater or VOCs generated during the dehalogenation process during the column reactivity test are shown in Figure 15 Figure 16 depicts the change of Eh and pH values with respect to residence time in the column at the end of the test The half lives determined for each compound are summarized in Table 7 along with their correlative coefficients Half lives for TCE and cDCE were determined to be 0 4 and 1 4 hours respectively The test was stopped after 46 pore volumes when the column had reached steady state conditions as defined when the column achieves a constant (i e unchanging) concentration profile along its length The column test data are included in Appendix E 1

Influent and effluent samples were collected at steady state condition and sent to Envirogen Laboratory and RECRA LabNet for analytical testing The analytical testing of the samples included the full suite of VOC compounds and select inorganic compounds and parameters using EPA approved methods in accordance with the Soil and Groundwater Field Sampling Plan for the Site The analytical laboratory test results are included in Appendix E 1

For high VOC concentrations RECRA LabNet have a reported detection limit of 50 µg/L and UW/ETI have a reported detection limit of 5 10 µg/L at low VOC concentrations RECRA LabNet have a reported detection limit of 0 1 to 1 µg/L and UW/ETI have a reported detection limit of 5 10 µg/L In the influent sample i e high VOC loading and high VOC concentration there is reasonable agreement and in the effluent i e low VOC loading and low VOC concentrations both laboratories reported virtually all VOC compounds to be non detect for their respective detection limits With the influent samples UW/ETI indicated trace amounts of PCE and cDCE at 2 1 and 39 ppb respectively however concentrations for these compounds were below the method of detection for the external laboratory analyses The TCE influent concentration was 4730 ppb and 3500 ppb for UW/ETI and the external laboratory respectively All effluent values for all compounds from both laboratories were non detectable or below the method detection limit with the exception of DCM which was measured to be 2 1 ppb and 3 2 ppb by UW/ETI and RECRA LabNet respectively

Comparison of the UW/ETI and Envirogen inorganic analyses of water samples obtained at the steady state condition shows good agreement for most of the anion analyses for the influent and effluent samples However the alkalinity value appears to show the largest variation with a 20% difference Due to the large volumes of water required for the inorganic analyses holding times were exceeded for the cation analyses

3 6 Desorption Column Test

3 6 1 General

A soil desorption column test was conducted on a Site soil sample to determine the desorption rates of VOCs present in the soil sample when flushed with fresh water The results of this test are used to estimate the VOCs concentration levels downgradient from the Iron Reactive Permeable Barrier once the groundwater is treated by the permeable barrier

3 6 2 Test Method

The laboratory soil desorption test was conducted using a contaminated soil sample obtained during the May 1998 soil and groundwater sampling program The sample was collected from the upper sands from soil boring GB 1 adjacent to monitoring well MW 3A (see Figure 3) The sample was properly packed and submerged in Site groundwater collected from MW 3A prior to shipment to the University of Waterloo for soil desorption column testing

The desorption column consists of a glass column with a height of 2 inches and an internal diameter of 3 3 in (see Figure 17) Influent and effluent ports are located at the bottom and top of the column respectively The column is carefully loaded with the contaminated soil between stainless steel plates connected to the influent and effluent ports The Site contaminated soil sample was flushed with distilled water at a constant rate of 0 6 ft/day (0 26 ml/min) This flow rate was selected by ETI for the type of soil being tested This flow velocity would not cause any piping/channeling through the sample Samples for organic analyses were collected periodically from the effluent port located on top of the column The test was conducted after 16 pore volumes (pore volume of 96 ml) when the column had reached very low VOCs concentration levels (below MCLs)

The soil sample used for desorption testing was sent to Golder soils laboratory in Atlanta Georgia for soil classification tests (grain size distribution and specific gravity)

3 6 3 Results

The observed trend for the TCE data indicates that the highest concentration of TCE was observed within the first four (4) pore volumes declining to trace amounts of 2 ppb at sixteen (16) pore volumes as shown on Figure 18 The TCE levels in the effluent from the soil desorption column test decreased significantly within the four (4) pore volumes The peak TCE concentration of 1 169 ppb was observed at 0 2 pore volumes with levels declining to below 100 ppb at 1 6 pore volumes and below 10 ppb at 4 pore volumes The TCE concentration in the effluent dropped to 5 ppb (MCL) at approximately eight (8) pore volumes The laboratory test data are included in Appendix E 2

3 7 Soil Total Organic Content

3 7 1 General

Soil TOC analytical laboratory testing was conducted on two soil samples collected from boring GB 1 in support of the Iron Reactive Permeable Barrier Evaluation in combination with Natural Attenuation TOC values are used to estimate retardation factors (R_f) used in 1D and 2D fate and transport transient modeling for Natural Attenuation evaluation The tests were conducted by Advanced Chemistry Labs Inc in Atlanta Georgia

3 7 2 Test Method

Test method EPA 9060 (modified for soils) was used to determine the TOC of the two samples tested The soil samples were placed in zip lock bags during sampling and stored at Golder s soils laboratory in Atlanta The samples were sent to the analytical laboratory approximately five months after sampling

3 7 3 Results

Testing for TOC was conducted about five (5) months after the samples had been collected While holding times and sample preservation (temperature) were not met values of TOC obtained from the laboratory analysis are considered representative of the nonvolatile organic carbon encountered in the soils The laboratory test results are included in Appendix E 5

4 0 NATURAL ATTENUATION EVALUATION AND RESULTS

4 1 General

An evaluation of recent and historic groundwater sampling was conducted to assess Natural Attenuation (advection dispersion sorption dilution and/or 1st order decay (biodegradation)) activity at the Site The initial evaluation involved the interpretation of several chemical and geochemical parameters These included the determination of concentrations and distributions of contaminants daughter products and groundwater geochemical parameters The Site was then ranked using the natural attenuation screening system of Wiedemeier et al (1996) Finally 1 D and 2 D analytical fate and transport modeling was performed to estimate the rate of natural attenuation occurring at the Site and then using these results evaluate the potential behavior of the residual TCE plume downgradient of the proposed Iron Reactive Permeable Barrier (see Section 5 6 4)

The groundwater elevations in the upper/intermediate sands are shown on Figure 6 for the latest sampling round of May 1998 These contours indicate groundwater flow from the NW to the SE with a low flow gradient from MW 5A to WT 18 and the Allen Well The TCE groundwater concentrations measured in the intermediate sands are shown as contours on Figure 7 for the latest sampling round of May 1998 and also highlights the groundwater flow direction at the Site The flow direction derived from the potentiometric contours given on Figure 6 is consistent with that inferred from the TCE groundwater concentration contours shown on Figure 7

4 2 Tabulation of Site Chemistry Data

Tables 1 2 and 3 summarize the relevant data as provided by MWR/Envirogen for the Natural Attenuation evaluation Table 1 lists data for thirty two (32) wells at the Site consisting of geochemical parameters measured in the field at the time of sampling (temperature pH Eh specific conductance and dissolved oxygen) as well as current TCE data historic TCE and dissolved iron data Tables 2 and 3 present the results of the sampling of the five selected natural attenuation wells chosen to monitor conditions within and to delineate the downstream extent of the TCE plume Table 2 provides inorganic parameters and relevant daughter products of the reductive dechlorination of TCE Table 3 lists other VOCs that were detected during the analysis

4 3 Spatial Delineation of Natural Attenuation Indicator Parameters

Dissolved oxygen (DO) is the favored electron acceptor used by microbes for the biodegradation of organic carbon whether natural or anthropogenic However reductive dechlorination (the principal mechanism likely to degrade TCE at the Site) occurs following the depletion of oxygen after which anaerobic microbes will use nitrate iron sulfate and carbon dioxide as the terminal electron acceptor DO measurements from the Site were difficult to obtain due to aeration of the sample prior to measurement due to the groundwater level drawn below the top of the screened interval and in many cases the wells purged dry Due to the difficulty in obtaining representative DO values of the groundwater the Redox Potential (Eh) measurements have been relied upon to indicate a reducing environment

The Redox Potential Eh indicates whether oxidizing or reducing conditions are present at the Site An Eh of <50 mV is indicative of an onset of a reducing environment and a negative Eh is the sign of an especially strong reducing environment A large number of the monitoring wells at the Site have low (<50mV) Eh values with negative Eh values determined in twelve (12) of the thirty two (32) wells sampled The Redox Potential values are shown as contours on Figure 19 with low Eh values measured in the overall general area of the TCE plume as given on Figure 7 The low Eh values indicate significant reducing conditions are present at the Site

In many cases iron (III) is used as the electron acceptor during biodegradation of the organic compound TCE During this process iron (III) is reduced to iron (II) ferrous iron which is more soluble than iron (III) Therefore higher concentrations of dissolved iron in comparison to background levels within the zone of contamination would likely indicate increased levels of the water soluble iron (II) Field testing for ferrous iron was not conducted in 1998 Aeration of the field samples (noted above) would have produced non representative values

After DO and bioavailable iron have been depleted in the zone of natural attenuation sulfate can be utilized as an electron acceptor therefore lower concentrations of sulfate as compared to background may be an indication of natural attenuation Sulfate concentrations were obtained for the five monitoring wells in the range of 15 to 160 mg/L (Table 2) and illustrated as contours on Figure 20 Well MW 23WT is apparently sufficiently downgradient of the plume (TCE was not detected) as to be considered background and the reported sulfate concentration is 120 mg/L The lowest concentration of sulfate is approximately an order of magnitude less and occurs in well MW 3A near the plume source indicating a contribution of sulfate reduction to the overall natural attenuation process The sulfate concentration at MW 8A being 160 ppb measured in the upper sand is one of the highest and is located adjacent to MW 8 with sulfate concentrations of 59 ppb MW 8 is screened in the intermediate sand MW 2 is in a perched water table and the high sulfate concentration of 160 ppb in this well is not representative of the groundwater regime The well with high TCE concentration MW 3A has a sulfate concentration one order of magnitude less than other wells

The end point reaction in reductive dechlorination of TCE is ethene and ethane As shown in Table 2 ethene was reported in all five wells sampled ranging from 13 ng/l to 49 021 ng/l The greatest concentration of ethene was reported at monitoring well MW 2 located in the source area of the TCE plume and is the monitoring well with the historically highest TCE concentrations Ethene and ethane levels measured at the Site are shown on Figures 21and 22 respectively The intermediate degradation compound of TCE cis 1 2 DCE was detected at high concentrations in monitoring well MW 2 also indicating significant natural degradation Previous sampling data (Woodward Clyde Consultants 1994) combined with this current groundwater sampling event which provides evidence of the presence of ethene help to document a complete dechlorination pathway mechanism being present at the Site

Alkalinity is a measure of the dissolved carbonate bicarbonate sulfates phosphates pH and other buffering anions in the aquifer It results from the interaction of carbon dioxide (an end point oxidative daughter product) with aquifer minerals and is also a direct product of the bacterial cell synthesis cycle It is indicative of natural attenuation when it can be shown that the concentrations within the natural attenuation zone are at least twice that of background Table 2 shows that measured alkalinity concentrations range from 230 mg/l to 1400 mg/l and the distribution of alkalinity concentrations at the Site are given as contours on Figure 23 If well MW 23WT is considered background for the Site the extremely high alkalinity level at MW 8 is consistent with the presence of anaerobic biodegradation activity Wells MW 5A and MW 8A did not have high alkalinity values compared to Well MW 23WT

4 4 Trend Analysis for VOCs

Further evidence of natural attenuation is apparent upon comparison of the 1994 TCE data with the 1998 data Table 1 indicates that in most wells within the zone of contamination the TCE concentration is decreasing Well MW 3A is located near the source and is observed to have decreased by about half (14 000 ppb to about 7 000 ppb from 1994 to 1998) MW 8A decreased from 240 ppb to 7 ppb MW 8 from 29 ppb to 1 ppb and the Allen Well from 560 ppb to 120 ppb to 51 ppb from 1986 1992 and 1998 respectively Noticeable increases in TCE concentration were reported at three wells MW 2 in a perched water table in the source area and wells MW 7 and WT 18 with minor increases detected in Wells MW 6 and WT 14 At well MW 2 the increase from 350 000 ppb to 1 100 00 ppb is consistent with its location within the source area where the perched groundwater concentration fluctuates in and around an order of magnitude of solubility At well WT 18 only a slight increase from 12 ppb to 45 ppb was reported and is similar in concentration to the nearby Allen Well MW 7 increased from non detect in 1994 to 31 ppb/1ppb (duplicate) in 1998

The spatial change in groundwater TCE concentration is best observed by comparing the two duplicate plumes from the 1994 and 1998 sampling events The TCE groundwater contamination plume as shown on Figure 7 has reduced in concentration and in the overall TCE mass contained in the plume over the past four (4) years The dissolved phase mass of TCE in the groundwater plume delineated in the Supplemental RI/FS Investigation Report (Woodward Clyde Consultants 1994) is estimated to be > 90 lbs while in 1998 Figure 7 the dissolved phase mass of TCE is estimated to be 33 lbs based on the TCE concentration contours shown on Figure 7 That is there is greater than a 60% reduction in TCE in the groundwater plume over the past four (4) years

A further indication that Natural Attenuation mechanisms are occurring is that cis 1 2 DCE is generated as is evident from wells MW 2 and MW 3A The significant reduction in the ratio of cis 1 2 DCE to TCE from the unsaturated source area MW 2 to the groundwater MW 3A is clearly indicative of significant Natural Attenuation mechanisms being active at the site As cis

1 2 DCE is a primary breakdown product of TCE it is expected that as the TCE concentration decreases e g cis 1 2 DCE concentration will change proportionately so as less TCE is available to degrade For example in MW 8A the TCE concentration decreased from 240 ppb to 7 ppb (1994 to 1998) and cis 1 2 DCE decreased from 0 8 ppb to non detect over the same period Furthermore it is expected that vinyl chloride (VC) though not detected has been generated as a daughter product of cis 1 2 DCE and then VC being biodegraded either by reduction to ethene and ethane or by oxidation

Overall the evaluation of the natural attenuation indicator parameters the presence of a complete degradation series from TCE to ethene and the decreasing TCE (concentrations and mass) in the aquifer indicate active bioremediation is occurring at the Site at rates significantly greater than that of current TCE loading to the aquifer

4 5 Ranking of the Site Using the Screening Scoring System

A recent development in the assessment of sites for the prospect of natural attenuation is a Scoring System developed by Wiedemeier et al (1996) which assigns points to various chemical and geochemical parameters which can be measured or analyzed for at a Site In totaling the points for the site a judgment can be made as to the potentiality of the Site for Natural Attenuation Table 8 lists the assessment of the Site utilizing the Scoring System

The total number of points accumulated in this analysis was 16 This total score is interpreted by the Scoring System as showing adequate evidence for Natural Attenuation The sub score for the DO field data of one (1) was assigned from the Redox Potential data because of the limited applicable DO measurements available Considering the low Redox Potential data assignment of one to the DO field data is conservative Some key parameters in the Scoring System were not measured due to sample deviation and thus result in a low score even though there is significant evidence of Natural Attenuation of TCE occurring at the Site

The score of 16 would mark the Site as having adequate evidence of Natural Attenuation The evaluation of Natural Attenuation at the Site is determined in order of importance from the following

1 Groundwater TCE Concentrations
  - Spatial distribution and Time Trends of Concentration Data

2 Presence of Daughter Products
  - cis 1 2 DCE
  - ethene and ethane

3 Natural Attenuation Indicators
  - presence of electron donors
  - reduction of computing electron acceptors
  - evidence of Cometabolic Degradation
  - availability of growth substrates
  - evidence of mineralization

4 Site Ranking of Parameters

Considering the significant reduction in TCE concentrations in the groundwater and the presence of daughter products it is concluded that there is adequate to strong evidence of Natural Attenuation mechanisms being active at the Site

Natural Attenuation (USEPA 1996b) is those processes being biodegradation dispersion dilution adsorption or other natural processes that will attain required cleanup levels within a reasonable time frame

4 6 Fate and Transport Modeling

To assess whether the groundwater constituents at the Site are a result of mass removal by Natural Attenuation fate and transport transient modeling of the TCE plume was performed The modeling involved utilizing analytical transient solutions that includes advection dispersion sorption dilution and/or 1st order decay (biodegradation) to best fit the measured data and thus determine the natural degradation mass removal of TCE from the system

A one dimensional transient analysis was performed along the centerline of the plume enabling the half life of TCE (1st order decay coefficient) to be determined A two dimensional transient model was then used to support the results of the one dimensional model and to determine the mass reduction of TCE from the plume due to natural degradation

4 6 1 One Dimensional Fate and Transport Transient Modeling

The plume was modeled using the advection dispersion transient equation with constituent retardation and contaminant exponential decay as presented by Bear (1979) Two solutions of this transient equation were developed for the following conditions

☐ Advective dispersive transport with constituent retardation due to adsorption and no degradation and

☐ Advective dispersive transport with constituent retardation and contaminant exponential decay

The governing transient equation is

$$\frac{\partial C}{\partial t}=\left(\frac{D}{R_f}\right)\left(\frac{\partial^2 C}{\partial x^2}\right)-\left(\frac{U}{nR_f}\right)\left(\frac{\partial C}{\partial x}\right)-\lambda C \qquad (7)$$

where D is the coefficient of hydrodynamic dispersion C is the TCE concentration U is the groundwater velocity x is the longitudinal ordinate t is Time n is porosity R_f is the TCE retardation coefficient and λ is the biodegradation decay constant for TCE

Several hydrogeologic parameters are required as inputs to the model as detailed in equation (7) Groundwater velocity was determined by first calculating the hydraulic gradient from the equipotential map of the intermediate sand (Figure 6) constructed from data measured in the recent sampling event of 1998 In the direction of the plume on a line from MW8 to MW 25WT the gradient was determined to be 0 0015 ft/ft The hydraulic conductivity of the intermediate sand of 0 005 cm/s (14 ft /day) was estimated from laboratory grain size and pump test data The porosity of the site was estimated to be of the order of 0 35 (i e 35%) for a medium dense sand to silty sand (Holtz and Kovacs 1981) thus giving a groundwater velocity of about 22 ft/year or 0 06 ft/day in the direction of the TCE plume For the model simulations a linear groundwater velocity of 22 ft/year was used

The retardation coefficient is estimated from the expression $R_f = 1 + \rho K_d(1 n)/n$ where ρ is the bulk density of the solid matrix (2 65 g/ml) K_d is the soil water distribution coefficient for TCE and n is the porosity The distribution coefficient K_d estimated from the Schwarzenbach and

Westall (1981) equation (K_d = Foc * Koc) has been shown to considerably underestimate K_d for sands with low values of organic carbon Curtis et al 1986 The fraction of organic carbon (Foc) in the upper and intermediate sands was determined from laboratory analyses to be an average of 0 02% as measured from field samples from borehole GB 1 and reported in Appendix E 3 The Foc values obtained from the laboratory analysis are considered conservative for the determination of K_d since the samples were tested a few months after the samples were collected in the field and the volatile organic carbon may have been lost during this period Field estimates for K_d in sands of similar organic carbon content have been reported Roberts et al 1986 and Rivett et al 1994 and provide R_f values for TCE from 1 2 to 2 as a reasonable range The retardation coefficient R_f was estimated to be in the range of 1 2 to 1 6

The coefficient of hydrodynamic dispersion was estimated from the expression $D=\alpha U/n$ where α is the longitudinal dispersivity The longitudinal dispersivity α is approximated as a function of the plume length and in this case was estimated to range from a low of 1/10 to a high of 1/4 of the plume length yielding a range for the dispersion coefficient D of from 7 to 22 ft /day

A transient sensitivity back analysis was conducted to determine the values of R_f D and λ that best matched the current observed groundwater TCE concentrations along the plume longitudinal axis The parameters R_f and D were only considered within an acceptable range as stated above The degradation decay constant λ for TCE was then determined to best match the measured TCE data The degradation half life for TCE (t_5) is related to λ by $t_5 = 0\ 693/\lambda$

Particular attention was given to calibration in the area of monitoring well WT18 and the Allen Well The model fit utilized the source area data from MW 3A which is the first well in the intermediate sand and is directly below the source area Other wells used were WT 18 the Allen Well and MW 23WT which was used as the downgradient limit of the plume as TCE was not detected in this well The back calculated parameters from the transient sensitivity analyses are detailed in Table 9 The range of t_5 to best fit the data was from a low of 500 days to a high of 700 days Equation solution and output from the 1D transient model are contained in Appendix F 1

As shown on Figure 24 without degradation i e if only advection dispersion and retardation are accounted for the model prediction curves lie significantly above all measured field data Computed curves for the range of back calculated parameters given in Table 8 are virtually identical as shown on Figure 23 The lower curves that account for a 1st order decay fit the field data well for TCE half lives ranging from 500 to 700 days This range of half lives is well within the range of reported half lives for TCE (e g Howard et al 1991 USEPA 1996)

The TCE concentration at the Allen Well has been declining over the past 10 years from 360 ppb in 1988 120 ppb in 1994 and 51 ppb in 1998 The above 1D fate and transport model was calibrated with current 1998 data and did not attempt to match the time delay decline in TCE concentration in the Allen Well As a further check on the validity of the 1D model s site parameters it was considered prudent to check if the model could simulate the declining TCE concentrations in the area of the Allen Well by solely modifying the source loading If the TCE concentration in the saturated source near MW 3A was assumed to be 20 000 ppb from 1968 to 1988 and 10 000 ppb thereafter the model predicted approximately three (3) times higher concentration in the vicinity of the Allen Well in 1988 compared to that computed for 1998 The ability of the model to predict a significant declining concentration at the Allen Well over the past ten (10) years with reasonable source loading reduction provided further evidence that the model s back calculated parameter values for TCE degradation and retardation are reasonable for this Site

The Natural Attenuation of TCE in the groundwater can be evaluated within the model by computing the mass of TCE lost between the two curves shown on Figure 24 From this figure it was calculated by the model that 80% of the TCE was removed due to Natural Attenuation

4 6 2 Two Dimensional BIOSCREEN Model

To further assess whether the groundwater constituents at a Site are undergoing biodegradation of mass a 2 D solute transport transient analysis was performed using the USEPA BIOSCREEN Model Version 1 4 (USEPA 1997) BIOSCREEN is a screening level model that can be used to help verify that Natural Attenuation is occurring at a site As an analytical model BIOSCREEN assumes simple groundwater flow and therefore can only approximate the complicated processes that occur at the field scale However it provides further validation of the one dimensional model and estimates the reduction in contaminant mass that is attributable to Natural Attenuation in the presence of transverse dispersion

Most of the model inputs are the same as the one dimensional model being source concentration groundwater velocity retardation coefficient longitudinal dispersivity and decay coefficient The only additional input parameters for the two dimensional model is the transverse dispersivity (α) and the source plan width The effect of transverse dispersivity (α_t) which is the only distinction between the one and two dimensional models can have a significant impact on contaminant concentration There is excellent agreement between the two models when α is set to a small number The geometry of the groundwater TCE plume see Figure 7 indicates a low transverse dispersivity for the upper and intermediate sands Field data on transverse dispersivities on similar sands have computed α values of approximately 1/50th to 1/100th of the longitudinal dispersivity Rivett et al 1994

The two dimensional model BIOSCREEN computed the TCE downgradient concentrations for the same parameters as the one dimensional model presented in Section 4 6 1 and are detailed in Table 10 The transverse dispersivity was selected to ensure the computed plume as determined by the two dimensional model was in reasonable agreement with the observed Site plume width Figure 7 The computed TCE concentrations along the plume major flow axis by the 1D and 2D models are in close agreement see Table 10 Output results for the 2D model are contained in Appendix F 2

Since both models (1 and 2D) predicted similar TCE concentrations along the longitudinal plume axes the 2D model BIOSCREEN provided a validation of the 1D model and also quantified the TCE degraded in the presence of transverse dispersion BIOSCREEN calculates the mass of the plume for each case with and without biodegradation and reports the difference as the mass removed due to biodegradation The important result is the percentage reduction in mass of TCE from the No Degradation curve to the 1st Order Decay curve and which is only slightly affected by changes in transverse dispersivity α_t The reduction represents the amount of TCE removed due to natural biodegradation and was predicted by the model to be 85% This result supports the conclusion that Natural Attenuation is contributing significantly to TCE mass removal at the Site The current mass of TCE dissolved in the groundwater is estimated from the model as being 13kgm (29 lbs) which is consistent with the dissolved mass of TCE of 33 lbs computed from the 1998 TCE concentration contours shown on Figure 7 and discussed in Section 2 3

4 7 Summary Of Intrinsic Degradation Evaluation

A Natural Attenuation evaluation was conducted for the Site using time trend analysis Natural Attenuation indicator parameters a scoring system and analytical fate and transport modeling The generally declining TCE conditions in the aquifer the evaluation of the Natural Attenuation indicator parameters and the presence of a complete degradation series from TCE to ethene indicate active bioremediation of TCE is occurring at the Site These findings are supported by Site specific modeling results that indicate that degradation is occurring and occurring at rates consistent with other published field values The fate transport model provided a reasonable fit to the data with realistic input supported by a sensitivity analysis of the input parameters From these results it is predicted by the model that 80% of the dissolved TCE in the groundwater has been removed to date by Natural Attenuation Such natural biodegradation will continue downgradient of an Iron Reactive Permeable Barrier and therefore such Natural Attenuation needs to be incorporated into the proposed Alternative Groundwater Remedy

5 0 IRON REACTIVE PERMEABLE BARRIER EVALUATION AND RESULTS

5 1 Hydraulic Fracturing Background

Hydraulic fracturing has been utilized in the petroleum industry for over 60 years to increase the yield in low permeability formations The hydraulic fractures in brittle rocks propagate in the direction of the maximum principal stress (Hubbert and Willis 1957) Horizontal fractures develop in high horizontal stress (overly consolidated) conditions while at depth vertical fractures dominate due to low horizontal stress (normally consolidated) conditions

During the past 5 years hydraulic fracturing of weak highly permeable formations has become standard practice in the petroleum industry primarily for sand and production control in a procedure called frac and pack (Wong et al 1995) Recently hydraulic fracturing has been used for environmental remediation applications (Hocking and Wells 1997 and Hocking Wells and Ospina 1998a and 1998b)

A series of field hydraulic fracturing experiments in loose sands and peat layers led to the realization that the azimuth of vertical hydraulic fractures could be controlled by a fracture initiation device (Hocking 1996) The field experiments have demonstrated that a) the vertical fractures can be placed at any required azimuth or bearing b) by the simultaneous injection of multiple fracture well heads continuous coalesced fractures are formed and c) by a process of tip screen out fracture thickness can be controlled The technology involves initiating the fracture at the correct orientation at depth and by controlled injection of multiple well heads as a continuous permeable barrier is created Figure 25 To date the technique has been demonstrated to work in a range of soil and stress conditions from loose cohesionless sands partly cemented dense sands to clay and silts Hydraulic fractures have been created with a variety of materials sand granular iron and sintered bauxite for permeable barriers and bentonite/cement mixtures for impermeable barriers

5 2 Hydraulic Fracturing Placement of Oriented Iron Reactive Permeable Barriers

Orientated vertical hydraulic fracturing technology requires an injection delivery system comprising three prime components 1) the fracture initiation device 2) the controlled pumping equipment and 3) the real time monitoring and inverse algorithms for determining fracture geometry The fracture initiation device controls the fracture orientation The pumping system is specially designed to achieve a precise control of fracture fluid pressures and flow rates The real time monitoring system provides feedback response to ensure the fractures are propagating as planned A flow chart of the entire mixing pumping and injection equipment and instrumentation is given on Figure 26 The downhole initiation tools comprise a suite of tools depending on the geological formation depth and the fracturing fluid required for the particular application

The real time instrumentation involves either high precision bi axial tilt meters for monitoring surface movements or resistivity receivers for monitoring surface and/or sub surface induced voltages when active resistivity is used to quantify fracture geometry For installation of iron reactive permeable barriers at great depths tilt meters are typically not used Active resistivity methods can be utilized to determine fracture geometry in real time during the injection process During injection the gel/iron mix is electrically energized with a low voltage 100 Hz signal Downhole resistivity receivers are monitored to record the in phase induced voltage by the propagating fracture From monitoring the fracture fluid induced voltages and utilizing an incremental inverse integral model the fracture fluid geometry can be quantified during the installation process

The hydraulic fracture iron reactive permeable barrier is constructed by injecting through multiple well heads spaced typically 15 feet apart along the permeable barrier alignment Generally two (2) well heads are initiated and injected simultaneously to achieve a coalesced continuous fracture filled with the iron reactive mixture The next cluster of two (2) simultaneously injected well heads are spatially located to ensure the neighboring fractures overlap sufficiently to provide a continuous treatment permeable barrier The quantities of injected iron reactive mixture are continuously monitored to ensure sufficient reactive iron is injected through the individual well heads

Golder implements strict quality control procedures during construction of Iron Reactive Permeable Barriers to provide the necessary assurance that the reactive barrier system s design performance requirements are achieved Golder s construction quality control procedures and acceptance criteria concentrate on the following

- ☐ Batch consistency tests of the iron reactive mixture
- ☐ Thickness and injected quantities of reactive iron in the various hydrogeologic units
- ☐ Geometry of the reactive wall monitored (active resistivity) during injection and
- ☐ Effectiveness of the wall from hydraulic pulse tests

The permeable reactive wall is tested for it s hydraulic effectiveness by pulse interference tests Pulse interference tests involve a cyclic injection of fluid into the source well and by high precision measurement of the pressure pulse in a neighboring well detailed hydraulic characterization between wells can be made

The pulse interference test is highly sensitive to hydrogeological properties between the wells and relatively insensitive to conditions outside of the wells The time delay and attenuation of the hydraulic pulse enable the hydraulic effectiveness of the wall to be assessed Before the gel cross link is broken the wall acts as a temporary flow barrier because the gel is an impermeable viscous fluid If the wall is continuous significant attenuation of the hydraulic pulse will occur If holes are present the time delav and lack of attenuation of the pulse enables the gross area and approximate location of any holes to be delineated Following breaking of the gel a Permeable Iron Reactive Permeable Barrier remains with minimal gel residue Laboratory permeability tests have quantified that the gel residue is minimal and does not impact the permeability of the Iron Reactive Permeable Barrier

Construction monitoring of the permeable barrier s installed geometry and hydraulic effectiveness provides the capability and flexibility to handle unanticipated conditions and events during the permeable barrier installation For example if the permeable barrier appears deficient in thickness in certain areas or unanticipated subsurface conditions or events are present additional reactive iron can be injected into the identified zone by multiple injections through the hydrofracturing wells Alternatively if any gaps or holes are identified in the permeable barrier or any previously unidentified contaminant pathways are revealed then an overlapping permeable barrier can be placed over the gap or potential pathway This construction and ongoing quality control monitoring activities ensures the reactive system is built to the required degree of integrity and hydraulic effectiveness

5 3 Fracturing Fluids

The placement of iron treatment permeable barriers by orientated vertical hydraulic fracturing requires a fracturing fluid gel that is both compatible with the iron and the hydraulic fracturing process In the petroleum industry water based fracturing fluids predominate The fracturing fluid needs to be compatible with the formation and formation fluids be capable of controlling viscosity and carrying proppant be an efficient fluid (i e low leak off) and have low friction coefficient (Gidley et al 1989) Hydraulic fracturing cross link gels are typically guar HPG (hydroxypropylguar) and cellulose based gels such as CMHEC (carboxymethyl hydroxyethylcellulose) The guar based gels are considered natural polymers while the cellulose polymers are usually considered synthetics

A wide variety of metal cross linkers have been developed with the earliest cross linkers being borate and antimony based When added to the fracturing fluid the metals within the cross linker are dispersed between the polymers A strong attraction occurs between the metals and the hydroxyl or carboxyl groups increasing the viscosity of the fluid to create a very viscous gel (Gidley et al 1989) Breakers are added to controllably degrade the viscous gel down to a thin watery fluid The two common breakers are enzymes and oxidizers The HPG and cross linker constituents and enzyme brand are proprietary chemicals of Golder and are referenced as Golder B 1 Golder BC 1 and Golder BE 1 respectively MSDS sheets are available on all of the constituents and extensive chemical analyses are available of the gel including priority pollutant scans The gel does not exceed drinking water MCLs for any compound Golder s standard fracturing fluid design was presented in Section 3 2 (Table 4)

5 4 Reactivity of Iron

Zero valent metals have been known to abiotically degrade certain compounds such as pesticides as described by Sweeny and Fisher (1972) and halogenated compounds such as TCE PCE VC and cis 1 2 DCE as detailed in Gillham and O Hannesin (1994) In the case of zero valent iron the abiotic degradation of halogenated aliphatics can be approximated by a first order reduction process The compounds are progressively degraded to daughter products and eventually broken down into ethanes and ethenes (Orth and Gillham 1996) as shown on Figure 27 In situ iron passive reactive permeable barriers have been placed at a number of sites dating back to the first constructed at CFB Borden in 1991 by the University of Waterloo The placement of granular iron in the subsurface for passive in situ treatment of contaminated groundwater was first discussed by Gillham (1993) The mode of placing the granular iron has been by conventional technologies such as shoring and excavation and trenching More recently methods for deep installation have been considered by Hubble Gillham & Cherry (1997)

Iron reactive walls have significant advantages over conventional technologies for remediating chlorinated solvent contaminated groundwaters with the prime advantages being that the system is passive It is a simple process that has been proven both in the laboratory and the field Site characterization and laboratory bench scale studies are sufficient to design and construct an iron reactive wall

5 5 Iron Reactive Permeable Barrier Feasibility Acceptance Criteria

The Iron Reactive Permeable Barrier at this Site should be designed to reduce VOCs in the groundwater to below MCL levels The feasibility of IRPB s as a remedial groundwater alternative for the McGraw Edison Site should consider the following general requirements and specific acceptance criteria

General Requirements

☐ The IRPB should consider geotechnical hydrogeological and groundwater chemistry data collected during the different Site field investigations

☐ The IRPB should consider the use of commercially available zero valent granular iron the selected emplacement technique and the installation depth

☐ The IRPB should consider the variability of Site data (hydrogeology and geochemistry) iron reactivity and soil desorption column test data and installed wall thickness

- ☐ The IRPB should be able to reduce the VOCs encountered in the Site groundwater to less than MCL levels and the downgradient concentrations from the IRPB should decline with time to less than MCL levels within a moderate time frame of 10 to 15 years

- ☐ The IRPB installation method selected should allow for implementation of construction quality assurance and quality control procedures during construction

- ☐ The performance of the IRPB can be properly monitored with time to evaluate its performance based on the ability of the system to reduce the VOCs encountered in the groundwater being treated to less than MCL levels

Specific Acceptance Criteria

- ☐ Fracturing fluids used in hydrofracturing technology should be efficient fluids with low leak off In a leak off test (Golder Test Method) the volume lost (leak off) measured during the test at 10 minutes under a test cell pressure of 25 pounds per square inch should not exceed 75 milliliters

- ☐ Fracturing fluids used in hydrofracturing technology should provide sufficient resistivity contrast with the in situ soils where the IRPB is installed for monitoring the geometry of the permeable barrier during construction The fracturing fluids should have a resistivity at least 30 times lower than the Site soils

- ☐ Reduction rates of groundwater VOCs downgradient the location of IRPB depend on the groundwater effluent concentrations from the IRPB treatment system and the Intrinsic Degradation and soil desorption rates of VOCs in the groundwater downgradient from the IRPB In a soil desorption column test (EnviroMetal Inc Test Method) the test results should indicate that the TCE concentration in the column effluent is reduced to less than 5% of the peak concentration of TCE observed during the test and

- ☐ The zero valent granular iron selected for the installation of the IRPB should be reactive enough to reduce the VOCs encountered in the Site groundwater to less than MCL levels From an iron reactive bench scale column test (EnviroMetal Inc Test Method) a field half life of less than 2 5 hours (1 25 hours in the laboratory) should be determined for TCE

Results of leak off tests indicate that Golder s standard fracturing fluid would produce low leak off during installation of an IRPB at the Site using the hydrofracturing technology A volume lost (leak off) of 13 3 milliliters was measured during the leak off test (Golder Test Method) at 10 minutes under a test cell pressure of 25 pounds per square inch This result is within the acceptance criteria because it is lower than the 75 milliliters maximum allowed for the selection of IRPBs and the use of hydrofracturing technology for installation

The soil resistivity test results indicate soil resistivity values in the range of 6 600 to 7 600 ohms cm The Golder standard fracturing fluid has resistivity values that range from 1 600 to 2 400 ohms cm with a mean of 1 900 ohms cm which is about 37 times lower than the measured laboratory resistivity of the Site soils Therefore the Golder standard fracturing fluid would produce sufficient resistivity contrast (greater than 30 times) with the in situ soils for mapping the geometry of the IRPB during installation and is thus deemed acceptable

Reduction rates of groundwater VOCs downgradient the location of the IRPB depend on the groundwater effluent concentrations from the IRPB treatment system and the Natural Attenuation and soil desorption rates of VOCs in the groundwater downgradient from the IRPB The results of the soil desorption column test (EnviroMetal Inc Test Method) indicated a peak TCE concentration of 1 169 ppb at 0 2 pore volumes declining to below 10 ppb at four (4) pore volumes and to 1 9 ppb after 16 pore volumes The TCE concentration after sixteen (16) pore volumes is less than the maximum allowed test acceptability criterion 5% the peak TCE concentration observed in the column and MCL making the IRPB acceptable for the site

The zero valent granular iron selected for the installation of the IRPB should be compatible with the hydraulic conductivity of the Site soils and be reactive enough to reduce the VOCs encountered in the Site groundwater to less than MCL levels The medium to fine Master Builders granular iron was selected for the IRPB This granular iron is compatible with the hydraulic conductivity of the sands in the upper and intermediate sand units and is reactive enough when in contact with the Site TCE contaminated groundwater to reduce VOCs to less than MCL levels The medium to fine Master Builders granular iron has a hydraulic conductivity ranging from 1 x 10 cm/sec to 5 8 x 10^2 cm/sec with a mean of 2 6 x 10 cm/sec which is greater than the estimated hydraulic conductivity of the upper and intermediate sands (see Table 11) Granular iron filings with a hydraulic conductivity lower than the Site soils would impact the natural groundwater flow regime across the Site

The medium to fine Master Builders granular iron selected for the IRPB is reactive enough to reduce the VOCs encountered in the Site groundwater to less than MCL levels The results of the iron reactivity bench scale column test (EnviroMetal Inc Test Method) indicated a laboratory half life of 0 4 hours for an anticipated field half life of 1 hour which is acceptable given it is less than the 2 5 hrs set as the minimum half life as part of the acceptance criteria for IRPBs

5 6 Alternative Groundwater Remedial Plan

5 6 1 General

The proposed groundwater remedial alternative involves the installation by the hydrofracturing technology of an Iron Reactive Permeable Barrier at the source area to intercept the Site TCE contamination in the upper/intermediate sands The IRPB would reduce the VOCs encountered in the Site groundwater to less than MCL levels and the VOCs concentrations in the remnant plume downgradient from the IRPB source control reactive barrier would decline with time to less than MCL levels by Natural Attenuation The proposed location of the IRPB with respect to the TCE plume is shown on Figure 28 A cross section along the IRPB is shown on Figure 29

The IRPB would be three (3) inches average thickness and 20 feet high by 240 feet long extending from about Elevation 995 ft MSL down to Elevation 975 ft MSL (25 ft to 45 ft BGS) covering a cross sectional area of 4 800 ft The IRPB will be constructed by hydraulic fracturing only the sand units shown in the cross section on Figure 29 The fracturing wells will be able to fracture individual sand units if necessary The overlying and underlying tills are sufficient to contain the fractures within the sand unit and thus maximize the thickness of the reactive barrier

The IRPB would be located approximately 70 feet downgradient from groundwater monitoring well MW 3A and 35 feet upgradient from monitoring well EW 1 The IRPB is intended to intercept the contaminated groundwater flowing in the direction of the TCE plume through the upper and intermediate sand units encountered at the Site

The location of the IRPB shown on Figure 28 is an optimum layout for a source control reactive barrier If access or legal issues dictate that the IRPB be located within the Site property an alternative location and layout of the IRPB is given in Appendix G This alternative location and extent of the IRPB is equivalent to the IRPB shown on Figure 28 however due to its increased length of 10% it would impact installation cost by approximately 10%

5 6 2 Site Characterization Data

A number of field investigations have been performed at the Site for hydrogeologic and geo chemistry characterization The Supplemental RI/FS Investigation Report prepared for the Site (Woodward Clyde Consultants 1994) summarizes the data collected from previous field investigations As part of the May 1998 supplemental soils and groundwater sampling field program implemented at the Site additional data was collected for the evaluation of Natural Attenuation (Section 4 0) and the feasibility assessment of a IRPB Two additional soil borings GB 1 and GB 1A were drilled to collect soil samples for geotechnical and soil desorption and iron reactivity bench scale column testing (Section 2 4)

The till clays encountered at the Site in general consist of stiff to very stiff medium plasticity silty clays (CL) The sands encountered in the upper and intermediate sand units consist generally of medium to fine silty sands (SP SM) The grain size distribution analysis results of sand samples taken from borehole GB 1 were analyzed using the Hazen method (K=(D_{10}) D_{10} in mm and K in cm/sec) for estimating hydraulic conductivity This analysis has yielded hydraulic conductivity values for the Site ranging from about 7 9 x 10 cm/sec to 1 4 x 10 cm/sec based on D_{10} values ranging from 0 07 mm to 0 12 mm respectively A summary of the analysis is shown on Table 11 The hydraulic conductivity of the intermediate sands based on results of aquifer pump tests (Woodward Clyde Consultants 1994) is on the order of 2 7 x 10 cm/sec Hydraulic groundwater flow gradients at the Site range from about 0 001 to 0 002 with an average of 0 0015 ft/ft Based on an average hydraulic conductivity of 5 x 10^{3} cm/sec a soil porosity of 0 35 and a flow gradient of 0 0015 ft/ft the groundwater flow velocity at the Site in the direction of the TCE plume is estimated to be on the order of 0 06 ft/day (22 ft/year) The groundwater flow gradient across the Site is shown by examining the potentiometric contours on Figure 16

Groundwater TCE concentration data are available for 1994 and the May 1998 sampling events The TCE concentration data for these two sampling events are summarized in Table 1 The maximum groundwater TCE concentrations in the upper and intermediate sands has been measured in monitoring well MW 3A with values of 14 000 ppb in 1994 and 7 000 ppb in May 1998 Concentrations of TCE in the Allen Well downgradient in the TCE plume (see Figure 28) have been steadily dropping from 360 ppb in 1988 120 ppb in 1994 and to 51 ppb in the May

1998 sampling event Concentrations of TCE in monitoring wells MW 25WT and MW 22WT have been non detect (ND) in both sampling events The location of the IRPB with respect to the TCE plume is shown on Figure 28

5 6 3 Iron Reactive Permeable Barrier Performance Forecast

An IRPB contaminant concentration reduction deterministic analysis was conducted to evaluate the performance of the IRPB based on the ability of the system to reduce VOCs encountered in the Site groundwater to less than MCL levels The analysis of an IRPB considers the groundwater VOCs influent concentrations the in situ IRPB porosity the formation groundwater flow gradient the formation hydraulic conductivity the velocity of the groundwater across the IRPB the anticipated field half lives for the different compounds the average IRPB in place thickness and the target IRPB effluent VOCs concentrations Only TCE and cis 1 2 DCE are currently present in the Site groundwater at levels of 7 000 ppb and 50 ppb respectively

One design case was evaluated for the IRPB to treat the contaminated groundwater in the upper and intermediate sands as follow

☐ *Design Case I* One wall of 3 in average thickness installed in the upper and intermediate sands which have an average hydraulic conductivity of 5 x 10 cm/sec

This design case was based on a maximum influent concentration of TCE of 7 000 ppb a mean IRPB porosity of 0 45 and an average groundwater flow gradient of 0 0015 ft/ft

The results of the deterministic analysis including the input parameters are summarized in Table 12 The single hydraulic fracture installed IRPB in the upper and intermediate sands Design Case I is sufficient to reduce the VOCs encountered in the Site groundwater to less than MCL levels (5 ppb for TCE) Based on the analysis results the groundwater would be in contact with the zero valent reactive iron for about 127 hours which is significantly greater than that required (10 hours for TCE 15 hours for cis 1 2 DCE and 28 hours for VC) to reduce the VOCs to less than MCL levels This significant residence time makes the designed IRPB a robust system capable of reducing influent concentrations of TCE up to the solubility levels in groundwater

(~40 000ppb) to concentrations below the MCL level immediately down gradient of the permeable reactive barrier

The column reactivity test indicated that an IRPB at this Site would have minimal potential for clogging and/or precipitation as to impact the permeable barrier s reductive performance The inorganic chemistry of the Site groundwater is very similar to sites where reactive barriers have been performing consistently for over 2 years The expected life of the reactive permeable barrier is difficult to assess from laboratory data however from comparative field sites and considering the low groundwater flow velocity at the Site the IRPB is expected to remain effective in reducing the VOC s to MCL levels for fifteen (15) years Depending on the amount of source reduced from the unsaturated zone by the SVE system and the reduction of the influent concentration by Natural Attenuation in the saturated zone it will most likely not be necessary to install a replacement IRPB system

5 6 4 Natural Attenuation of VOCs Downgradient of Iron Reactive Permeable Barrier

To evaluate the Natural Attenuation degradation of the remnant downgradient portion of the TCE plume beyond the treatment area of the IRPB the 1 D fate and transport model was utilized using the same sensitivity range of input parameters as described in Section 4 6 1 The results of the modeling are shown on Figure 50 for the 2 year 5 year and 10 year predictions after the IRPB is constructed for values of R_f D and t_5 of 1 4 16 6 ft /day and 600 days respectively Sensitivity analyses were conducted on the entire range of input parameters as detailed in Table 9 These sensitivity analyses computed a post IRPB period of 9 to 13 2 years with a mean of 11 ¼ years would be required to reduce TCE concentrations to below MCL (i e 5 ppb)

The highest TCE concentrations downgradient of the IRPB in 2 5 and 10 years were estimated by the model to be approximately 500 ppb 80 ppb and 5 ppb respectively That is the remnant plume is predicted to be degraded by 65% 92% and 99% (i e mass removal of TCE) after 2 5 and 10 years respectively following IRPB installation These analyses show that the alternative Iron Reactive Permeable Barrier system in combination with the Site s documented Natural Attenuation will reduce the remnant downgradient of the IRPB TCE plume concentration to MCL levels within approximately ten (10) years

5 6 5 Proposed Monitoring of Alternative Groundwater Remedy

The Alternative Groundwater Remedy consists of an IRPB for source control and Natural Attenuation for biodegradation of the remnant TCE contamination downgradient of this source control reactive barrier Monitoring activities are proposed to ensure the IRPB performs as designed and that Natural Attenuation of the contaminants continues as expected It is proposed that two (2) monitoring wells would be installed immediately downgradient of the IRPB These wells and upgradient wells such as MW 3A would be sampled and analyzed periodically to ensure the reactive barrier performs as designed Also site wide monitoring wells both up and downgradient of the IRPB would be sampled and analyzed for TCE concentration periodically at a sufficient frequency to be confident that Natural Attenuation is proceeding as expected

5 7 Comparative Analyses of Groundwater Remedial Alternatives

The Record of Decision (ROD) dated September 1993 presented the USEPA selected remedy which included groundwater extraction and ultraviolet catalyzed oxidation to treat the groundwater and in situ treatment of the soils using soil vapor extraction The USEPA issued an Explanation of Significant Difference (ESD) to the ROD in June 1994 The ESD presented Vacuum Enhanced Groundwater Recovery (VGR) as an alternative technology to conventional pumping of groundwater at the Site

Various alternative groundwater remedies such as a pump and treat system using either air stripping granular activated carbon (GAC) or UV/oxidation to remove the VOCs from the treatment stream and discharge to the POTW or southeast drainage ditch have been comparatively analyzed earlier by Woodward Clyde Consultants 1993 The VGR groundwater extraction method using either UV oxidation or GAC for processing of the extracted groundwater has been analyzed by ETG Environmental Inc in January 1995 and recommended VGR with GAC for the waste/stream treatment

It is now well known that pump and treat methodologies for remediating groundwater contaminated with DNAPLs such as trichloroethene (TCE) are not as effective as earlier anticipated and have led to Superfund Reforms for Updating Remedy Decisions (USEPA 1996b) The Alternative Groundwater Remedial Plan of an IPRB and natural attenuation of the remnant downgradient plume from the reactive barrier has been proposed because it meets the essential criteria of acceptance as outlined in the memorandum Superfund Reforms Updating Remedy Decisions (USEPA 1996b) The criteria for acceptance as outlined in this memorandum are 1) an innovative cost effective technology for remediating the contaminated groundwater that has been demonstrated since the time of the ROD and 2) recent data documenting natural attenuation is active at the Site The Alternative Groundwater Remedy of an IRPB and Natural Attenuation satisfies both of the above criteria the IRPB being a recent cost effective technology since the time of the ROD and the Natural Attenuation evaluation having been derived from recent field data The Alternative Groundwater Remedy can be implemented in a timely manner is comparable or better in effectiveness and significantly more cost effective than the current VGR groundwater extraction system utilizing GAC

A comparative analysis of the Alternative Groundwater Remedial Plan to the proposed VGR groundwater extraction system follows using the National Contingency Plan (40CFR300) (NCP) criteria The IRPB system is effective in degrading TCE in the groundwater to below the MCL of 5 ppb Natural attenuation of the remnant TCE contaminated groundwater downgradient of the reactive barrier based on model predictions will be reduced to MCL levels in approximately ten (10) years The VGR system would also be effective in containing the plume and reducing TCE concentrations within a fifteen (15) year time frame to MCL levels (ETG 1994)

The NCP criteria have been used as a basis of comparison between the ROD modified remedy VGR groundwater extraction and the proposed Alternative Remedial Plan using an IRPB and such a comparison is summarized below and in Table 13

- ☐ *Overall Protection of Human Health and the Environment* Both systems are protective of the overall human health and environment since both will reduce the level of TCE concentration in the Site s groundwater however the VGR being an ex situ system has the potential for surface spills and exposure to humans The Alternative Groundwater Remedy being in situ poses no such risks

- ☐ *Compliance with ARAR s* Both systems are judged to be equivalent as regards compliance with ARAR s

- ☐ *Reduction of Toxicity Mobility or Volume* Both systems will remove equivalent amounts of TCE with the IRPB using an in situ treatment compared to an ex situ treatment for the VGR The VGR system will disrupt and be detrimental to Natural

Attenuation mechanisms at the Site The TCE mass removed over a 2 year period by the ROD Modified Remedy (SVE and VGR) and the Alternative Remedy (consisting of the current Soil Remedy (SVE) and IRPB) are shown on Figure 51 The VGR and IRPB essentially extract and degrade respectively similar amounts of TCE and both remedies (ROD Modified and Alternative) are equivalent for contaminant mass removal except that the VGR system will reduce the effectiveness of the Natural Attenuation mechanisms active at the Site

☐ *Short Term Effectiveness* Both systems are judged to be limited in the short term the IRPB being limited to the low groundwater flow rates at the Site and the VGR being limited due to its low imposed gradient and thus groundwater velocity in the upper/intermediate sands However the low natural groundwater flow rates enable the IRPB system to be robust in reducing very high concentration of TCE to below the MCL of 5 ppb

☐ *Long Term Effectiveness and Permanence* The IRPB is assessed to be more effective and more reliable than an active on going vacuum enhanced pump and treat system because the VGR system is limited in effectiveness due to its low volume of contaminated groundwater drawn from the upper/intermediate sands compared to the total volume of groundwater extracted by the system including a significant volume of clean groundwater from the channel sands The VGR system requires continual operations and maintenance to ensure the system remains functional

☐ *Implementability* The IRPB is less disruptive and can be constructed quicker and easier than the VGR system The IRPB system with an expected useful life of at least fifteen (15) years is virtually free of continuing operations and maintenance and

☐ *Cost Effectiveness* The IRPB is more cost effective than the VGR system in present 1998 dollars The costs for the ROD Modified Remedy consisting of SVE and VGR is estimated at $3 5M while the current Soil Remedy and Alternative Groundwater Remedy (SVE and IRPB) is estimated at $2M for a cost savings of $1 5M see Table 13

6 0 SOIL REMEDY IMPLEMENTATION AND PROPOSED ALTERNATIVE GROUNDWATER REMEDY

6 1 Soil Remedy Implementation

The current soil remedy involves utilizing soil vapor extraction in the unsaturated zone in the TCE Storage Area inside of the Manufacturing Building and in the South Culvert Area The current field sampling program further delineated the soil contamination in the South Culvert Area as discussed in section 2 2 The soils in the South Culvert Area were found to have TCE concentrations less than 150 µg/kg with 98% of the soil volume sampled having TCE concentrations less than 100 µg/kg and 65% of the soil volume sampled having TCE concentrations below detection limits The TCE contamination in the soils in the South Culvert Area are below the clean up limit of 750 µg/kg and therefore do not require or warrant active remediation by soil vapor extraction

The soil contamination in the TCE Storage Area and inside of the Manufacturing Building was determined by some thirteen (13) borings as shown on Figure 4 and reported earlier (Woodward Clyde Consultants 1994) The planar area of the estimated extent of the soil contamination exceeding 750 µg/kg is shown on Figure 32 based on the results of these earlier borings The maximum depth of the soil contamination in these areas in the till that exceeds the clean up criterion is twenty (20) feet in the TCE Storage Area and thirty (30) feet inside of the Manufacturing Building based on the highest reading from field GC and laboratory CLP data reported earlier (Woodward Clyde Consultants 1994) The contaminated soils above the clean up level are contained in the upper till unit designated as till #3 It is proposed in the implementation of the soil remedy that these identified areas will undergo active remediation by soil vapor extraction to ensure the soil contamination falls below the clean up limit

The TCE contamination within the upper and intermediate sands are planned to be remediated by the alternative groundwater remedy a IRPB with the on going Natural Attenuation mechanisms active at the Site The proposed IRPB is downgradient of those source areas identified on Figure 32 planned for active remediation by SVE The IRPB is sufficiently robust in degrading high concentrations of TCE in the groundwater to below MCL The IRPB would degrade any contamination that may migrate from these source areas and thus provides a greater degree of conservatism for the overall remedial system

6 2 Alternative Groundwater Remedy

The current groundwater remedy is Vacuum Groundwater Recovery (VGR) with Granular Activated Carbon (GAC) for extracted groundwater treatment with treated groundwater disposal to the POTW The feasibility assessment of an Iron Reactive Permeable Barrier (IRPB) is presented in Section 5 0 of this report with quantification of Natural Attenuation processes active at the Site discussed in Section 4 0 It was concluded in Section 5 7 that the alternative groundwater remedy of an IRPB with Natural Attenuation was equivalent to or superior than the current groundwater remedy based on a comparative analysis utilizing the NCP criteria This alternative groundwater remedy could be implemented and be functional quicker than the current remedy The alternative remedy has significant cost savings as compared to the current remedy

The alternative groundwater remedy would involve the installation of an IRPB in the source area as illustrated in plan on Figures 28 & 32 and in cross section on Figure 29 The IRPB proposed is 240 feet in length and extends from a depth of 25 feet down to a total depth of 45 feet The IRPB is proposed to be installed by vertical hydraulic fracturing in the sand units within the cross sectional area shown The IRPB would have a minimum thickness of 3 inches and consist of medium to fine zero valent granular iron The IRPB would have an in placed hydraulic conductivity at least equal to or greater than the Site upper and intermediate sands Construction quality control and in situ monitoring activities would ensure the IRPB is installed as designed

The IRPB is capable of degrading the TCE in the groundwater from an influent concentration of 7 000 ppb to below MCLs with no detectable daughter products emanating from the IRPB The IRPB is considered to have sufficient longevity to ensure the Site groundwater is remediated to MCL levels In order to monitor the performance of the IRPB immediately down gradient monitoring wells are proposed to be installed and sampled periodically for volatile and inorganic compounds The IRPB is sufficiently robust at this site due to the low groundwater flow velocities that it is capable of degrading very high levels of TCE concentration to below the MCL Groundwater contamination up gradient of the IRPB such as the TCE storage area and the South Culvert Area will flow into the barrier and be degraded to below the MCL It is recommended that the current Groundwater Remedy be changed from VGR to an IRPB and Natural Attenuation It is recommended that groundwater monitoring wells be installed immediately downgradient of the IRPB and be sampled and analyzed periodically to ensure the IRPB is functioning as expected

Natural Attenuation was documented as being active at the Site as discussed in Section 4 0 In fact Natural Attenuation is considered to be of such significance at the Site that it has accounted for approximately 75% of the reduction to date in groundwater TCE concentrations The groundwater contamination has been documented from historical and current data to be reducing over the past ten (10) years as discussed in Sections 2 3 and Section 4 0 Numerical model simulations presented in Section 5 6 4 concluded that the TCE groundwater concentrations in the remnant plume down gradient of the IRPB would be degraded by Natural Attenuation to MCLs in ten (10) years Therefore it is recommended that the current Site s Natural Attenuation mechanisms be relied upon to remediate the remnant plume down gradient of the IRPB It is recommended that some of the existing groundwater monitoring wells be sampled and analyzed periodically to verify that such degradation mechanisms continue in the future

7 0 SUMMARY AND CONCLUSIONS

The current field sampling program further delineated the soil contamination in the South Culvert Area from nine (9) soil borings to depths of 40 feet The soils in the South Culvert Area were found to have TCE concentrations less than 150 µg/kg with 98% of the soil volume sampled having TCE concentrations less than 100 µg/kg and 65% of the soil volume sampled having TCE concentrations below detection limits The TCE contamination in the soils in the South Culvert Area are below the clean up limit of 750 µg/kg and therefore do not require or warrant active remediation by soil vapor extraction

The thirty two (32) existing monitoring wells were sampled and analyzed for TCE contamination and five (5) of these wells were further sampled and analyzed for Natural Attenuation parameters Groundwater samples were also taken at the bottom of eight (8) of the soil borings in the South Culvert Area and analyzed for TCE TCE concentrations in the groundwater were found to be lower in most cases by at least 50% than those values reported in the last sampling round of 1994 Groundwater TCE concentrations are generally declining across the entire site and in many wells have experienced significant reduction

An Natural Attenuation evaluation was conducted for the Site using time trend analysis natural attenuation indicator parameters a scoring system and analytical fate and transport modeling The generally declining TCE conditions in the aquifer the evaluation of the Natural Attenuation indicator parameters the presence of a complete degradation series from TCE to ethene indicate active natural bioremediation is occurring at the Site These findings are supported by Site specific modeling results that indicate that degradation is occurring and occurring at rates consistent with other published field values The evidence supporting that Natural Attenuation is active at the site is considered adequate to strong

Based on the results of laboratory tests conducted for the evaluation of IRPBs the review of the Site subsurface conditions and geochemistry of the groundwater an IRPB installed using hydrofracturing technology is an alternative remedial system for the in situ passive treatment of the TCE contamination in the saturated zone at the Site The proposed IRPB would have an average thickness of three inches be 20 feet high by 240 feet long and be located immediately downgradient of MW 3A and thus act as a source control barrier The IRPB would reduce TCE concentration levels and other VOCs encountered in the Site groundwater to less than MCL levels The IRPB is sufficiently robust at the Site to reduce TCE concentrations to MCL levels from near saturation levels The 1 D fate and transport modeling for the Site indicates that concentration levels of TCE in the remnant portion of the plume downgradient from the IRPB will be reduced to less than 5 ppb (MCL level) by Natural Attenuation in approximately 10 years

The NCP criteria have been used as a basis of comparison between the ROD modified remedy VGR groundwater extraction and the proposed Alternative Groundwater Remedy utilizing an Iron Permeable Reactive Barrier for source control in the saturated zone and natural degradation for the remnant TCE plume downgradient of this reactive barrier The proposed Iron Reactive Permeable Barrier alternative remedial system compares more favorable than the VGR groundwater extraction remedy based on effectiveness implementability and cost

The conclusions from this field work and feasibility assessment are as follow

- ☐ the South Culvert Area soils are below the contamination level of 750 µg/kg and therefore do not require or warrant active remediation by soil vapor extraction
- ☐ groundwater concentrations of TCE are generally declining across the entire site
- ☐ there is adequate to strong evidence that natural attenuation is occurring at the Site
- ☐ an IRPB can be constructed at the Site by the vertical hydraulic fracturing technology
- ☐ the IRPB will degrade all of the VOCs of concern to below MCLs and is considered to have sufficient longevity for the Site groundwater to be remediated to below MCLs
- ☐ the remnant plume down gradient of the IRPB will be degraded by Natural Attenuation mechanisms to below MCLs in approximately ten (10) years and
- ☐ the alternative groundwater remedy of an IRPB and Natural Attenuation was determined to be equivalent or superior to the current groundwater remedy utilizing the NCP criteria The alternative groundwater remedy was determined to be superior to the current remedy in respect to effectiveness implementability and cost

The recommendations from this work are as follow

- ☐ to implement the soil remedy using soil vapor extraction in the areas of the TCE Storage Area and inside of the Manufacturing Building of the upper till #3 unit down to depths of 20 and 30 feet respectively
- ☐ to eliminate the South Culvert Area for active remediation and
- ☐ to modify the groundwater remedy to construct an IRPB Barrier and to rely on Natural Attenuation at the Site to achieve remediation levels in the remnant down gradient plume

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REFERENCES

Bear J (1979) Hydraulics of Groundwater McGraw Hill N Y pp 268 – 269

Curtis G P P V Roberts and M Reinhard (1986) A natural gradient experiment on solute transport in a sand aquifer and sorption of organic solvates and its influence on mobility Water Resources Res V22 N13 p 2059 2067

ETG Environmental Inc (1994) Post Record Decision Evaluation of Vacuum Groundwater Recovery as a Groundwater Remedial Process Option McGraw Edison Site Centerville Iowa May 2

Gidley J L S A Holditch D E Nierode & R W Veatch Jr (1989) Recent Advances in Hydraulic Fracturing SPE Monograph Series Richardson TX

Gillham R W (1996) In Situ Treatment of Groundwater Metal enhanced Degradation of Chlorinated Organic Contaminants In Advances in Groundwater Pollution Control and Remediation p 249 274 Kluwer Academic Publishers Netherlands

Gillham R W & S F O Hannesin (1994) Enhanced Degradation of Halogenated Aliphatics by Zero Valent Iron Ground Water Vol 32 No 6 pp 958 967

Gillham R W (1995) Cleaning Halogenated Contaminants from Groundwater U S Patent No 5 266 213

Gillham R W and O Hannesin S F (1992) Metal Catalysed Abiotic Degradation of Halogenated Organics Compounds IAH Conference Modern Trends in Hydrogeology Hamilton Ontario May 10 13 pp 94 105

Hocking G (1996) Azimuth Control of Hydraulic Fractures in weakly Cemented Sediments 2nd North American Rock Mechanics Symp Montreal A A Balkema Rotterdam pp1045 1048

Hocking G & S L Wells (1997) Oriented Vertical Hydraulic Fracture Iron Reactive Walls ASCE Environmental Group Meeting Atlanta GA

Hocking G S L Wells and R I Ospina (1998a) Design and Construction of Vertical Hydraulic Fracture Placed Iron Reactive Walls Submitted to 1st International Conference on Remediation of Chlorinated and Recalcitrant Compounds Monterey California May 1998

Hocking G S L Wells and R I Ospina (1998b) Field Performance of Vertical Hydraulic Fracture Placed Iron Reactive Walls Submitted to 1st International Conference on Remediation of Chlorinated and Recalcitrant Compounds Monterey California May 1998

Holtz R D and W D Kovacs (1981) An Introduction to Geotechnical Engineering Prentice Hall Inc Englewood Cliffs New Jersey p104

Howard P H R S Boethling W F Jarvis W M Meylan and E M Michalenko (1991) Handbook of Environmental Degradation Rates Lewis Publishers

Hubbert M K & D G Willis (1957) Mechanics of Hydraulic Fracturing Trans AIME v 210 pp153 168

Hubble D W R W Gillham and J A Cherry (1997) Emplacement of Zero valent Iron for Remediation of Deep Contaminant Plumes In Proceedings 1997 International Containment Technology Conference and Exhibition Feb 9 12 St Petersburg Florida

Orth S & R W Gillham (1996) Dehalogenation of Trichlorethene in the Presence of Zero Valent Iron Environ Sci Technol Vol 30 pp 66 71

Sweeney K H & J R Fisher (1972) Reductive Degradation of Halogenated Pesticides U S Patent No 3 640 821

USEPA (1996a) Symposium on Natural Attenuation of Chlorinated Organics in Ground Water USEPA Office of Research and Development EPA/540/R 96/509 Dallas Texas September 11 13

USEPA (1996b) Superfund Reforms Updating Remedy Decisions USEPA memorandum EPA540/F 96/026 9200 0 22 PB96 963252 September 27

Wiedemeier T H M A Swanson D E Moutoux J T Wilson D H Kambell J E Hansen and P Haas (1996) Overview of Technical Protocol for Natural Attenuation of Chlorinated Aliphatic Hydrocarbons in Groundwater Under Development for the U S Air Force Center for Environmental Excellence in USEPA 1996 Symposium on Natural Attenuation of Chlorinated Organics in Groundwater September 11 13 pp 35 59

Wong G K R R Fors J S Casassa & R J Hite (1993) Design Execution and Evaluation of Frac and Pack (F&P) Treatments in Unconsolidated Sand Formation in the Gulf of Mexico SPE 26563

Woodward Clyde Consultants (1993) Groundwater Operable Unit Feasibility Study McGraw Edison Site Centerville Iowa

Woodward Clyde Consultants (1994) Supplemental RI/FS Investigation Report McGraw Edison Site Centerville Iowa

Table 1

Summary of May 1998 Sampling Field Parameters and TCE and Historic TCE and Dissolved Iron Data

McGraw Edison Site
Centerville Iowa

Well ID	Temperature (C)	pH	Redox (mV)	Specific Conductance (mohm/cm)	Dissolved Oxygen (mg/L)	1994 TCE (µg/L)	1998 TCE (µg/L)
MW 1	12 8	6 98	70	0 621			nd
MW 2	11	7 01	151	0 473		370 000	1 100 000
MW 3	16 4	7 43	59	0 007	2 6	2	nd
MW 3A	15 2	7 53	80	0 1		14 000	6400 7000dup
MW 4	12 2	7 21	32	0 587		0 7	nd
MW 5	14 8	8 88	62	0 295	6 2	2	nd
MW 6	12 7	7 46	94	0 55	4	5	9 2
MW 7	14 9	6 85	82	0 321		nd	31 1dup
MW 7A	14 4	6 84	14	0 889		9	2
MW 8	17 2	8 26	95	0 024		29	1
MW 8A	12 7	8 14	1	0 781		240	7
MW 9							
MW 19WT	11 9	6 34	114	1 904		77	70
MW 20WT	13	7 46	49	0 647			20
MW 21	13 8	7 12	53	0 007	1 6		nd
MW 22WT	13 2	7 2	67	0 787	2 2		nd
MW 23WT	15 5	7 65	98	0 753	2 2	nd	nd
ALLEN WELL						120	51
WT 11	11 9	7 37	22	0 555	2		nd
WT 12	14 8	7 14	35	0 004	4 2		nd
WT 13	13 4	9 46	12	1 73		0 4	nd
WT 14	12 8	7 63	42	0 684		0 5	0 8
WT 16	13 6	9 14	68	0 34			nd

Table 1

Summary of May 1998 Samplıng Fıeld Parameters and TCE and Hıstorıc TCE and Dıssolved Iron Data

McGraw Edıson Sıte
Centervılle Iowa

Well ID	Temperature (C)	pH	Redox (mV)	Specıfıc Conductance (mohm/cm)	Dıssolved Oxygen (mg/L)	1994 TCE (µg/L)	1998 TCE (µg/L)
WT 18	12 8	6 7	74	0 366	3 8	12	45
EW 1	13 8	7 88	94	0 242			14 12dup
BD 11	12 5	7 42	107	0 915			nd
BD 12	14 6	7 34	13	0 018	1 2		nd
BD 13	15 6	9 67	16	0 26			nd
BD 14	13 3	7 42	30	1 874	0 9	nd	nd
BD 16	14 4	9 18	148	0 01			nd
BD 18	14	7 01	2	0 212		8	4
BR 10	14 4	7 02	82	2 37			nd

NOTES

* Grab Sample
dup Duplıcate Sample
nd Constıtuent not detected durıng analysıs of sample
Not Obtaıned
Monıtorıng well MW 9 was not sampled durıng the May 1998 soıl and groundwater samplıng program due to a dead anımal ın the

Table 2

Natural Attenuation Bioparameters and TCE Daughter Products Detected

McGraw Edison Site
Centerville Iowa

Indicator Parameter	Well ID				
	MW 2	**MW 3A**	**MW 8A**	**MW 8**	**MW 23WT**
Chloride (mg/L)	170	2	380	46	7 3
Nitrate (mg/L as N)	nd	0 9	nd	1 3	nd
Nitrite (mg/L as N)	nd	nd	nd	nd	nd
Phosphate (mg/L as P)	nd	nd	nd	nd	nd
Sulfate as (mg/L as SO4)	160	15	160	39	120
Alkalinity (mg/L)	230	350	560	1400	410
Hardness (mg/L as CaCO3)	340	340	1100	1200	430
Carbon Dioxide (mg/L)	230	17	4	nd	51
BOD (mg/L)	160	5	6	nd	6
COD (mg/L)	660	42	37	30	nd
Sulfide (mg/L)	0 02	nd	nd	nd	0 02
Methane (ng/L)	217238	378	283	137	166
Ethene (ng/L)	49021	68	13	55	25
Ethane (ng/L)	14239	54	21	<5	<5
1 2 DCE (total) (ug/L) (1994)	19 000	6	0 8	nd	
1 2 DCE (total) (ug/L) (1998)	130 000	47	nd	nd	nd

NOTES

nd Constituent not detected during analysis of sample

Not obtained

Table 3
Other VOC Detected in Wells Sampled for Natural Attenuation
McGraw Edison Site
Centerville Iowa

Indicator Parameter	Year	Well ID				
		MW 2	MW 3A	MW 8A	MW 8	MW 23WT
Benzene (ug/L)	1994	nd	nd	0 6	0 3	
	1998	nd	nd	nd	nd	nd
Toluene (ug/L)	1994	nd	0 3			
	1998	nd	nd	nd	2	nd
Xylene (total) (ug/L)	1994	nd	nd			
	1998	nd	nd	nd	0 6	nd
Ethylbenzene (ug/L)	1994	nd	nd			
	1998	nd	nd	nd	nd	nd
Acetone (ug/L)	1994	nd	nd	nd	100	
	1998	nd	nd	nd	44	nd
Carbon Tetrachloride (ug/L)	1994	nd	0 9	nd	nd	
	1998	nd	nd	nd	nd	nd
Chloroform (ug/L)	1994	nd	2	3	0 3	
	1998	nd	0 5	nd	nd	nd

NOTES

Sample contaminated in field or in lab

nd Constituent not detected during analysis of sample

Not Obtained

Table 4

Golder Fracturing Fluid Iron/Gel Design

McGraw Edison Site
Centerville Iowa

	Product Name	Product per 1000 gallons of water	Product per liter of water
Hydroxypropyl Guar	Golder B1	48 lb	5 8 g
Enzyme Breaker	Golder BE1	1 lb	0 12 g
Borate Cross Linker	Golder BC1	5 gal	5 ml
Granular Iron	100 % m f Master Builders Iron	16 000 lb	1 900 g

Table 5

Summary of Leak Off Test Results

McGraw Edison Site
Centerville Iowa

Sample ID	USCS	Soil Description	Grain Size			Sample Initial Conditions		Leak Off Test			
			D_{15}	D_{50}	D_{85}			Test Pressure	Cw	Spurt	Fluid Lost @ 10 min
			(mm)			γ_d (pcf)	n	(psi)	(cm/min´)	(cm)	(ml)
GB 1/15	SP SM	MEDIUM TO FINE SAND little silt trace fine gravel	0 11	0 29	0 56	110 5	0 34	25	0 02	0 09	13 3
GB 1/15	SP SM	MEDIUM TO FINE SAND little silt trace fine gravel	0 11	0 29	0 56	112 2	0 33	50	0 03	0 08	13 1
GB 1/15	SP SM	MEDIUM TO FINE SAND little silt trace fine gravel	0 11	0 29	0 56	114 1	0 34	100	0 04	0 16	23 5

NOTES

γ_d Dry Unit Weight
n Porosity

Table 6

Summary of Soil Resistivity Test Results

McGraw Edison Site
Centerville Iowa

Sample ID	**Sample Depth** (feet)	**Moisture Condition (1)**	**Resistivity** @ 15 5 C ohms cm
GB 1/9	41 43 2	saturated	7 600
GB 1/10	45 48	saturated	7 600
GB 1/15	70 72 5	saturated	6 600

NOTES

(1) Samples were saturated with groundwater obtained form monitoring well MW 3A with a specific conductance of 100 umohm/cm (conductivity measurement by MWR personnel)

Table 7

Summary of Iron Column Test Half Lives

McGraw Edison Site
Centerville Iowa

Compound	**M F Master Builders Iron**		
	Laboratory Half Life $t_{0\,5}$ (hr)	Laboratory Half Life Correlation Coefficient r^2	Anticipated Field Half Life(6) $t_{0\,5}$ (hr)
TCE	0 40	0 995	1
cis 1 2 DCE	1 4(1)	0 990	3
VC	nd	nd	4(7)

NOTES

(1) Determined from a peak concentration of 62 ppb at sampling port at 0 08ft
(2) Half lives determined from test data collected at stable conditions after 46 pore volumes
(3) Not determined in the laboratory
(4) The tests were conducted using site groundwater from wells MW 3A with the medium to fine Master Builders iron
(5) Tests conducted by EnviroMetal Technologies Inc (ETI)
(6) The field half life values are the laboratory half life values adjusted for field conditions (temperature)
(7) VC half life obtained from ETI database
(8) nd Compound not detected in the column influent or effluent groundwater

Table 8
Natural Attenuation Screening Scoring System
McGraw Edison Site
Centerville Iowa

Analyte	Criterion & Score		Site Allocated Score
Dissolved Oxygen	< 0 5 mg/L	3	1
	> 1 mg/L	3	
Nitrate	< 1 mg/L	2	2
Iron (II)	> 1 mg/L	3	0
Sulfate	< 20 mg/L	2	2
Sulfide	> 1 mg/L	3	0
Methane	> 0 1 mg/L	2	2
	> 1 mg/L	3	
Redox Potential	< 50 mV	1	1 5
	< 100 mV	2	
pH	5 < pH < 9	0	0
DOC	> 20 mg/L	2	0
Temperature	> 20 °C	1	0
Carbon Dioxide	> 2x background	1	0 5
Alkalinity	> 2x background	1	0 5
Chloride	> 2x background	2	1 5
Hydrogen	> 1 nM	3	0
Volatile Fatty Acids	> 0 1 mg/L	2	0
BTEX	> 0 1 mg/L	2	0
cis 1 2 DCE	Presence if daughter product	2	2
Ethene/ethane	> 10 ug/L	2	3
	> 100 ug/L	3	
TOTAL			**16**

Score	Interpretations
0 to 5	Inadequate evidence for biodegradation of chlorinated organics
6 to 14	Limited evidence for biodegradation of chlorinated organics
15 to 20	Adequate evidence for biodegradation of chlorinated organics
> 20	Strong evidence for biodegradation of chlorinated organics

Table 9

SENSITIVITY ANALYSIS FOR BACK CALCULATED MODELING PARAMETERS

McGraw Edison Site

Centerville Iowa

Retardation Factor for TCE (R_f)	Dispersion Coefficient (D) (ft^2/day)	Degradation Half Life for TCE (t_{50}) (days)	Computed Groundwater TCE Concentration (ppb) at 30 Yrs Along Plume Major Flow Axis		
			200 ft	**400 ft**	**600 ft**
1 6	> 22	500	na	na	na
1 4	21 4	500	1292	249	48
1 2	17 3	500	1293	249	48
1 6	20	600	1291	249	48
1 4	16 6	600	1291	249	48
1 2	13 2	600	1294	250	48
1 6	16 1	700	1291	249	48
1 4	13 2	700	1292	249	48
1 2	10 2	700	1290	249	48

NOTES

(1) Parameters R_f D and t_{50} were computed to fit current site TCE groundwater concentrations and be within the acceptable parameter range

na Not applicable

Table 10
COMPARISON OF 1D AND 2D FATE AND TRANSPORT TRANSIENT MODELS
McGraw Edison Site
Centerville Iowa

Model	Transverse Distance (ft)	Computed Groundwater TCE Concentration (ppb) at 30 Yrs along Plume Major Flow Axis (ft)						
		0	100	200	300	400	500	600
1D	0	6700	2944	1294	569	250	110	48
2D	0	6700	3067	1373	602	263	114	48
2D	50	0	1111	565	270	127	59	26
2D	100	0	0	4	8	8	6	3

NOTES

(1) Parameters R_f D and t_{50} were 1 4 16 6 ft^2/day and 600 days respectively for both models
Source concentration 6700 ppb and groundwater flow velocity of 0 06 ft/day for both models
Source width for 2D model was 90

(2) Transverse dispersivity for 2D model was set to 1 ft to match transverse spreading of Site plume as observed on TCE concentration contours Figure 7

Table 11
Summary of Hydraulic Conductivity Estimates
McGraw Edison Site
Centerville Iowa

Sample	Sample Depth (ft)	D_{10} (mm)	Hydraulic Conductivity (2) (cm/sec)
M F Master Builders Iron (iron column test)	NA	0 16	2 6E 02
M F Master Builders Iron (typical range) (1)	NA	0 1 0 24	1 0E 02 to 5 8E 02
M F Master Builders Iron (mean) (1)	NA	0 16	2 6E 02
GB 1 (desorption test sample)	30 3 to 31 3	0 07	4 9E 03
GB 1/9	41 to 43 2	0 12	1 4E 02
GB 1/10	45 to 48	0 085	7 2E 03
GB 1/15 (leak-off test sample)	70 to 72 5	0 089	7 9E 03
Geometric Mean (GB 1)			8 0E 03
MW 14WT & MW 18WT Pump Test (3)	Intermediate Sand	NA	2 7E 03

NOTES
(1) Values based on Golder s data base
(2) The hydraulic conductivity values are calculated using the Hazen method based on D_{10}
(3) Aquifer pump tests conducted by Woodward Clyde Consultants Supplemental RI/FS Investigation April 1994

Table 12

Compound Concentration Reduction Deterministic Analysis

McGraw Edison Site
Centerville Iowa

DESIGN CASE I **One Wall (3 thick)** **Formation K_{me} = 5 x 10^{3} cm/sec**

Compound	Wall Influent Concentration Co (ppb)	Wall Porosity n	Formation Flow Gradient i	Formation Hydraulic Conductivity k (cm/sec)	Wall Groundwater Flow Velocity v_p (ft/day)	Effective Wall Thickness W_{th} (in)	Wall Residence Time t (hr)	Design Half Life t_{50} (hr)	Wall Effluent Concentration C (ppb)
TCE	7000	0 45	0 0015	0 005	0 05	3	127	1	nd
cDCE	50	0 45	0 0015	0 005	0 05	3	127	3	nd
VC	nd	0 45	0 0015	0 005	0 05	3	127	4	nd

NOTES

(1) Half Lives based on laboratory test results from column test performed by ETI using site groundwater from MW 3A and medium to fine Master Builders Iron/Gel The laboratory half life values have been adjusted for field conditions (temperature)

(2) nd Compound not detected in the wall influent and wall effluent groundwater

Table 13

NCP Criteria Comparison of Alternative Groundwater Remedy

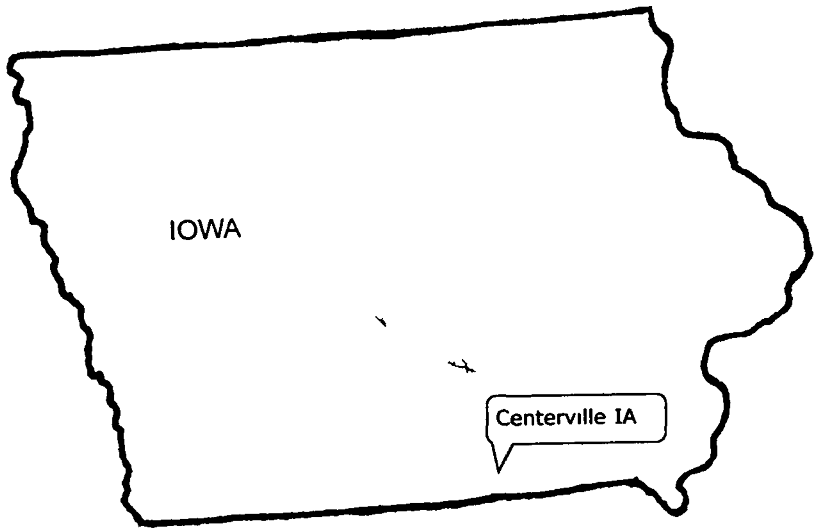
McGraw Edison Site
Centerville Iowa

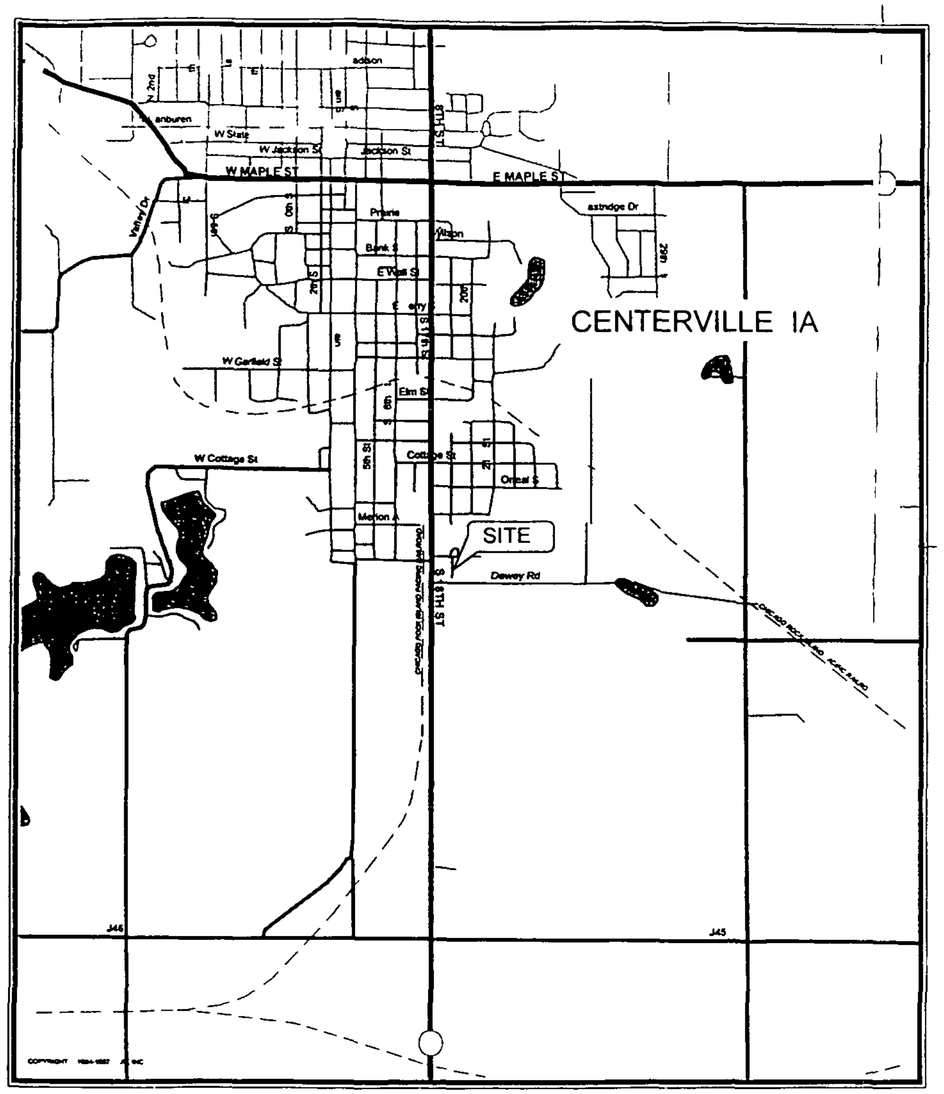
NCP Criteria	**ROD Modified Remedy**	**Alternative Remedial Plan**
	Vacuum Groundwater Recovery (VGR)	**Iron Reactive Permeable Barrier (IRPB)**
Overall Protection of Human Health and the Environment	Protective	Protective
Compliance with ARAR s	Equivalent	Equivalent
Reduction of Toxicity Mobility or Volume	Provides Mass Removal and uses Ex Situ Treatment	Provides Equal Mass Removal and uses In Situ Treatment
Short Term Effectiveness	Limited	Limited
Long Term Effectiveness and Permanence	Limited	Better Effectiveness More Reliable
Implementability	Access Disruption with Continual Operations and Maintenance (O&M)	Better Less Disruption Minimal O&M
Cost Effectiveness	Not Cost Effective SVE and VGR ($3 5 Million)	Much More Cost Effective SVE and IRPB ($2 Million)

NOTES

SVE Soil Vapor Extraction

Cost includes Capital Costs Operations & Maintenance and Compliance Monitoring and Reporting





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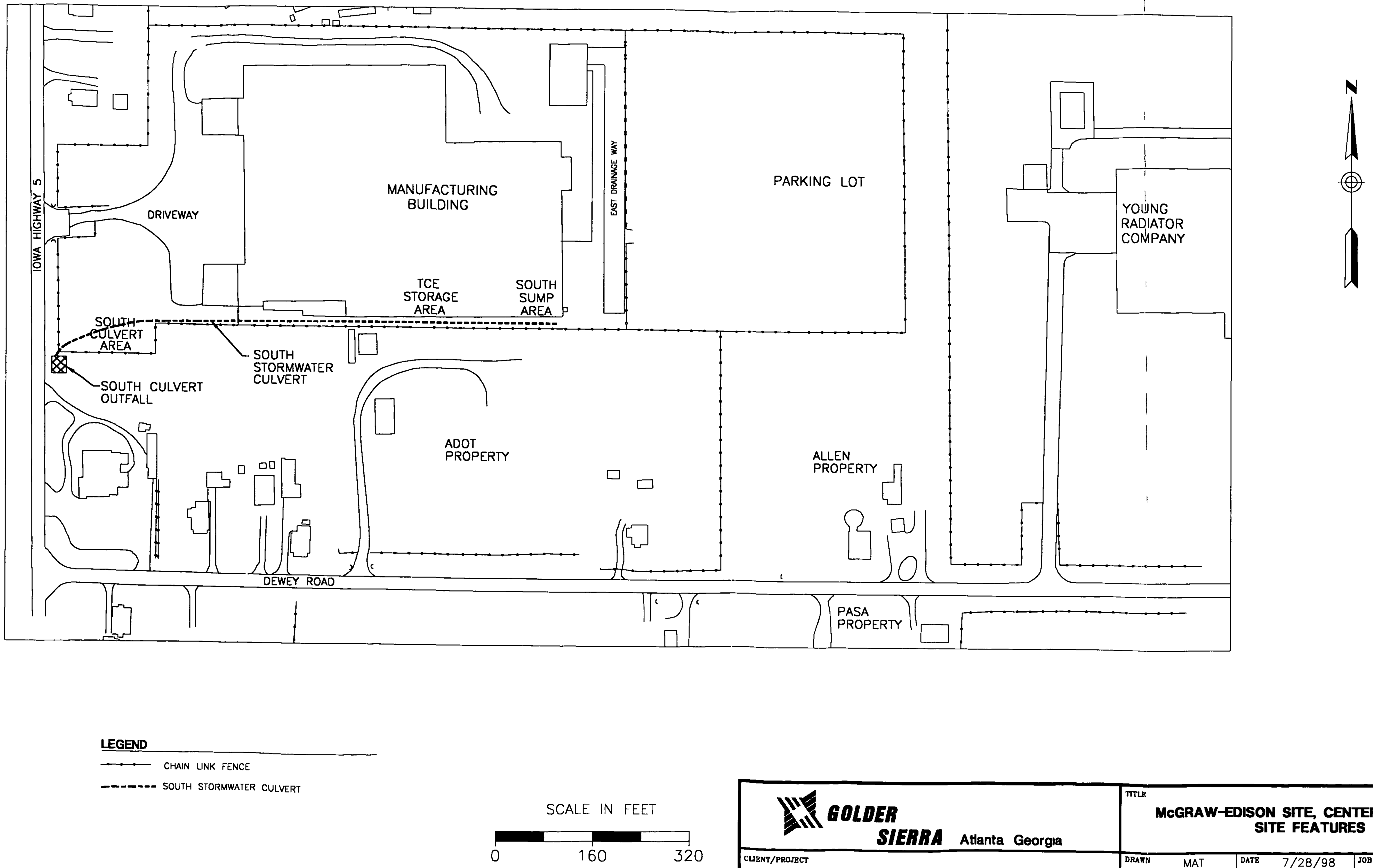
GOLDER SIERRA Atlanta, Georgia	TITLE **SITE LOCATION MAP**		
CLIENT/PROJECT **McGRAW-EDISON SITE CENTERVILLE, IOWA**	DRAWN MAT	DATE 7/10/98	JOB NO 986-1083
	CHECKED RJO	SCALE AS SHOWN	DWG NO 1083-D14
			REV NO
	REVIEWED	FILE NO 1083-D14	SUBTITLE
			FIGURE NO 1

PLOT SCALE 1 100



GOLDER SIERRA Atlanta Georgia

CLIENT/PROJECT

McGRAW-EDISON SITE CENTERVILLE, IOWA

TITLE

McGRAW-EDISON SITE, CENTERVILLE, IOWA
SITE FEATURES

DRAWN	MAT	DATE	7/28/98	JOB NO	986-1083
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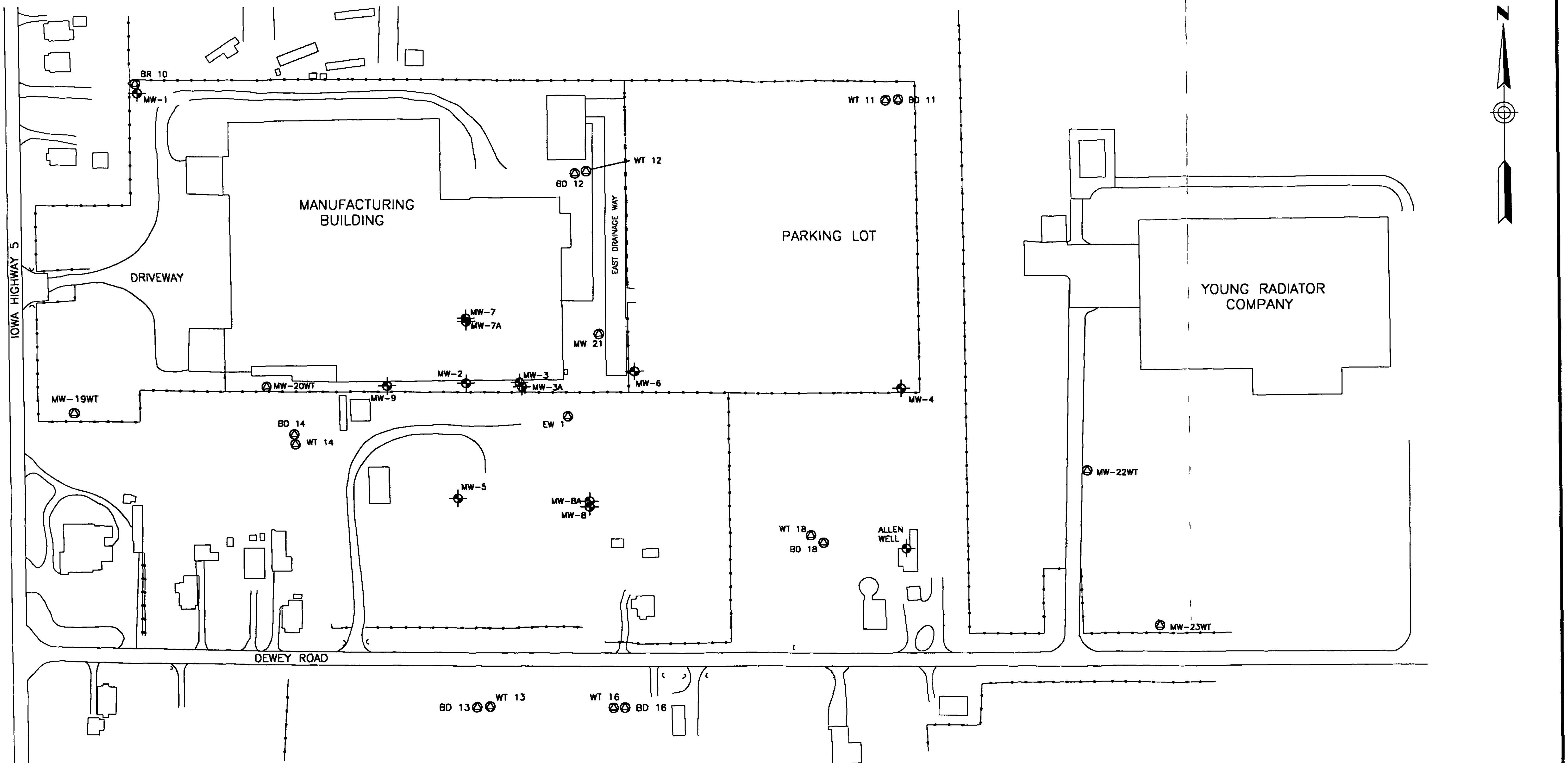
REV NO					
REVIEWED		FILE NO	1083-D22	SUBTITLE	
FIGURE NO	2				



SCALE IN FEET

0 160 320

LEGEND

CHAIN LINK FENCE

BORINGS CONVERTED TO MONITORING WELLS

⊙	WT	TOP OF WATER TABLE BORING
	BD	BASE OF GLACIAL DRIFT BORING
	BR	BEDROCK BORING
	EW	EXTRACTION WELL
☆	SB RI 1 & SB RI 2	SOIL BORING REMEDIAL INVESTIGATION AND BORINGS NOT CONVERTED TO MONITORING WELLS
	PZ	PIEZOMETER LOCATIONS
⊕		PREVIOUSLY INSTALLED MONITORING AND SUMP WELLS

NOTE. SEE FIGURE 3 FOR LOCATION OF BORINGS GB 1 AND GB 1A (MAY 1998)

⊕ SB-SC	SOIL BORING/SOUTH CULVERT SAMPLE LOCATIONS
⊕ SB-TCE	SOIL BORING/TCE STORAGE AREA SAMPLE LOCATIONS
	HYDROPUNCH LOCATION

BASE MAP PROVIDED BY

MWR INCORPORATED
A Division of Envirogen Inc

GOLDER SIERRA Atlanta, Georgia

CLIENT/PROJECT

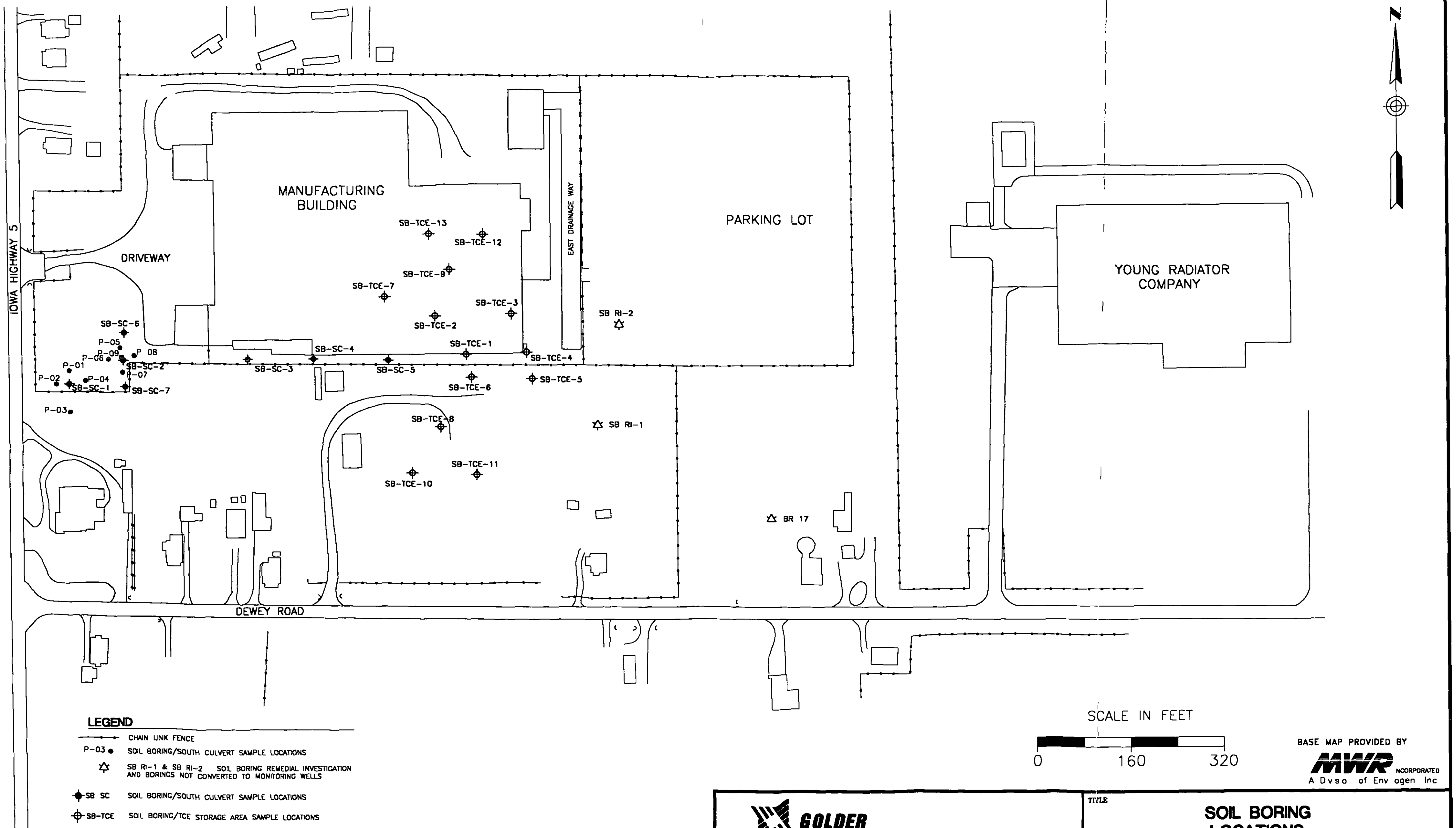
McGRAW-EDISON SITE CENTERVILLE, IOWA

TITLE

GROUNDWATER MONITORING WELL LOCATIONS

DRAWN MAT	DATE 07/09/98	JOB NO 986-1083	
CHECKED RIO	SCALE AS SHOWN	DWG NO 1083-D24	REV NO
REVIEWED	FILE NO 1083-D24	SUBTITLE	FIGURE NO 3

PLOT SCALE 80



GOLDER SIERRA Atlanta, Georgia

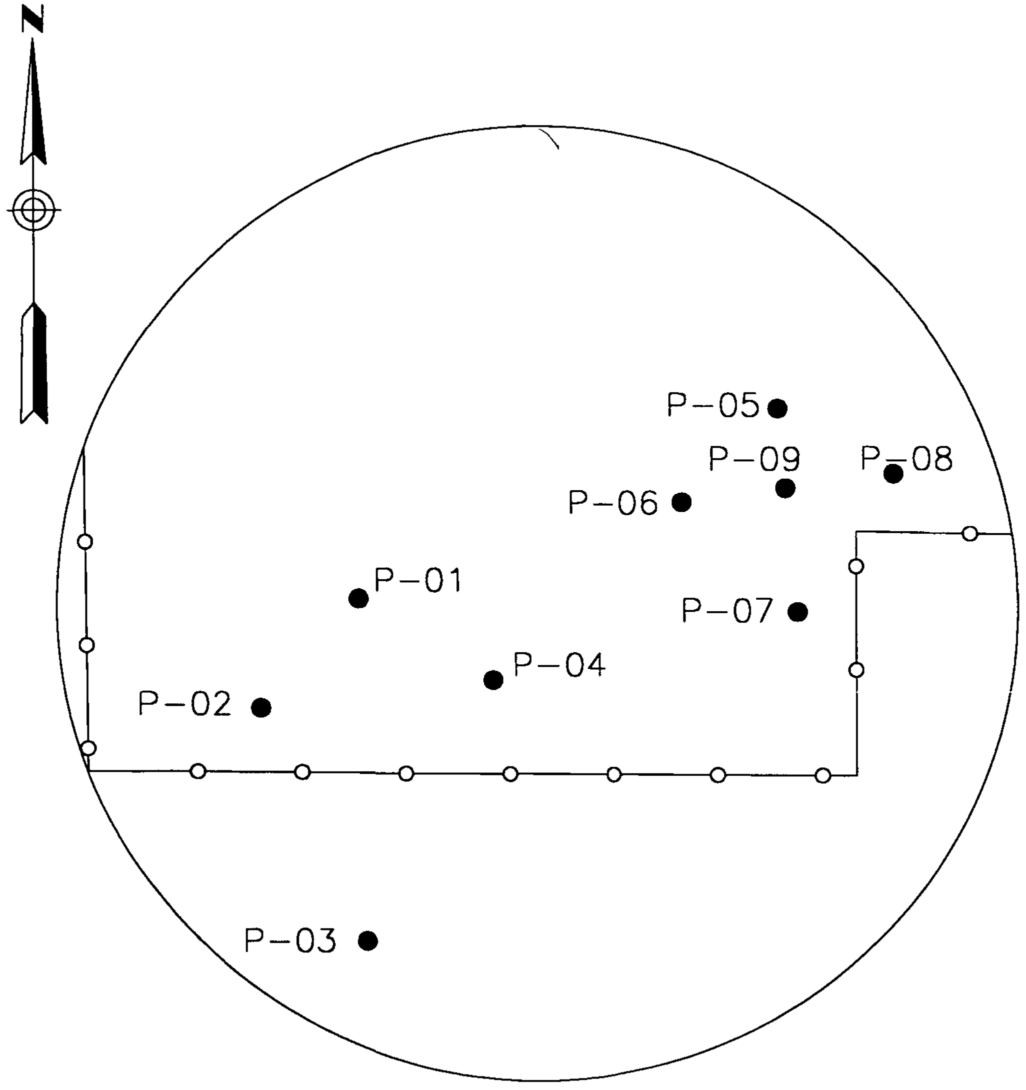
CLIENT/PROJECT

McGRAW-EDISON SITE CENTERVILLE, IOWA

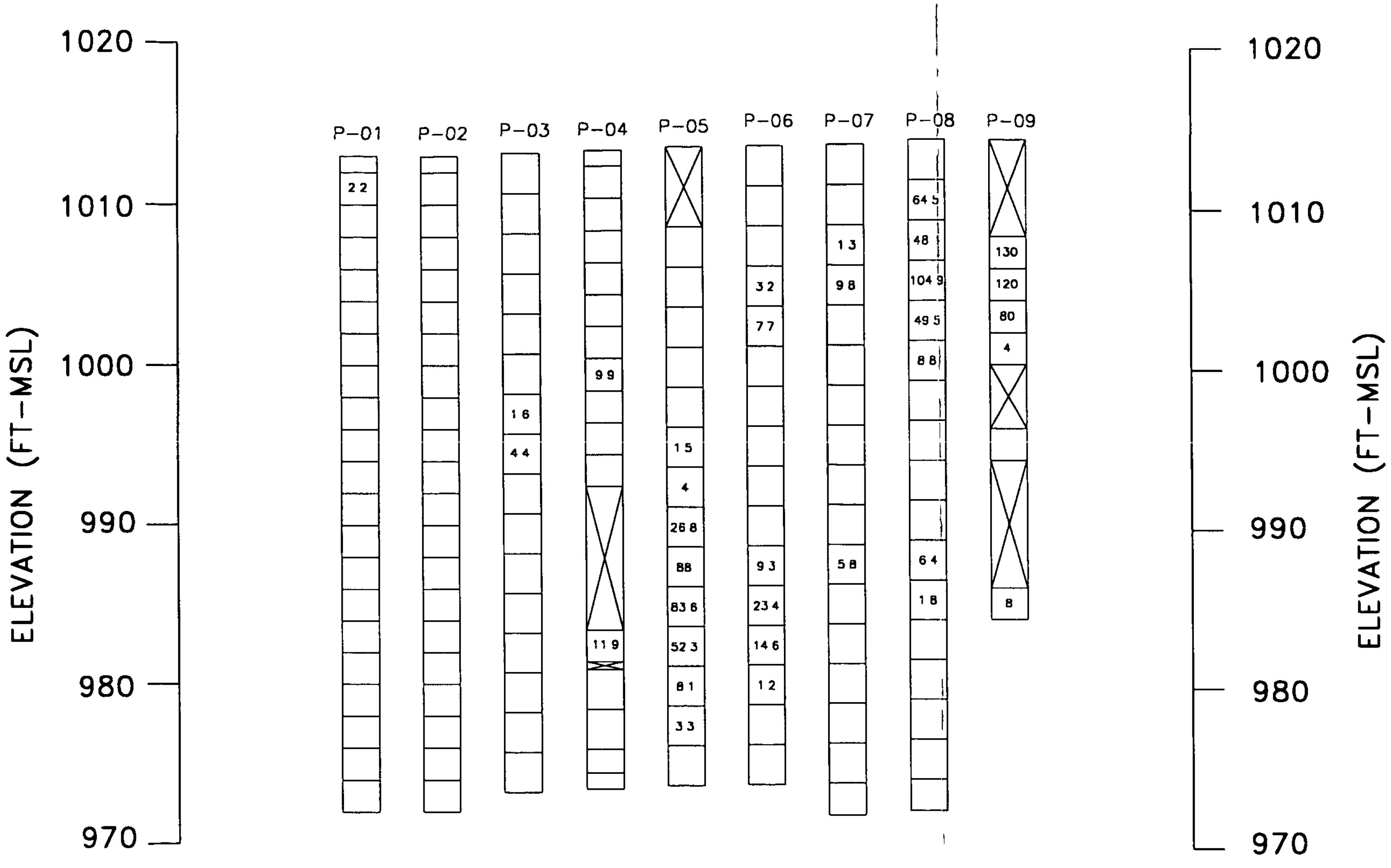
TITLE

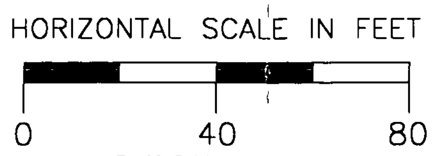
SOIL BORING LOCATIONS

DRAWN MAT	DATE 07/09/98	JOB NO 986-1083
CHECKED RIO	SCALE AS SHOWN	DWG NO 1083-D23
		REV NO
REVIEWED	FILE NO 1083-D23	SUBTITLE
		FIGURE NO 4



PLAN OF SOUTH CULVERT AREA





VERTICAL SCALE
EXAGGERATED 4X

DATA PROVIDED BY
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LEGEND

○— CHAIN LINK FENCE

P-03 ● SOIL BORING/SOUTH CULVERT SAMPLE LOCATIONS

33 TCE CONCENTRATION IN SOIL DEPTH ZONE(μg/kg)
(FROM FIELD GC) ND=NON DETECT

☒ NO SAMPLE TAKEN IN THIS DEPTH ZONE

WT TOP OF WATER TABLE BORING

SOIL BORING/SOUTH CULVERT SAMPLE LOCATIONS

GOLDER SIERRA Atlanta Georgia

TITLE	TCE CONCENTRATION IN SOILS IN THE SOUTH CULVERT AREA (MAY 1998)
CLIENT/PROJECT	McGRAW-EDISON SITE CENTERVILLE IOWA

DRAWN MAT	DATE 7/28/98	JOB NO 986-1083	
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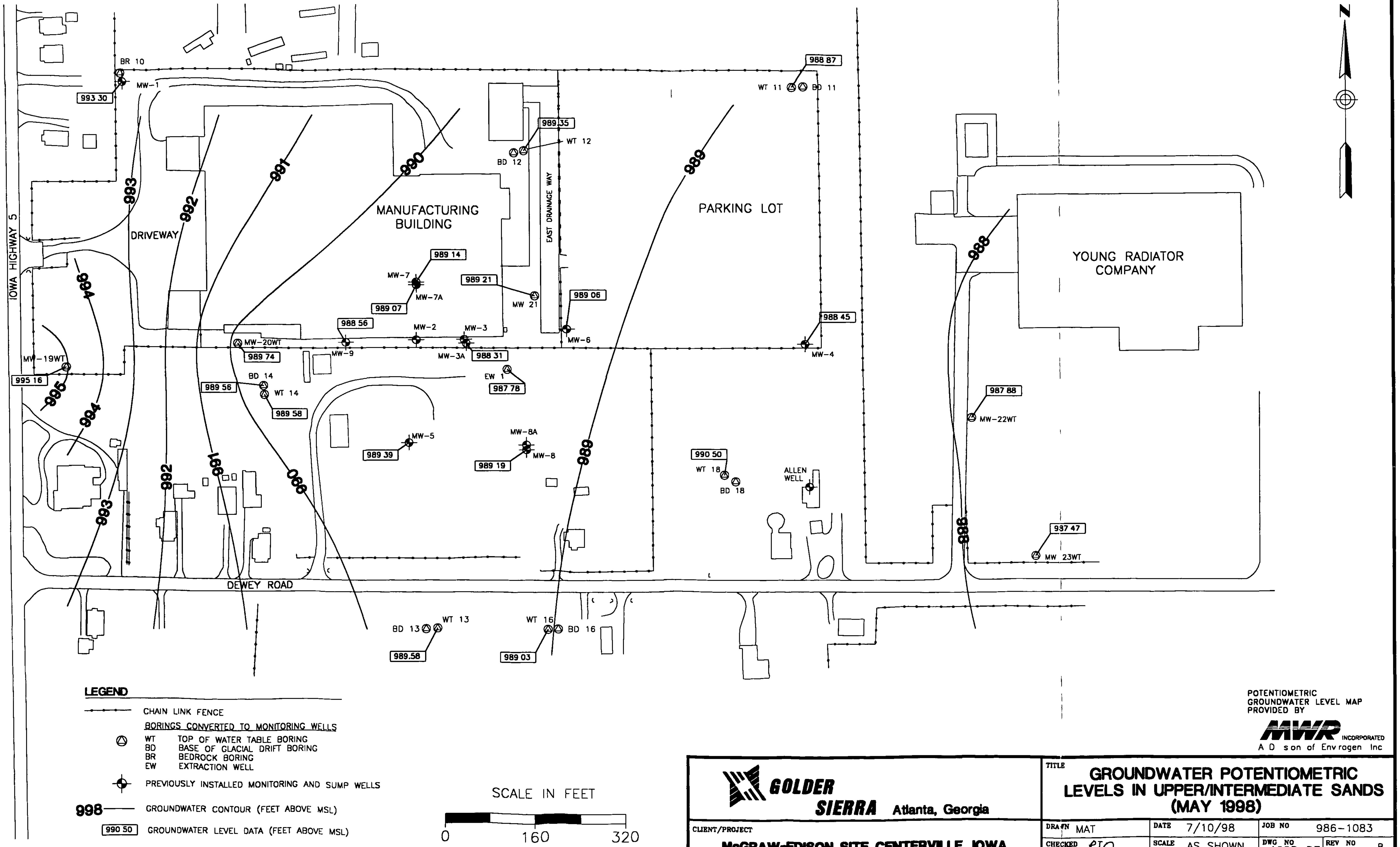
REVIEWED	FILE NO 1083-D21	SUBTITLE	FIGURE NO 5



POTENTIOMETRIC
GROUNDWATER LEVEL MAP
PROVIDED BY
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GOLDER
SIERRA Atlanta, Georgia

CLIENT/PROJECT
McGRAW-EDISON SITE CENTERVILLE IOWA

TITLE
GROUNDWATER POTENTIOMETRIC LEVELS IN UPPER/INTERMEDIATE SANDS (MAY 1998)

DRAWN MAT	DATE 7/10/98	JOB NO 986-1083	
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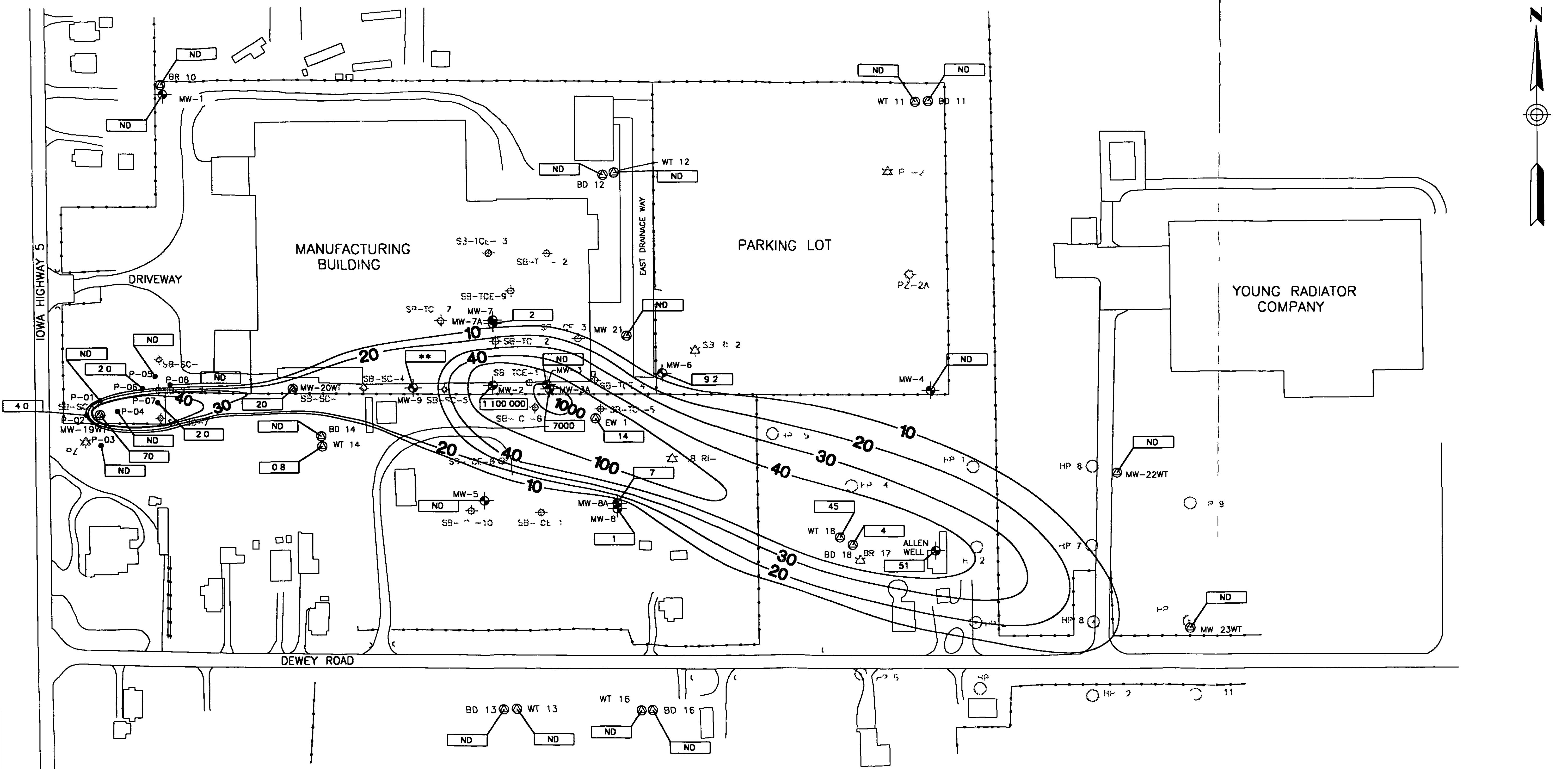
REVIEWED	FILE NO 1083-D7	SUBTITLE	FIGURE NO 6



LEGEND

CHAIN LINK FENCE

BORINGS CONVERTED TO MONITORING WELLS

◬	WT	TOP OF WATER TABLE BORING
	BD	BASE OF GLACIAL DRIFT BORING
	BR	BEDROCK BORING
	EW	EXTRACTION WELL

☆ SB RI-1 & SB RI-2 SOIL BORING REMEDIAL INVESTIGATION AND BORINGS NOT CONVERTED TO MONITORING WELLS

✡ PZ PIEZOMETER LOCATIONS

⊕ PREVIOUSLY INSTALLED MONITORING AND SUMP WELLS

P-03● SOIL BORING/SOUTH CULVERT SAMPLE LOCATIONS

NOTE. SEE FIGURE 3 FOR LOCATION OF SOIL BORINGS GB-1 AND GB-1A (MAY 1998)

⊕ SB SC SOIL BORING/SOUTH CULVERT SAMPLE LOCATIONS

-○- SB C SOIL BORING/TCE STORAGE AREA SAMPLE LOCATIONS

○ HP HYDROPUNCH LOCATION

—40— GROUND WATER TCE CONCENTRATION CONTOURS (ug/L)

45 TCE DATA (ug/L)

MW-2 SCREENED IN PERCHED WATER TABLE DATA POINT NOT USED FOR CONTOURS

** WELL NOT SAMPLED DUE TO DEAD ANIMAL

SCALE IN FEET

0 160 320

BASE MAP AND
TCE DATA PROVIDED BY
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SIERRA Atlanta, Georgia

CLIENT/PROJECT
McGRAW-EDISON SITE CENTERVILLE, IOWA

TITLE
GROUNDWATER TCE CONCENTRATIONS SITE WIDE (MAY 1998)

DRAWN MAT	DATE 7/10/98	JOB NO 986-1083	
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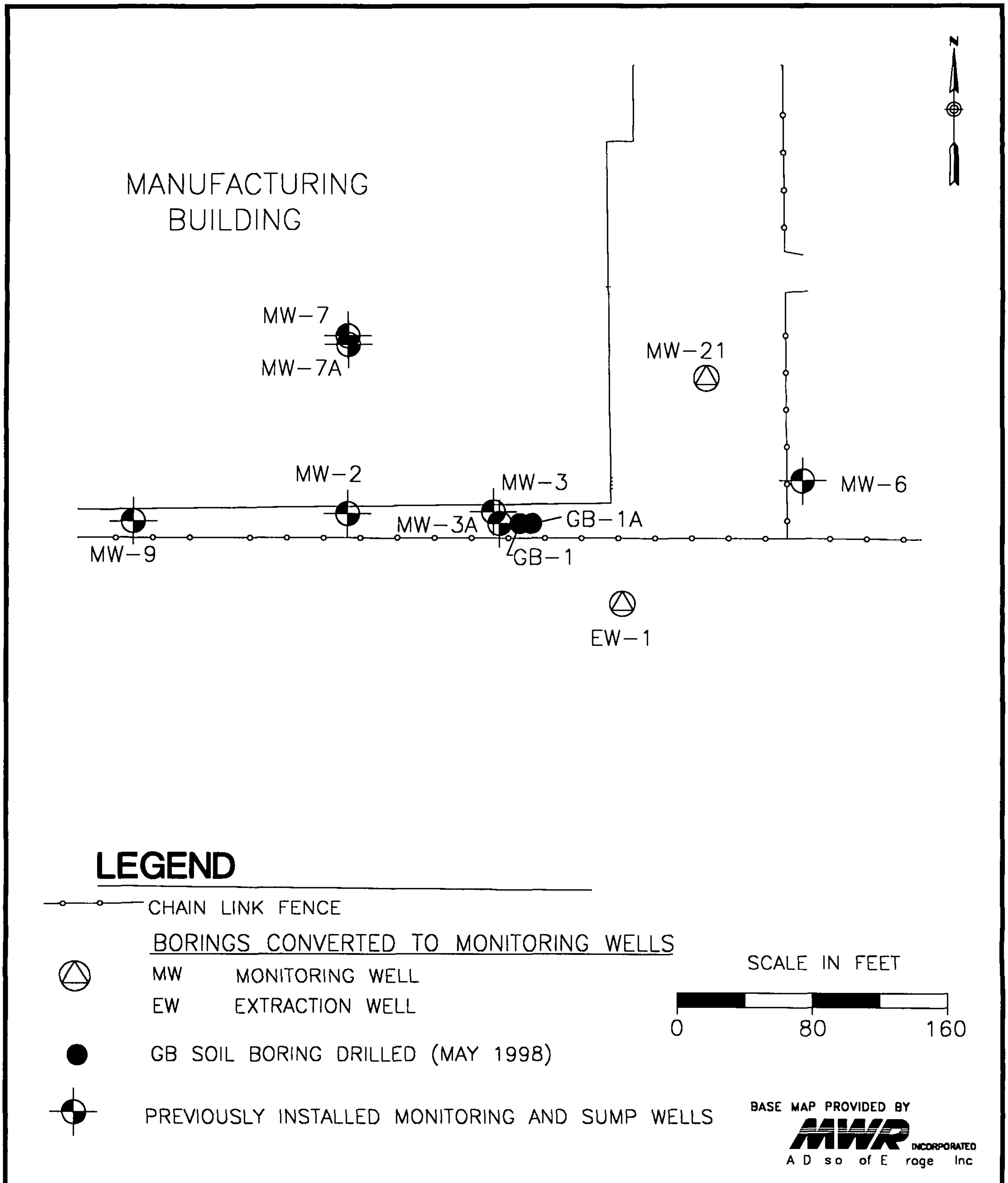
REVIEWED	FILE NO 1083-D15	SUBTITLE	FIGURE NO 7



CLIENT/PROJECT

McGRAW-EDISON SITE CENTERVILLE, IOWA

GOLDER SIERRA Atlanta Georgia

TITLE

BOREHOLE LOCATIONS FOR IRON REACTIVE PERMEABLE BARRIER EVALUATION

DATE	DRAWN	CHECKED	REVIEWED
7/31/98	MAT	RIO	

SCALE	FILE NO	JOB NO
AS SHOWN	1083-D2	986-1083

DWG NO	SUBTITLE	REV NO	FIGURE
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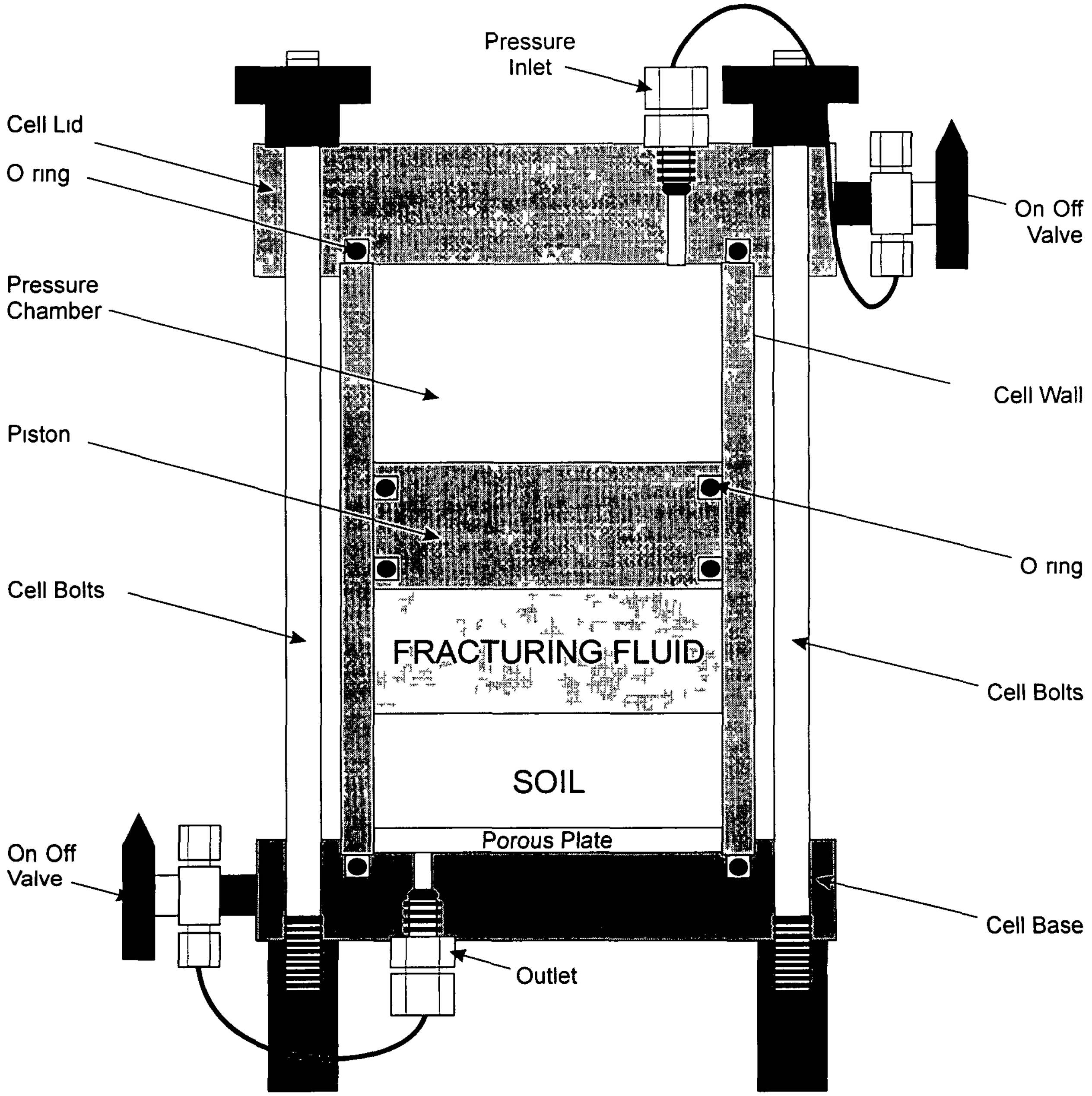
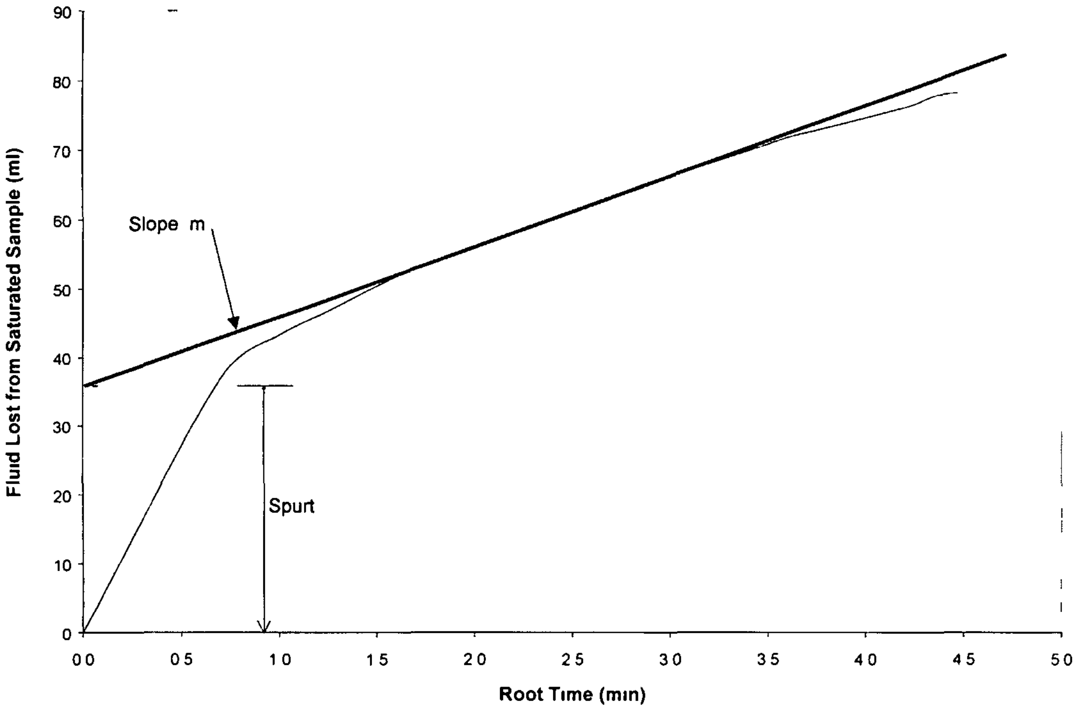


GOLDER SIERRA Atlanta Georgia

TITLE	Golder Leak Off Test Cell
CLIENT/PROJECT	McGRAW EDISON SITE CENTERVILLE IOWA

DRAWN	BSL	DATE	7/10/98	JOB NO	986-1083		
CHECKED		SCALE	N/A	DWG NO		REV NO	
REVIEWED		FILE NO	1083 dd1 cdr	SUBTITLE		FIGURE NO	9



$$\text{Spurt} = \frac{\text{Fluid Lost}}{2\,\text{Ac}}$$

$$\text{Cw} = \frac{m}{2\,\text{Ac}}$$

Ac = area of sample

GOLDER SIERRA Atlanta Georgia	TITLE Leak Off Test Profile					
CLIENT/PROJECT McGRAW EDISON SITE CENTERVILLE IOWA	DRAWN	BSL	DATE	7/10/98	JOB NO	986 1083
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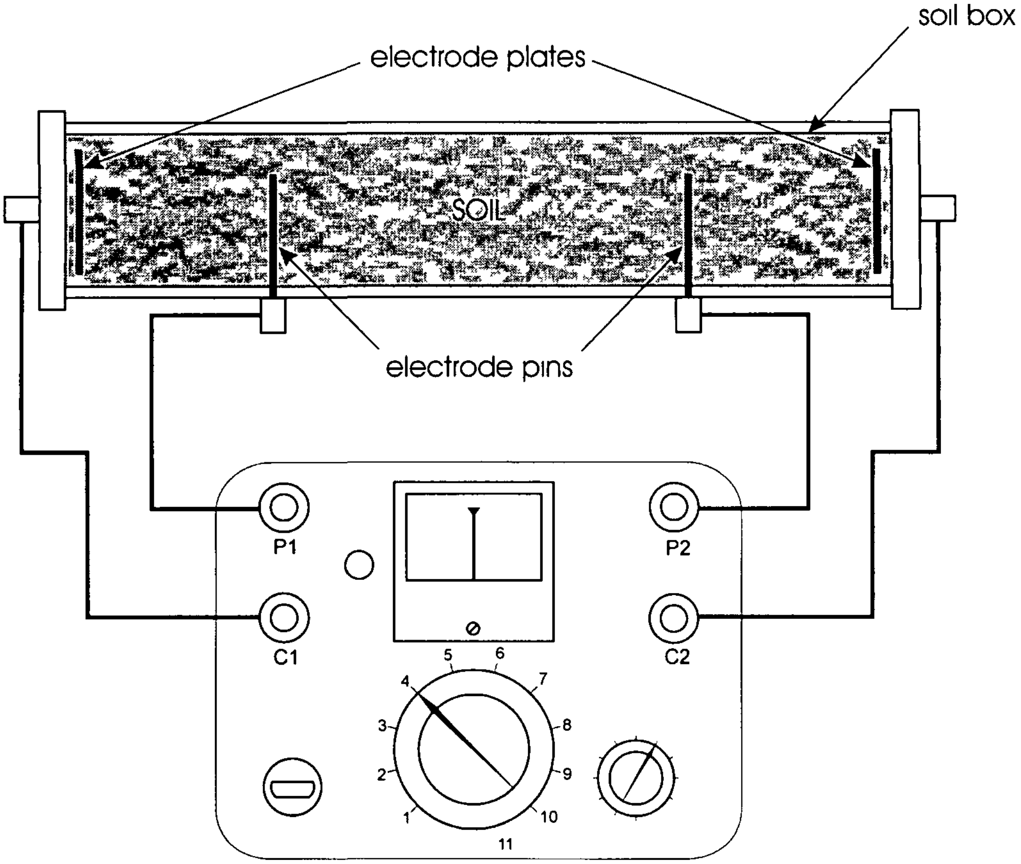
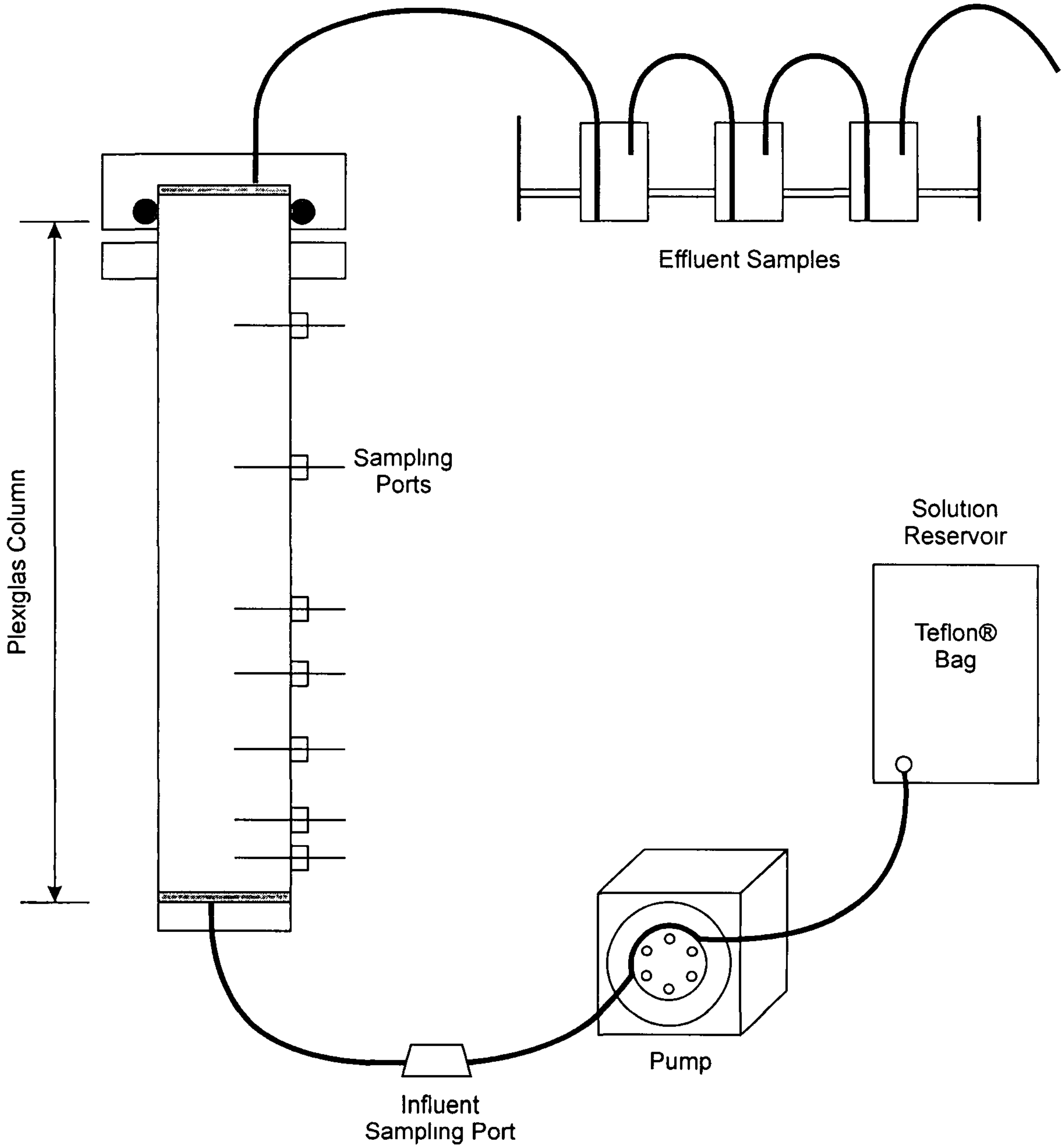
	REVIEWED		FILE NO	1083 dd2 cdr	SUBTITLE	FIGURE NO 10



Nilsson Model 400
Soil Resistance Meter

GOLDER SIERRA Atlanta Georgia	TITLE Soil Resistance Meter
CLIENT/PROJECT McGRAW EDISON SITE CENTERVILLE IOWA	DRAWN BSL DATE 7/10/98 JOB NO 986 1083 CHECKED SCALE n/a DWG NO REV NO REVIEWED FILE NO 1083 dd3 cdr SUBTITLE FIGURE NO 11



GOLDER SIERRA

Atlanta Georgia

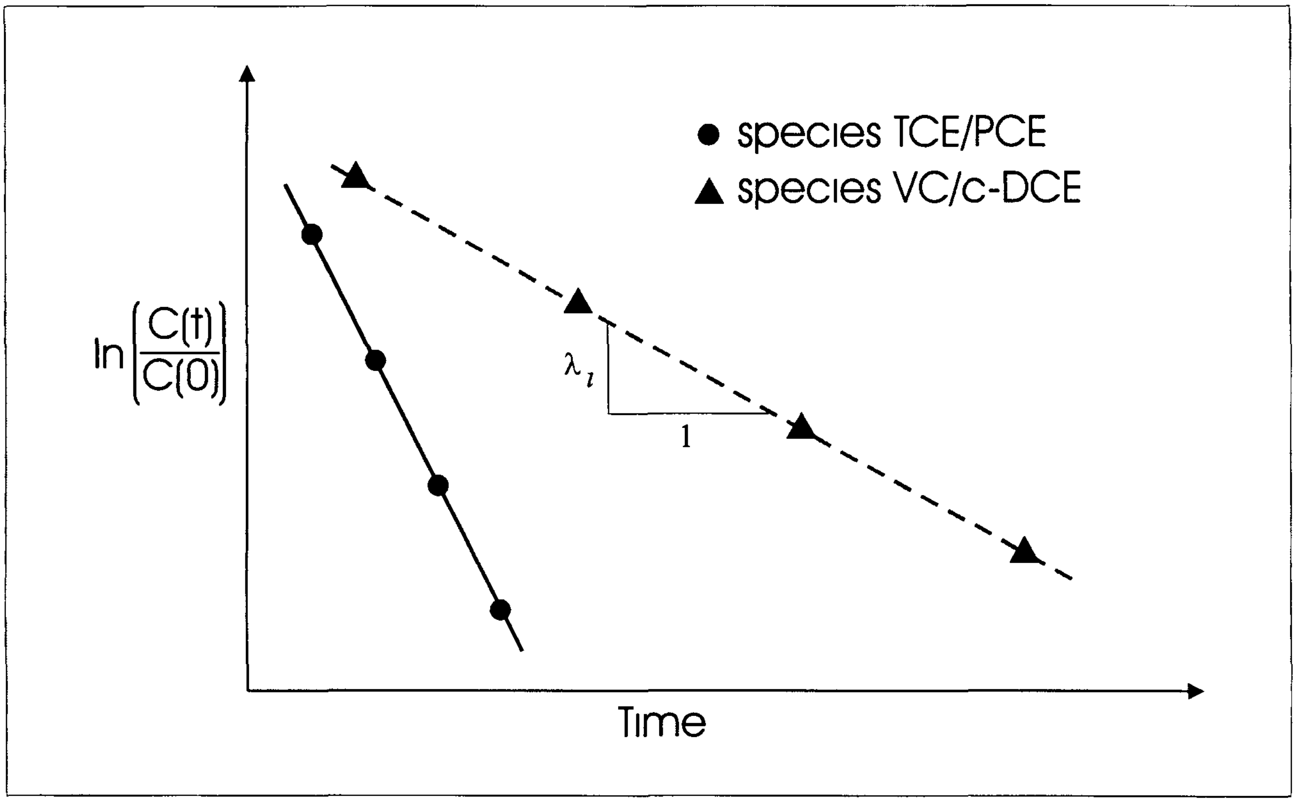
TITLE

EnviroMetal Process Column Test Apparatus

CLIENT/PROJECT

McGRAW EDISON SITE CENTERVILLE IOWA

DRAWN	BSL	DATE	7/10/98	JOB NO	986 1083		
CHECKED		SCALE	N/A	DWG NO		REV NO	
REVIEWED		FILE NO	1083 dd4 cdr	SUBTITLE		FIGURE NO	12



Results of Column Reactivity Tests with Iron

First Order Reduction $\frac{dC}{dt} = \lambda_l C$

i e $C(t) = C(0)\, e^{-\lambda_l t}$

First order reductive reaction is dependent on surface area of iron filings:

$$\lambda_l = k(SA) \cdot A$$

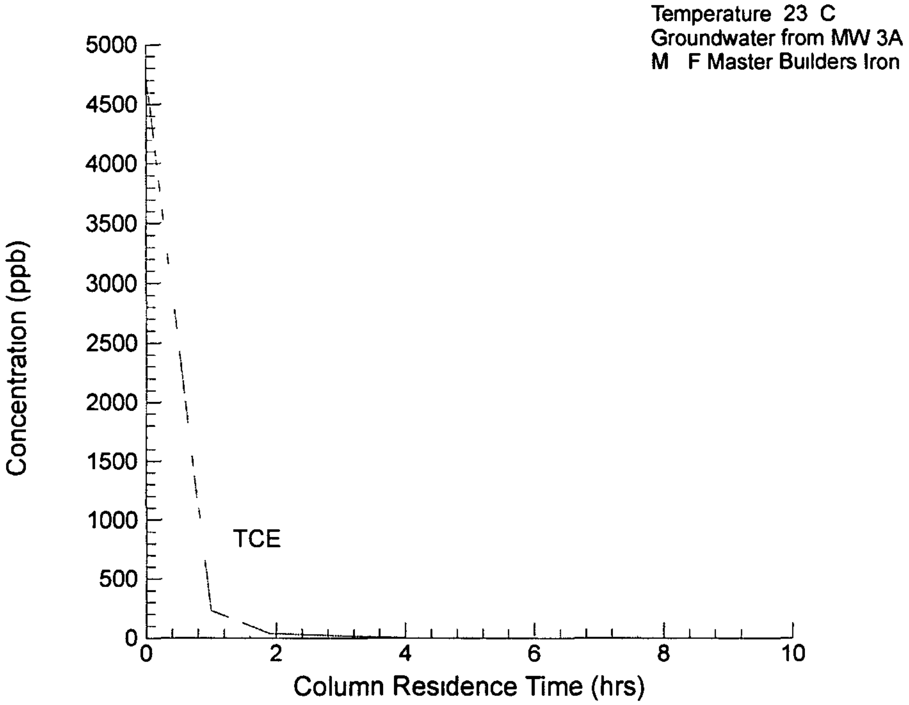
where k(SA) is proportional constant of reductive medium and is in units of litre/m^{2}hr and A is surface area of reductive medium per volume with units of m^2/litre.

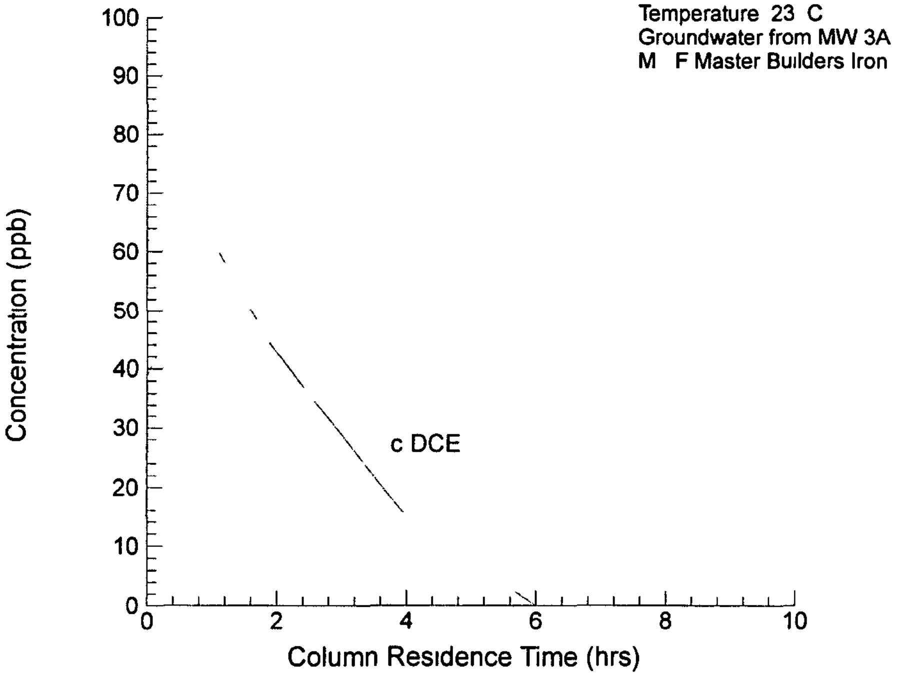
GOLDER SIERRA Atlanta Georgia

TITLE
First Order Reduction by Zero Valent Iron

CLIENT/PROJECT
McGRAW EDISON SITE CENTERVILLE IOWA

DRAWN	BSL	DATE	7/10/98	JOB NO	986 1083		
CHECKED		SCALE		DWG NO		REV NO	
REVIEWED		FILE NO	1083 dd5 cdr	SUBTITLE		FIGURE NO	13





GOLDER SIERRA Atlanta Georgia

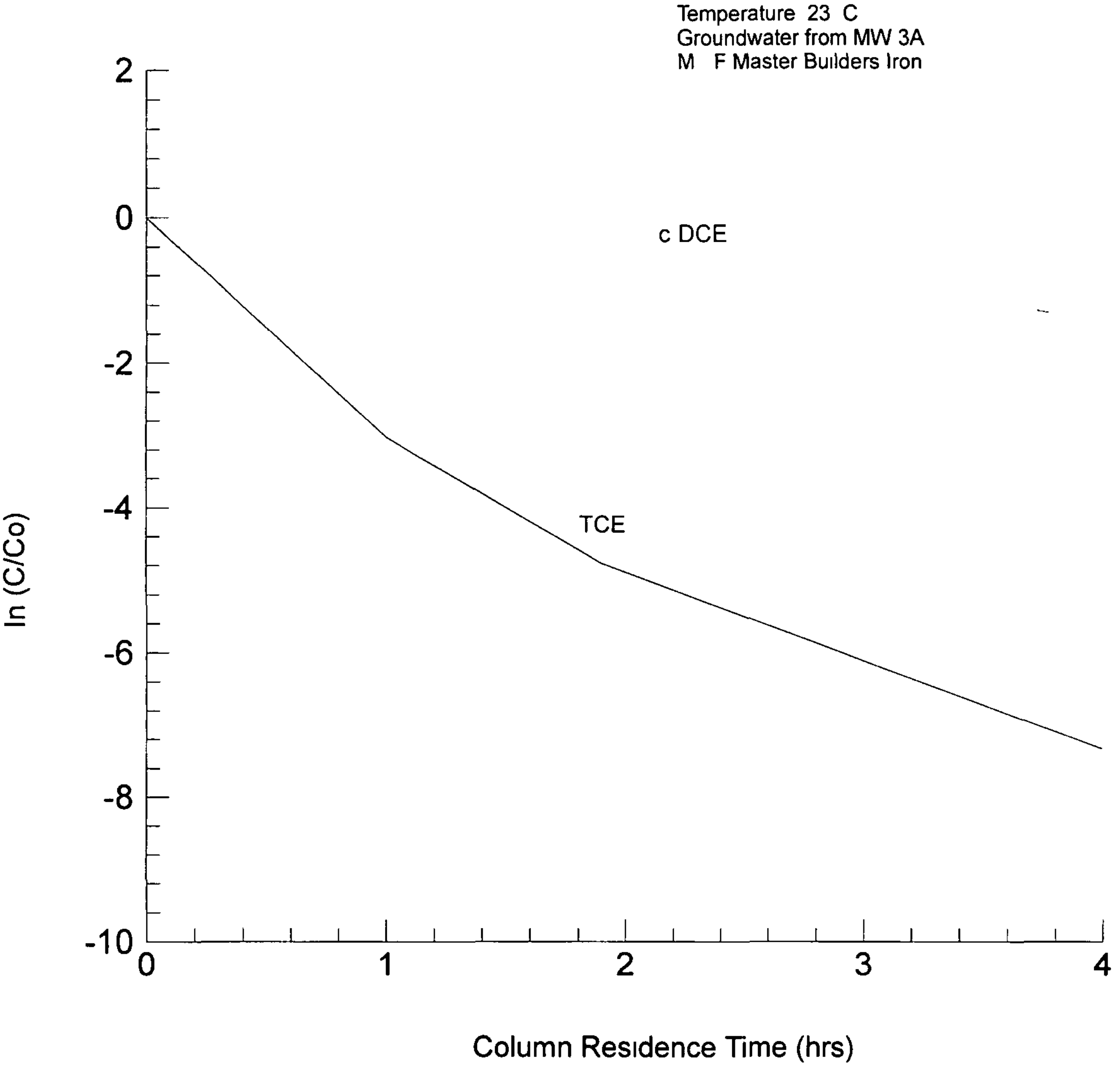
TITLE

Master Builders Iron Column Test Results

CLIENT/PROJECT

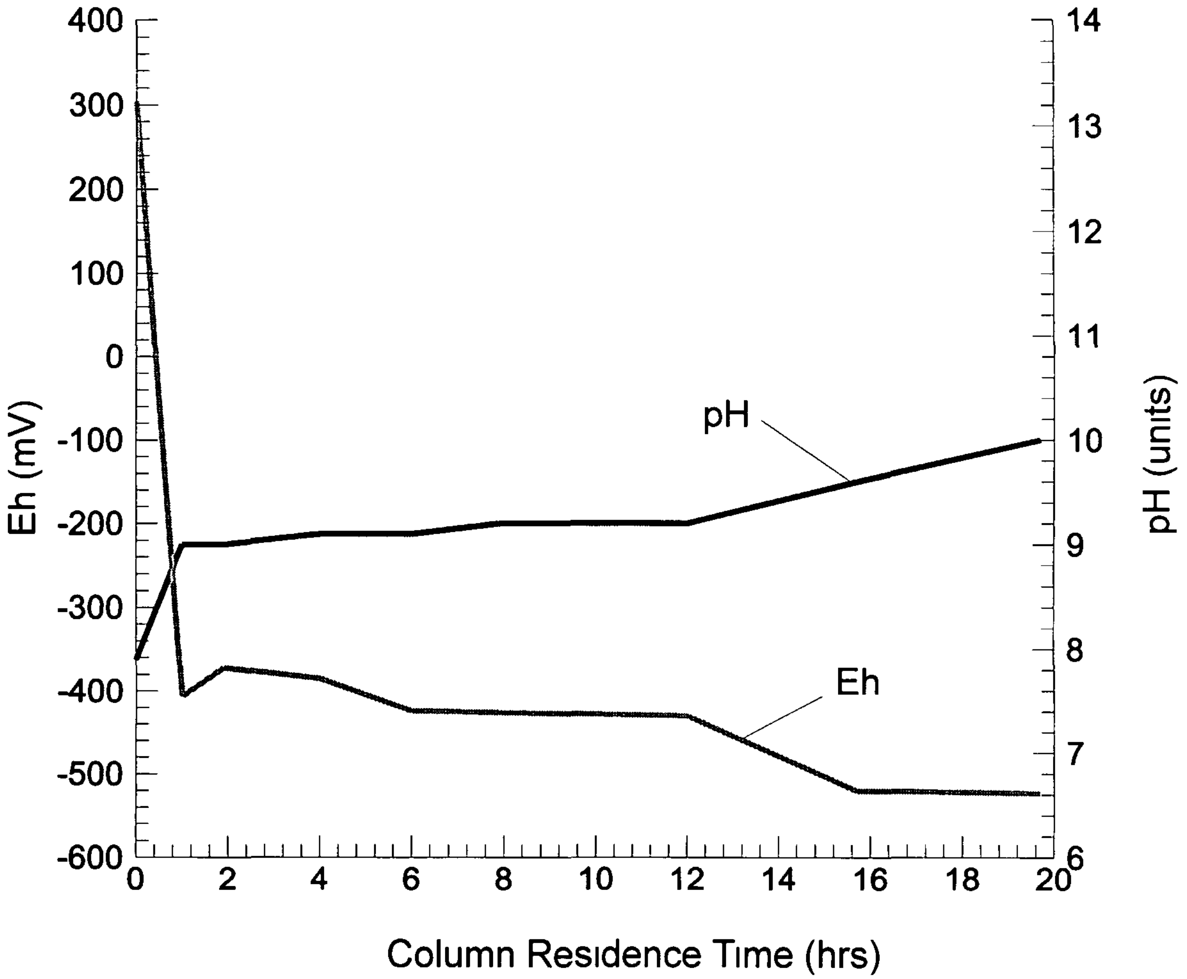
McGRAW EDISON SITE CENTERVILLE IOWA

DRAWN MAT	DATE 7/31/98	JOB NO 986 1083	
CHECKED	SCALE	DWG NO	REV NO
REVIEWED	FILE NO 1083 dd13 cdr	SUBTITLE	FIGURE NO 14



GOLDER SIERRA Atlanta Georgia	TITLE Master Builders Iron Column Test Half Life Determination		
CLIENT/PROJECT McGRAW EDISON SITE CENTERVILLE IOWA	DRAWN MAT	DATE 7/31/98	JOB NO 986 1083
	CHECKED	SCALE	DWG NO / REV NO
	REVIEWED	FILE NO 1083 dd14 cdr	SUBTITLE / FIGURE NO 15

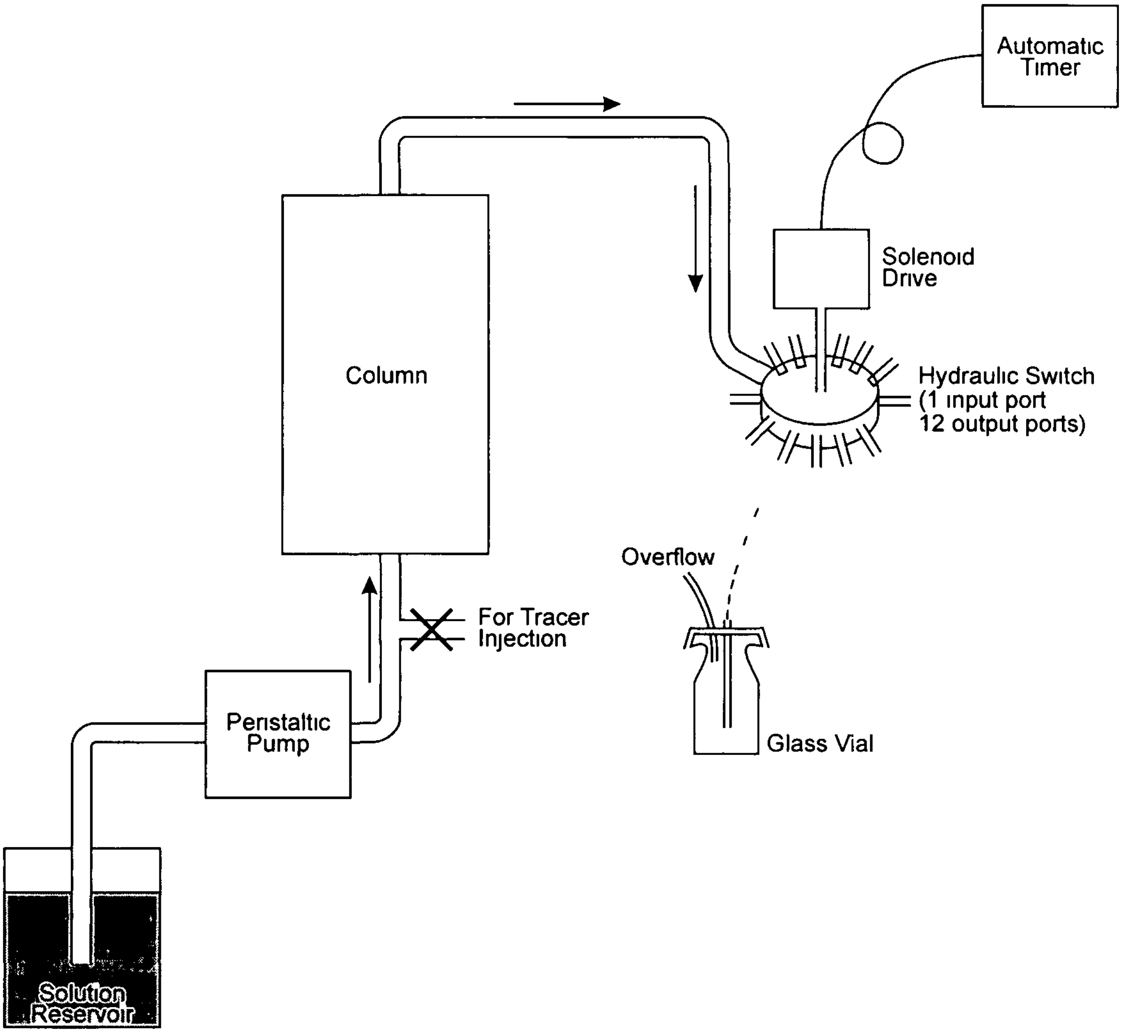
Temperature 23 C
Groundwater from MW 3A
M F Master Builders Iron



GOLDER SIERRA Atlanta Georgia

TITLE	Master Builders Iron Column Test Eh and pH Data				
DRAWN MAT	DATE 7/31/98	JOB NO 986 1083			
CHECKED	SCALE	DWG NO	REV NO		
REVIEWED	FILE NO 1083 dd12 cdr	SUBTITLE	FIGURE NO 16		

CLIENT/PROJECT
McGRAW EDISON SITE CENTERVILLE IOWA



GOLDER SIERRA Atlanta Georgia

TITLE

Soil Desorption Test Apparatus

CLIENT/PROJECT

McGRAW EDISON SITE CENTERVILLE IOWA

DRAWN	BSL	DATE	7/10/98	JOB NO	986-1083		
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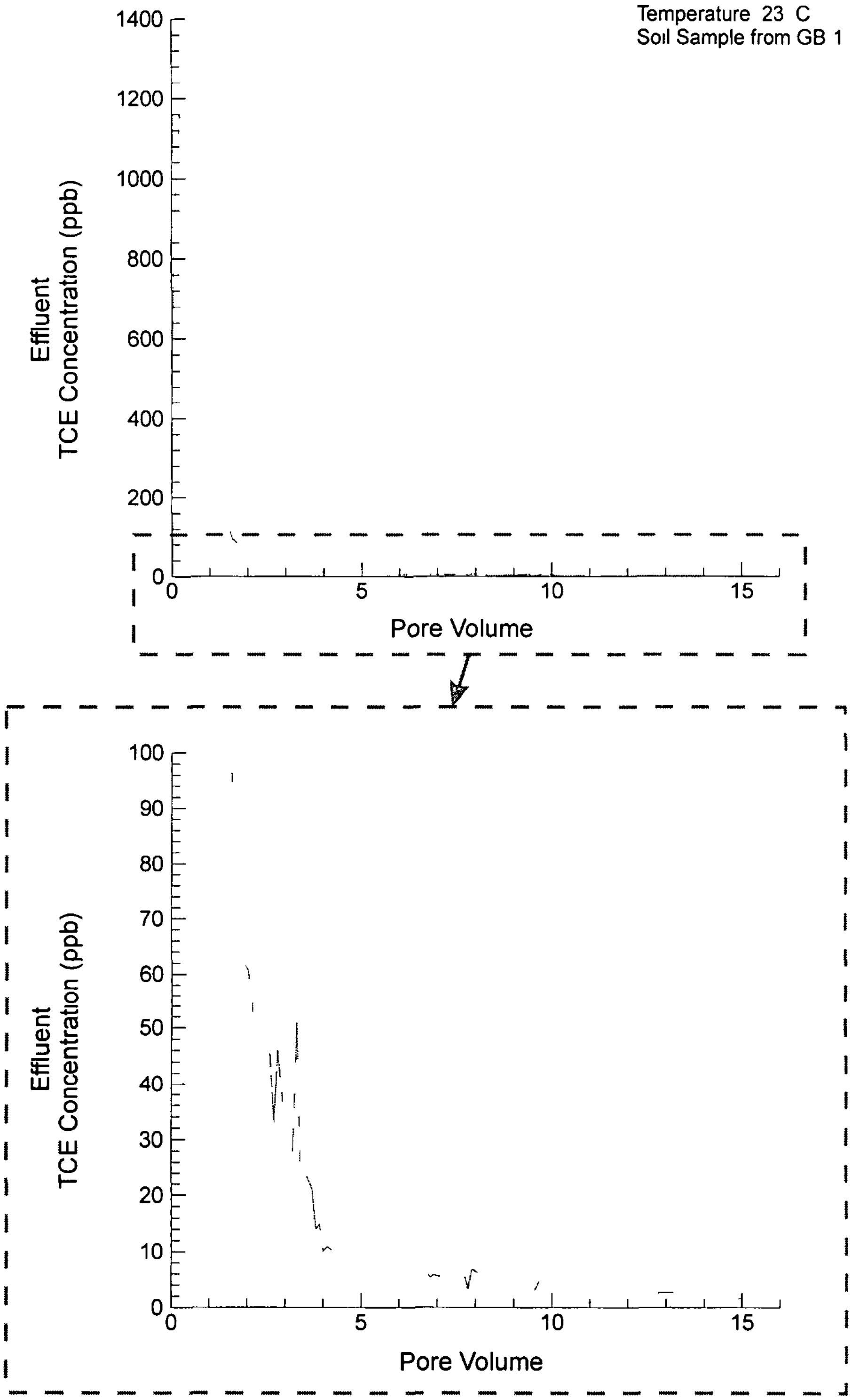

GOLDER SIERRA

Atlanta Georgia

TITLE

Soil Desorption Test Results

CLIENT/PROJECT

McGRAW EDISON SITE CENTERVILLE IOWA

DRAWN	MAT	DATE	7/31/98	JOB NO	986 1083		
CHECKED		SCALE		DWG NO		REV NO	
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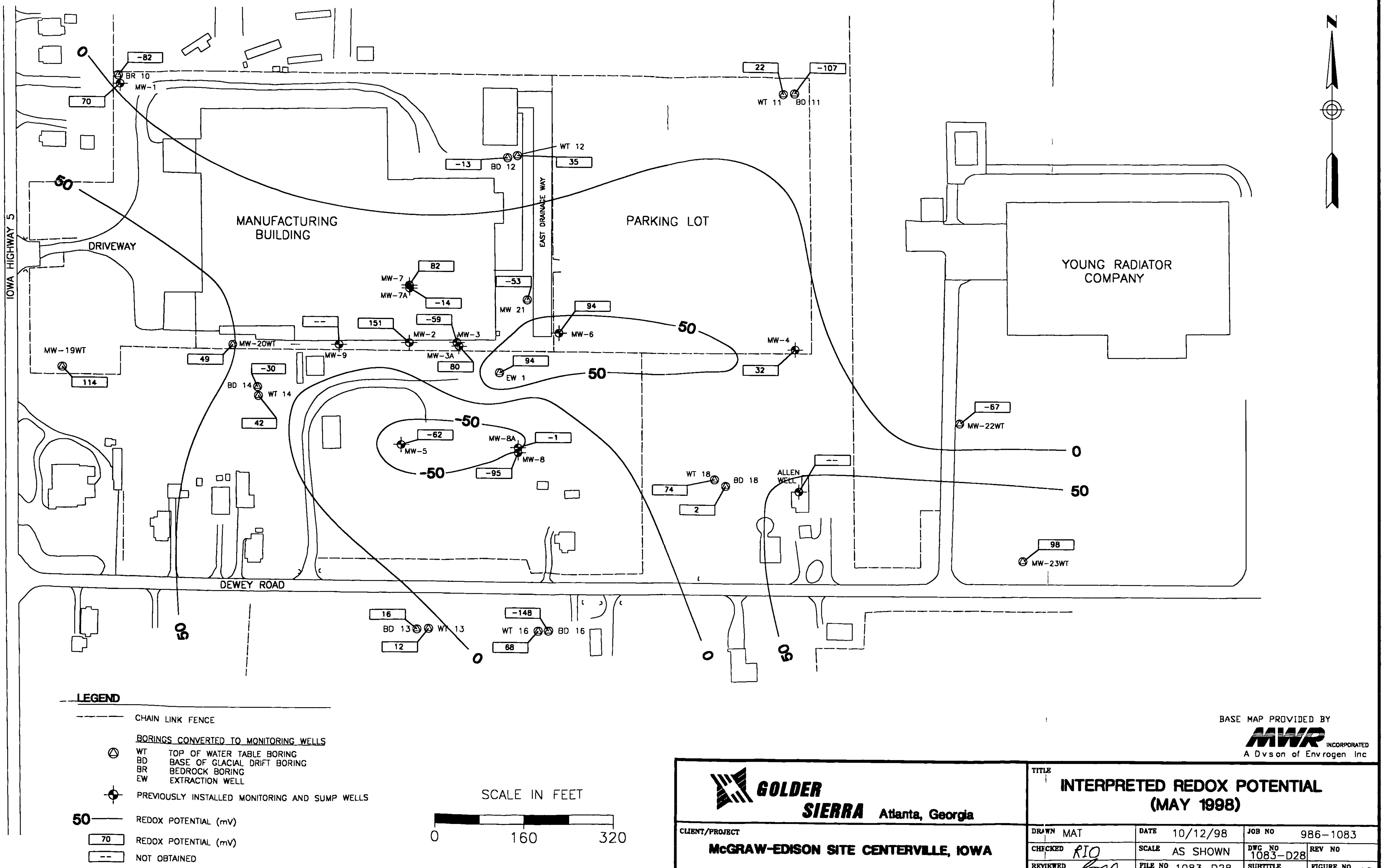

BASE MAP PROVIDED BY
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GOLDER SIERRA Atlanta, Georgia

CLIENT/PROJECT	McGRAW-EDISON SITE CENTERVILLE, IOWA
TITLE	INTERPRETED REDOX POTENTIAL (MAY 1998)

DRAWN MAT	DATE 10/12/98	JOB NO 986-1083			
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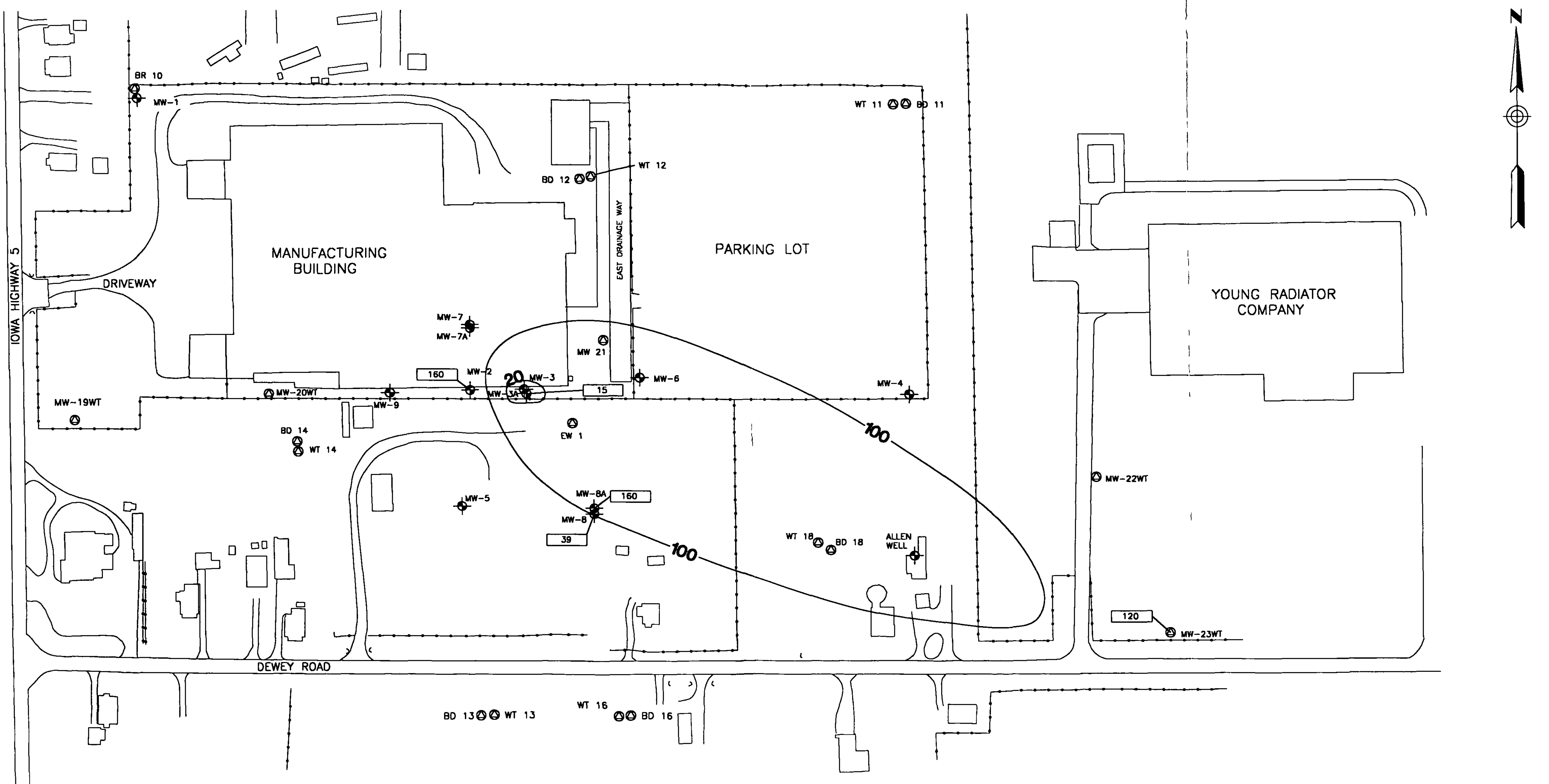
REVIEWED	FILE NO 1083-D28	SUBTITLE	FIGURE NO 19		



LEGEND

—•—•— CHAIN LINK FENCE

BORINGS CONVERTED TO MONITORING WELLS

⊗	WT	TOP OF WATER TABLE BORING
	BD	BASE OF GLACIAL DRIFT BORING
	BR	BEDROCK BORING
	EW	EXTRACTION WELL

⊕ PREVIOUSLY INSTALLED MONITORING AND SUMP WELLS

20 —— GROUNDWATER SULPHATE CONCENTRATION CONTOUR (mg/L)

160 SULPHATE DATA (mg/L)

SCALE IN FEET

0 160 320

BASE MAP AND
ALKALINITY DATA PROVIDED BY
MWR INCORPORATED
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GOLDER SIERRA Atlanta, Georgia

TITLE

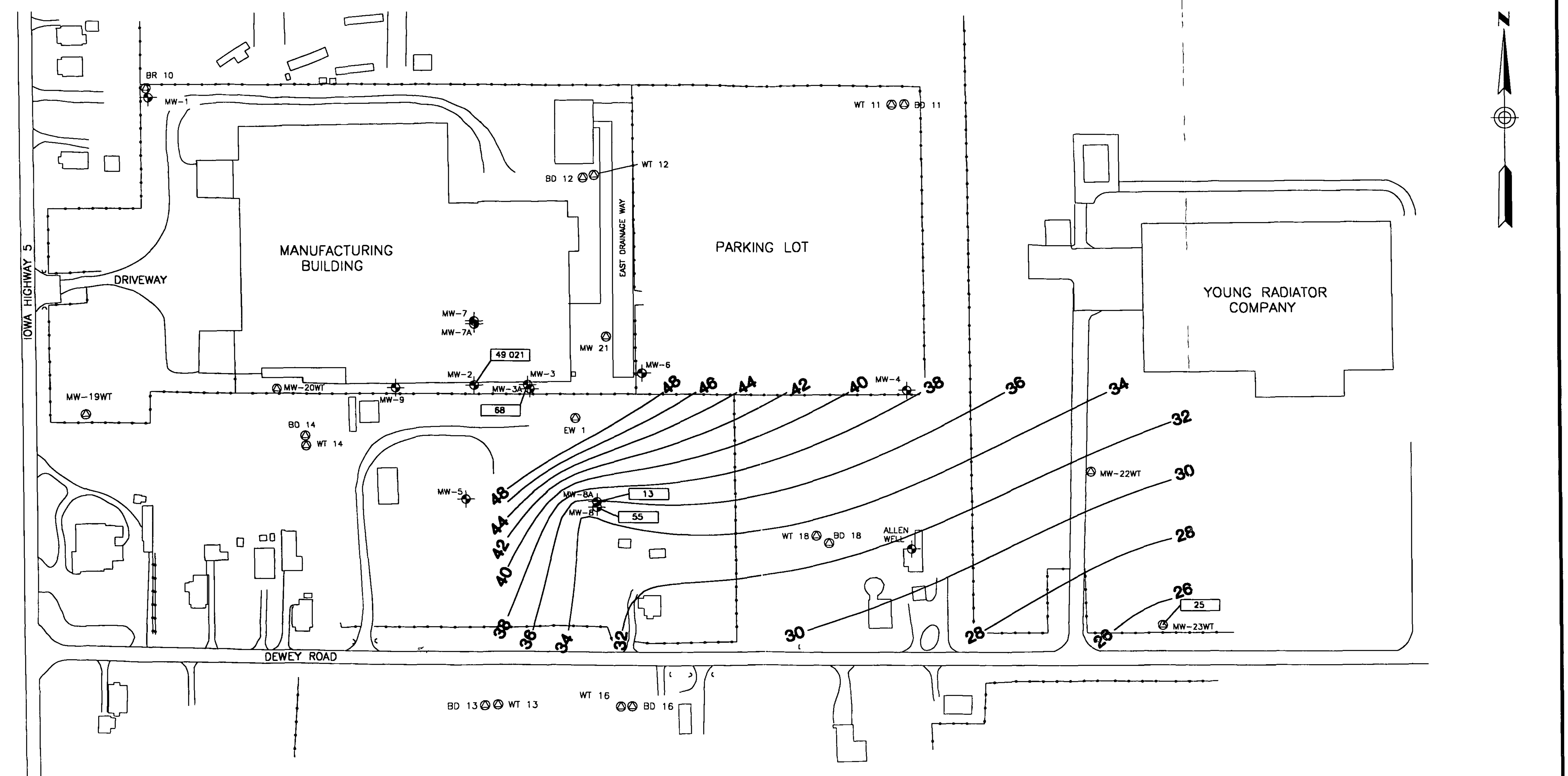
INTERPRETED SULPHATE CONCENTRATIONS (MAY 1998)

CLIENT/PROJECT

McGRAW-EDISON SITE CENTERVILLE, IOWA

DRAWN MAT	DATE 7/10/98	JOB NO 986-1083	
CHECKED RIO	SCALE AS SHOWN	DWG NO 1083-D29	REV NO A
REVIEWED	FILE NO 1083-D29	SUBTITLE	FIGURE NO 20

PLOT SCALE 60



LEGEND

CHAIN LINK FENCE

BORINGS CONVERTED TO MONITORING WELLS

○	WT	TOP OF WATER TABLE BORING
	BD	BASE OF GLACIAL DRIFT BORING
	BR	BEDROCK BORING
	EW	EXTRACTION WELL

⊕ PREVIOUSLY INSTALLED MONITORING AND SUMP WELLS

40 —— ETHENE CONCENTRATION CONTOUR (ng/L)

25 ETHENE DATA (g/L)

PLO SCALE 80

SCALE IN FEET

0 160 320

BASE MAP AND
ETHENE DATA PROVIDED BY
MWR INCORPORATED
A D so of E vroge I c

GOLDER SIERRA Atlanta, Georgia

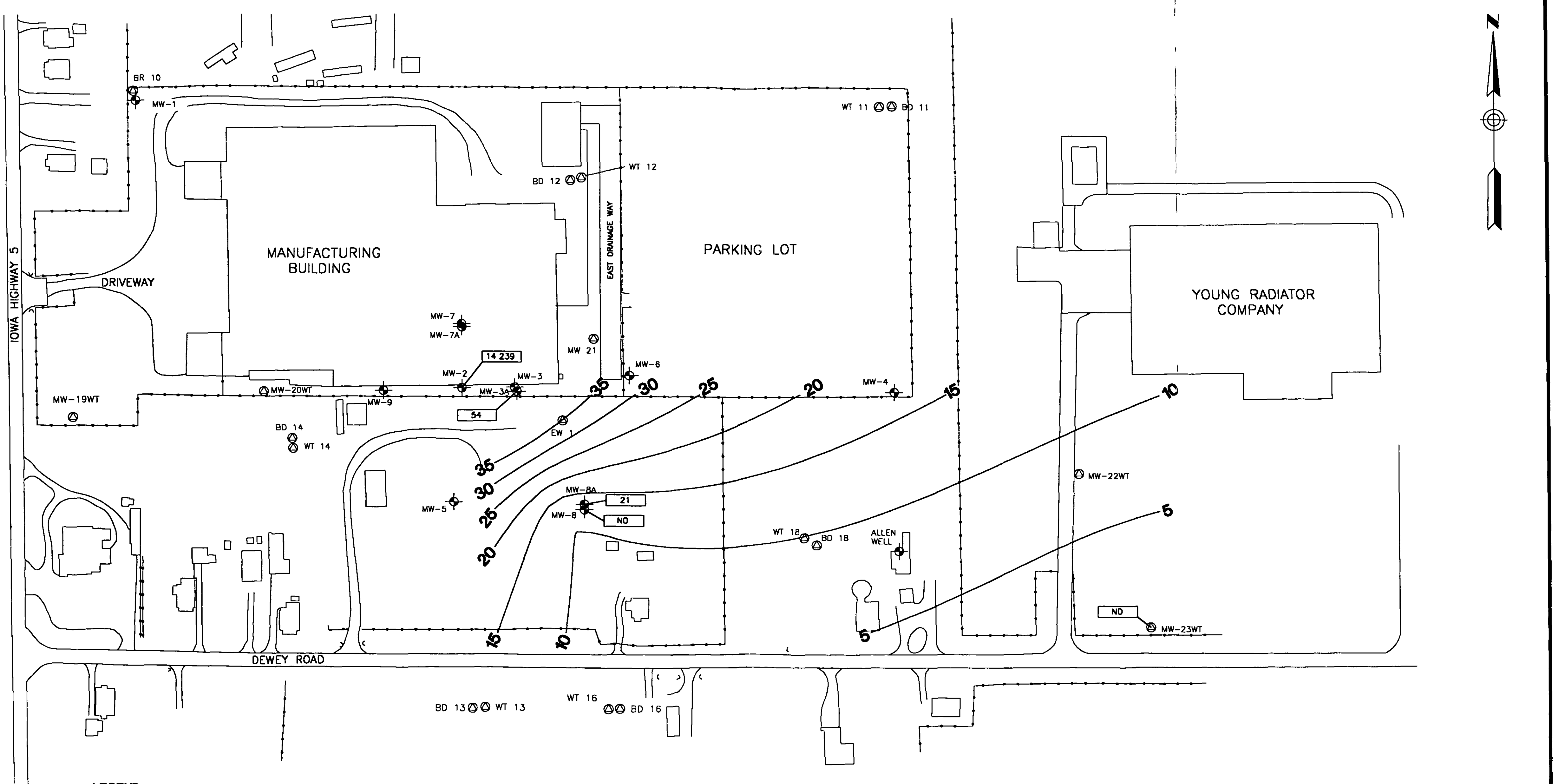
TITLE

INTERPRETED ETHENE CONCENTRATIONS (MAY 1998)

CLIENT/PROJECT

McGRAW-EDISON SITE CENTERVILLE, IOWA

DRAWN MAT	DATE 7/10/98	JOB NO 986-1083	
CHECKED RIO	SCALE AS SHOWN	DWG NO 1083-D5	REV NO A
REVIEWED	FILE NO 1083-D5	SUBTITLE	FIGURE NO 21



LEGEND

CHAIN LINK FENCE

BORINGS CONVERTED TO MONITORING WELLS

WT	TOP OF WATER TABLE BORING
BD	BASE OF GLACIAL DRIFT BORING
BR	BEDROCK BORING
EW	EXTRACTION WELL

PREVIOUSLY INSTALLED MONITORING AND SUMP WELLS

15 ETHANE CONCENTRATION CONTOUR (ng/L)

ND ETHANE DATA (g/L)

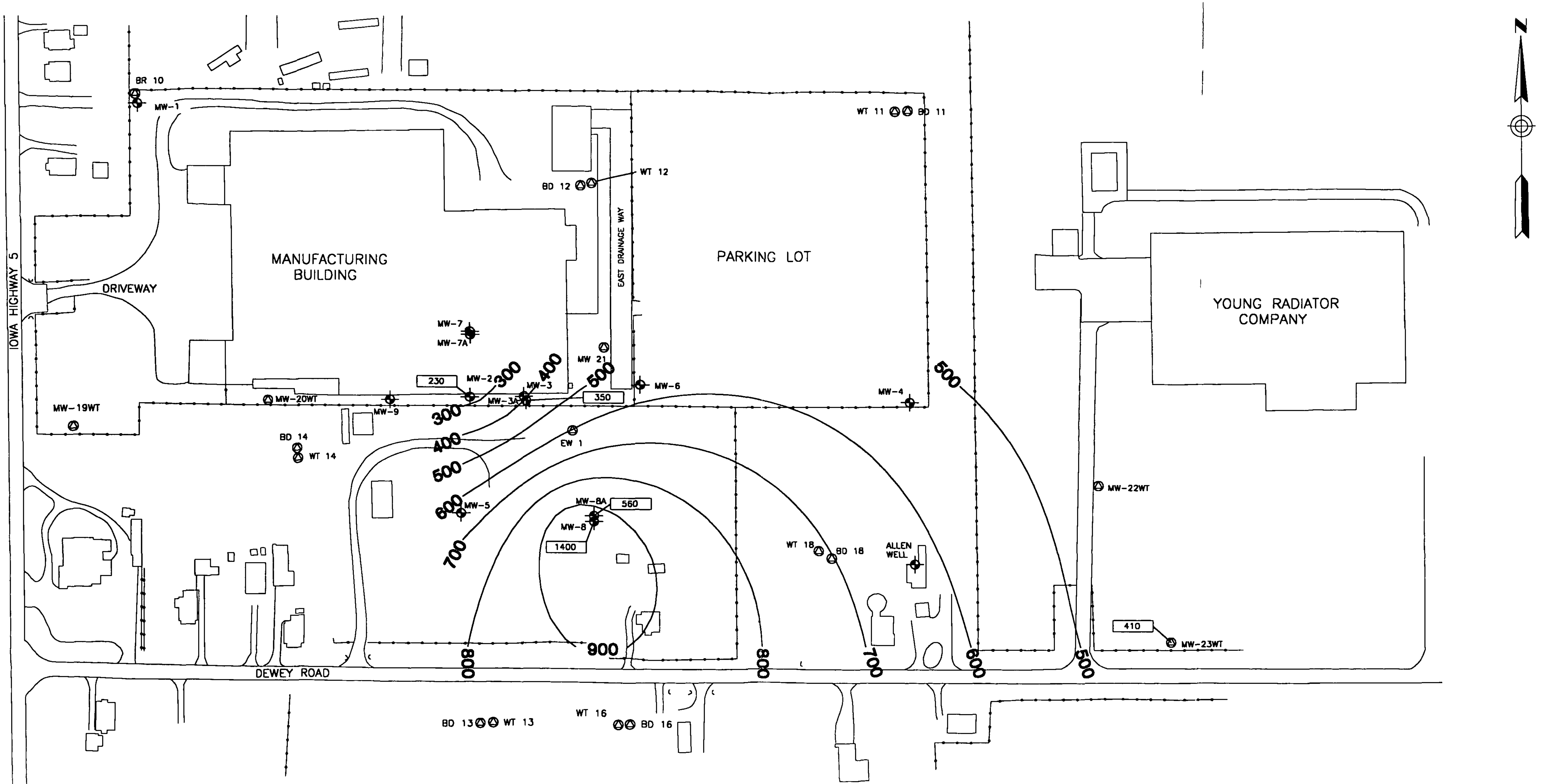
BASE MAP AND
ETHANE DATA PROVIDED BY
MWR INCORPORATED
A Division of Envirogen Inc

GOLDER SIERRA Atlanta, Georgia

TITLE
INTERPRETED ETHANE CONCENTRATIONS (MAY 1998)

CLIENT/PROJECT
McGRAW-EDISON SITE CENTERVILLE, IOWA

DRAWN MAT	DATE 7/10/98	JOB NO 986-1083	
CHECKED RIO	SCALE AS SHOWN	DWG NO 1083-D4	REV NO A
REVIEWED	FILE NO 1083-D4	SUBTITLE	FIGURE NO 22



LEGEND

CHAIN LINK FENCE

BORINGS CONVERTED TO MONITORING WELLS

WT	TOP OF WATER TABLE BORING
BD	BASE OF GLACIAL DRIFT BORING
BR	BEDROCK BORING
EW	EXTRACTION WELL

PREVIOUSLY INSTALLED MONITORING AND SUMP WELLS

500 ALKALINITY CONCENTRATION CONTOUR (mg/L)

410 ALKALINITY DATA (mg/L)

PLOT SCALE 80

SCALE IN FEET

0 160 320

BASE MAP AND
ALKALINITY DATA PROVIDED BY
MWR INCORPORATED
A Dvson of En rogen Inc

GOLDER SIERRA Atlanta, Georgia

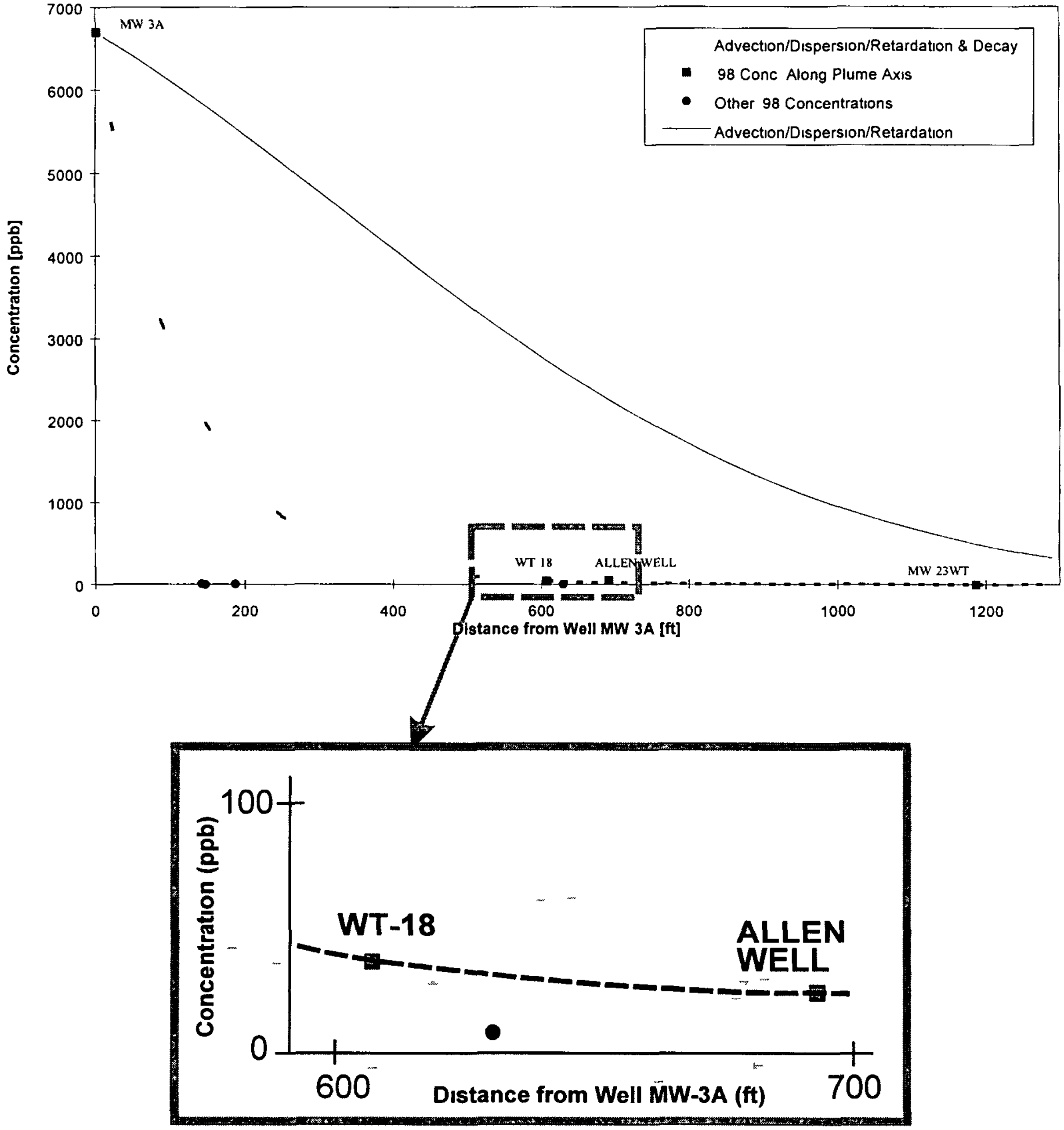
TITLE

INTERPRETED ALKALINITY CONCENTRATIONS (MAY 1998)

CLIENT/PROJECT

McGRAW-EDISON SITE CENTERVILLE, IOWA

DRAWN MAT	DATE 7/10/98	JOB NO 986-1083	
CHECKED RIO	SCALE AS SHOWN	DWG NO 1083-D3	REV NO A
REVIEWED	FILE NO 1083-D3	SUBTITLE	FIGURE NO 23



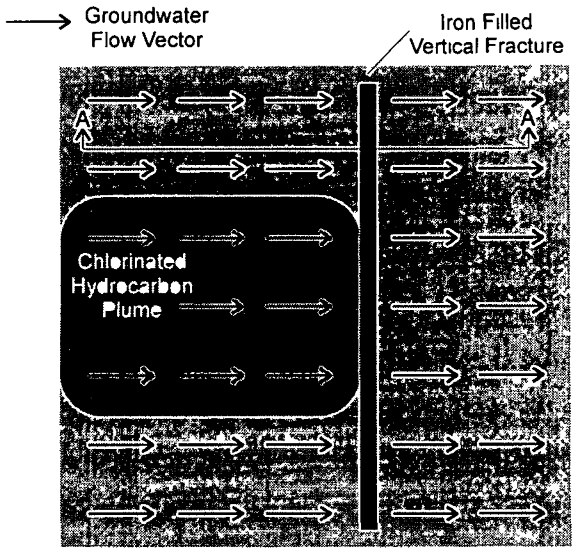
GOLDER SIERRA

Atlanta Georgia

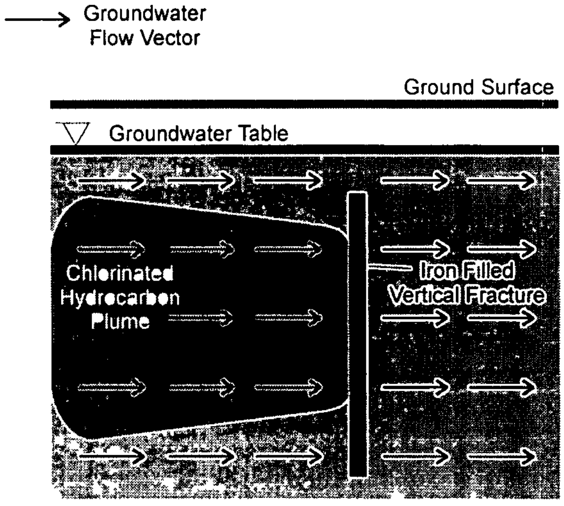
TITLE

Predicted TCE Concentrations Downgradient of MW 3A
1 D Advection/Dispersion with Reaction Terms

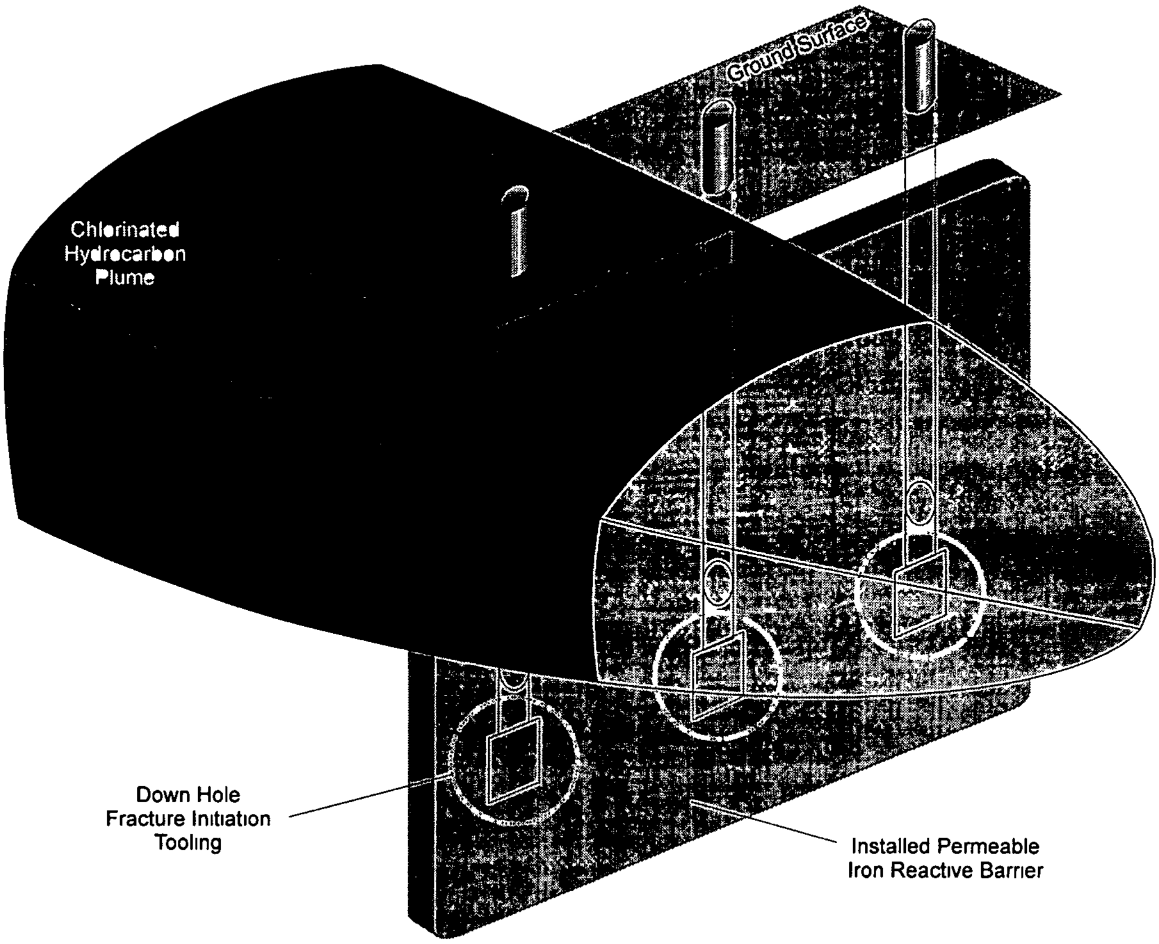
CLIENT/PROJECT McGraw Edison Site Centerville Iowa	DRAWN BSL	DATE 26 Jun 1998	JOB NO 986-1083
	CHECKED	SCALE N/A	PAGE NO 12	REV NO
	REVIEWED	FILE NO 1083 graphs cdr	SUBTITLE	FIGURE NO 24



Plan View



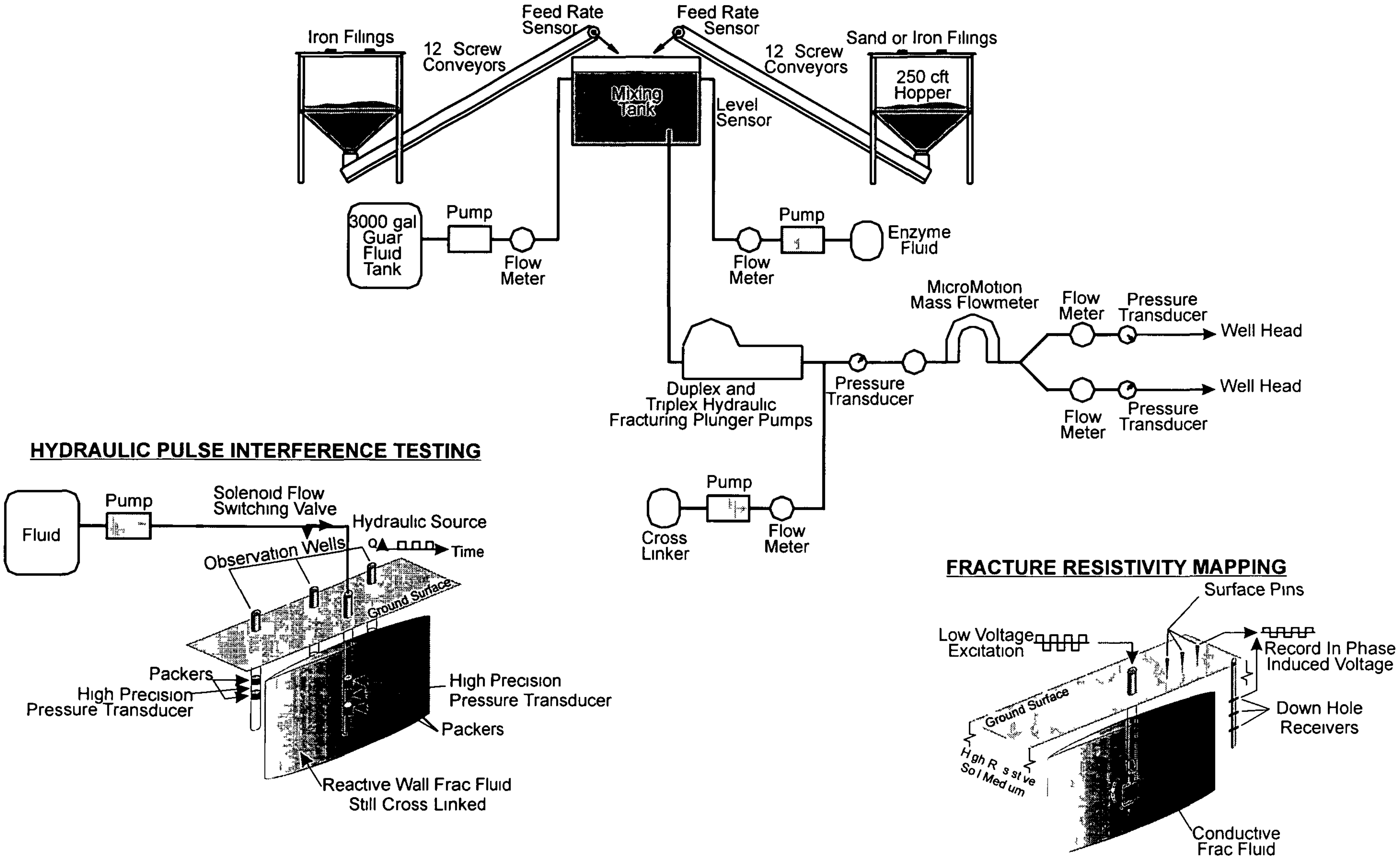
Section A A



GOLDER SIERRA

Atlanta Georgia

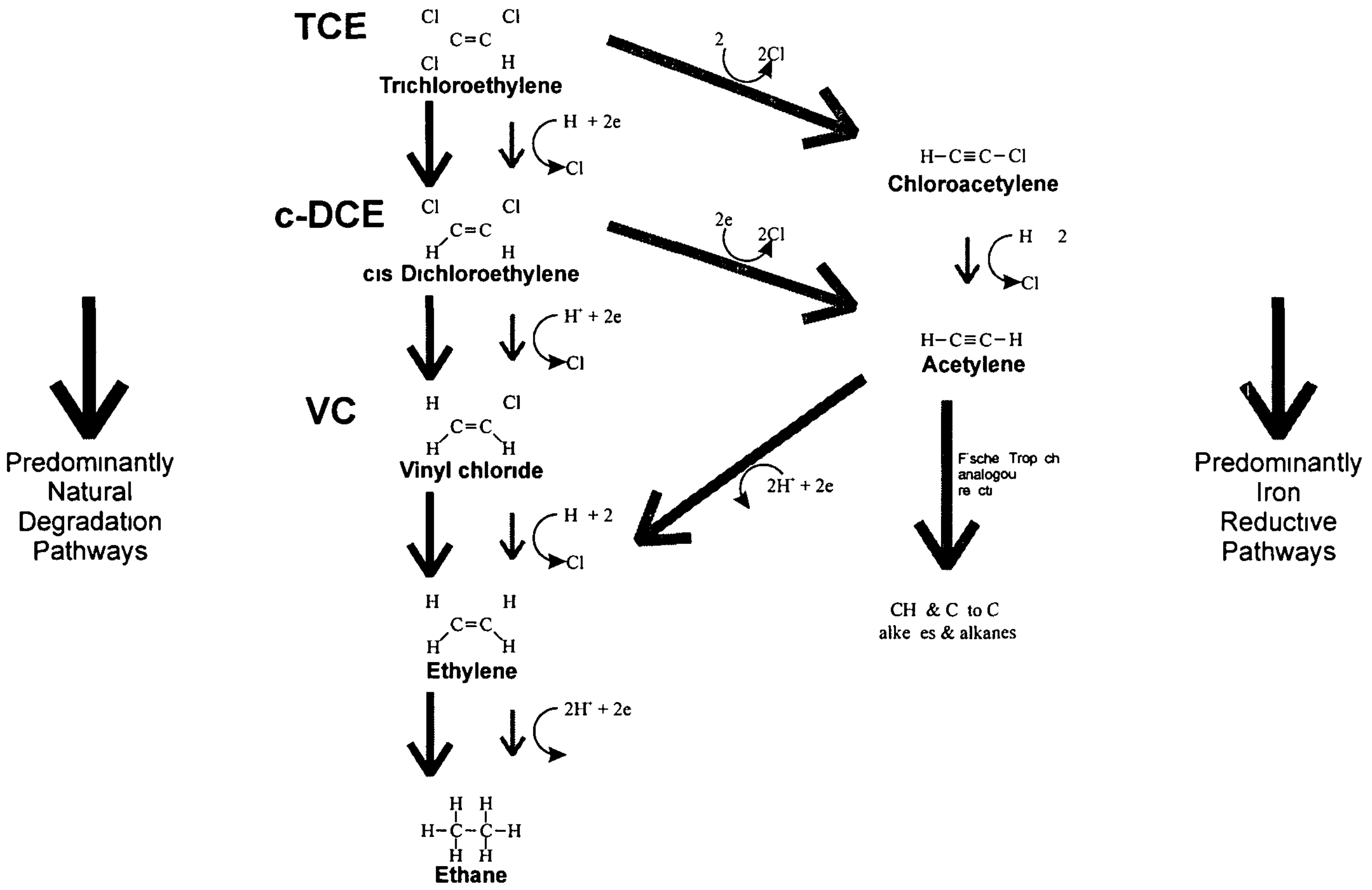
TITLE	Vertically Orientated Hydraulic Fractures Iron Reactive Permeable Barrier		
CLIENT/PROJECT	McGRAW EDISON SITE CENTERVILLE IA		
DRAWN BSL	DATE 9/27/96	JOB NO 986 1083	
CHECKED	SCALE	DWG NO	REV NO
REVIEWED	FILE NO 1083 dd6 cdr	SUBTITLE	FIGURE NO 25



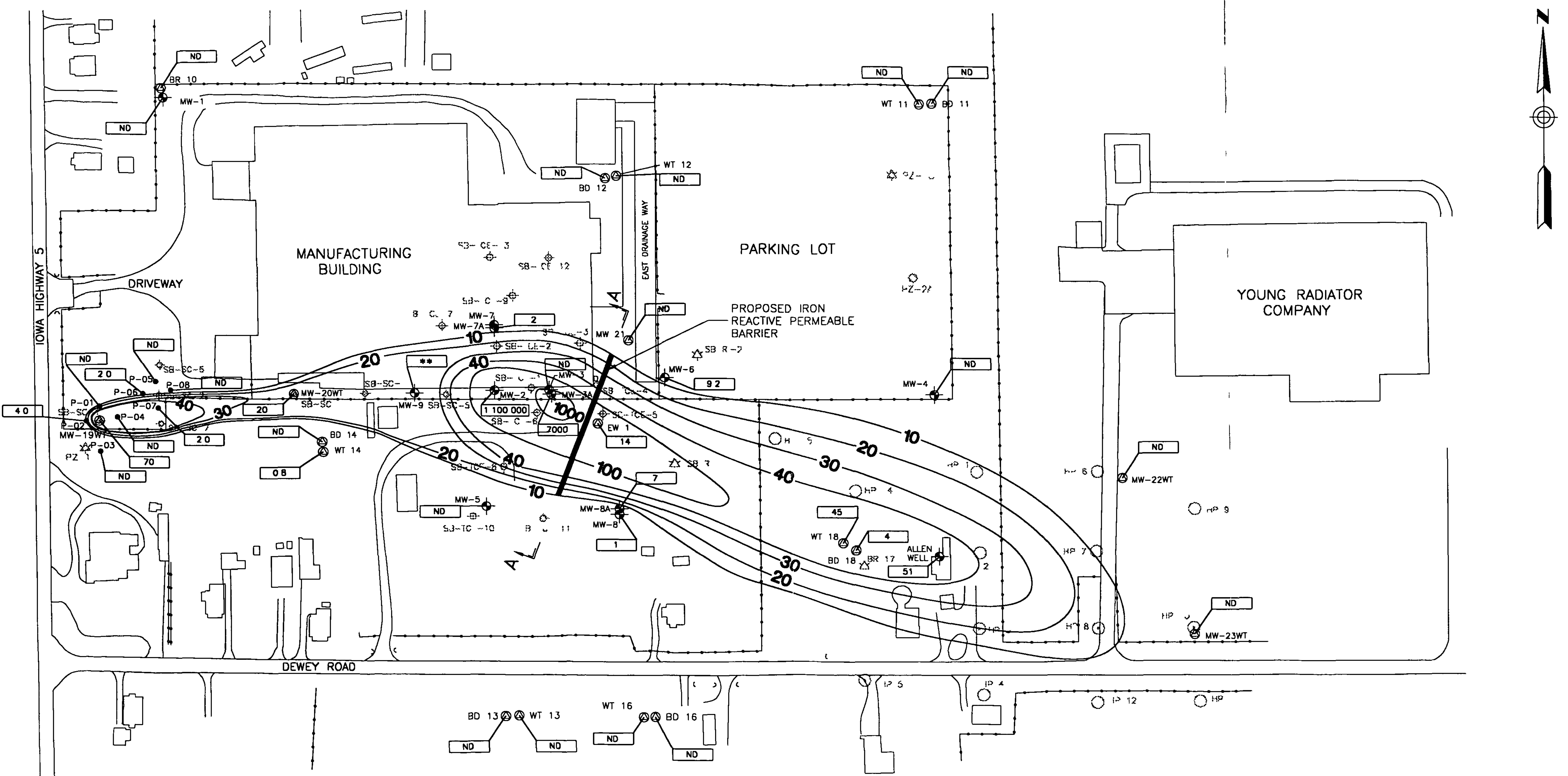
CLIENT/PROJECT McGRAW EDISON SITE CENTERVILLE IA	GOLDER SIERRA Atlanta Georgia	TITLE Flow Diagram of Hydraulic Fracturing System Equipment and Instrumentation

DRAWN	CHECKED	REVIEWED	DATE	SCALE	FILE NO	JOB NO	DWG NO./REV NO	FIGURE
MAT	f		7/10/98	NTS	1083 dd8 cdr	986 1083		26

Reductive Dehalogenation Pathways



GOLDER SIERRA Atlanta Georgia	TITLE Reductive Dehalogenation Pathways		
CLIENT/PROJECT McGRAW EDISON SITE CENTERVILLE IA	DRAWN BSL	DATE 7/10/98	JOB NO 986 1083
	CHECKED	SCALE	DWG NO / REV NO
	REVIEWED	FILE NO 1083 dd7 cdr	SUBTITLE / FIGURE NO 27



SCALE IN FEET

0 160 320

BASE MAP AND TCE DATA PROVIDED BY

MWR INCORPORATED
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LEGEND

———•——— CHAIN LINK FENCE

BORINGS CONVERTED TO MONITORING WELLS

- WT TOP OF WATER TABLE BORING
- BD BASE OF GLACIAL DRIFT BORING
- BR BEDROCK BORING
- EW EXTRACTION WELL

SB RI-1 & SB RI-2 SOIL BORING REMEDIAL INVESTIGATION AND BORINGS NOT CONVERTED TO MONITORING WELLS

PZ PIEZOMETER LOCATIONS

PREVIOUSLY INSTALLED MONITORING AND SUMP WELLS

P-03 ● SOIL BORING/SOUTH CULVERT SAMPLE LOCATIONS

PROPOSED LOCATION OF IRON REACTIVE PERMEABLE BARRIER

NOTE SEE FIGURE 3 FOR LOCATION OF SOIL BORINGS GB-1 AND GB-1A (MAY 1998)

SB SC SOIL BORING/SOUTH CULVERT SAMPLE LOCATIONS

SB CE SOIL BORING/TCE STORAGE AREA SAMPLE LOCATIONS

○ HP 5 HYDROPUNCH LOCATION

—40— GROUND WATER TCE CONCENTRATION CONTOURS (ug/L)

45 TCE DATA (ug/L)

MW-2 SCREENED IN PERCHED WATER TABLE DATA POINT NOT USED FOR CONTOURS

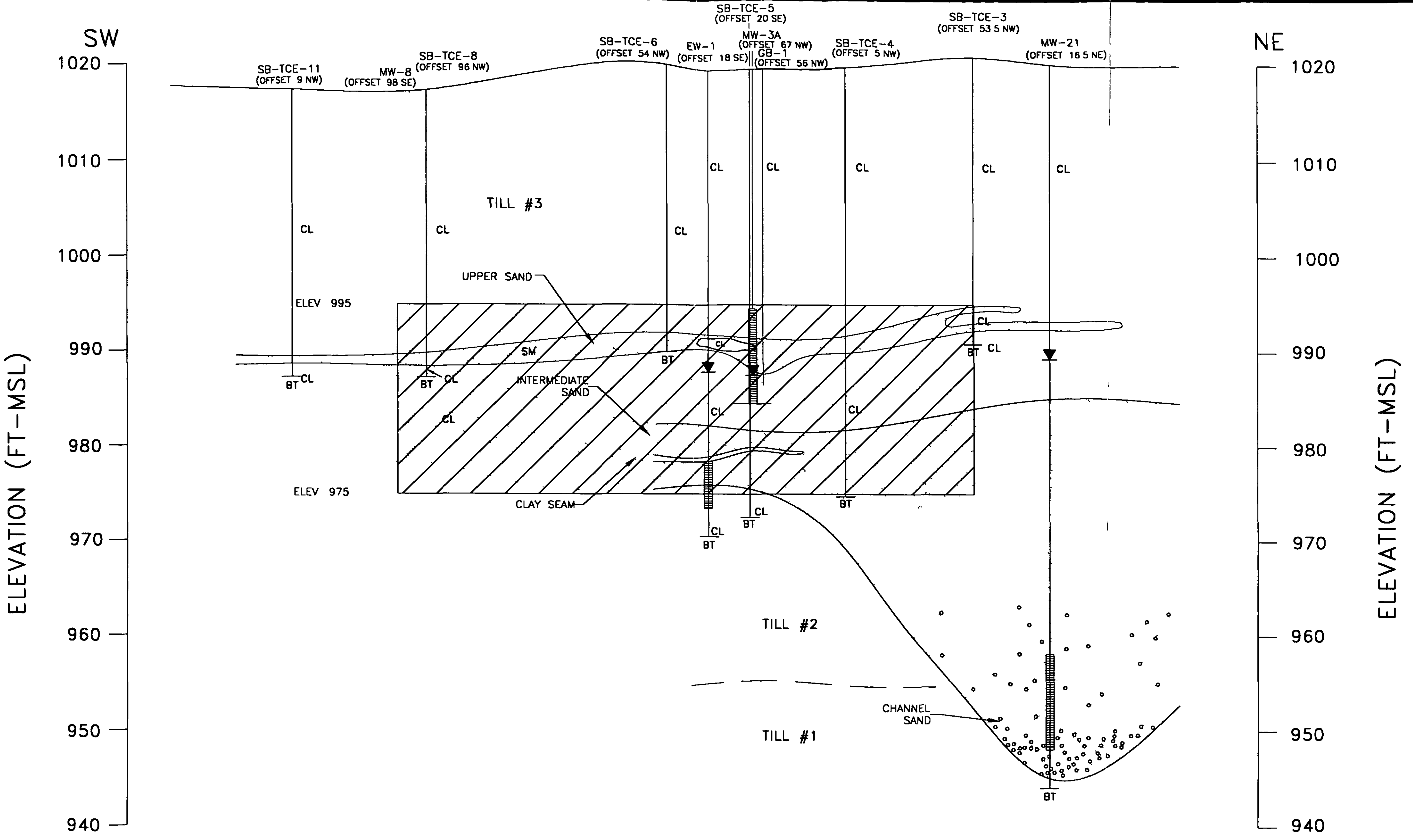
** WELL NOT SAMPLED DUE TO DEAD ANIMAL

GOLDER SIERRA Atlanta, Georgia

CLIENT/PROJECT
McGRAW-EDISON SITE CENTERVILLE, IOWA

TITLE
LOCATION OF PROPOSED IRON REACTIVE PERMEABLE BARRIER

DRAWN	MAT	DATE	7/10/98	JOB NO	986-1083
CHECKED	RIO	SCALE	AS SHOWN	DWG NO 1083-D9	REV NO C
REVIEWED		FILE NO	1083-D9	SUBTITLE	FIGURE NO 28



LEGEND

- ▼ GROUNDWATER LEVEL DATA (MAY 3 1998)
- BT BORING TERMINATED
- ▤ MONITORING WELL SCREEN
- ▨ PROPOSED IRON REACTIVE PERMEABLE BARRIER (20ft X 240ft)

HORIZONTAL SCALE IN FEET

0 40 80

VERTICAL SCALE EXAGGERATED 4X

GOLDER SIERRA Atlanta, Georgia

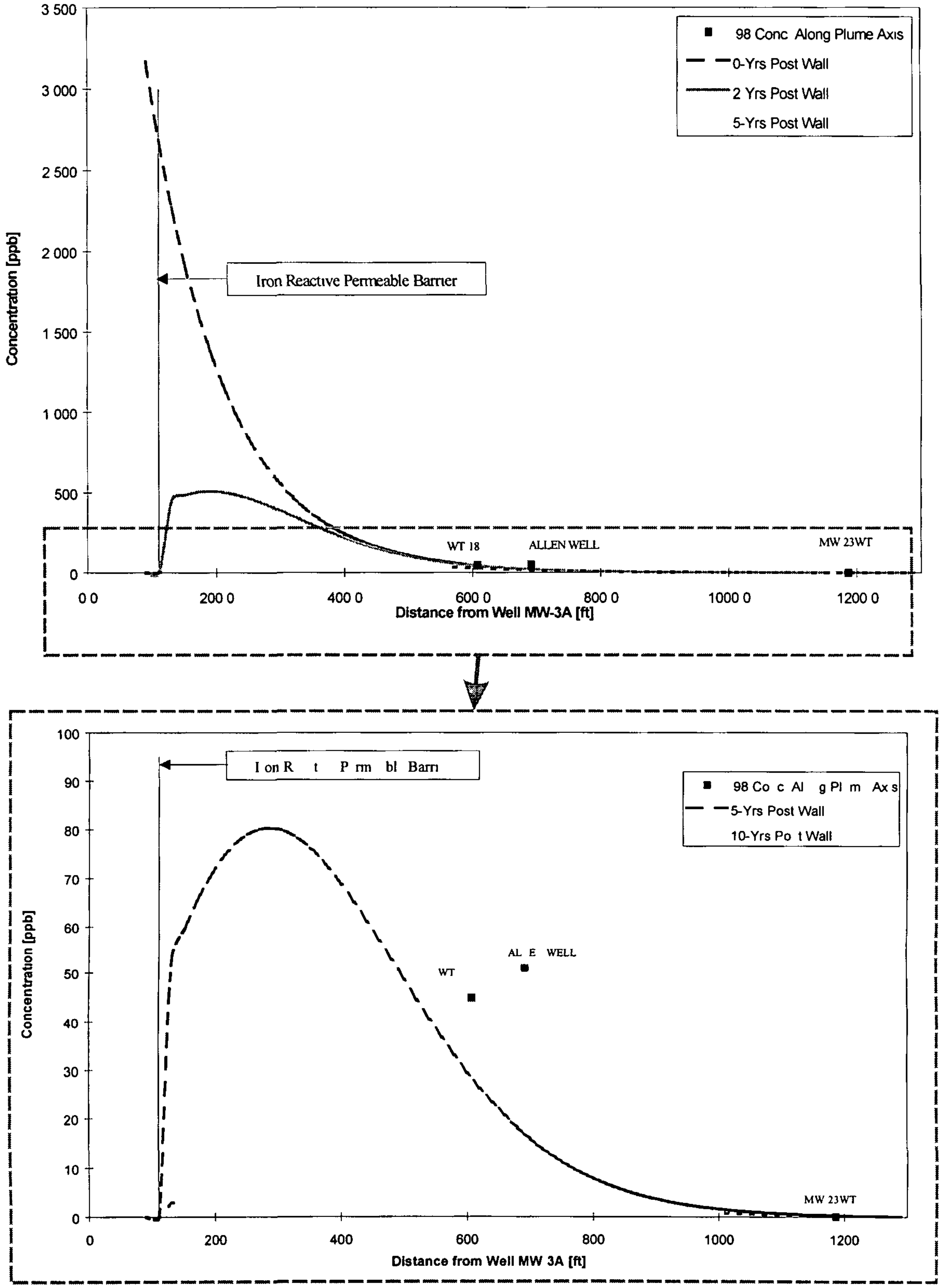
CLIENT/PROJECT

McGRAW-EDISON SITE CENTERVILLE IOWA

TITLE

IRON REACTIVE PERMEABLE BARRIER CROSS SECTION A-A'

DRAWN MAT	DATE 7/10/98	JOB NO 986-1083	
CHECKED RIO	SCALE AS SHOWN	DWG NO 1083-D10	REV NO C
REVIEWED	FILE NO 1083-D10	SUBTITLE	FIGURE NO 29



GOLDER SIERRA

Atlanta Georgia

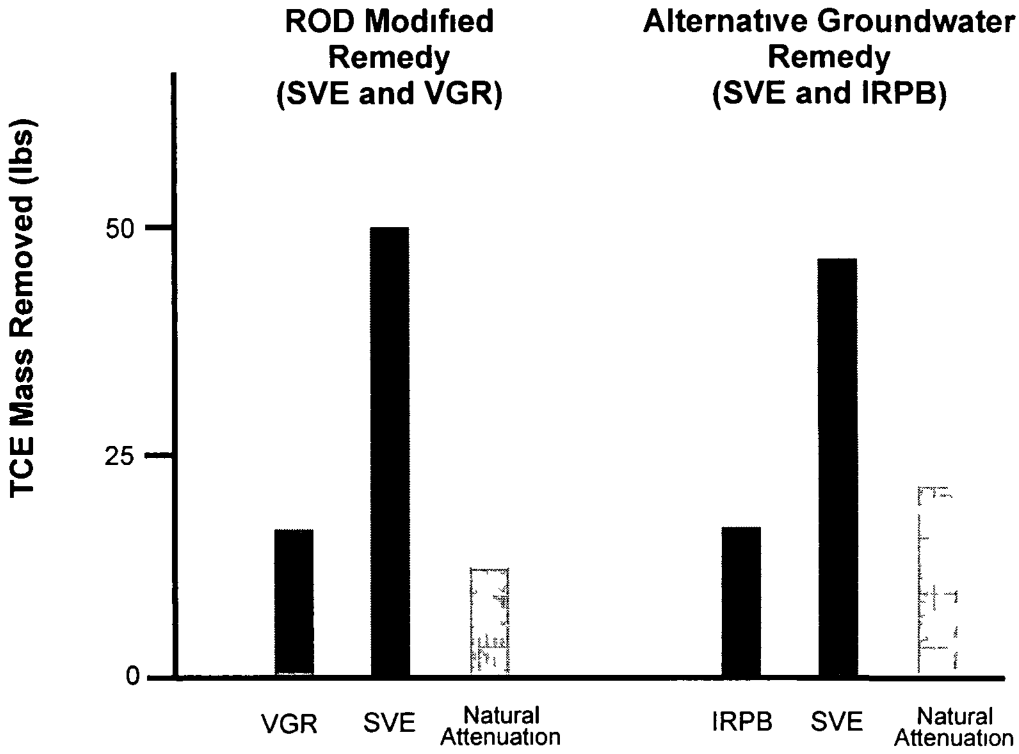
TITLE

Predicted TCE Concentrations Downgradient
of Iron Reactive Permeable Barrier

CLIENT/PROJECT

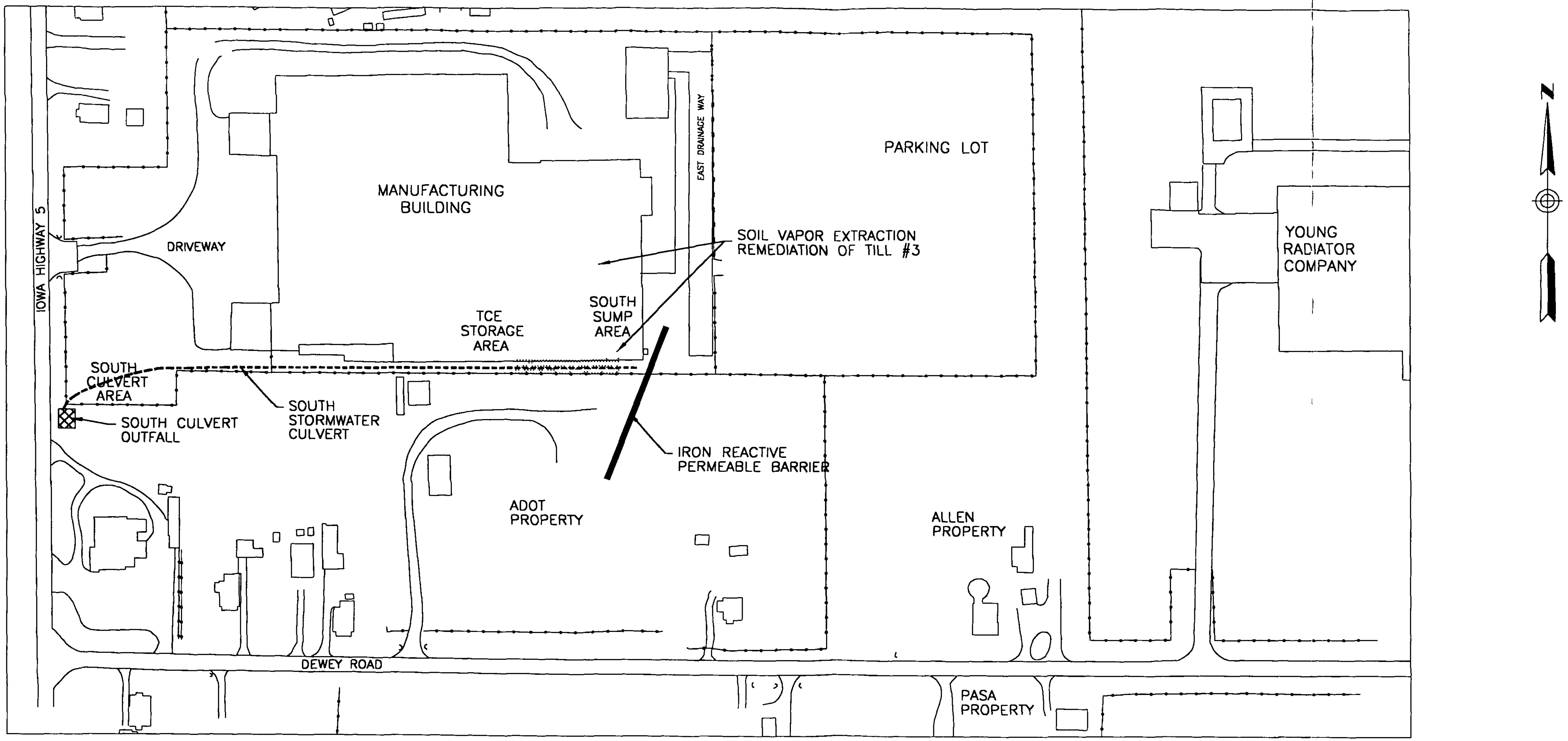
McGRAW EDISON SITE CENTERVILLE IOWA

DRAWN	MAT	DATE	7/28/98	JOB NO	986-1083		
CHECKED		SCALE	N/A	DWG NO		REV NO	
REVIEWED		FILE NO	1083 dd9 cdr	SUBTITLE		FIGURE NO	30



VGR- Vacuum Groundwater Recovery
SVE- Soil Vapor Extraction
IRPB- Iron Reactive Permeable Barrier

GOLDER SIERRA Atlanta Georgia	TITLE Estimated Contaminant Mass Removed Over 2 Year Period		
CLIENT/PROJECT McGRAW EDISON SITE CENTERVILLE IOWA	DRAWN MAT	DATE 7/31/98	JOB NO 986 1083
	CHECKED	SCALE	DWG NO / REV NO
	REVIEWED	FILE NO 1083 dd10 cdr	SUBTITLE / FIGURE NO 31



LEGEND

—•—•— CHAIN LINK FENCE

- - - - - SOUTH STORMWATER CULVERT

▬ PROPOSED LOCATION OF IRON REACTIVE PERMEABLE BARRIER

SCALE IN FEET

0 160 320

GOLDER SIERRA Atlanta, Georgia

CLIENT/PROJECT

McGRAW-EDISON SITE CENTERVILLE IOWA

TITLE

PROPOSED REMEDIATION SYSTEM FOR SOIL AND GROUNDWATER REMEDY at McGRAW EDISON SITE

DRAWN	MAT	DATE	7/28/98	JOB NO	986-1083
CHECKED	RIO	SCALE	1 160	DWG NO	1083-25
REVIEWED		FILE NO	1083-D25	SUBTITLE	

REV NO

FIGURE NO 32

OT CALE.

PROJECT NUMBER 44061	LOGGED BY C ELVRUM
DRILLING CO ERM	DATE DRILLED 4-27-98
BORING METHOD GEOPROBE	FIELD SCREENING EQUIP PID
SAMPLING METHOD LASKEY SAMPLER	ANALYTICAL METHOD TCE
NOTES MISSED INTERVAL AT 37 -39	DWG NAME borings logs

DEPTH (FT)	BORING LOG	DESCRIPTION AND COMMENTS	SAMPLES	HEAD SPACE (ppm)	RECOVERY
0					
	FILL	Fill brown silt brick fragments organic material moist	SS	0	1 3/2
	CL	Black, silty clay soft medium plasticity	SS	0	2/2
		Gray-black, silty clay soft medium plasticity with brick fragments	SS	0	1 8/2
	CH	Dark gray silty clay very soft wet medium plasticity Grayish-brown silty clay stiff highly plastic wet with roots.	SS	0	1 5/2
10	CL	Dark gray silty clay stiff highly plastic moist with yellow-brown mottles roots	SS	0	2/2
	CH CL	Dark gray silty clay very soft wet medium plasticity with roots Yellow-brown silty clay stiff highly plastic moist with gray mottles	SS	0	1 7/2
	CH CL	Dark gray silty clay very soft wet medium plasticity with roots Yellow-brown silty clay very stiff moist with gravel	SS	0	1 75/2
	?				0
	ML	Brownish-yellow silty clay hard medium plasticity moist with trace medium sand	SS	0	2/2
20	CL	Yellow-brown silty clay hard medium plasticity moist with trace medium sand and gravel with some gray mottling	SS	0	1 8/2
		Light olive-brown silty clay soft medium plasticity wet Hard at bottom 7	SS	0	1 7/2
	CH	Olive-brown silty clay very soft very wet	SS	0	1 6/2
	CL	Yellow-brown silty clay firm moist medium plasticity with trace of sand and gravel	SS	0	1 3/2
	ML	Light olive-brown silty clay soft low plasticity increasing silt with trace of sand and gravel with increasing depth moist	SS	0	1 3/2
30	CL	Light olive-brown silty clay with trace of sand and gravel medium plasticity firm increasing sand and gravel with depth moist	SS	0	1 3/2
		Light olive-brown clay with silt hard low plasticity moist with 1/4 sand and gravel seen at 31 5	SS	0	1 8/2
		Light olive-brown clay with silt, low plasticity moist with trace of sand and gravel	SS	0	1 5/2
		Yellowish-brown clay with silt with trace sand and gravel hard low plasticity	SS	0	0
	?		SS	0	1/2
40	SM	Yellowish-brown fine sand moist with trace of silt	WS	0	0
50					

ENVIROGEN
NEW SOLUTIONS TO HAZARDOUS WASTE PROBLEMS

McGRAW-EDISON
CENTERVILLE, IA

BORING NUMBER P-01

PLO CALE

PROJECT NUMBER 44061	LOGGED BY C ELVRUM
DRILLING CO ERM/AQUADRILL	DATE DRILLED 4-29-98
BORING METHOD GEOPROBE/DRILLING RIG	FIELD SCREENING EQUIP PID
SAMPLING METHOD LASKEY SAMPLER	ANALYTICAL METHOD TCE
NOTES	DWG NAME borings logs

DEPTH (FT)	BORING LOG	DESCRIPTION AND COMMENTS	SAMPLES	HEAD SPACE (ppm)	RECOVERY
0	ML	Reddish-brown topsoil clay with red brick fragments moist soft medium plasticity	SS	0	1 5/2
	FILL	Reddish-brown fill with red brick fragments at top moist soft medium plasticity	SS	0	1 5/2
		Black clay fill moist soft medium plasticity	SS	0	2/2
		Black clay fill more gray at bottom medium plasticity	SS	0	2/2
10	CL	Dark yellowish-brown silty clay moist firm medium plasticity	SS	0	1 5/2
		Black silty clay soft medium plasticity	SS	0	1 5/2
		Black silty clay soft medium plasticity wet yellowish-brown silty clay with gray mottles soft highly plastic moist	SS	0	1/2
			SS	0	1/2
	CH	Black silty clay very soft wet	SS	3	2/2
20		Yellowish-brown clay with grey mottles soft highly plastic moist	SS	2	2/2
	CL	Dark gray silty clay wet with some fine sand	SS	0	2/2
		Yellowish-brown silty clay firm, moist with gray mottles fine yellowish-brown sand at bottom 2	SS	0	2/2
	MH	Yellowish-brown fine medium sand wet	SS	0	2/2
	CL	Light olive-brown silty clay with trace of sand and gravel soft near top firm near bottom	SS	0	2/2
30	SW	Light olive-brown fine to medium sand with trace of gravel and clay wet	SS	0	2/2
	SW	Yellowish-brown silty clay with gray streaks and trace of fine sand with increasing depth		0	2/2
		Yellowish-brown fine to medium sand wet with 2 yellow-brown silty clay at top Yellowish-brown fine to medium sand wet		0	1/2
	CL	Yellowish-brown silty clay hard medium plasticity moist with trace of sand and gravel and gray streaks	WS	0	1/2
	SW	Dark, yellowish-brown medium to coarse graded sand moist		0	2/2
40	SM	Light olive-brown silty sand moist		0	2/2
50					

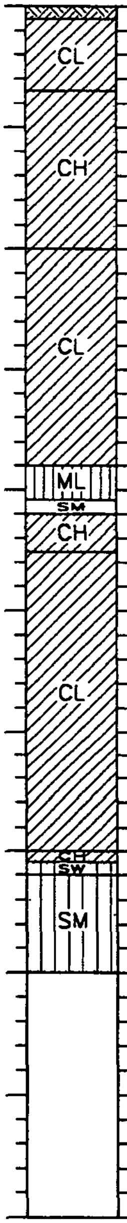
ENVIROGEN
NEW SOLUTIONS TO HAZARDOUS WASTE PROBLEMS

McGRAW-EDISON
CENTERVILLE, IA

BORING NUMBER P-02

PL CALC.

PROJECT NUMBER 44061	LOGGED BY C ELVRUM
DRILLING CO ERM/AQUADRILL	DATE DRILLED 5-3-98
BORING METHOD GEOPROBE/DRILL RIG	FIELD SCREENING EQUIP PID
SAMPLING METHOD LASKEY SAMPLER	ANALYTICAL METHOD TCE
NOTES	DWG NAME borings logs



DEPTH (FT)	BORING LOG	DESCRIPTION AND COMMENTS	SAMPLES	HEAD SPACE (ppm)	RECOVERY
0		Black clayey topsoil with rock soft moist			
		Dark yellowish-brown silty clay moist soft medium plasticity			
		Dark grayish-brown silty clay soft moist medium plasticity	SS	0	2.5/2.5
		Olive-brown silty clay firm moist high plasticity	SS	0	2.5/2.5
			SS	0	2.5/2.5
		Light olive-brown silty clay firm moist highly plastic with gray streaks	SS	0	2.5/2.5
10		Light gray silty clay with olive-brown mottling moist firm medium plasticity with trace sand and gravel	SS	0	2.5/2.5
			SS	0	2.5/2.5
			SS	0	2.5/2.5
		Strong brown silty clay moist medium plasticity with trace gravel and gray nodules	SS	0	2.5/2.5
			SS	0	2.5/2.5
20		Silty sandy clay yellowish-brown low plasticity moist soft	SS	0	2.5/2.5
		Yellowish-brown silty fine sand wet			
		Light olive-brown silty clay soft wet high plasticity with gray mottles	SS	0	2/2.5
		Light olive-brown silty clay soft moist medium plasticity with grey and strong brown mottles with trace gravel and rock fragments	SS	0	2/2.5
			SS	0	2.5/2.5
			SS	0	2.5/2.5
30		Yellowish-brown silty clay crumbly moist with gray mottles and trace gravel	SS	0	2.5/2.5
			SS	0	2.5/2.5
		Dark grayish-brown silty clay with trace gravel firm medium plasticity			
		Light olive-brown silty clay moist firm medium plasticity	SS	0	2.5/2.5
		Light olive-brown silty clay wet firm medium plasticity			
		Yellowish-brown coarse sand and gravel wet.	SS	6	2.5/2.5
		Yellowish-brown silty fine sand wet	SS	0	2/2.5
40			SS	0	2/2.5
			WS		
50					

ENVIROGEN NEW SOLUTIONS TO HAZARDOUS WASTE PROBLEMS	McGRAW-EDISON CENTERVILLE, IA	BORING NUMBER P-03

PLOT SCALE

PROJECT NUMBER 44061	LOGGED BY C ELVRUM
DRILLING CO ERM/AQUADRILL	DATE DRILLED 4-30-98
BORING METHOD GEOPROBE/DRILL RIG	FIELD SCREENING EQUIP PID
SAMPLING METHOD LASKEY SAMPLER	ANALYTICAL METHOD TCE
NOTES INTERVALS BETWEEN 21 -30 WERE NOT RECOVERED (SEE P4 (2))	DWG NAME borings logs

DEPTH (FT)	BORING LOG	DESCRIPTION AND COMMENTS	SAMPLES	HEAD SPACE (ppm)	RECOVERY
0	FILL	Reddish-brown silty clayey fill with red brick fragments Light-gray rock fragments with roots at bottom	SS	0	2/2
		Light-gray rock fragments at top reddish-brown silty clayey fill with brick fragments moist	SS	0	2/2
		Reddish-brown silty clay fill with brick fragments moist	SS	0	1 3/2
	CL	Dark-gray silty clay soft medium plasticity harder at bottom more moist some organic material	SS	0	1 3/2
10	CH	Dark-gray silty clay soft highly plastic some organic material wet	SS	0	2/2
	CL	Brown silty clay firm highly plastic moist	SS	0	2/2
	CH	Gray clay hard very plastic more yellowish-brown at bottom moist	SS	0	2/2
	CL	Yellowish-brown silty clay firm medium plasticity with trace medium sand moist	SS	0	2/2
	CH	Olive-brown silty clay hard very plastic with trace medium sand	SS	0	1/2
20	CL	Brownish-yellowish, silty clay with trace sand and gravel firm medium plasticity moist	SS	0	1/2
	?				
30	CL	Olive-yellow silty clay firm medium plasticity with trace sand and gravel wet rock fragments at top	SS	0	1/2
		Olive-yellow silty clay firm with gray mottles, medium plasticity with trace sand and gravel wet rock fragments at top	SS	0	2 5/2 5
		Olive-yellowish silty clay soft medium plastic wet with 8 fine silt sand seen at 36 clay	SS	0	2 5/2 5
40		Olive-yellowish silty clay wet soft medium plasticity fine sand with some silt at bottom 1	SS	0	2 5/2 5
			WS		
50					

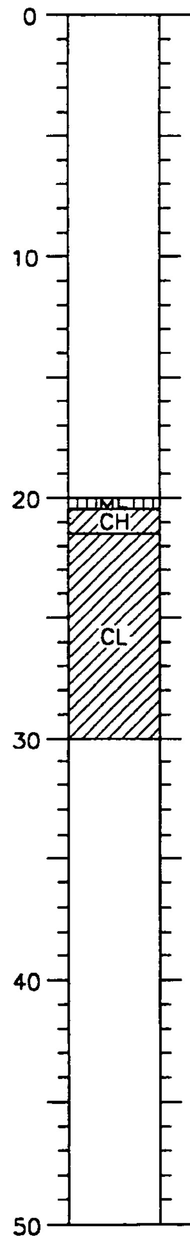
ENVIROGEN
NEW SOLUTIONS TO HAZARDOUS WASTE PROBLEMS

McGRAW-EDISON
CENTERVILLE, IA

BORING NUMBER P-04

PLOT CALE

PROJECT NUMBER 44061	LOGGED BY C ELVRUM
DRILLING CO ERM/AQUADRILL	DATE DRILLED 5-3-98
BORING METHOD GEOPROBE/DRILL RIG	FIELD SCREENING EQUIP PID
SAMPLING METHOD LASKEY SAMPLER	ANALYTICAL METHOD TCE
NOTES	DWG NAME borings logs



DEPTH (FT)	BORING LOG	DESCRIPTION AND COMMENTS	SAMPLES	HEAD SPACE (ppm)	RECOVERY
20	ML	Yellowish-brown silty sandy clay soft wet low plasticity	SS	0	2 5/2 5
	CH	Yellowish-brown silty clayey firm wet			
			SS	0	2 5/2 5
	CL	Light olive-brown silty clay soft medium plasticity with gray mottles			
			SS	0	2 5/2 5
30			SS	0	2 5/2 5

ENVIROGEN
NEW SOLUTIONS TO HAZARDOUS WASTE PROBLEMS

McGRAW-EDISON
CENTERVILLE, IA

BORING NUMBER P-04(2)

PLOT CALE.

PROJECT NUMBER 44061	LOGGED BY C ELVRUM
DRILLING CO ERM/AQUADRILL	DATE DRILLED 4-30-98
BORING METHOD GEOPROBE/DRILL RIG	FIELD SCREENING EQUIP PID
SAMPLING METHOD LASKEY SAMPLER	ANALYTICAL METHOD TCE
NOTES STOPPED AT 21 DUE TO CAVING OF HOLE	DWG NAME borings logs

DEPTH (FT)	BORING LOG	DESCRIPTION AND COMMENTS	SAMPLES	HEAD SPACE (ppm)	RECOVERY
0	FILL	Red clayey fill with sand and gravel	SS	0	2/2
	SW	Black medium sand and gravel moist	SS	0	2/2
	CL	Black, silty clay soft medium plasticity moist			
	SW	Black fine to medium sand moist	SS	0	2/2
	CL	Dark gray silty clay soft medium plasticity	SS	0	2/2
10	SW	Black fine to medium sand wet	SS	0	2/2
	CL	Black silty clay soft medium plasticity			
	CH	Yellowish-brown silty clay firm moist with gray mottles high plasticity	SS	0	2/2
	SW	Black, fine to medium sand wet with gravel	SS	0	1 7/2
	CH	Gray clay hard very plastic moist yellowish-brown at bottom 3	SS	0	2/2
	SW	Black, fine to medium wet with trace of gravel	SS	0	1/2
	CH	Gray clay firm very plastic moist			
20	CL	Yellowish-brown silty clay firm medium plasticity	SS	0	1/2
30					
40					
50					

ENVIROGEN
NEW SOLUTIONS TO HAZARDOUS WASTE PROBLEMS

McGRAW-EDISON
CENTERVILLE, IA

BORING NUMBER P-05

PLOT CALE

PROJECT NUMBER 44061	LOGGED BY C ELVRUM
DRILLING CO ERM/AQUADRILL	DATE DRILLED 5-1-98
BORING METHOD GEOPROBE/DRILL RIG	FIELD SCREENING EQUIP PID
SAMPLING METHOD LASKEY SAMPLER	ANALYTICAL METHOD TCE
NOTES	DWG NAME borings logs

DEPTH (FT)	BORING LOG	DESCRIPTION AND COMMENTS	SAMPLES	HEAD SPACE (ppm)	RECOVERY
0	FILL	Red clayey fill with sand and gravel		0	2/2
	SW	Black, medium sand and gravel moist		0	2/2
	CL	Black, silty clay soft medium plasticity moist Grayish-brown silty clay soft wet medium plasticity some organic material with trace sand	SS	0	2 5/2 5
		Yellowish-brown silty clay firm high plasticity moist with gray streaks	SS	0	2 5/2 5
10	CH	Yellowish-brown silty clay firm high plasticity moist with gray streaks more gray near bottom	SS	0	2 5/2 5
		Light gray silty clay with yellowish-brown mottles near top 1 yellowish-red silty clay medium plasticity hard, moist at bottom	SS	0	2 5/2 5
		Brownish-yellow silty clay with gray mottles with trace medium sand and gravel low plasticity crumbly	SS	0	2/2 5
			SS	0	2/2 5
20	CL	Brownish-yellow silty clay with gray streaks with trace medium sand and gravel moist low plasticity crumbly			
			SS	0	2/2 5
		Brownish-yellow silty clay with gray streaks with trace medium sand and gravel moist low plasticity crumbly more gravel and rock fragments toward bottom 8 yellowish-brown hard medium plasticity	SS	0	2 5/2 5
		Yellowish-brown silty clay firm medium plasticity moist with some gravel and grey mottles Thin (~8") gravel layers at 26 wet	SS	0	2 5/2 5
		Yellowish-brown silty clay with some gravel and rock fragments moist medium plasticity firm with gray streaks	SS	0	2 5/2 5
30		Yellowish-brown silty clay with some gravel moist medium plasticity firm with gray streaks	SS	10	2 5/2 5
		Yellowish-brown silty clay with some gravel moist low plasticity firm with gray streaks	SS	8	2 5/2 5
		Yellowish-brown silty clay with some gravel moist low plasticity firm with gray streaks more silty towards bottom	SS	3 5	2 5/2 5
	MH	Yellowish-brown silty fine sand wet	SS	3 5	2 5/2 5
40			WS		
50					

ENVIROGEN NEW SOLUTIONS TO HAZARDOUS WASTE PROBLEMS	McGRAW-EDISON CENTERVILLE, IA	BORING NUMBER P-05(2)

PLOT SCALE

PROJECT NUMBER 44061	LOGGED BY C ELVRUM
DRILLING CO ERM/AQUADRILL	DATE DRILLED 5-2-98
BORING METHOD GEOPROBE/DRILL RIG	FIELD SCREENING EQUIP PID
SAMPLING METHOD LASKEY SAMPLER	ANALYTICAL METHOD TCE
NOTES	DWG NAME borings logs

DEPTH (FT)	BORING LOG	DESCRIPTION AND COMMENTS	SAMPLES	HEAD SPACE (ppm)	RECOVERY
0	CL	Dark brown silty clay medium plasticity soft moist with trace sand gravel and roots with red brick fragments	SS	0	2.5/2.5
	CH	Black silty clay firm highly plastic with organic material and trace fine sand	SS	0	2.5/2.5
		Dark gray soft silty clay with organic material moist very plastic	SS	0	2.5/2.5
		Light olive-brown silty clay hard very plastic moist with gray streaks.	SS	0	2.5/2.5
10		Light olive-brown silty clay firm very plastic moist with gray mottles	SS	0	2.5/2.5
		Olive silty clay with olive-brown streaks hard very plastic moist with gravel	SS	0	2.5/2.5
	CL		SS	0	2/2.5
		Yellowish-red silty clay crumbly medium plasticity moist	SS	0	2/2.5
20		Brownish-yellow silty clay medium plasticity moist with gray mottles firm	SS	0	2/2.5
		Light olive-brown silty clay firm medium plasticity moist with gray mottles	SS	0	2/2.5
	SW	Medium coarse sand and gravel yellowish-brown wet	SS	0	2.5/2.5
	CH		SS	0	2.5/2.5
30		Light olive-brown silty clay with trace gravel moist high plasticity firm with gray streaks	SS	0	2.5/2.5
			SS	0	2.5/2.5
		Light olive-brown silty clay with trace gravel moist high plasticity firm with gray streaks more silty at bottom	SS	0	2/2.5
	SM	Light olive-brown silty fine sand wet	SS	0	2/2.5
40			WS		
50					

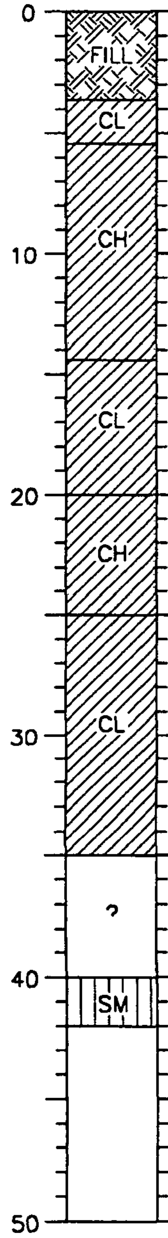
ENVIROGEN
NEW SOLUTIONS TO HAZARDOUS WASTE PROBLEMS

McGRAW-EDISON
CENTERVILLE, IA

BORING NUMBER P-06

PLOT SCALE 5

PROJECT NUMBER 44061	LOGGED BY C ELVRUM
DRILLING CO ERM/AQUADRILL	DATE DRILLED 5-2-98
BORING METHOD GEOPROBE/DRILL RIG	FIELD SCREENING EQUIP PID
SAMPLING METHOD LASKEY SAMPLER	ANALYTICAL METHOD TCE
NOTES BETWEEN 35 -40 LASKET TUBE WAS	DWG NAME borings logs
DEFORMED BY SAMPLER	



DESCRIPTION AND COMMENTS	SAMPLES	HEAD SPACE (ppm)	RECOVERY
Dark brown silty clayey fill with gravel and brick fragments moist soft with organic material	SS	0	1.5/2.5
Very dark gray silty clay soft medium plasticity wet with gravel and organic material slight odor	SS	0	1.5/2.5
Grayish-brown silty clay firm highly plastic moist with gray streaks	SS	0	2.5/2.5
Light olive-brown silty clay fine highly plastic moist with grey streaks	SS	0	2.5/2.5
Olive silty clay hard very plastic wet with gray and yellow-brown mottles	SS	0	2.5/2.5
Olive-gray silty clay hard very plastic with trace sand moist	SS	0	2.5/2.5
Silty clay hard medium plasticity with trace sand moist			
Gray silty clay with trace sand and gravel hard medium plasticity moist	SS	0	2.5/2.5
Strong brown silty clay with trace sand firm medium plasticity moist with gray streaks			
Strong brown silty clay with trace sand firm medium plasticity moist with gray streaks more olive-brown near bottom	SS	0	2.5/2.5
	SS	0	2.5/2.5
Yellowish-brown silty clay soft highly plastic with gray mottles trace gravel and few black mottles moist	SS	0	
Light olive-brown silty clay soft medium plasticity with trace sand and gravel and rock fragments wet	SS	0	2.5/2.5
	SS	0	2.5/2.5
Light olive-brown silty with trace sand and gravel very hard medium plasticity moist with gray streaks	SS	0	2.5/2.5
	SS	0	2.5/2.5
	SS		
	SS		
Silty fine sand light olive-brown wet	SS	0	2/2
	WS		

ENVIROGEN
NEW SOLUTIONS TO HAZARDOUS WASTE PROBLEMS

McGRAW-EDISON
CENTERVILLE, IA

BORING NUMBER P-07

PLOT CALE

PROJECT NUMBER 44061	LOGGED BY C ELVRUM
DRILLING CO ERM/AQUADRILL	DATE DRILLED 5-3-98
BORING METHOD GEOPROBE/DRILL RIG	FIELD SCREENING EQUIP PID
SAMPLING METHOD LASKEY SAMPLER	ANALYTICAL METHOD TCE
NOTES	DWG NAME borings logs

DEPTH (FT)	BORING LOG	DESCRIPTION AND COMMENTS	SAMPLES	HEAD SPACE (ppm)	RECOVERY
0	FILL	Dark brown silty clay fill with red brick fragments with trace gravel and roots soft medium plasticity moist	SS	0	2.5/2.5
	SW	Black medium coarse sand and gravel moist	SS	0	2.5/2.5
	CL	Very dark gray soft silty clay with trace gravel moist			
	CH	Light olive-brown silty clay firm moist highly plastic with gray mottles	SS	0	2.5/2.5
			SS	0	2.5/2.5
10		Light gray silty clay with olive-brown mottling firm moist highly plastic	SS	0	2.5/2.5
		Light gray silty clay with olive-brown mottling firm moist highly plastic with grey bottom	SS	0	2.5/2.5
	CL	Strong brown silty clay hard with black nodules and gray mottles moist medium plasticity			
		Strong brown silty clay hard with black nodules and gray mottles moist medium plasticity crumbly	SS	0	2.5/2.5
			SS	0	2.5/2.5
20		Yellowish-brown silty clay firm moist medium plastic with black nodules and grey mottles trace gravel	SS	0	2.5/2.5
		Yellowish-brown silty clay firm moist medium plastic with black nodules and grey mottles trace gravel olive-brown towards bottom	SS	0	2.5/2.5
	SW	Yellowish-brown medium to coarse graded sand	SS	0	1/2.5
	CH	Olive-brown silty clay hard highly plastic moist.	SS	0	1/2.5
30	CL	Light olive-brown silty clay with gray streaks and trace gravel firm low plasticity crumbly moist	SS	0	2.5/2.5
			SS	0	2.5/2.5
	SM	Light olive-brown silty fine sand wet, clayey near bottom	SS	0	2.5/2.5
	CL	Light olive-brown silty clay low plasticity wet soft	SS	0	2.5/2.5
40	SM	Light olive-brown fine silty sand wet	SS	0	2/2
			WS		
50					

ENVIROGEN
NEW SOLUTIONS TO HAZARDOUS WASTE PROBLEMS

McGRAW-EDISON
CENTERVILLE, IA

BORING NUMBER P-08

PLOT SCALE

PROJECT NUMBER 44061	LOGGED BY Y CHANG
DRILLING CO ERM/AQUADRILL	DATE DRILLED 5-13-98
BORING METHOD GEOPROBE/DRILL RIG	FIELD SCREENING EQUIP NA
SAMPLING METHOD LASKEY SAMPLER	ANALYTICAL METHOD TCE
NOTES	DWG NAME borings logs

DEPTH (FT)	BORING LOG	DESCRIPTION AND COMMENTS	SAMPLES	HEAD SPACE (ppm)	RECOVERY
0					
	CL	Dark gray silty clay moist medium plasticity turning brownish gray clay at ~8	SS		2/2
	CH	Dark brown clay highly plastic hard with yellowish-brown streaks	SS		2/2
10		Dark gray clay highly plastic hard with yellowish-brown streaks	SS		2/2
		Dark gray clay stiff highly plastic with yellowish-brown streaks	SS		2/2
	?				
20	CL		SS		2/2
		Yellowish-brown clayey sand wet medium plasticity			
	SC	Yellowish-brown sandy clay wet.			
30	SW	Yellowish-brown sand and gravel well graded wet	SS		1/2
40					
50					

ENVIROGEN
NEW SOLUTIONS TO HAZARDOUS WASTE PROBLEMS

McGRAW-EDISON
CENTERVILLE, IA

BORING NUMBER P-09

Table B 1 1 TCE concentrations of soil borings
McGraw Edison Site Centerville Iowa

Borehole ID	Sample Date	Depth (feet)	Lab TCE (ug/kg)	Field TCE (ug/kg)	Borehole ID	Sample Date	Depth (feet)	Lab TCE (ug/kg)	Field TCE (ug/kg)
P 01	27 Apr 98	1 3	ns	2 2	P 05	30-Apr 98	9-11	d	d
P 01	27 Apr 98	3-5	ns	nd	P 05	30-Apr 98	11 13	ns	nd
P 01	27 Apr 98	5-7		d	P 05	30-Apr 98	13-15		d
P-01	27 Apr 98	7 9	ns	nd	P 05	30-Apr 98	15 17	ns	nd
P-01	27 Apr 98	9 11	d	d	P 05	30-Apr 98	17 19		d
P 01	27 Apr 98	11 13	ns	d	P 05	30 Apr 98	19-21	ns	d
P 01	27 Apr 98	13 15	ns	d	P 05 (2)	1 May 98	5-7 5	ns	d
P 01	27 Apr 98	17 19	ns	nd	P 05 (2)	1 May 98	7 5 10	d	nd
P 01	27 Apr 98	19 21	ns	nd	P 05 (2)	1 May 98	10 12 5	ns	d
P 01	27 Apr 98	21 23	s	nd	P 05 (2)	1 May 98	12 5-15	ns	d
P 01	27 Apr 98	23 25	s	d	P 05 (2)	1 May 98	15 17 5	ns	d
P 01	27 Apr 98	25 27	s	d	P 05 (2)	1 May 98	17 5-20	s	1 5
P 01	28 Apr 98	27 29	ns	d	P 05 (2)	1 May 98	20 22 5	s	4
P 01	28-Apr 98	29 31	ns	nd	P 05 (2)	1 May 98	22 5-25	ns	26 8
P 01	28 Apr 98	31 33		d	P 05 (2)	1 May 98	25 27 5		88
P 01	28-Apr 98	33-35	d	nd	P 05 (2)	1 May 98	27 5-30	ns	83 6
P 01	29 Apr 98	35 37	n	d	P 05 (2)	1 May 98	30 32 5		52 3
P 01	28 Apr 98	39-41	ns	d	P 05 (2)	1 May 98	32 5 35	ns	8 1
P 02	29 Apr 98	1 3	d	d	P 05 (2)	1 May 98	35 37 5		3 3
P 02	29 Apr 98	3 5	ns	d	P 05 (2)	1 May 98	37 5-40	d	d
P 02	29 Apr 98	5-7		d	P 06	2 May 98	0-2 5	n	d
P 02	29-Apr 98	7 9	n	d	P 06	2 May 98	2 5-5		d
P 02	29 Apr 98	9 11	n	nd	P 06	2 May 98	5 7 5	ns	d
P 02	29 Apr 98	11 13	s	d	P 06	2 May 98	7 5-10		3 2
P 02	29 Apr 98	13 15	s	d	P 06	2 May 98	10-12 5		7 7
P 02	29-Apr 98	15-17		d	P 06	2 May 98	12 5-15	d	nd
P 02	29 Apr 98	17 19	ns	d	P 06	2 May 98	15 17 5		d
P-02	29 Apr 98	19 21	ns	d	P 06	2 May 98	17 5 20	s	d
P 02	29 Apr 98	21 23		d	P 06	2 May 98	20 22 5		d
P 02	29 Apr 98	23-25	ns	nd	P 06	2 May 98	22 5-25	ns	d
P 02	29 Apr 98	25-27		d	P 06	2 May 98	25-27 5		9 3
P 02	29-Apr 98	27 29	ns	d	P 06	2 May 98	27 5-30		23 4
P 02	29 Apr 98	29 31		d	P 06	2 May 98	30 32 5		14 6
P-02	29 Apr 98	31 33	s	nd	P 06	2 May 98	32 5-35	ns	1 2
P 02	29-Apr 98	33 35	ns	d	P 06	2 May 98	35 37 5	n	nd
P 02	29 Apr 98	35 37	n	nd	P 06	2 May 98	37 5-40	d	d
P 02	29 Apr 98	37 39		nd	P 07	2 May 98	0-2 5		d
P 02	29 Apr 98	39 41	d	d	P 07	2 May 98	2 5-5	nd	d
P 03	3-May 98	0 2 5	n	d	P 07	2 May 98	5 7 5		1 3
P 03	3-May 98	2 5 5	ns	nd	P 07	2 May 98	7 5-10	ns	9 8
P 03	3-May 98	5-7 5	n	d	P 07	2 May 98	10 12 5		d
P 03	3 May 98	7 5 10	ns	nd	P 07	2 May 98	12 5-15	s	nd
P 03	3-May 98	10 12 5	d	d	P 07	2 May 98	15-17 5		d
P 03	3-May 98	12 5-15	ns	nd	P 07	2 May 98	17 5-20		d
P 03	3 May 98	15 17 5	ns	1 6	P 07	2 May 98	20 22 5		d
P 03	3-May 98	17 5-20	n	4 4	P 07	2 May 98	22 5-25	nd	d
P 03	3-May 98	20-22 5	n	d	P 07	2 May 98	25-27 5	ns	5 8
P 03	3-May 98	22 5 25	s	d	P 07	2 May 98	27 5-30		d
P 03	3-May 98	25-27 5		nd	P 07	2 May 98	30 32 5	ns	d
P 03	3 May 98	27 5-30	s	d	P 07	2 May 98	32 5-35	s	d
P 03	3-May 98	30-32 5		d	P 07	2 May 98	35-37 5		d
P-03	3 May 98	32 5-35	ns	nd	P 07	2 May 98	37 5-40	ns	d
P-03	3-May 98	35-37 5	ns	nd	P 07	2 May 98	40-42	ns	d
P-03	3 May 98	37 5-40	nd	nd	P 08	3-May 98	0-2 5	ns	nd
P 04	30-Apr 98	1 3		d	P 08	3-May 98	2 5-5		64 4
P 04	30-Apr 98	3 5	s	nd	P 08	3-May 98	5-7 5	s	48 4
P 04	30-Apr 98	5-7	ns	d	P 08	3-May 98	7 5-10	ns	104 9
P 04	30-Apr 98	7 9	ns	nd	P 08	3-May 98	10-12 5	ns	49 5
P 04	30-Apr 98	9-11	ns	d	P 08	3-May 98	12 5-15	s	8 8
P 04	30-Apr 98	11 13	ns	nd	P 08	3-May 98	15-17 5		d
P-04	30-Apr 98	13-15	ns	9 9	P 08	3-May 98	17 5-20	ns	nd
P-04	30-Apr 98	15-17	ns	nd	P 08	3-May 98	20-22 5	nd	nd
P 04	30 Apr 98	17 19	nd	nd	P 08	3-May 98	22 5-25	ns	nd
P 04	30-Apr 98	19-21	s	d	P 08	3-May 98	25-27 5	ns	6 4
P 04	1 May 98	30-32	ns	11 9	P 08	3-May 98	27 5-30	ns	1 8
P-04	1 May 98	32 5-35	ns	nd	P 08	3-May 98	30-32 5	nd	nd
P 04	1 May 98	35-37 5	ns	nd	P 08	3-May 98	32 5-35	ns	d
P-04	1 May 98	37 5-39	ns	nd	P 08	3-May 98	35-37 5	ns	d
P 04	1 May 98	39-40	ns	nd	P 08	3-May 98	37 5-40	ns	nd
P 04 (2)	3-May 98	20-22 5	ns	nd	P 08	3-May 98	40-42	ns	nd
P 04 (2)	3-May 98	22 5-25	ns	nd	P 09 (SB SC2)	13-May 98	6 8	130	ns
P 04 (2)	3-May 98	25-27 5	ns	nd	P 09 (SB-SC2)	13 May 98	8-10	120	ns
P 04 (2)	3-May 98	27 5-30	ns	nd	P 09 (SB SC2)	13-May 98	10-12	80	ns
P 05	30-Apr 98	1 3	ns	nd	P 09 (SB SC2)	13-May 98	12 14	4	ns
P 05	30 Apr 98	3-5	ns	nd	P 09 (SB SC2)	13-May 98	18-20	d	
P 05	30-Apr 98	5-7	ns	nd	P 09 (SB SC2)	13-May 98	28-30	8	ns
P 05	30-Apr 98	7 9	ns	nd					

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(2) B ri g w re- itia ed d mpl d

Table B 1 2 Concentration of TCE (hydropunch) in groundwater from soil borings McGraw-Edison Site Centerville Iowa

Borehole ID	Sample Date	Sample Depth (ft)	Lab TCE (ppb)	Field TCE (ppb)
P 01	28 Apr 98	39-41	ns	nd
P 02	30 Apr 98	32-41	4 0	4 3
P 03	3 May 98	40-43	ns	nd
P 04	1 May 98	40-43	ns	nd
P 05 (2)	1 May 98	40-43	ns	nd
P 06	2 May 98	42-45	2 0	1 0
P 07	2 May 98	42-45	ns	1 3
P 08	3 May 98	40-43	ns	nd

ns Not sampled

nd Constituent not detected in alalysis

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(1 3)
Sampling Date	4/27/98
Analysis Code	CI0010
Analysis Date	4/27/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	2 2
TOTAL VOCs	2 2

COOPER IOWA

Field Analysis Report Form

Target Compounds

by Photovac GC/PID

Sample Identification	P1(3 5)
Sampling Date	4/27/98
Analysis Code	CI0011
Analysis Date	4/27/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(5 7)
Sampling Date	4/27/98
Analysis Code	CI0012
Analysis Date	4/27/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(7 9)
Sampling Date	4/27/98
Analysis Code	CI0013
Analysis Date	4/27/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(9 11)
Sampling Date	4/27/98
Analysis Code	CI0014
Analysis Date	4/27/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(11 13)
Sampling Date	4/27/98
Analysis Code	CI0015
Analysis Date	4/27/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(13 15)
Sampling Date	4/27/98
Analysis Code	CI0016
Analysis Date	4/27/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(17 19)
Sampling Date	4/27/98
Analysis Code	CI0019
Analysis Date	4/27/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(19 21)
Sampling Date	4/27/98
Analysis Code	CI0020
Analysis Date	4/27/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(21 23)
Sampling Date	4/27/98
Analysis Code	CI0021
Analysis Date	4/27/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(23 25)
Sampling Date	4/27/98
Analysis Code	CI0022
Analysis Date	4/27/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(25 27)
Sampling Date	4/27/98
Analysis Code	CI0023
Analysis Date	4/27/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	RINSATEBLANK1
Sampling Date	4/28/98
Analysis Code	CI0030
Analysis Date	4/28/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/l)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(27 29)
Sampling Date	4/28/98
Analysis Code	CI0031
Analysis Date	4/28/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(29 31)
Sampling Date	4/28/98
Analysis Code	CI0032
Analysis Date	4/28/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(31 33)
Sampling Date	4/28/98
Analysis Code	CI0033
Analysis Date	4/28/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(33 35)
Sampling Date	4/28/98
Analysis Code	CI0034
Analysis Date	4/28/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P 1(35 37)
Sampling Date	4/29/98
Analysis Code	CI0050
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1(39 41)
Sampling Date	4/28/98
Analysis Code	CI0035
Analysis Date	4/28/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(1 3)
Sampling Date	4/29/98
Analysis Code	CI0057
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(3 5)
Sampling Date	4/29/98
Analysis Code	CI0058
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(5 7)
Sampling Date	4/29/98
Analysis Code	CI0059
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(7 9)
Sampling Date	4/29/98
Analysis Code	CI0060
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(9 11)
Sampling Date	4/29/98
Analysis Code	CI0061
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(11 13)
Sampling Date	4/29/98
Analysis Code	CI0062
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(13 15)
Sampling Date	4/29/98
Analysis Code	CI0063
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(15 17)
Sampling Date	4/29/98
Analysis Code	CI0065
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(19 21)
Sampling Date	4/29/98
Analysis Code	CI0067
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(15 17)
Sampling Date	4/29/98
Analysis Code	CI0065
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(21 23)
Sampling Date	4/29/98
Analysis Code	CI0068
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(23 25)
Sampling Date	4/29/98
Analysis Code	CI0069
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(25 27)
Sampling Date	4/29/98
Analysis Code	CI0070
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(27 29)
Sampling Date	4/29/98
Analysis Code	CI0071
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(29 31)
Sampling Date	4/29/98
Analysis Code	CI0072
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(31 33)
Sampling Date	4/29/98
Analysis Code	CI0073
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(33 35)
Sampling Date	4/29/98
Analysis Code	CI0074
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(37 39)
Sampling Date	4/29/98
Analysis Code	CI0076
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2(39 41)
Sampling Date	4/29/98
Analysis Code	CI0077
Analysis Date	4/29/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(0 2 5)
Sampling Date	5/3/98
Analysis Code	CI0030
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(2 5 5)
Sampling Date	5/3/98
Analysis Code	C10031
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(5 7 5)
Sampling Date	5/3/98
Analysis Code	CI0033
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(2 5 5)
Sampling Date	5/3/98
Analysis Code	CI0031
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(7 5 10)
Sampling Date	5/3/98
Analysis Code	CI0032
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(10 12 5)
Sampling Date	5/3/98
Analysis Code	CI0034
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(12 5 15)
Sampling Date	5/3/98
Analysis Code	CI0035
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(17 5 20)
Sampling Date	5/3/98
Analysis Code	CI0037
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	4 4
TOTAL VOCs	4 4

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(20 22 5)
Sampling Date	5/3/98
Analysis Code	CI0038
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(22 5 25)
Sampling Date	5/3/98
Analysis Code	CI0039
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(25 27 5)
Sampling Date	5/3/98
Analysis Code	CI0042
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(27 5 30)
Sampling Date	5/3/98
Analysis Code	CI0043
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(30 32 5)
Sampling Date	5/3/98
Analysis Code	CI0044
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(32 5 35)
Sampling Date	5/3/98
Analysis Code	C10045
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(35 37 5)
Sampling Date	5/3/98
Analysis Code	CI0046
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (μg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3(37 5 40)
Sampling Date	5/3/98
Analysis Code	CI0047
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(1 3)
Sampling Date	4/30/98
Analysis Code	C10022
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(3 5)
Sampling Date	4/30/98
Analysis Code	CI0023
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(5 7)
Sampling Date	4/30/98
Analysis Code	CI0024
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(7 9)
Sampling Date	4/30/98
Analysis Code	CI0025
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(9 11)
Sampling Date	4/30/98
Analysis Code	CI0034
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA

Field Analysis Report Form

Target Compounds

by Photovac GC/PID

Sample Identification	P4(11 13)
Sampling Date	4/30/98
Analysis Code	CI0035
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(13 15)
Sampling Date	4/30/98
Analysis Code	CI0031
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	9 9
TOTAL VOCs	9 9

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(13 15)
Sampling Date	4/30/98
Analysis Code	CI0031
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	9 9
TOTAL VOCs	9 9

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(15 17)
Sampling Date	4/30/98
Analysis Code	CI0030
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(17 19)
Sampling Date	4/30/98
Analysis Code	CI0032
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(19 21)
Sampling Date	4/30/98
Analysis Code	CI0033
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(30 32)
Sampling Date	5/1/98
Analysis Code	CI0008
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	11 9
TOTAL VOCs	11 9

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(32 5 35)
Sampling Date	5/1/98
Analysis Code	CI0011
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(35 37 5)
Sampling Date	5/1/98
Analysis Code	CI0012
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(37 5 39)
Sampling Date	5/1/98
Analysis Code	CI0013
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(39 40)
Sampling Date	5/1/98
Analysis Code	CI0014
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (μg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(1 3)
Sampling Date	4/30/98
Analysis Code	CI0011
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(3 5)
Sampling Date	4/30/98
Analysis Code	CI0012
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(5 7)
Sampling Date	4/30/98
Analysis Code	CI0013
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(7 9)
Sampling Date	4/30/98
Analysis Code	CI0014
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(9 11)
Sampling Date	4/30/98
Analysis Code	CI0015
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(11 13)
Sampling Date	4/30/98
Analysis Code	CI0016
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (μg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(13 15)
Sampling Date	4/30/98
Analysis Code	CI0017
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(15 17)
Sampling Date	4/30/98
Analysis Code	CI0018
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(17 19)
Sampling Date	4/30/98
Analysis Code	CI0019
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(19 21)
Sampling Date	4/30/98
Analysis Code	CI0020
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)5 7 5
Sampling Date	5/1/98
Analysis Code	CI0026
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (μg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)7 5 10
Sampling Date	5/1/98
Analysis Code	CI0025
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)10 12 5
Sampling Date	5/1/98
Analysis Code	CI0027
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)12 5 15
Sampling Date	5/1/98
Analysis Code	CI0028
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)15 17 5
Sampling Date	5/1/98
Analysis Code	CI0029
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)17 5 20
Sampling Date	5/1/98
Analysis Code	CI0030
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	1 5
TOTAL VOCs	1 5

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)20 22 5
Sampling Date	5/1/98
Analysis Code	CI0031
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	4 0
TOTAL VOCs	4 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)22 5 25
Sampling Date	5/1/98
Analysis Code	CI0032
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	26 8
TOTAL VOCs	26 8

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)25 27 5
Sampling Date	5/1/98
Analysis Code	CI0033
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	88 0
TOTAL VOCs	88 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)27 5 30
Sampling Date	5/1/98
Analysis Code	CI0034
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	83 6
TOTAL VOCs	83 6

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)30 32 5
Sampling Date	5/1/98
Analysis Code	CI0035
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	52 3
TOTAL VOCs	52 3

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)32 5 35
Sampling Date	5/1/98
Analysis Code	CI0036
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	8 1
TOTAL VOCs	8 1

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)35 37 5
Sampling Date	5/1/98
Analysis Code	CI0037
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	3 3
TOTAL VOCs	3 3

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)37 5 40
Sampling Date	5/1/98
Analysis Code	CI0038
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)32 5 35
Sampling Date	5/1/98
Analysis Code	CI0036
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	8 1
TOTAL VOCs	8 1

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(0 2 5)
Sampling Date	5/2/98
Analysis Code	CI0007
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(2 5 5)
Sampling Date	5/2/98
Analysis Code	CI0008
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(5 7 5)
Sampling Date	5/2/98
Analysis Code	CI0009
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(7 5 10)
Sampling Date	5/2/98
Analysis Code	CI0010
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	3 2
TOTAL VOCs	3 2

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(10 12 5)
Sampling Date	5/2/98
Analysis Code	CI0011
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (μg/Kg)
Trichloroethene (TCE)	7 7
TOTAL VOCs	7 7

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(15 17 5)
Sampling Date	5/2/98
Analysis Code	CI0013
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(17 5 20)
Sampling Date	5/2/98
Analysis Code	CI0014
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(20 22 5)
Sampling Date	5/2/98
Analysis Code	CI0015
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(22 5 25)
Sampling Date	5/2/98
Analysis Code	CI0016
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (μg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(25 27 5)
Sampling Date	5/2/98
Analysis Code	CI0017
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	9 3
TOTAL VOCs	9 3

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(27 5 30)
Sampling Date	5/2/98
Analysis Code	CI0018
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	23 4
TOTAL VOCs	23 4

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(30 32 5)
Sampling Date	5/2/98
Analysis Code	CI0019
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	14 6
TOTAL VOCs	14 6

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(32 5 35)
Sampling Date	5/2/98
Analysis Code	CI0020
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	1 2
TOTAL VOCs	1 2

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(35 37 5)
Sampling Date	5/2/98
Analysis Code	CI0021
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6(37 5 40)
Sampling Date	5/2/98
Analysis Code	CI0022
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(0 2 5)
Sampling Date	5/2/98
Analysis Code	CI0029
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(2 5 5)
Sampling Date	5/2/98
Analysis Code	CI0030
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(5 7 5)
Sampling Date	5/2/98
Analysis Code	CI0031
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	1 3
TOTAL VOCs	1 3

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(7 5 10)
Sampling Date	5/2/98
Analysis Code	CI0032
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	9 8
TOTAL VOCs	9 8

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(10 12 5)
Sampling Date	5/2/98
Analysis Code	CI0033
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(12 5 15)
Sampling Date	5/2/98
Analysis Code	CI0034
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(15 17 5)
Sampling Date	5/2/98
Analysis Code	CI0035
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(17 5 20)
Sampling Date	5/2/98
Analysis Code	CI0036
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(20 22 5)
Sampling Date	5/2/98
Analysis Code	CI0037
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(22 5 25)
Sampling Date	5/2/98
Analysis Code	CI0038
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(25 27 5)
Sampling Date	5/2/98
Analysis Code	CI0039
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	5 8
TOTAL VOCs	5 8

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(27 5 30)
Sampling Date	5/2/98
Analysis Code	CI0040
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(30 32 5)
Sampling Date	5/2/98
Analysis Code	CI0041
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(32 5 35)
Sampling Date	5/2/98
Analysis Code	CI0042
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7(40 42)
Sampling Date	5/2/98
Analysis Code	CI0044
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(0 2 5)
Sampling Date	5/3/98
Analysis Code	CI0007
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(5 7 5)
Sampling Date	5/3/98
Analysis Code	CI0009
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	48 4
TOTAL VOCs	48 4

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(7 5 10)
Sampling Date	5/3/98
Analysis Code	CI0010
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	104 9
TOTAL VOCs	104 9

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(10 12 5)
Sampling Date	5/3/98
Analysis Code	CI0011
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	49 5
TOTAL VOCs	49 5

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(12 5 15)
Sampling Date	5/3/98
Analysis Code	CI0012
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	8 8
TOTAL VOCs	8 8

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(15 17 5)
Sampling Date	5/3/98
Analysis Code	CI0013
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(17 5 20)
Sampling Date	5/3/98
Analysis Code	CI0014
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(20 22 5)
Sampling Date	5/3/98
Analysis Code	CI0015
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(22 5 25)
Sampling Date	5/3/98
Analysis Code	CI0016
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(25 27 5)
Sampling Date	5/3/98
Analysis Code	CI0017
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	6 4
TOTAL VOCs	6 4

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(27 5 30)
Sampling Date	5/3/98
Analysis Code	CI0018
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	1 8
TOTAL VOCs	1 8

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(30 32 5)
Sampling Date	5/3/98
Analysis Code	CI0019
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(32 5 35)
Sampling Date	5/3/98
Analysis Code	CI0020
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(35 37 5)
Sampling Date	5/3/98
Analysis Code	CI0021
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(37 5 40)
Sampling Date	5/3/98
Analysis Code	CI0022
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8(40 42)
Sampling Date	5/3/98
Analysis Code	CI0023
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/Kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(2)20 22 5
Sampling Date	5/3/98
Analysis Code	CI0049
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(2)22 5 25
Sampling Date	5/3/98
Analysis Code	CI0050
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(2)25 27 5
Sampling Date	5/3/98
Analysis Code	CI0051
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4(2)27 5 30
Sampling Date	5/3/98
Analysis Code	CI0052
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	RINSATEBLANK1
Sampling Date	4/28/98
Analysis Code	C10030
Analysis Date	4/28/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/l)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P1 WATER
Sampling Date	4/28/98
Analysis Code	CI0037
Analysis Date	4/28/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/l)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P2 WATER
Sampling Date	4/30/98
Analysis Code	CI0036
Analysis Date	4/30/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/l)
Trichloroethene (TCE)	4 3
TOTAL VOCs	4 3

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P3WATER
Sampling Date	5/3/98
Analysis Code	CI0048
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/l)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P4 WATER
Sampling Date	5/1/98
Analysis Code	CI0015
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/l)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P5(2)WATER
Sampling Date	5/1/98
Analysis Code	CI0039
Analysis Date	5/1/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/kg)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P6 WATER
Sampling Date	5/2/98
Analysis Code	CI0023
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/l)
Trichloroethene (TCE)	1 0
TOTAL VOCs	1 0

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P7WATER
Sampling Date	5/2/98
Analysis Code	CI0045
Analysis Date	5/2/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/l)
Trichloroethene (TCE)	1 3
TOTAL VOCs	1 3

COOPER IOWA
Field Analysis Report Form
Target Compounds
by Photovac GC/PID

Sample Identification	P8 WATER
Sampling Date	5/3/98
Analysis Code	CI0028
Analysis Date	5/3/98
Instrument Code/Initials	C

Chemical Name	*Field GC Concentration* **Cs** (µg/l)
Trichloroethene (TCE)	0 0
TOTAL VOCs	0 0

Table B 2 1 Well details for existing monitoring wells
McGraw Edison Site Centerville Iowa

Well ID	Top of casing elevation (ft above MSL)	Ground surface elevation (ft above MSL)	Depth to bottom of well (ft below casing)	Screen elevation (ft above MSL)	Formation
MW 1	1022 85	1020 35	40 00	980 35 995 35	Intermediate sand
MW 2	1020 25	1020 50	13 00	1010 50 1015 5	Till unit #3 (perched water)
MW 3	1023 23	1020 70	70 00	950 70 960 70	Channel sand
MW 3A	1019 88	1020 63	35 00	985 63 995 63	Intermediate sand
MW-4	1020 45	1018 14	42 50	975 64 985 64	Intermediate sand
MW 5	1018 34	1015 84	39 90	975 76 985 64	Intermediate sand
MW 6	1021 46	1018 52	49 00	972 52 982 52	Intermediate sand
MW 7	1020 54	1020 76	69 00	951 54 976 54	Intermediate and channel sand
MW 7A	1020 24	1020 64	35 50	984 74 992 74	Upper sand
MW 8	1020 52	1018 16	40 90	978 26 982 26	Intermediate sand
MW 8A	1021 23	1018 27	34 00	984 27 993 27	Upper sand
MW 9	1020 26	1020 42	32 70	987 83 988 66	Till unit #3
MW 19WT	1015 91	1013 69	34 50	984 19 979 19	Intermediate sand
MW 20WT	1020 09	1017 67	39 50	988 17 978 17	Intermediate sand
MW 21	1022 21	1020 13	72 00	958 13 948 13	Channel sand
MW 22WT	1015 00	1015 20	35 00	985 2 980 2	Intermediate sand
MW 23WT	1013 64	1013 91	38 00	980 91 975 91	Intermediate sand
ALLEN WELL	Not surveyed		45 00	not installed	Till unit #2
WT 11	1020 27	1017 64	44 00	973 64 983 64	Intermediate sand
WT 12	1023 13	1020 49	47 00	973 49 983 49	Till unit #1
WT 13	1015 76	1013 24	47 00	966 24 976 24	Intermediate sand
WT 14	1019 46	1020 56	42 10	975 26 985 26	Intermediate sand
WT 16	1019 25	1017 19	42 50	976 69 985 09	Intermediate sand
WT 18	1021 62	1019 16	42 50	976 66 987 06	Intermediate sand
EW 1	1019 44	1019 44	47 50	978 44 973 44	Intermediate sand
BD 11	1021 19	1017 60	113 00	903 80 913 80	Base of till unit #1
BD 12	1022 83	1020 49	87 66	932 83 942 83	Intermediate sand and till #3
BD 13	1014 58	1012 47	83 00	929 47 939 87	Till unit #1
BD 14	1019 49	1020 75	70 00	947 55 957 55	Channel sand
BD 16	1019 66	1017 58	108 00	909 58 919 58	Till unit #1
BD 18	1021 28	1019 30	83 00	936 3 946 3	Till #1 and some lower sand
BR 10	1021 39	1020 09	136 00	not installed	Bedrock

From installation records measured by Woodward Clyde Consultants in the documents titled *Groundwater Operable Unit Feasibility Study (April 23 1993)* and *Supplemental RI/FS Investigation Report (April 1994)*

Table B 2 2 Water level data recorded on May 3 1998
McGraw Edison Site Centerville Iowa

Well ID	Top of casing elevation (ft above MSL)	Ground surface elevation (ft above MSL)	Depth to groundwater (ft below top of casing)	Water elevation (ft above MSL)
MW 1	1022 85	1020 35	29 55	993 30
MW 2	1020 25	1020 50	1 40	1018 85
MW 3	1023 23	1020 70	33 90	989 33
MW 3A	1019 88	1020 63	31 57	988 31
MW-4	1020 45	1018 14	32 00	988 45
MW 5	1018 34	1015 84	28 95	989 39
MW 6	1021 46	1018 52	32 40	989 06
MW 7	1020 54	1020 76	31 40	989 14
MW 7A	1020 24	1020 64	31 17	989 07
MW 8	1020 52	1018 16	31 33	989 19
MW 8A	1021 23	1018 27	29 00	992 23
MW 9	1020 26	1020 42	31 70	988 56
MW 19WT	1015 91	1013 69	20 75	995 16
MW 20WT	1020 09	1017 67	30 35	989 74
MW 21	1022 21	1020 13	33 00	989 21
MW 22WT	1015 00	1015 20	27 12	987 88
MW 23WT	1013 64	1013 91	26 17	987 47
ALLEN WELL	Not surveyed		31 47	
WT 11	1020 27	1017 64	31 40	988 87
WT 12	1023 13	1020 49	33 78	989 35
WT 13	1015 76	1013 24	26 18	989 58
WT 14	1019 46	1020 56	29 88	989 58
WT 16	1019 25	1017 19	30 22	989 03
WT 18	1021 62	1019 16	31 12	990 50
EW 1	1019 44	1019 44	31 66	987 78
BD 11	1021 19	1017 60	70 00	951 19
BD 12	1022 83	1020 49	49 90	972 93
BD 13	1014 58	1012 47	40 90	973 68
BD 14	1019 49	1020 75	29 93	989 56
BD 16	1019 66	1017 58	69 00	950 66
BD 18	1021 28	1019 30	40 88	980 40
BR 10	1021 39	1020 09	60 83	960 56

Table B 2 3 Calculated purge volume and amount of water purged from existing monitoring well

McGraw Edison Site Centerville Iowa

Well ID	Date Sampled	Three volumes (gallons)	Amount of water purged (gallons)
MW 1	7 May 98	33	33
MW 2	14 May 98	25 25	12
MW 3	13 May 98	84	83
MW 3A	13 May 98	5 75	6
MW-4	6 May 98	31	31
MW 5	12 May 98	27 75	10
MW-6	6 May 98	34	34
MW 7	13 May 98	86 75	50
MW 7A	13 May 98	13 25	2 5
MW 8	12 May 98	27 5	7
MW 8A	13 May 98	15	9
MW 9	Well not sampled due to dead animal		
MW 19WT	8 May 98	7 25	7 5
MW 20WT	7 May 98	5	5
MW 21	5 May 98	16 5	16 5
MW 22WT	6 May 98	6 5	6 5
MW 23WT	12 May 98	6 25	6 25
ALLEN WELL	13 May 98	Grab sample only	
WT 11	5-May 98	6 5	6 5
WT 12	5-May 98	6 5	6 5
WT 13	12 May 98	11 5	12
WT 14	7-May 98	7 5	7 5
WT 16	12 May 98	7 25	2 5
WT 18	13 May 98	7	7
EW 1	12 May 98	37 75	15
BD 11	6 May 98	24 5	24 5
BD 12	5 May 98	21	21
BD 13	12 May 98	23 7	2 5
BD 14	7 May 98	21 5	21 5
BD 16	12 May 98	22	13
BD 18	13 May 98	22 25	10
BR 10	8 May 98	224	47

Woodward-Clyde

Memorandum

To McGraw Edison File

From Tony Misercola

Office Detroit

Date July 31 1998

Subject Data Validation and Quality Assurance Summary
Soil and Groundwater Samples Collected In April and May 1998
McGraw Edison Centerville Iowa Site
Project # 91C3337D 300

Data Validation

Analytical results provided by Recra Environmental (Recra) were validated in accordance with Section 10 0 of the approved Quality Assurance Project Plan (QAPP) All TCE results and iron results reported for groundwater and soil samples were subjected to data validation The following U S EPA documents were used as guidance during the validation process

1 U S EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review February 1993

2 U S EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review February 1994

The overall conclusion of the data validation was that the data reported were acceptable for their intended use with minor qualification Acceptable levels of accuracy and precision were achieved for this data set except where noted below In addition completeness defined to be the percentage of analytical results which are judged to be valid including estimated values was 100 percent for this data set which satisfies the QAPP completeness goal of 90 percent Sample results for this data set required data qualification based on the minor QC deficiencies described below

- TCE results for four samples required qualification as estimated (J for detects UJ for non detects) based on holding time exceedances The four samples were analyzed between 18 and 21 days from sample collection and the U S EPA validation guidelines require that samples for VOC analyses be analyzed within 14 days of sample collection The implication is that the

TCE results for the subject samples may be biased low The affected samples included SB SC2 8 10 SB SC2 10 12 SB SC2 12 14 and SB SC2 18 20

- Sample MW 7A was analyzed as a matrix spike/matrix spike duplicate (MS/MSD) sample No other groundwater samples and no soil samples were analyzed as MS/MSD samples for this data set The MSD recovery for TCE indicated a potential high bias at 426 percent with an upper control limit of 118 percent Since the outlying spike recovery indicates a potential high bias detected TCE results for all groundwater samples were qualified as estimated (J)

- The TCE result for soil sample P6 12 5 15 required qualification as estimated (UJ for non detect) based on a low surrogate spike recovery (recovery was 74% with a lower control limit of 78%) The implication is that the TCE result for this sample may be biased low

- Soil sample P4 17 19 was reanalyzed due to outlying surrogate spike recoveries Surrogate spike recoveries for the initial sample analysis were biased high The reanalysis surrogate recoveries were biased low Since the sample TCE concentration was reported as non detected for both analyses and the surrogate recoveries from the initial analysis indicated a potential high bias the initial sample TCE analysis result is acceptable for use with out data qualification The TCE result for the reanalysis should not be used based on the potential low bias

- TCE results for groundwater field duplicate samples collected from MW 7 were not reproducible (MW 7 31μg/l and MW 7DUP 1μg/l) Typically field duplicate sample results that agree within a relative percent difference (RPD) of 50 percent are considered reproducible Based on the divergence in the TCE sample results the TCE results for MW 7 and MW 7DUP were qualified as estimated (data qualifier J)

It should be noted that an additional two TCE MS/MSD analyses for groundwater samples and two TCE MS/MSD analyses for soil samples (none were analyzed) were required to fulfill the QC frequency requirements of the QAPP Additionally all aqueous samples were delivered to the laboratory without accompanying trip blank samples for TCE analyses As such the potential for cross contamination during shipping activities could not be evaluated

Quality Assurance Audits

The field procedures were audited by Woodward Clyde on April 28 29 and May 4 6 1998 Mr John Seymour audited soil boring and sampling field gas chromatagraph analyses and decontamination procedures in the south culvert area

Mr Hosam Hassanien audited water level measurements the soil boring and sampling completed for IRPB wall soil sampling (for Golder) and groundwater monitoring well purging and sampling

It was concluded that MWR/Envirogen and Golder met associated procedures

Table B 1
QUALITY ASSURANCE/QUALITY CONTROL
FIELD SUMMARY
MAY 1998
McGraw Edison Site
Centerville, Iowa

I D #	Sample Date	Description	Data Package
MW 7	5/13/98	GW Duplicate	CC
MW 23WT	5/6/98	GW Duplicate	AA
EW 1	5/12/98	GW Duplicate	CC
BR 10	5/8/98	GW Duplicate	DD
MW 7A	5/13/98	GW Matrix Spike	CC
MW 7A	5/13/98	GW MS Duplicate	CC
MW 24	5/26/98	GW Field Blank	BB
MW 30	5/6/98	GW Field Blank	AA
MW 31	5/6/98	GW Field Blank	AA
MW 32	5/7/98	GW Field Blank	DD
MW 33	5/8/98	GW Field Blank	DD
MW 34	5/13/98	GW Field Blank	CC
Rinsate 2	4/29/98	Soil Field Blank	FF
Rinsate 3	4/30/98	Soil Field Blank	FF
Rinsate 4	5/1/98	Soil Field Blank	EE
Rinsate 5	5/2/98	Soil Field Blank	EE
Rinsate 6	5/2/98	Soil Field Blank	EE
P 2	4/30/98	GW Duplicate of Field GC Analysis	EE
P 6	5/2/98	GW Duplicate of Field GC Analysis	EE

<u>Notes/Legend</u>

GW = Groundwater

QC duplicates for soil samples collected and analyzed by field GC are shown on the attached B 1 1QA/QC

Table B 1 1 QA/QC
TCE Concentrations of Soil Samples
McGraw Edison Site Centerville Iowa

Bo eh le ID	Sample D te	Depth (feet)	Lab TCE (g/kg)	Field TCE (g/kg)	Borehole ID	Sampl Date	Depth (feet)	Lab TCE (ug/kg)	Fi ld TCE (ug/kg)
P 01	27 Ap 98	1 3		2 2	P 05	30-Ap 98	9 11	d	d
P-01	27 Ap 98	3-5	ns	nd	P 05	30-Apr 98	11 13	ns	nd
P 01	27 Ap 98	5-7	s	d	P 05	30-Ap 98	13-15	s	d
P-01	27 Apr 98	7 9	ns	nd	P 05	30-Apr 98	15-17	s	d
P 01	27 Ap 98	9-11	nd	d	P 05	30-Ap 98	17 19		d
P-01	27 Apr 98	11 13	n	nd	P 05	30 Ap 98	19-21	ns	d
P 01	27 Ap 98	13-15	s	nd	P 05 (2)	1 May 98	5-7 5	ns	d
P 01	27 Ap 98	17 19	ns	nd	P-05 (2)	1 May 98	7 5-10	nd	nd
P 01	27 Apr 98	19 21	ns	d	P 05 (2)	1 May 98	10-12 5	s	nd
P-01	27 Ap 98	21 23	ns	nd	P-05 (2)	1 May 98	12 5-15	ns	nd
P 01	27 Ap 8	23-25	s	nd	P 05 (2)	1 May 98	15-17 5	s	nd
P-01	27 Apr 98	25-27	ns	d	P-05 (2)	1 May 98	17 5-20	ns	1 5
P 01	28-Apr 98	27 29	ns	d	P 05 (2)	1 May 98	20-22 5		4
P-01	28-Apr 98	29-31	ns	nd	P-05 (2)	1 May 98	22 5-25	ns	26 8
P-01	28-Ap 98	31 33		nd	P 05 (2)	1 M y 98	25-27 5	ns	88
P-01	28-Apr 98	33-35	nd	nd	P-05 (2)	1-May 98	27 5-30	ns	83 6
P-01	29-Apr 98	35-37	s	d	P 05 (2)	1 May 98	30-32 5	s	52 3
P-01	28-Apr 98	39-41	ns	nd	P-05 (2)	1 May 98	32 5-35	ns	8 1
P-02	29 Apr 98	1 3	nd	d	P 05 (2)	1 May 98	35-37 5	s	3 3
P-02	29-Apr 98	3-5	ns	nd	P 05 (2)	1 May 98	37 5-40	nd	nd
P-02	29 Ap 98	5-7	s	d	P 06	2 May 98	0-2 5	s	nd
P-02	29-Apr 98	7 9	ns	nd	P-06	2 May-98	2 5-5	ns	nd
P 02	29 Ap 98	9 11		d	P 06	2 M y 98	5-7 5		d
P-02	29-Apr 98	11 13	ns	nd	P-06	2 May 98	7 5-10	ns	3 2
P 02	29-Ap 98	13-15	s	d	P 06	2 May 98	10-12 5	ns	7 7
P-02	29-Ap 98	15-17	ns	nd	P-06	2 May 98	12 5-15	nd (UJ)	nd
P 02	29-Ap 98	17 19	ns	d	P 06	2 May 98	15-17 5	s	d
P 02	29-Apr 98	19-21	ns	nd	P 06	2-May 98	17 5-20	ns	nd
P 02	29-Apr 98	21 23	ns	d	P 06	2 May 98	20 22 5		d
P 02	29-Apr 98	23-25	ns	nd	P-06	2 May-98	22 5-25	ns	nd
P 02	29-Ap 98	25 27	s	nd	P 06	2 May 98	25-27 5	ns	9 3
P 02	29-Apr 98	27 29	ns	nd	P-06	2 May 98	27 5-30	ns	23 4
P 02	29-Apr 98	29 31	ns	nd	P 06	2 May 98	30-32 5	s	14 6
P-02	29-Ap 98	31 33	ns	nd	P-06	2 May 98	32 5-35	ns	1 2
P 02	29 Ap 98	33-35	s	nd	P 06	2 May 98	35-37 5	s	d
P-02	29-Apr 98	35-37	ns	nd	P 06	2 May 98	37 5-40	nd	nd
P 02	29 Ap 98	37 39		nd	P 07	2 May 98	0-2 5	s	nd
P-02	29-Apr-98	39-41	nd	nd	P-07	2 May-98	2 5-5	nd	nd
P 03	3-M y 98	0-2 5		nd	P 07	2 May 98	5-7 5		1 3
P-03	3-May 98	2 5-5	s	nd	P-07	2 May 98	7 5-10	ns	9 8
P 03	3-May 98	5-7 5	ns	nd	P 07	2 May 98	10-12 5	s	nd
P-03	3-May 98	7 5-10	ns	nd	P-07	2 May 98	12 5-15	ns	nd
P 03	3-May 98	10-12 5	nd	d	P 07	2 May 98	15-17 5	s	d
P-03	3-May-98	12 5-15	ns	nd	P 07	2 May 98	17 5-20	ns	nd
P 03	3-May 98	15-17 5	s	1 6	P 07	2 May 98	20 22 5	ns	nd
P 03	3-May 98	17 5-20	ns	4 4	P 07	2-May-98	22.5-25	nd	nd
P 03	3-May 98	20-22 5	s	d	P 07	2 May 98	25-27 5	s	5 8
P-03	3-May 98	22 5-25	ns	nd	P-07	2 May 98	27 5-30	ns	nd
P 03	3-May 98	25-27 5	s	d	P 07	2 May 98	30-32 5		d
P-03	3-May 98	27 5-30	ns	nd	P-07	2 May 98	32 5-35	ns	nd
P 03	3-May 98	30-32 5	ns	nd	P 07	2 May 98	35-37 5	ns	nd
P-03	3-May 98	32 5-35		d	P 07	2-May 98	37 5-40	s	d
P-03	3-May 98	35-37 5	ns	d	P 07	2 May 98	40-42	s	d
P-03	3-May 98	37.5-40	nd	nd	P-08	3-May 98	0-2 5	ns	nd
P 04	30-Apr 98	1 3	ns	nd	P 08	3-May 98	2 5-5	ns	64 4
P-04	30-Apr 98	3-5	ns	nd	P-08	3-May 98	5-7 5	ns	48 4
P-04	30 Apr 98	5-7	ns	d	P 08	3-May 98	7 5-10	s	104 9
P-04	30-Apr 98	7 9	ns	nd	P-08	3-May 98	10-12 5	ns	49 5
P 04	30-Apr 98	9 11	ns	nd	P 08	3 May 98	12 5-15	ns	8 8
P-04	30-Apr 98	11 13	ns	nd	P 08	3-May 98	15-17 5	ns	nd
P 04	30-Ap 98	13-15	n	9 9	P 08	3-May 98	17 5-20		d
P-04	30-Apr 98	15-17	ns	nd	P-08	3-May 98	20-22 5	nd	nd
P 04	30-Apr 98	17 19	nd	nd	P 08	3-May 98	22 5-25	ns	nd
P 04	30-Apr 98	19-21	ns	nd	P-08	3-May 98	25-27 5	ns	6 4
P 04	1 May 98	30-32	s	11 9	P-08	3-M y 98	27 5-30	ns	1 8
P-04	1-May-98	32 5-35	ns	nd	P-08	3-May 98	30-32 5	nd	nd
P 04	1 May 98	35-37 5	ns	nd	P-08	3-May 98	32 5-35	ns	nd
P-04	1 May-98	37 5-39	ns	nd	P 08	3-May 98	35-37 5	ns	nd
P 04	1 May 98	39-40	ns	d	P-08	3 May 98	37 5-40	ns	d
P-04 (2)	3-May 98	20-22 5	ns	nd	P-08	3-May-98	40-42	ns	nd
P 04 (2)	3-May 98	22 5-25	ns	d	P 09 (SB SC2)	13-May 98	6-8	130	ns
P-04 (2)	3-May 98	25-27 5	ns	nd	P-09 (SB-SC2)	13-May 98	8-10	120 (J)	ns
P 04 (2)	3-May 98	27 5-30	ns	nd	P 09 (SB SC2)	13-May 98	10-12	80 (J)	ns
P-05	30-Apr 98	1 3	ns	nd	P-09 (SB-SC2)	13-May 98	12 14	4 (J)	ns
P 05	30-Apr 98	3-5	ns	nd	P 09 (SB SC2)	13 May 98	18-20	nd (UJ)	ns
P-05	30-Apr 98	5-7	ns	nd	P 09 (SB SC2)	13-May 98	28-30	8	ns
P 05	30-Ap 98	7 9	ns	d					

d compo d d cted ly J E t m d co ce trat f d cted lyt W C d lid t m m f J ly 998

mpl d f l b ly

(2) B g ed d mpled

Table B 2 2 QA/QC

Summary of May 1998 Groundwater TCE Analyses

McGraw Edison Site
Centerville Iowa

Well ID	1998 TCE (µg/L)
MW 1	nd
MW 2	1 100 000 J
MW 3	nd
MW 3A	6 400J 7 000dupJ
MW-4	nd
MW 5	nd
MW 6	9 2J
MW 7	31J 1dupJ
MW 7A	2J
MW 8	1J
MW 8A	7J
MW 9	
MW 19WT	70J
MW 20WT	20J
MW 21	nd
MW 22WT	nd
MW 23WT	nd
ALLEN WELL	51 J
WT 11	nd
WT 12	nd
WT 13	nd
WT 14	0 8J
WT 16	nd
WT 18	45J
EW 1	14J 12dupJ
BD 11	nd
BD 12	nd
BD 13	nd
BD 14	nd
BD 16	nd
BD 18	4J
BR 10	nd

NOTES

* Grab Sample
dup Duplicate Sample
nd Constituent not detected during analysis of sample
Not Obtained

J= Estimated concentration for detected analytes
see W C July 30 1998 memo

MOnitoring well MW 9 was not analyzed in May 1998 because a dead animal was stuck in the well

RECORD OF BOREHOLE GB 1

PROJECT McGRAW EDISON SITE
PROJECT LOCATION CENTERVILLE IOWA
PROJECT NUMBER 986 1083
GROUND ELEVATION NA

BORING DATE 5/4/98
BORING LOCATION N/A
TOC ELEVATION NA

SHEET 1 OF 2
DATUM
COORDINATES

DEPTH SCALE FEET	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV DEPTH	SAMPLES NUMBER	TYPE	BLOWS / 6	N	REC/ATT	NOTES/WELL SKETCH
0	4 25 ID HOLLOW STEM AUGER	0-0 5ft. Grass Topsoil Road Aggregate 0 5 to 18 0 ft Moist firm to very stiff mottled med gray-dark brown yellow-orange SILTY CLAY trace fine/med sand	 CL	 ▨	 0 50	1	DO	N/A	N/A	4 5/ 4 5	Boring location 12 east of MW 3A note soil sampling conducted w/ 5 long continuous Laske Samplers and acetate tubes Borehole abandoned w/ Be seal bentonite slurry Slurry was tremie pumped through auger flights
5						2	DO	N/A	N/A	5/5	
10						3	DO	N/A	N/A	5/5	
15		18 0 to 20 0 ft Slightly moist very stiff dark yellow/orange med gray/black SILTY CLAY trace of coarse to fine sand	CL	▨	18 00	4	DO	N/A	N/A	5/5	
20		20 0 to 25 0 ft Slightly moist firm stiff mottled dark yellow-orange light med gray gray SILTY CLAY trace little firm sand	CL	▨	20 00	5	DO	N/A	N/A	5/5	
25		25 0 to 28 5 ft Interbedded stiff very stiff moist yellow-orange SILTY CLAY and med gray SILTY CLAY trace sand 28 5 to 32 0 ft moist wet med gray to dark yellow-orange fine-coarse SAND little to some clayey silt, trace of gravel	CL SM	▨ 	25 00 28 50	6	DO	N/A	N/A	4/5	
30		32 0 to 40 0ft moist VERY STIFF HARD mottled yellow-orange/ med gray/med brown SILTY CLAY trace to little med to fine sand trace gravel	CL	▨	32 00	7	DO	N/A	N/A	3 2/5	
35						8	DO	N/A	N/A	4 7/5	
40					40 00						

DRILL RIG CME 75
DRILLING CONTRACTOR AQUADRILL
DRILLER M k Claasse

Golder Associates

LOGGED JGC
CHECKED JGC
DATE 6/25/98

RECORD OF BOREHOLE GB 1a

PROJECT McGRAW EDISON SITE
PROJECT LOCATION CENTERVILLE IOWA
PROJECT NUMBER 986-1083
GROUND ELEVATION NA

BORING DATE 5/5/98
BORING LOCATION N/A
TOC ELEVATION NA

SHEET 1 OF 1
DATUM
COORDINATES

DEPTH SCALE FEET	BORING METHOD	SOIL PROFILE				SAMPLES					NOTES/WELL SKETCH
		DESCRIPTION	USCS	GRAPHIC LOG	ELEV DEPTH	NUMBER	TYPE	BLOWS / 6	N	REC/ATT	
0	4 25 ID HOLLOW STEM AUGER	0-30 bgs for soil description see soil boring log GB-1									Boring location 7 east of GB-1 19 east of MW 3A. Note This boring was designed to retrieve a sample from the upper sand located in ~29-35 bgs Sampling started at 30 bgs Borehole abandoned w/ Benseal bentonite slurry Slurry was tremied after removing auger flights
5											
10											
15											
20											
25											
30		30 0-30 3 ft moist very stiff hard med gray/yellow-orange SILTY CLAY trace med to fine sand 30 3 31 3 ft wet dark yellow-orange coarse to fine SAND little to some clayey silt, trace gravel 31 3-32 5 ft moist VERY STIFF HARD mottled med gray/yellow-orange SILTY CLAY trace med to fine sand trace gravel 32 5 35 0 ft no recovery	CL SM CL	▨ ▨	30 00	1	DO	N/A	N/A	2 5/5	
35		Boring terminated @35 0 bgs			35 00						
40											

DRILL RIG CME 75
DRILLING CONTRACTOR AQUADRILL
DRILLER Mark Claas

Golder Associates

LOGGED JGC
CHECKED JGC
DATE 6/25/98

PROJECT McGRAW EDISON SITE

RECORD OF BOREHOLE GB 1

SHEET 2 OF 2

PROJECT LOCATION CENTERVILLE IOWA
BORING DATE 5/4/98
DATUM
PROJECT NUMBER 986-1083
BORING LOCATION N/A
COORDINATES
GROUND ELEVATION NA
TOC ELEVATION NA

DEPTH SCALE FEET	BORING METHOD	SOIL PROFILE				SAMPLES					NOTES/WELL SKETCH
		DESCRIPTION	USCS	GRAPHIC LOG	ELEV DEPTH	NUMBER	TYPE	BLOWS / 6	N	REC/ATT	
40	4 25 ID HOLLOW STEM AUGER	40 0 to 41 0ft wet yellow-orange med to fine SAND and SILTY CLAY	SC/CL	▨	40 00						
		41 0 to 55 0 ft wet dark yellow orange well sorted fine SAND trace to little clayey silt.	SM		41 00	9	DO	N/A	N/A	3 2/5	
45						10	DO	N/A	N/A	3/5	
50						11	DO	N/A	N/A	2/5	
55		55 0 to 56 0ft moist firm dark med-gray CLAYEY SILT and very fine SAND	SM/ML	▨	55 00	12	DO	N/A	N/A	1/5	
		56 0 to 68 5 ft wet dark yellow-orange well sorted fine SAND trace to little clayey silt.	SM		56 00						
60						13	DO	N/A	N/A	0/5	
65						14	DO	N/A	N/A	1 5/5	
		68 5 to 70 0ft moist hard med-brown SILTY CLAY, trace fine sand	CL	▨	68 50						
70		70 0 to 72 5ft wet yellow-orange coarse to fine SAND trace clayey Silt.	SM		70 00	15	DO	N/A	N/A	2 5/ 2.5	
		72 5 bgs Auger Refusal Limestone Fragments			72 50						
75											
80											

DRILL RIG CME 75
DRILLING CONTRACTOR AQUADRILL
DRILLER Mark Claasse

Golder Associates

LOGGED JGC
CHECKED JGC
DATE 6/25/98

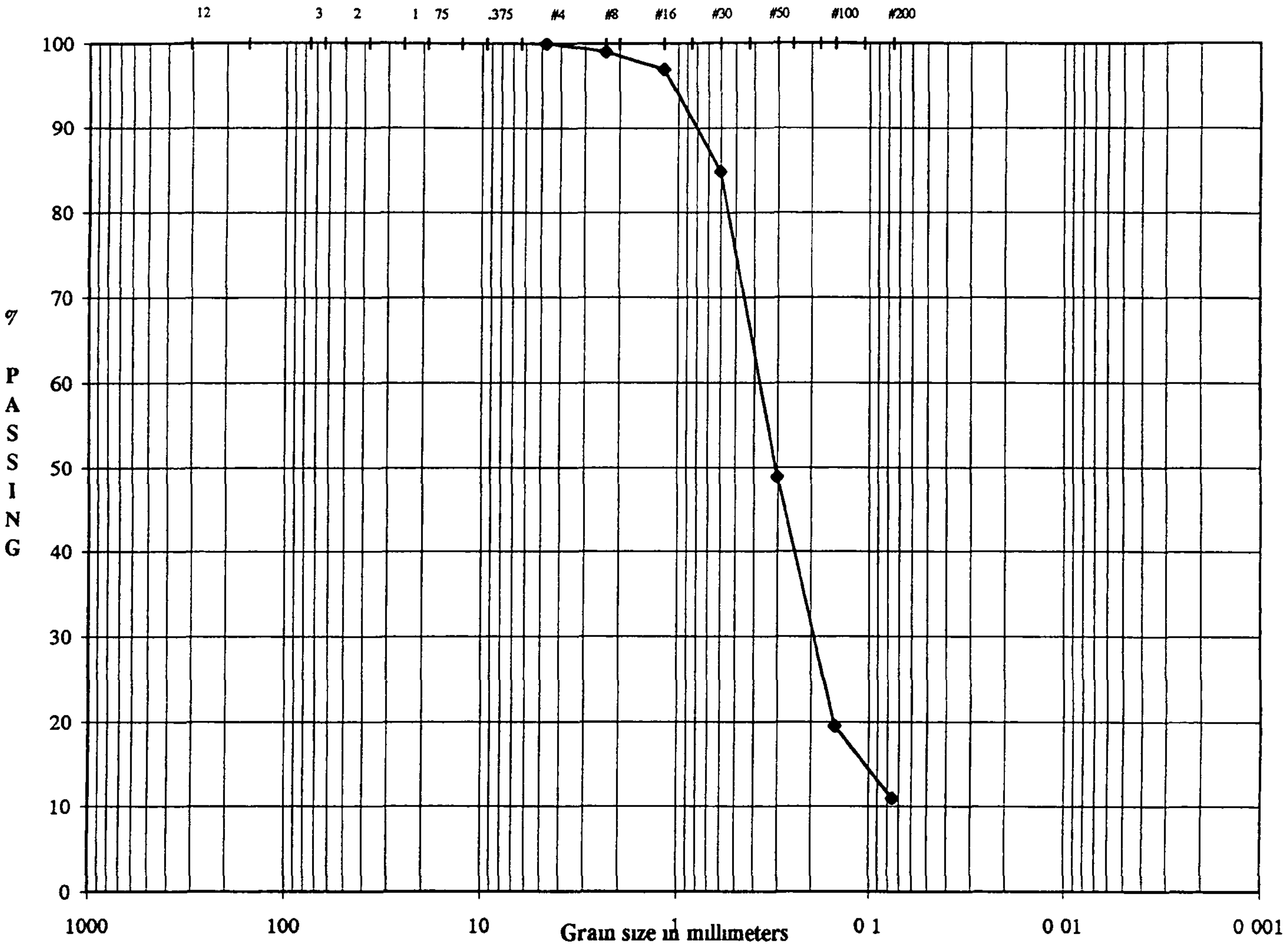
GSL / 986 1083 ENVIROGEN / IA
SUMMARY OF SOIL DATA

Sample Identification		Sample Type	Sample Depth	Soil Classification	Natural Moisture %	Atterberg Limits				Grain Size Distribution			Compaction		Gs	Unit Weight		Permeability (cm/sec)	Additional Tests Conducted (See Notes)
Boring Number	Sample Number					L L	P L	P I	L I	% Finer No 4 Sieve	% Finer No 200 Sieve	% Finer 005 mm	Maximum ry Densit (lb/cuft)	Optimum Moisture %		Moisture %	Dry (lb/cuft)		
GB 1	SA 8	Bag	35 0 39 7	CL	19 1	33 0	15 0	18 0	0 23	100 0	67 1	33 5			2 71				
GB 1	SA 9	Bag	41 0 43.2	SP						100 0	2 5				2 66				R
GB 1	SA 10	Bag	45 0 48 0	SP SM						100 0	5 7				2 72				R
GB 1	SA 11	Bag	55 0 56 0	ML	29 8	NP	NP	NP	NP	100 0	83 6	13 0			2 69				
GB 1	SA 14	Bag	68.5 70 0	CL	15 8	36 0	15 0	21 0	0 06	99 4	67 9	38 0			2 72				
GB 1	SA 15	Bag	70 0 72.5	SP SM						99 9	7 2				2 69				R L
GB 1	COL-253	Bag	28 5 31 9	SP SM						100 0	11 0				2 71				
IRON	161	Bag		SP						100 0	1 3				6 95				

ABBREVIATIONS
LIQUID LIMIT (LL)
PLASTIC LIMIT (PL)
PLASTICITY INDEX (PI)
LIQUIDITY INDEX (LI)
SPECIFIC GRAVITY (Gs)
MOISTURE (Mc)

NOTES
T = TRIAXIAL TEST
U = UNCONFINED COMPRESSION TEST
C = CONSOLIDATION TEST
DS = DIRECT SHEAR TEST
O = ORGANIC CONTENT
P = pH
R = RESISTIVITY
L = LEAK OFF

PARTICLE SIZE DISTRIBUTION
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	GB 1 COL 253
SAMPLE TYPE	Bag
SAMPLE DEPTH	28 5 31 9

LL	
PL	
PI	

DESCRIPTION Yellow MEDIUM TO FINE SAND little clayey silt
(DESORPTION TEST SAMPLE)

USCS SP-SM

Cu = D60/D10 = 0 38/0 07 = 5 43 < 6
Cc = D30 2/(D60 D10) = 0 19 2/(0.38 0 07) = 1 36 > 1

GSL/986-1083 ENVIROGEN /IA
IC3-3808

TECH	LB
DATE	6/23/98
CHECK	
REVIEW	

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	GSL/986 1083 ENVIROGEN /IA	**SAMPLE ID**	GB 1	COL-253
PROJECT NO	IC3 3808	**SAMPLE TYPE**	Bag	
REMARKS		**SAMPLE DEPTH**	28.5 31 9	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1 w2)	
Weight of Dry Soil (gm)	(w5=w2 w3)	
Moisture Content (%)	(w4/w5)*100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	541 58
	Tare Weight (gm)	114 13
(W6)	Total Dry Weight (gm)	427 45

SIEVE ANALYSIS

Tare Weight

0 00

	Wt Ret +Tare	(Wt Tare)	Cumulative (% Retained) {(wt ret/w6) 100	% PASS (100-% ret)	SIEVE	
12 0					12 0	cobbles
3 0					3 0	coarse gravel
2 5					2 5	coarse gravel
2 0					2 0	coarse gravel
1 5					1 5	coarse gravel
1 0					1 0	coarse gravel
0 75					0 75	fine gravel
0 50					0 50	fine gravel
0 375					0 375	fine gravel
#4	0 00	0 00	0 00	100 00	#4	coarse sand
#8	4 11	4 11	0 96	99 04	#8	coarse sand
#16	12 98	12 98	3 04	96 96	#16	medium sand
#30	64 83	64 83	15 17	84 83	#30	medium sand
#50	218 50	218 50	51 12	48 88	#50	fine sand
#100	343 87	343 87	80 45	19 55	#100	fine sand
#200	380 57	380 57	89 03	10 97	#200	fines
PAN					PAN	

% COBBLES	0 00
% C GRAVEL	0 00
% F GRAVEL	0 00
% C SAND	1 46
% M SAND	31 59
% F SAND	55 98
% FINES	10 97
% TOTAL	100 00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	
PL	
PI	
Gs	2 706

DESCRIPTION Yellow MEDIUM TO FINE SAND little clayey silt (DESORPTION TEST SAMPLE)

USCS SP-SM

TECH	LB
DATE	6/23/98
CHECK	
REVIEW	

SPECIFIC GRAVITY OF SOILS
ASTM D 854
PYCNOMETER METHOD

PROJECT TITLE	GSL / 986-1083 ENVIROGEN / IA		
PROJECT NUMBER	IC3 3808	**SAMPLE ID**	GB 1 COL-253
		SAMPLE TYPE	Bag
TESTED FOR	SPECIFIC GRAVITY	**SAMPLE DEPTH**	28.5 31 9

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare Inital (gm)	(W1)	17 63
Weight Soil and Tare Final (gm)	(W2)	17 62
Weight Of Tare (gm)	(W3)	3 23
Weight Of Moisture (gm)	(W4=W1 W2)	0 01
Weight Of Dry Soil (gm)	(W5=W2 W3)	14.39
Hygroscopic Moisture In (%)	(HM=(W4/W5) 100)	0 1%

AIR REMOVAL METHOD

VACUUM

Trial		1	2	3
Pycnometer Number		10		
Weight Pycnometer Empty (gm)	(Mf)	209 08		
Weight of Soil & Pycnometer (gm)		262 73		
Weight of Soil Water & Pycnometer (gm)	(Mb)	740 99		
Observed Temperature (Tb) for (Mb) In Degrees C		24 0		
Observed Temperature (Ta) for (Ma) In Degrees C		23 00		
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	707.30		
Relative Density of Water @ (Ta)		0 99757		
Relative Density of Water @ (Tx)		0 99732		
Correction Factor due to Temperature @Tx	(K)	0 9991		
Weight of Soil (gm)		53 65		
Weight of Dry Soil (gm)	(Mo)	53 61		
Weight of Pycnometer & Water (gm)	(Ma)	707 18		

SPECIFIC GRAVITY

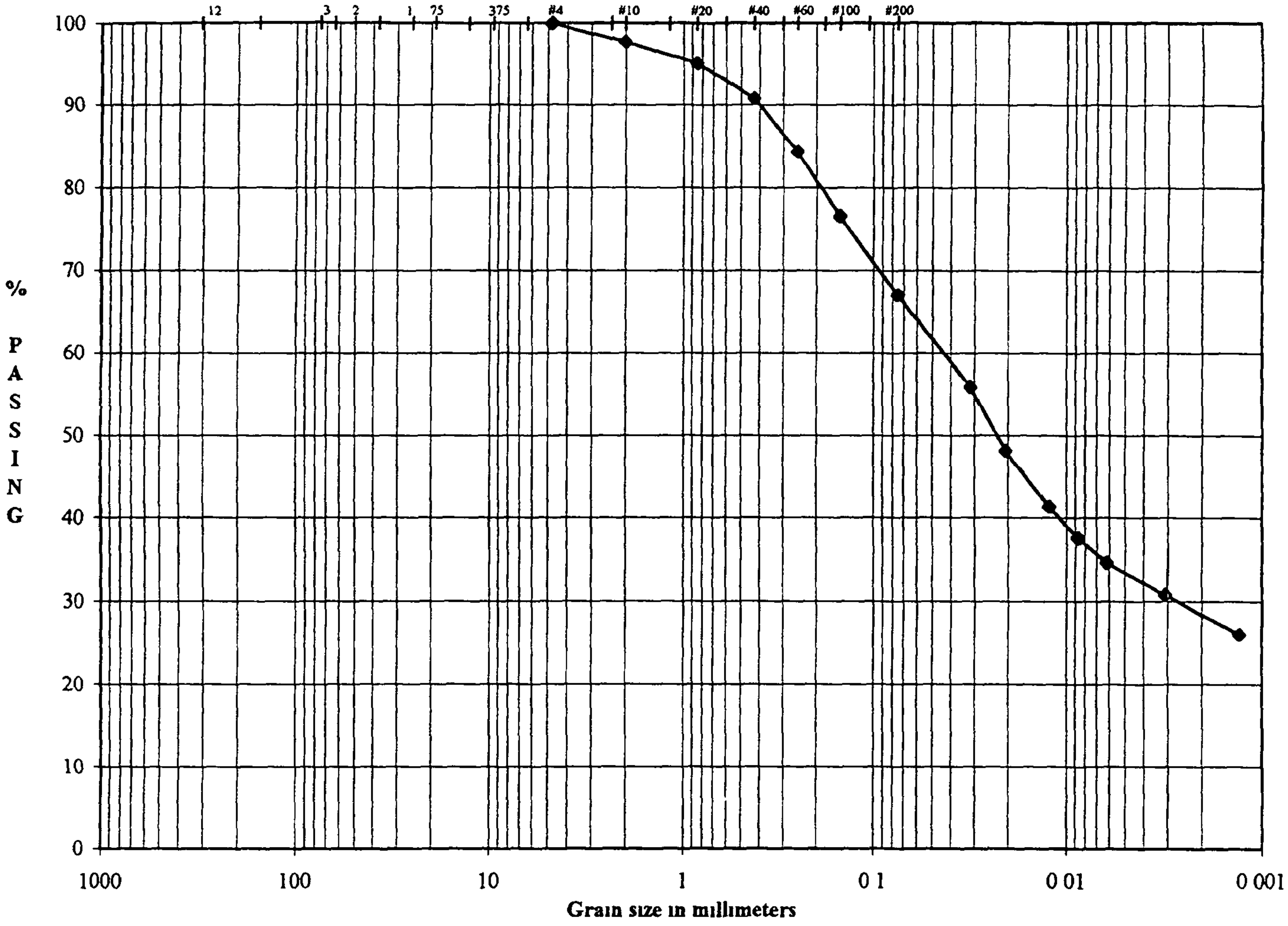
				Gs Average
G @ 20 degrees C = [Mo/(Mo+((Ma Mb))]*(K)	2 706			2 706

Correction Values Due To Temperature

Temp (C)	Rel Density	Corr (K)	Temp (C)	Rel Density	Corr (K)
16 00	0 99897	1 0007	23 50	0 99745	0 9992
16 50	0 99889	1 0007	24 00	0 99732	0 9991
17 00	0 99880	1 0006	24 50	0 99720	0 9990
17 50	0 99871	1 0005	25 00	0 99707	0 9988
18 00	0 99862	1 0004	25 50	0 99694	0 9987
18 50	0 99853	1 0003	26 00	0 99681	0 9986
19 00	0 99843	1 0002	26 50	0 99668	0 9984
19 50	0 99833	1 0001	27 00	0 99654	0 9983
20 00	0 99823	1 0000	27 50	0 99640	0 9982
20 50	0 99812	0 9999	28 00	0 99626	0 9980
21 00	0 99802	0 9998	28 50	0 99612	0 9979
21 50	0 99791	0 9997	29 00	0 99597	0 9977
22 00	0 99780	0 9996	29 50	0 99582	0 9976
22 50	0 99768	0 9995	30 00	0 99567	0 9974
23 00	0 99757	0 9993			

TECH	LB
DATE	6/23/98
CHECK	
REVIEW	

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	GB 1 SA 8
SAMPLE TYPE	Bag
SAMPLE DEPTH	35 0 39 7'

LL	33
PL	15
PI	18

DESCRIPTION Yellowish Brown and Gray SILTY CLAY
and medium to fine sand.

USCS CL

GSL/ 986 1083 ENVIROGEN/ IA
IC3-3808

TECH	TF
DATE	5/29/98
CHECK	
REVIEW	

Golder Construction Services, Inc

ASTM GRAIN SIZE ANALYSIS
ASTM C117 C136 D421 D422 D1140 and D2217

PROJECT TITLE	GSL/ 986-1083 ENVIROGEN/ IA	SAMPLE ID	GB 1 SA 8
PROJECT NO	IC3 3808	SAMPLE TYPE	Bag
		SAMPLE DEPTH	35 0 39 7

AS RECEIVED WATER CONTENT

Tare No		
Wt. Wet Soil & Tare (gm)	(W1)	583 53
Wt. Dry Soil & Tare (gm)	(W2)	503 49
Weight of Tare (gm)	(W3)	84 59
Weight of Water (gm)	(W4-W1 W2)	80 04
Weight of Dry Soil (gm)	(W5 W2 W3)	418 90
Moisture Content (%)	(W4/W5) 100	19 11

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	116 60
Dry Soil & Tare (gm)	114 95
Tare Weight (gm)	3 22
Moisture Content (%)	1 48

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	934 14	
Tare Weight (gm)	233 75	
Total Weight (gm)	690 20	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0 00

	(Wt+Tare)	(((Wt Tare)/W6)*100)	%PASSING		
12 0				12 0	cobbles
3 0				3 0	coarse gravel
2.5				2.5	coarse gravel
2 0				2 0	coarse gravel
1 5				1.5	coarse gravel
1 0				1 0	coarse gravel
0 75				0 75	fine gravel
0.50				0.50	fine gravel
0.375				0.375	fine gravel
#4	0 00	0 0	100 0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	
Specific Gravity	(tested)	2 713
Amount Dispersing Agent (ml)		125 00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	52 19
Calculated Dry Wt. used in test (gm)	51 43
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100 00

TARE WEIGHT 203 12

HYDROMETER BACKSIEVE (Percent Passing #10 #200 Sieves)

	(Wt+Tare)	Cumul Wt. Retained	% PASSING		
#10	204 27	1 15	97.8	#10	medium sand
#20	205 63	2 51	95.1	#20	medium sand
#40	207 80	4 68	90 9	#40	fine sand
#60	211 19	8 07	84.3	#60	fine sand
#100	215 19	12 07	76.5	#100	fine sand
#200	220 05	16 93	67 1	#200	fines

HYDROMETER CALCULATIONS

DATE	TIME	ET	READING	TEMP	TEMP COR.	HYD COR.	READING	EFFECTIVE	
6/1/98	12 04	(min)	R	T	K	Cc	C	LENGTH	A
6/1/98	12 06	2 00	33 5	22 00	0 013	4 50	29 00	11 5	0 99
6/1/98	12 09	5 00	29 5	22 00	0 013	4 50	25 00	12 2	0 99
6/1/98	12 19	15 00	26 0	22 00	0 013	4 50	21 50	12 9	0 99
6/1/98	12 34	30 00	24 0	22 00	0 013	4 50	19 50	13 2	0 99
6/1/98	13 04	60 00	22 5	22 00	0 013	4 50	18 00	13.3	0 99
6/1/98	16 14	250 00	20 5	22 00	0 013	4 50	16 00	13 7	0.99
6/2/98	12 04	1440 00	18 0	22 00	0 013	4 50	13 50	14 2	0 99

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING		
0 0314	55 8	% COBBLES	0 00
0 0205	48 1	% COARSE GRAVEL	0 00
0 0121	41 4	% FINE GRAVEL	0 00
0 0087	37 5	% COARSE SAND	2 24
0 0062	34 6	% MEDIUM SAND	6 86
0 0031	30 8	% FINE SAND	23 82
0 0013	26 0	% FINES	67 08
		% TOTAL SAMPLE	100 00

Description Yellowish Brown and Gray SILTY CLAY and medium to fine sand.

USCS CL

33	LL
15	PL
18	PI

TECH	TF
DATE	5/29/98
CHECK	
REVIEW	

Golder Construction Services, Inc

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	GSL / 986-1083 ENVIROGEN / IA		
PROJECT NUMBER	IC3-3808	**SAMPLE ID**	GB 1 | SA 8
		SAMPLE TYPE	Bag
TESTED FOR	SPECIFIC GRAVITY	**SAMPLE DEPTH**	35 0 39 7

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare Inital (gm)	(W1)	160 91
Weight Soil and Tare Final (gm)	(W2)	159 77
Weight Of Tare (gm)	(W3)	51 49
Weight Of Moisture (gm)	(W4=W1 W2)	1 14
Weight Of Dry Soil (gm)	(W5=W2 W3)	108 28
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	1 1%

AIR REMOVAL METHOD

VACUUM

Trial		1	2	3
Pycnometer Number		13	19	23
Weight Pycnometer Empty (gm)	(Mf)	171 39	176 36	176 23
Weight of Soil & Pycnometer (gm)		223 39	228 52	228 43
Weight of Soil Water & Pycnometer (gm)	(Mb)	701 96	707 08	707 07
Observed Temperature (Tb) for (Mb) In Degrees C		24 0	24 0	24 0
Observed Temperature (Ta) for (Ma) In Degrees C		23 00	23 00	23 00
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	669 78	674 46	674 49
Relative Density of Water @ (Ta)		0 99757	0 99757	0 99757
Relative Density of Water @ (Tx)		0 99732	0 99732	0 99732
Correction Factor due to Temperature @Tx	(K)	0 9991	0 9991	0 9991
Weight of Soil (gm)		52 00	52 16	52 20
Weight of Dry Soil (gm)	(Mo)	51 46	51 62	51 66
Weight of Pycnometer & Water (gm)	(Ma)	669 66	674 34	674 37

SPECIFIC GRAVITY

	1	2	3	Gs Average
G @ 20 degrees C = [Mo/(Mo+((Ma Mb))]*(K)	2 684	2 733	2 723	2 713

Correction Values Due To Temperature

Temp (C)	Rel Density	Corr (K)	Temp (C)	Rel Density	Corr (K)
16 00	0 99897	1 0007	23 50	0 99745	0 9992
16 50	0 99889	1 0007	24 00	0 99732	0 9991
17 00	0 99880	1 0006	24 50	0 99720	0 9990
17 50	0 99871	1 0005	25 00	0 99707	0 9988
18 00	0 99862	1 0004	25 50	0 99694	0 9987
18 50	0 99853	1 0003	26 00	0 99681	0 9986
19 00	0 99843	1 0002	26 50	0 99668	0 9984
19 50	0 99833	1 0001	27 00	0 99654	0 9983
20 00	0 99823	1 0000	27 50	0 99640	0 9982
20 50	0 99812	0 9999	28 00	0 99626	0 9980
21 00	0 99802	0 9998	28 50	0 99612	0 9979
21 50	0 99791	0 9997	29 00	0 99597	0 9977
22 00	0 99780	0 9996	29 50	0 99582	0 9976
22.50	0 99768	0 9995	30 00	0 99567	0 9974
23 00	0 99757	0 9993			

TECH	TF
DATE	5/30/98
CHECK	
REVIEW	

ATTERBERG LIMITS
ASTM D-4318

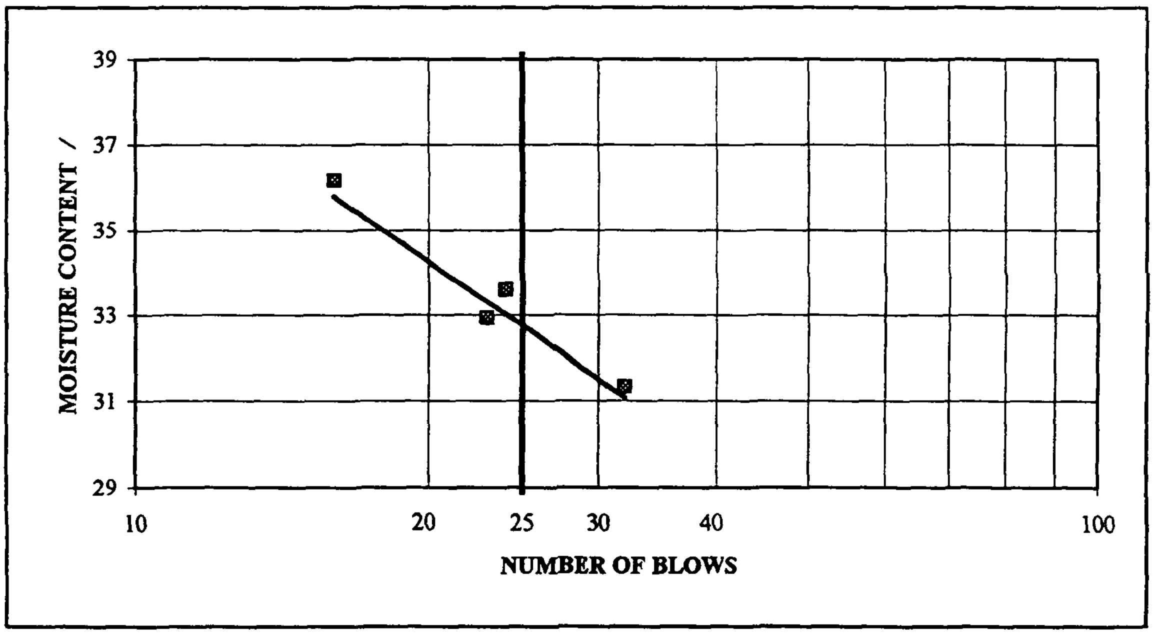
PROJECT TITLE	GSL/ 986-1083 ENVIROGEN/ IA	**SAMPLE ID**	GB 1	SA 8
PROJECT NUMBER	IC3-3808	**SAMPLE TYPE**	Bag	
		SAMPLE DEPTH	35.0 39.7	

SAMPLE PREPARATION

Wet or Dry	Dry	Minus #40 Sieve	Yes

		PLASTIC LIMIT DETERMINATION			NATURAL MOISTURE
Weight of Wet Soil & Tare (gm)	(W1)	26.79	27.42	24.80	583.53
Weight of Dry Soil & Tare (gm)	(W2)	24.83	25.39	23.04	503.49
Weight of Tare (gm)	(W3)	11.79	11.84	11.36	84.59
Weight of Water (gm)	(W4=W1 W2)	1.96	2.03	1.76	80.04
Weight of Dry Soil (gm)	(W5=W2 W3)	13.04	13.55	11.68	418.90
Water Content %	(W4/W5) 100	15.03	14.98	15.07	19.11

		LIQUID LIMIT DETERMINATION				NOTE
Number of Blows		32	23	24	16	
Weight of Wet Soil & Tare (gm)	(W6)	16.08	20.60	13.81	19.11	
Weight of Dry Soil & Tare (gm)	(W7)	13.26	16.57	11.39	15.19	
Weight of Tare (gm)	(W8)	4.26	4.33	4.19	4.35	
Weight of Water (gm)	(W9=W6-W7)	2.82	4.03	2.42	3.92	
Weight of Dry Soil (gm)	(W10=W7 W8)	9.00	12.24	7.20	10.84	
Water Content %	(W9/W10) 100	31.33	32.92	33.61	36.16	

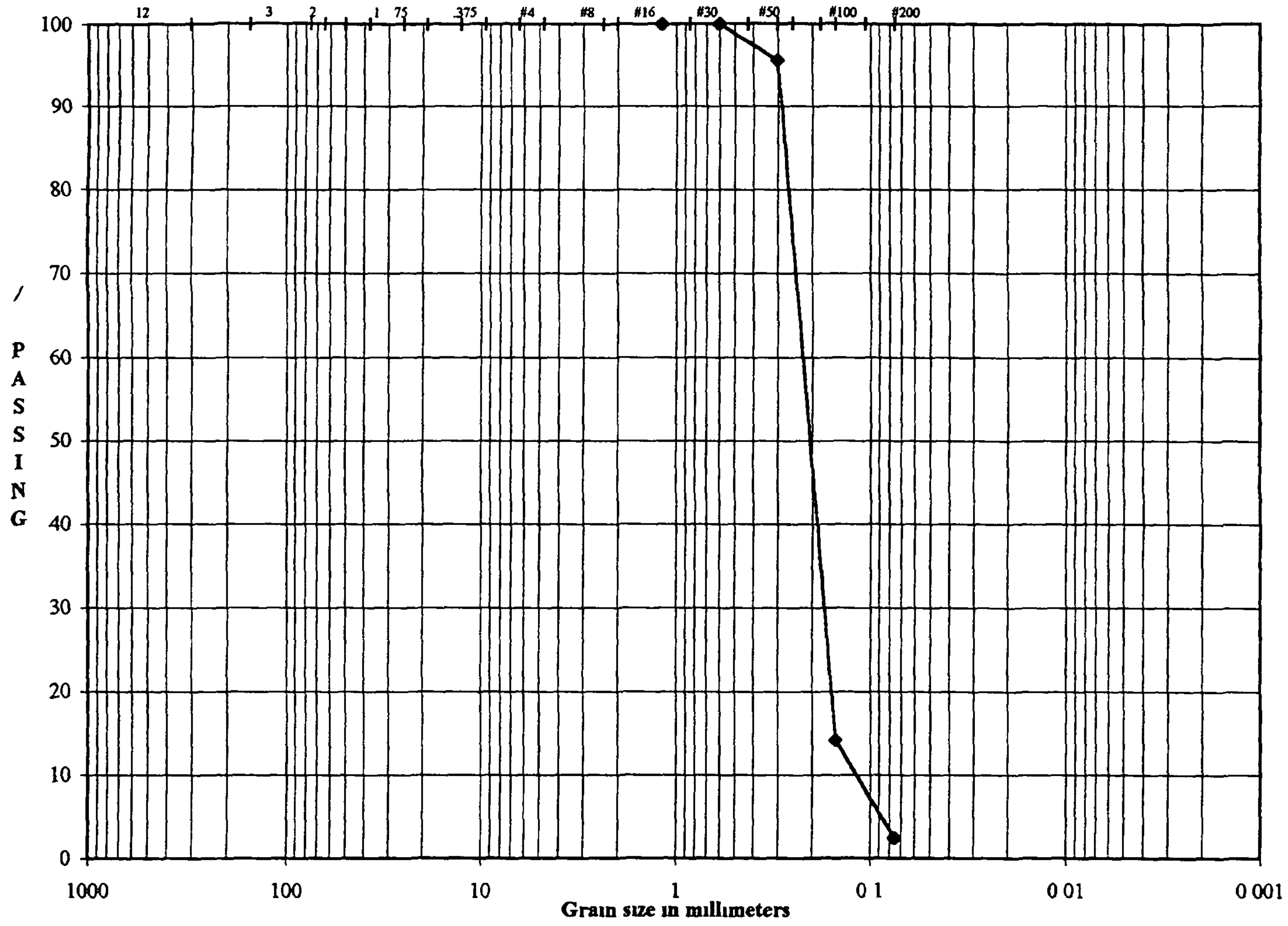


LIQUID LIMIT (Wl)	32.95	33
PLASTIC LIMIT (Wp)	15.03	15
PLASTICITY INDEX (Ip)		18
LIQUIDITY INDEX (I)		0.23
MOISTURE CONTENT		19.11

DESCRIPTION	Yellowish Brown and Gray SILTY CLAY and medium to fine sand.
USCS	CL

TECH	GM
DATE	6/1/98
CHECK	GM
REVIEW	PWM

PARTICLE SIZE DISTRIBUTION
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID GB 1 SA 9

SAMPLE TYPE Bag

SAMPLE DEPTH 41 0 43 2

LL

PL

PI

DESCRIPTION Brownish Yellow FINE SAND trace silt

USCS SP

Cu = D60/D10 = 0 21/0 12 = 1 75 < 6

Cc = D30^2/(D60 D10) = 0 17^2/(0 21*0 12) = 1 15 > 1

GSL/ 986-1083 ENVIROGEN/ IA
IC3 3808

TECH TF
DATE 6/1/98
CHECK
REVIEW

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	GSL/ 986-1083 ENVIROGEN/ IA	**SAMPLE ID**	GB 1	SA 9
PROJECT NO	IC3 3808	**SAMPLE TYPE**	Bag	
REMARKS		**SAMPLE DEPTH**	41 0 43.2	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1 w2)	
Weight of Dry Soil (gm)	(w5=w2 w3)	
Moisture Content (%)	(w4/w5)*100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	969 31
	Tare Weight (gm)	113 72
(W6)	Total Dry Weight (gm)	855 59

SIEVE ANALYSIS

Tare Weight: 0 00

	Wt Ret +Tare	(Wt Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12 0					12 0	cobbles
3 0					3 0	coarse gravel
2 5					2 5	coarse gravel
2 0					2 0	coarse gravel
1 5					1 5	coarse gravel
1 0					1 0	coarse gravel
0 75					0 75	fine gravel
0 50					0 50	fine gravel
0 375					0 375	fine gravel
#4					#4	coarse sand
#8					#8	coarse sand
#16	0 00	0 00	0 00	100 00	#16	medium sand
#30	0 18	0 18	0 02	99 98	#30	medium sand
#50	37 48	37 48	4 38	95 62	#50	fine sand
#100	733 99	733 99	85 79	14.21	#100	fine sand
#200	834 29	834 29	97 51	2 49	#200	fines
PAN	855 06	855 06	99 94	0 06	PAN	

% COBBLES	0 00
% C GRAVEL	0 00
% F GRAVEL	0 00
% C SAND	0 00
% M SAND	2 19
% F SAND	95 32
% FINES	2 49
% TOTAL	100 00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	
PL	
PI	
Gs	2 660

DESCRIPTION Brownish Yellow FINE SAND trace silt.

USCS SP

TECH	TF
DATE	6/1/98
CHECK	
REVIEW	

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	GSL / 986-1083 ENVIROGEN / IA		
PROJECT NUMBER	IC3-3808	**SAMPLE ID**	GB 1 SA 9
		SAMPLE TYPE	Bag
TESTED FOR	SPECIFIC GRAVITY	**SAMPLE DEPTH**	41 0-43 2

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare Initial (gm)	(W1)	35 58
Weight Soil and Tare Final (gm)	(W2)	35 54
Weight Of Tare (gm)	(W3)	3 18
Weight Of Moisture (gm)	(W4=W1 W2)	0 04
Weight Of Dry Soil (gm)	(W5=W2 W3)	32 36
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0 1%

AIR REMOVAL METHOD
VACUUM

Trial		1	2	3
Pycnometer Number		1	2	4
Weight Pycnometer Empty (gm)	(Mf)	178 52	201 25	208 47
Weight of Soil & Pycnometer (gm)		193 72	216 79	224 58
Weight of Soil Water & Pycnometer (gm)	(Mb)	686 09	709 04	716 53
Observed Temperature (Tb) for (Mb) In Degrees C		24 0	24 0	24 0
Observed Temperature (Ta) for (Ma) In Degrees C		23 00	23 00	24 00
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	676 63	699 49	706 58
Relative Density of Water @ (Ta)		0 99757	0 99757	0 99732
Relative Density of Water @ (Tx)		0 99732	0 99732	0 99732
Correction Factor due to Temperature @Tx	(K)	0 9991	0 9991	0 9991
Weight of Soil (gm)		15 20	15 54	16 11
Weight of Dry Soil (gm)	(Mo)	15 18	15 52	16 09
Weight of Pycnometer & Water (gm)	(Ma)	676 51	699 37	706 58

SPECIFIC GRAVITY

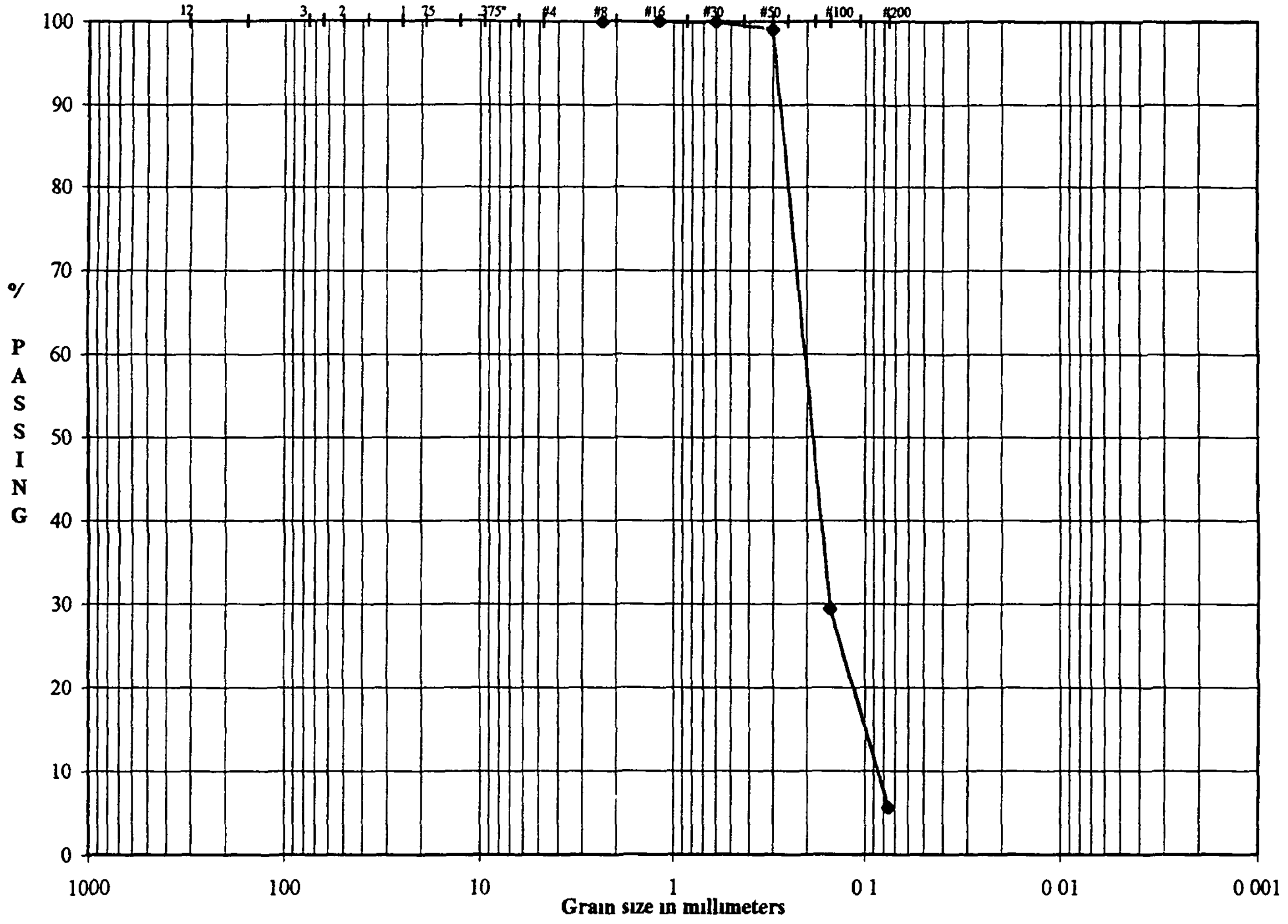
				Gs Average
G @ 20 degrees C = [Mo/(Mo+((Ma Mb))]*(K)	2 710	2 653	2 618	2 660

Correction Values Due To Temperature

Temp (C)	Rel. Density	Corr (K)	Temp (C)	Rel Density	Corr (K)
16 00	0 99897	1 0007	23 50	0 99745	0 9992
16 50	0 99889	1 0007	24 00	0 99732	0 9991
17 00	0 99880	1 0006	24 50	0 99720	0 9990
17 50	0 99871	1 0005	25 00	0 99707	0 9988
18 00	0 99862	1 0004	25 50	0 99694	0 9987
18 50	0 99853	1 0003	26 00	0 99681	0 9986
19 00	0 99843	1 0002	26 50	0 99668	0 9984
19 50	0 99833	1 0001	27 00	0 99654	0 9983
20 00	0 99823	1 0000	27 50	0 99640	0 9982
20 50	0 99812	0 9999	28 00	0 99626	0 9980
21 00	0 99802	0 9998	28 50	0 99612	0 9979
21 50	0 99791	0 9997	29 00	0 99597	0 9977
22 00	0 99780	0 9996	29 50	0 99582	0 9976
22 50	0 99768	0 9995	30 00	0 99567	0 9974
23 00	0 99757	0 9993			

TECH	TF
DATE	6/1/98
CHECK	
REVIEW	

PARTICLE SIZE DISTRIBUTION
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB 1 SA 10
SAMPLE TYPE	Bag
SAMPLE DEPTH	45 0 48 0

LL	
PL	
PI	

DESCRIPTION Brownish Yellow FINE SAND little silt.

USCS SP-SM

Cu = D60/D10 = 0 21/0 085 = 2 47 < 6

Cc = D30^2/(D60 D10) = 0 15^2/(0.21*0 085) = 1.26 > 1

GSL/ 986-1083 ENVIROGEN/ IA
IC3 3808

TECH	TF
DATE	6/1/98
CHECK	
REVIEW	PWM

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	GSL/ 986-1083 ENVIROGEN/ IA	**SAMPLE ID**	GB 1	SA 10
PROJECT NO	IC3 3808	**SAMPLE TYPE**	Bag	
REMARKS		**SAMPLE DEPTH**	45.0 48.0	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1 w2)	
Weight of Dry Soil (gm)	(w5=w2 w3)	
Moisture Content (%)	(w4/w5) 100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	961.30
	Tare Weight (gm)	114.27
(W6)	Total Dry Weight (gm)	847.03

SIEVE ANALYSIS

Tare Weight: 0.00

	Wt Ret +Tare	(Wt Tare)	Cumulative (% Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0					12.0	cobbles
3.0					3.0	coarse gravel
2.5					2.5	coarse gravel
2.0					2.0	coarse gravel
1.5					1.5	coarse gravel
1.0					1.0	coarse gravel
0.75					0.75	fine gravel
0.50					0.50	fine gravel
0.375					0.375	fine gravel
#4					#4	coarse sand
#8	0.00	0.00	0.00	100.00	#8	coarse sand
#16	0.07	0.07	0.01	99.99	#16	medium sand
#30	0.81	0.81	0.10	99.90	#30	medium sand
#50	8.30	8.30	0.98	99.02	#50	fine sand
#100	597.59	597.59	70.55	29.45	#100	fine sand
#200	799.11	799.11	94.34	5.66	#200	fines
PAN	846.31	846.31	99.91	0.09	PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.00
% M SAND	0.53
% F SAND	93.81
% FINES	5.66
% TOTAL	100.00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	
PL	
PI	
Gs	2.717

DESCRIPTION Brownish Yellow FINE SAND little silt.

USCS SP-SM

TECH	TF
DATE	6/1/98
CHECK	
REVIEW	PWM

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	GSL / 986-1083 ENVIROGEN / IA		
PROJECT NUMBER	IC3 3808	**SAMPLE ID**	GB 1 · SA 10
		SAMPLE TYPE	Bag
TESTED FOR	SPECIFIC GRAVITY	**SAMPLE DEPTH**	45 0 48 0

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare Inital (gm)	(W1)	185 95
Weight Soil and Tare Final (gm)	(W2)	185 75
Weight Of Tare (gm)	(W3)	51 62
Weight Of Moisture (gm)	(W4=W1 W2)	0 20
Weight Of Dry Soil (gm)	(W5=W2 W3)	134 13
Hygroscopic Moisture In (%)	(HM=(W4/W5) 100)	0 1%

AIR REMOVAL METHOD
VACUUM

Trial		1	2	3
Pycnometer Number		21	24	25
Weight Pycnometer Empty (gm)	(Mf)	177 05	171 40	177 66
Weight of Soil & Pycnometer (gm)		229 50	223 23	228 70
Weight of Soil Water & Pycnometer (gm)	(Mb)	707 97	702 20	707 84
Observed Temperature (Tb) for (Mb) In Degrees C		25 0	25 0	25 0
Observed Temperature (Ta) for (Ma) In Degrees C		23 00	22 00	23 00
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	675 19	669 80	675 81
Relative Density of Water @ (Ta)		0 99757	0 99780	0 99757
Relative Density of Water @ (Tx)		0 99707	0 99707	0 99707
Correction Factor due to Temperature @Tx	(K)	0 9988	0 9988	0 9988
Weight of Soil (gm)		52 45	51 83	51 04
Weight of Dry Soil (gm)	(Mo)	52 37	51 75	50 96
Weight of Pycnometer & Water (gm)	(Ma)	674 94	669 44	675 56

SPECIFIC GRAVITY

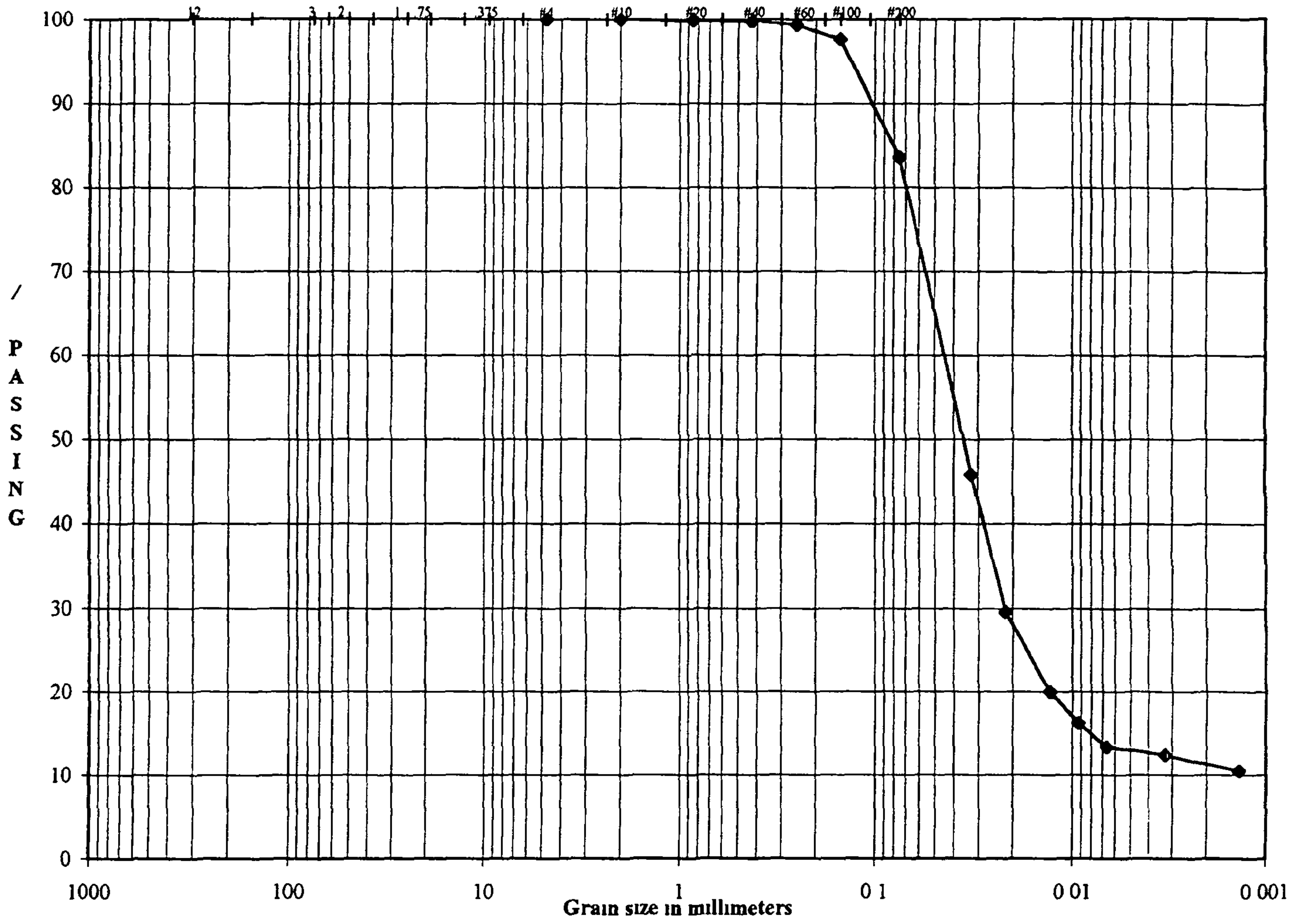
				Gs Average
G @ 20 degrees C = [Mo/(Mo+((Ma Mb))]*(K)	2 704	2 722	2 724	2 717

Correction Values Due To Temperature

Temp (C)	Rel Density	Corr (K)	Temp (C)	Rel Density	Corr (K)
16 00	0 99897	1 0007	23 50	0 99745	0 9992
16 50	0 99889	1 0007	24 00	0 99732	0 9991
17 00	0 99880	1 0006	24 50	0 99720	0 9990
17 50	0 99871	1 0005	25 00	0 99707	0 9988
18 00	0 99862	1 0004	25 50	0 99694	0 9987
18 50	0 99853	1 0003	26 00	0 99681	0 9986
19 00	0 99843	1 0002	26 50	0 99668	0 9984
19 50	0 99833	1 0001	27 00	0 99654	0 9983
20 00	0 99823	1 0000	27 50	0 99640	0 9982
20 50	0 99812	0 9999	28 00	0 99626	0 9980
21 00	0 99802	0 9998	28 50	0 99612	0 9979
21 50	0 99791	0 9997	29 00	0 99597	0 9977
22 00	0 99780	0 9996	29 50	0 99582	0 9976
22 50	0 99768	0 9995	30 00	0 99567	0 9974
23 00	0 99757	0 9993			

TECH	TF
DATE	6/3/98
CHECK	
REVIEW	

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB 1 SA 11	**LL**	NP
SAMPLE TYPE	Bag	**PL**	NP
SAMPLE DEPTH	55 0 56 0	**PI**	NP

DESCRIPTION	Olive Brown, CLAYEY SILT some fine sand
USCS	ML

GSL/ 986-1083 ENVIROGEN/ IA
IC3-3808

TECH	TF
DATE	5/29/98
CHECK	
REVIEW	

ASTM GRAIN SIZE ANALYSIS
ASTM C117 C136 D421 D422 D1140 and D2217

PROJECT TITLE	GSL/ 986-1083 ENVIROGEN/ IA	SAMPLE ID	GB 1 / SA 11
PROJECT NO	IC3 3808	SAMPLE TYPE	Bag
		SAMPLE DEPTH	55 0 56 0

AS RECEIVED WATER CONTENT

Tare No		
Wt Wet Soil & Tare (gm)	(W1)	385 12
Wt Dry Soil & Tare (gm)	(W2)	316 29
Weight of Tare (gm)	(W3)	85 35
Weight of Water (gm)	(W4=W1 W2)	68 83
Weight of Dry Soil (gm)	(W5=W2 W3)	230 94
Moisture Content (%)	(W4/W5) 100	29 80

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	28 97
Dry Soil & Tare (gm)	28 79
Tare Weight (gm)	3 17
Moisture Content (%)	0 70

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	568 18	
Tare Weight (gm)	235 49	
Total Weight (gm)	330 37	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0 00

	(Wt+Tare)	(((Wt Tare)/W6)*100)	%PASSING		
12 0				12 0	cobbles
3 0				3 0	coarse gravel
2 5				2.5	coarse gravel
2 0				2 0	coarse gravel
1 5				1.5	coarse gravel
1 0				1 0	coarse gravel
0 75				0 75	fine gravel
0.50				0.50	fine gravel
0.375				0.375	fine gravel
#4	0 00	0 0	100 0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	
Specific Gravity	(tested)	2 686
Amount Dispersing Agent (ml)		125 00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	52 80
Calculated Dry Wt. used in test (gm)	52 43
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100 00

TARE WEIGHT 203 14

HYDROMETER BACKSIEVE (Percent Passing #10 #200 Sieves)

	(Wt+Tare)	Cumul Wt. Retained	% PASSING		
#10	203 14	0 00	100 0	#10	medium sand
#20	203 20	0 06	99 9	#20	medium sand
#40	203 25	0 11	99.8	#40	fine sand
#60	203 47	0 33	99 4	#60	fine sand
#100	204 37	1 23	97 7	#100	fine sand
#200	211 75	8 61	83 6	#200	fines

HYDROMETER CALCULATIONS

DATE 6/1/98	TIME 12 02	ET (min)	READING R	TEMP T	TEMP COR. K	HYD COR. Cc	READING C	EFFECTIVE LENGTH	A
6/1/98	12 04	2 00	28 5	22 00	0 013	4 50	24 00	12.4	1 00
6/1/98	12 07	5 00	20 0	22 00	0 013	4 50	15 50	13 8	1 00
6/1/98	12 17	15 00	15 0	22 00	0 013	4 50	10 50	14 7	1 00
6/1/98	12.32	30 00	13 0	22 00	0 013	4 50	8 50	15 0	1 00
6/1/98	13 02	60 00	11 5	22 00	0 013	4 50	7 00	15 2	1 00
6/1/98	16 12	250 00	11 0	22 00	0 013	4 50	6 50	15.3	1 00
6/2/98	12 02	1440 00	10 0	22 00	0 013	4 50	5 50	15 5	1 00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING		
0 0326	45 8	% COBBLES	0 00
0 0218	29 6	% COARSE GRAVEL	0 00
0 0130	20 0	% FINE GRAVEL	0 00
0 0093	16 2	% COARSE SAND	0 00
0 0066	13 4	% MEDIUM SAND	0 21
0 0032	12.4	% FINE SAND	16 21
0 0014	10 5	% FINES	83 58
		% TOTAL SAMPLE	100 00

Description Olive Brown, CLAYEY SILT some fine sand.

USCS ML

NP	LL
NP	PL
NP	PI

TECH	TF
DATE	5/29/98
CHECK	
REVIEW	

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	GSL / 986-1083 ENVIROGEN / IA			
PROJECT NUMBER	IC3-3808	**SAMPLE ID**	GB 1	SA 11
		SAMPLE TYPE	Bag	
TESTED FOR	SPECIFIC GRAVITY	**SAMPLE DEPTH**	55 0 56 0	

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare Inital (gm)	(W1)	155 10
Weight Soil and Tare Final (gm)	(W2)	154 37
Weight Of Tare (gm)	(W3)	51 12
Weight Of Moisture (gm)	(W4=W1 W2)	0 73
Weight Of Dry Soil (gm)	(W5=W2 W3)	103 25
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0 7%

AIR REMOVAL METHOD
VACUUM

Trial		1	2	3
Pycnometer Number		8	9	16
Weight Pycnometer Empty (gm)	(Mf)	178 87	177 37	178 82
Weight of Soil & Pycnometer (gm)		231 21	229 42	231 07
Weight of Soil Water & Pycnometer (gm)	(Mb)	709 48	708 14	709 53
Observed Temperature (Tb) for (Mb) In Degrees C		25 0	25 0	25 0
Observed Temperature (Ta) for (Ma) In Degrees C		24 50	23 00	23 00
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	677 15	675 71	677 15
Relative Density of Water @ (Ta)		0 99720	0 99757	0 99757
Relative Density of Water @ (Tx)		0 99707	0 99707	0 99707
Correction Factor due to Temperature @Tx	(K)	0 9988	0 9988	0 9988
Weight of Soil (gm)		52 34	52 05	52 25
Weight of Dry Soil (gm)	(Mo)	51 97	51 68	51 88
Weight of Pycnometer & Water (gm)	(Ma)	677 09	675 46	676 90

SPECIFIC GRAVITY

G @ 20 degrees C = [Mo/(Mo+((Ma Mb))]*(K)	2 652	2 716	2 692	Gs Average 2 686

Correction Values Due To Temperature

Temp (C)	Rel Density	Corr (K)	Temp (C)	Rel Density	Corr (K)
16 00	0 99897	1 0007	23 50	0 99745	0 9992
16 50	0 99889	1 0007	24 00	0 99732	0 9991
17 00	0 99880	1 0006	24 50	0 99720	0 9990
17 50	0 99871	1 0005	25 00	0 99707	0 9988
18 00	0 99862	1 0004	25 50	0 99694	0 9987
18 50	0 99853	1 0003	26 00	0 99681	0 9986
19 00	0 99843	1 0002	26 50	0 99668	0 9984
19 50	0 99833	1 0001	27 00	0 99654	0 9983
20 00	0 99823	1 0000	27 50	0 99640	0 9982
20 50	0 99812	0 9999	28 00	0 99626	0 9980
21 00	0 99802	0 9998	28 50	0 99612	0 9979
21 50	0 99791	0 9997	29 00	0 99597	0 9977
22 00	0 99780	0 9996	29 50	0 99582	0 9976
22 50	0 99768	0 9995	30 00	0 99567	0 9974
23 00	0 99757	0 9993			

TECH	TF
DATE	5/30/98
CHECK	
REVIEW	

Golder Construction Services Inc

ATTERBERG LIMITS
ASTM D-4318

PROJECT TITLE	GSL/ 986-1083 ENVIROGEN/ IA	**SAMPLE ID**	GB 1 SA 11
PROJECT NUMBER	IC3 3808	**SAMPLE TYPE**	Bag
		SAMPLE DEPTH	55.0 56.0

SAMPLE PREPARATION

Wet or Dry: Dry

Minus #40 Sieve: Yes

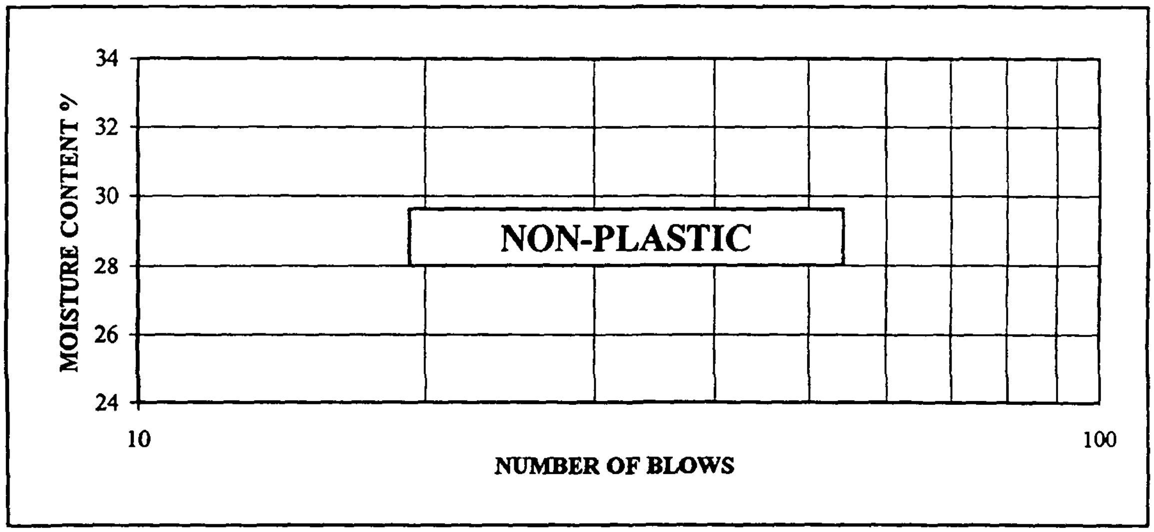
PLASTIC LIMIT DETERMINATION / NATURAL MOISTURE

					NATURAL MOISTURE
Weight of Wet Soil & Tare (gm)	(W1)	30 88	30 55	31 57	385 12
Weight of Dry Soil & Tare (gm)	(W2)	27 42	27 20	28 03	316 29
Weight of Tare (gm)	(W3)	11 48	11 69	11 71	85 35
Weight of Water (gm)	(W4=W1 W2)	3 46	3 35	3 54	68 83
Weight of Dry Soil (gm)	(W5=W2 W3)	15 94	15 51	16 32	230 94
Water Content %	(W4/W5) 100	21 71	21 60	21 69	29 80

LIQUID LIMIT DETERMINATION

Number of Blows		5	5
Weight of Wet Soil & Tare (gm)	(W6)	23 26	20 26
Weight of Dry Soil & Tare (gm)	(W7)	19 36	16 96
Weight of Tare (gm)	(W8)	4 30	4 28
Weight of Water (gm)	(W9=W6-W7)	3 90	3 30
Weight of Dry Soil (gm)	(W10=W7 W8)	15 06	12 68
Water Content %	(W9/W10) 100	25 90	26 03

NOTE DIFFICULT TO ROLL
SUSPECT TO BE NON PLASTIC



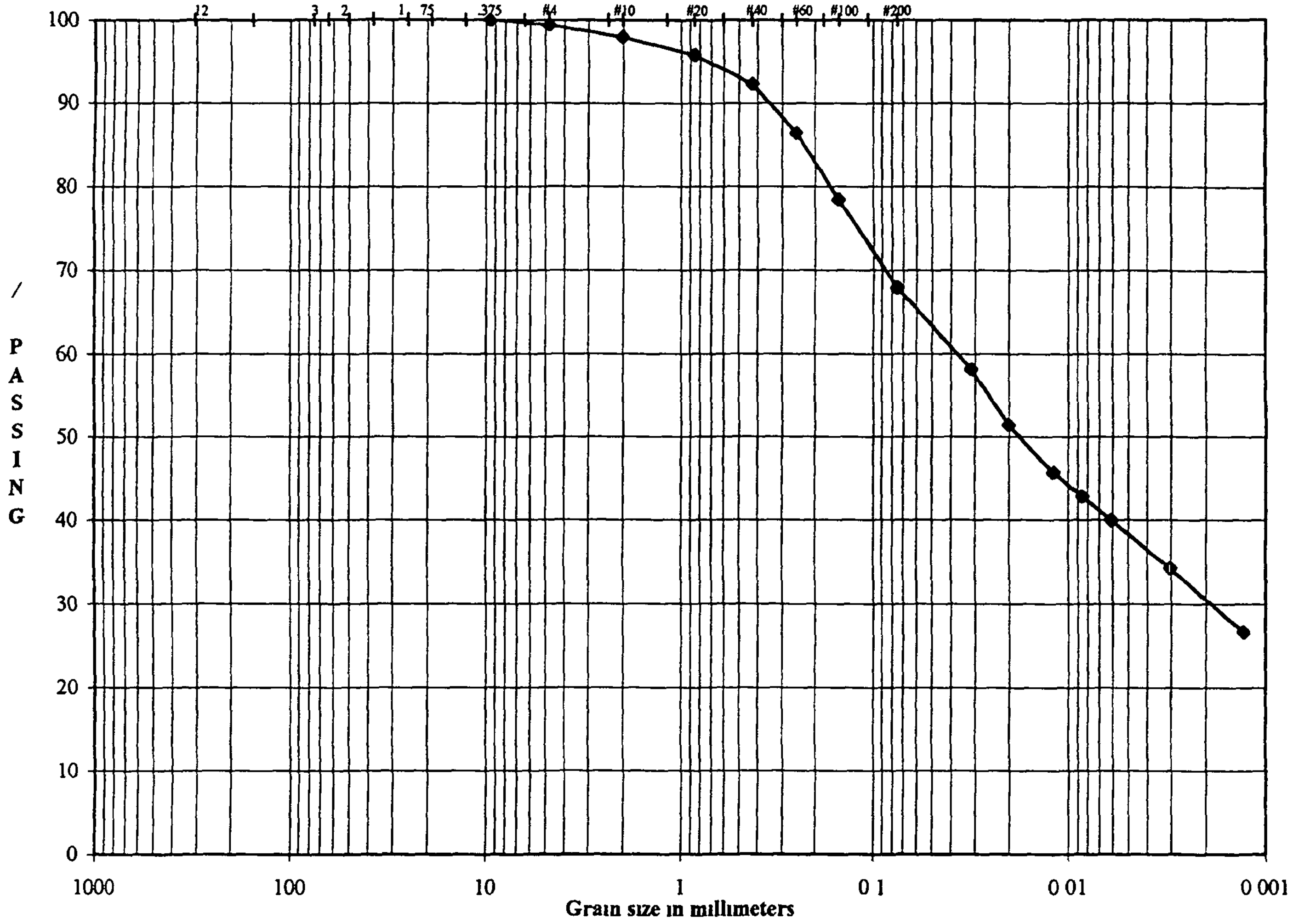
LIQUID LIMIT (Wl)		NP
PLASTIC LIMIT (Wp)		NP
PLASTICITY INDEX (Ip)		NP
LIQUIDITY INDEX (I)		NP
MOISTURE CONTENT		29 80

DESCRIPTION: Olive Brown, CLAYEY SILT some fine sand

USCS: (ML)

TECH	JR
DATE	6/1/98
CHECK	
REVIEW	

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	G 1 SA 14
SAMPLE TYPE	Bag
SAMPLE DEPTH	68 5 70 0

LL	36
PL	15
PI	21

DESCRIPTION Olive Brown and Gray SILTY CLAY and medium to fine sand, trace fine gravel.

USCS CL

GSL/ 986-1083 ENVIROGEN/ IA
IC3-3808

TECH	TF
DATE	5/29/98
CHECK	Gm
REVIEW	PWM

ASTM GRAIN SIZE ANALYSIS
ASTM C117 C136 D421 D422 D1140 and D2217

PROJECT TITLE	GSL/ 986-1083 ENVIROGEN/ IA	SAMPLE ID	G 1 SA 14
PROJECT NO	IC3 3808	SAMPLE TYPE	Bag
		SAMPLE DEPTH	68 5 70 0

AS RECEIVED WATER CONTENT

Tare No		
Wt Wet Soil & Tare (gm)	(W1)	408 25
Wt. Dry Soil & Tare (gm)	(W2)	364 26
Weight of Tare (gm)	(W3)	85 35
Weight of Water (gm)	(W4–W1 W2)	43 99
Weight of Dry Soil (gm)	(W5 W2 W3)	278 91
Moisture Content (/)	(W4/W5) 100	15 77

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	30 63
Dry Soil & Tare (gm)	30 35
Tare Weight (gm)	3 16
Moisture Content (/)	1 03

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	705 60	
Tare Weight (gm)	235 44	
Total Weight (gm)	465 37	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0 00

	(Wt+Tare)	(((Wt Tare)/W6) 100)	/PASSING		
12 0				12 0	cobbles
3 0				3 0	coarse gravel
2 5				2.5	coarse gravel
2 0				2 0	coarse gravel
1 5				1.5	coarse gravel
1 0				1 0	coarse gravel
0 75				0 75	fine gravel
0.50				0.50	fine gravel
0.375	0 00	0 0	100 0	0.375	fine gravel
#4	2 90	0 6	99 4	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	
Specific Gravity	(tested)	2 715
Amount Dispersing Agent (ml)		125 00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	52 17
Calculated Dry Wt. used in test (gm)	51 64
Hydrometer Bulb Number	624378
/ Pass #4 Sieve For Whole Sample	99 38

TARE WEIGHT 203 14

HYDROMETER BACKSIEVE (Percent Passing #10 #200 Sieves)

	(Wt+Tare)	Cumul Wt. Retained	/ PASSING		
#10	203 91	0 77	97 9	#10	medium sand
#20	205 00	1 86	95.8	#20	medium sand
#40	206 86	3 72	92.2	#40	fine sand
#60	209 87	6 73	86.4	#60	fine sand
#100	214 04	10 90	78.4	#100	fine sand
#200	219 49	16.35	67.9	#200	fines

HYDROMETER CALCULATIONS

DATE 6/1/98	TIME 12 00	ET (min)	READING R	TEMP T	TEMP COR. K	HYD COR. Cc	READING C	EFFECTIVE LENGTH	A
6/1/98	12 02	2 00	35 0	22 00	0 013	4 50	30 50	11 4	0 99
6/1/98	12 05	5 00	31 5	22 00	0 013	4 50	27 00	11 9	0 99
6/1/98	12 15	15 00	28 5	22 00	0 013	4 50	24 00	12 4	0 99
6/1/98	12 30	30 00	27 0	22 00	0 013	4 50	22 50	12 7	0 99
6/1/98	13 00	60 00	25 5	22 00	0 013	4 50	21 00	12 9	0 99
6/1/98	16 10	250 00	22 5	22 00	0 013	4 50	18 00	13 3	0 99
6/2/98	12 00	1440 00	18 5	22 00	0 013	4 50	14 00	14 0	0 99

GRAIN SIZE PERCENTAGES

Particle Diameter	/ PASSING	/ COBBLES	0 00
0 0313	58 1	% COARSE GRAVEL	0 00
0 0202	51 4	% FINE GRAVEL	0 62
0 0119	45 7	% COARSE SAND	1 48
0 0085	42 9	% MEDIUM SAND	5 68
0 0061	40 0	% FINE SAND	24 31
0 0030	34 3	% FINES	67 91
0 0013	26 7	% TOTAL SAMPLE	100 00

Description Olive Brown and Gray SILTY CLAY and medium to fine sand, trace fine gravel.

USCS CL

36	LL
15	PL
21	PI

TECH	TF
DATE	5/29/98
CHECK	
REVIEW	

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	GSL / 986-1083 ENVIROGEN / IA		
PROJECT NUMBER	IC3 3808	**SAMPLE ID**	GB 1 SA 14
		SAMPLE TYPE	Bag
TESTED FOR	SPECIFIC GRAVITY	**SAMPLE DEPTH**	68.5 70 0

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare Inital (gm)	(W1)	342.35
Weight Soil and Tare Final (gm)	(W2)	339 55
Weight Of Tare (gm)	(W3)	51 78
Weight Of Moisture (gm)	(W4=W1 W2)	2 80
Weight Of Dry Soil (gm)	(W5=W2 W3)	287 77
Hygroscopic Moisture In (%)	(HM=(W4/W5) 100)	1 0%

AIR REMOVAL METHOD
VACUUM

Trial		1	2	3
Pycnometer Number		17	18	26
Weight Pycnometer Empty (gm)	(Mf)	170 60	206 34	178 23
Weight of Soil & Pycnometer (gm)		222 91	258 59	230 45
Weight of Soil Water & Pycnometer (gm)	(Mb)	701 33	737 11	708 88
Observed Temperature (Tb) for (Mb) In Degrees C		24 0	25 0	25 0
Observed Temperature (Ta) for (Ma) In Degrees C		25 00	23 00	22 00
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	668 66	704 59	676 42
Relative Density of Water @ (Ta)		0 99707	0 99757	0 99780
Relative Density of Water @ (Tx)		0 99732	0 99707	0 99707
Correction Factor due to Temperature @Tx	(K)	0 9991	0 9988	0 9988
Weight of Soil (gm)		52 31	52 25	52 22
Weight of Dry Soil (gm)	(Mo)	51 81	51 75	51 72
Weight of Pycnometer & Water (gm)	(Ma)	668 78	704 34	676 06

SPECIFIC GRAVITY

	1	2	3	Gs Average
G @ 20 degrees C = [Mo/(Mo+((Ma Mb))]*(K)	2 687	2 724	2 734	2 715

Correction Values Due To Temperature

Temp (C)	Rel Density	Corr (K)	Temp (C)	Rel Density	Corr (K)
16 00	0 99897	1 0007	23 50	0 99745	0 9992
16 50	0 99889	1 0007	24 00	0 99732	0 9991
17 00	0 99880	1 0006	24 50	0 99720	0 9990
17 50	0 99871	1 0005	25 00	0 99707	0 9988
18 00	0 99862	1 0004	25 50	0 99694	0 9987
18 50	0 99853	1 0003	26 00	0 99681	0 9986
19 00	0 99843	1 0002	26 50	0 99668	0 9984
19 50	0 99833	1 0001	27 00	0 99654	0 9983
20 00	0 99823	1 0000	27 50	0 99640	0 9982
20 50	0 99812	0 9999	28 00	0 99626	0 9980
21 00	0 99802	0 9998	28 50	0 99612	0 9979
21 50	0 99791	0 9997	29 00	0 99597	0 9977
22 00	0 99780	0 9996	29 50	0 99582	0 9976
22 50	0 99768	0 9995	30 00	0 99567	0 9974
23 00	0 99757	0 9993			

TECH	AK
DATE	5/30/98
CHECK	
REVIEW	

ATTERBERG LIMITS
ASTM D-4318

PROJECT TITLE	GSL/ 986-1083 ENVIROGEN/ IA	**SAMPLE ID**	GB 1	SA 14
PROJECT NUMBER	IC3-3808	**SAMPLE TYPE**	Bag	
		SAMPLE DEPTH	68.5 70 0	

SAMPLE PREPARATION

Wet or Dry: Dry

Minus #40 Sieve: Yes

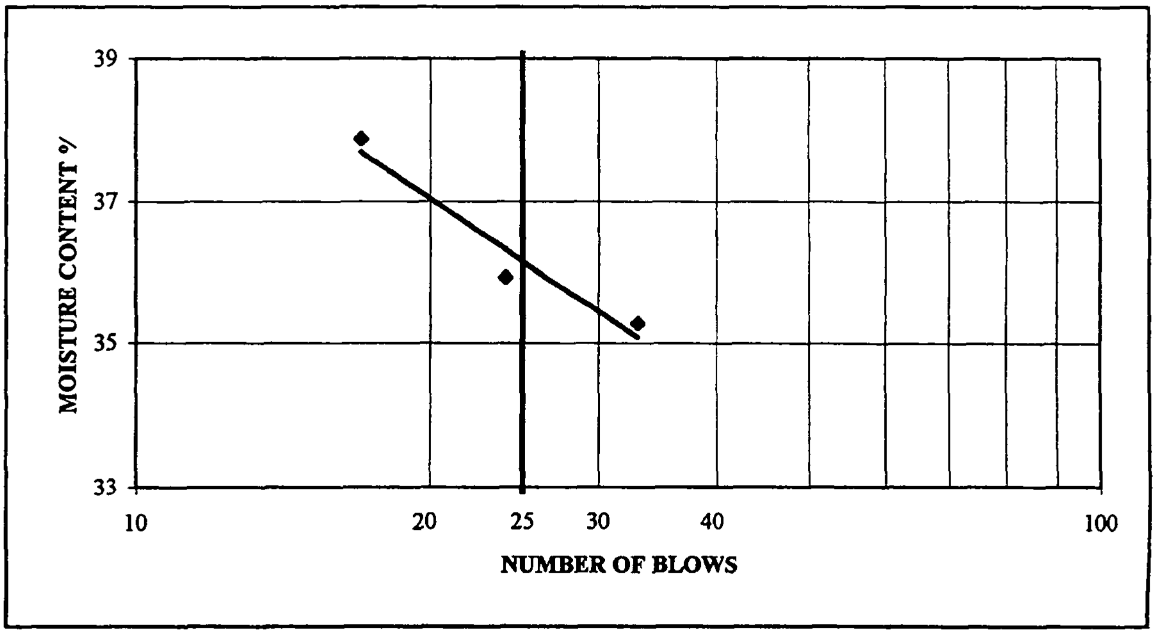
PLASTIC LIMIT DETERMINATION

					NATURAL MOISTURE
Weight of Wet Soil & Tare (gm) (W1)	23 08	21 45	22 04		408 25
Weight of Dry Soil & Tare (gm) (W2)	21 61	20 20	20 69		364 26
Weight of Tare (gm) (W3)	11 65	11 42	11 46		85 35
Weight of Water (gm) (W4=W1 W2)	1 47	1 25	1 35		43 99
Weight of Dry Soil (gm) (W5=W2 W3)	9 96	8 78	9 23		278 91
Water Content % (W4/W5)*100	14 76	14 24	14 63		15 77

LIQUID LIMIT DETERMINATION

Number of Blows	33	24	17
Weight of Wet Soil & Tare (gm) (W6)	21 46	23 45	24 85
Weight of Dry Soil & Tare (gm) (W7)	16 99	18 40	19 20
Weight of Tare (gm) (W8)	4 32	4 35	4 28
Weight of Water (gm) (W9=W6-W7)	4 47	5 05	5 65
Weight of Dry Soil (gm) (W10=W7 W8)	12 67	14 05	14 92
Water Content % (W9/W10) 100	35 28	35 94	37 87

NOTE



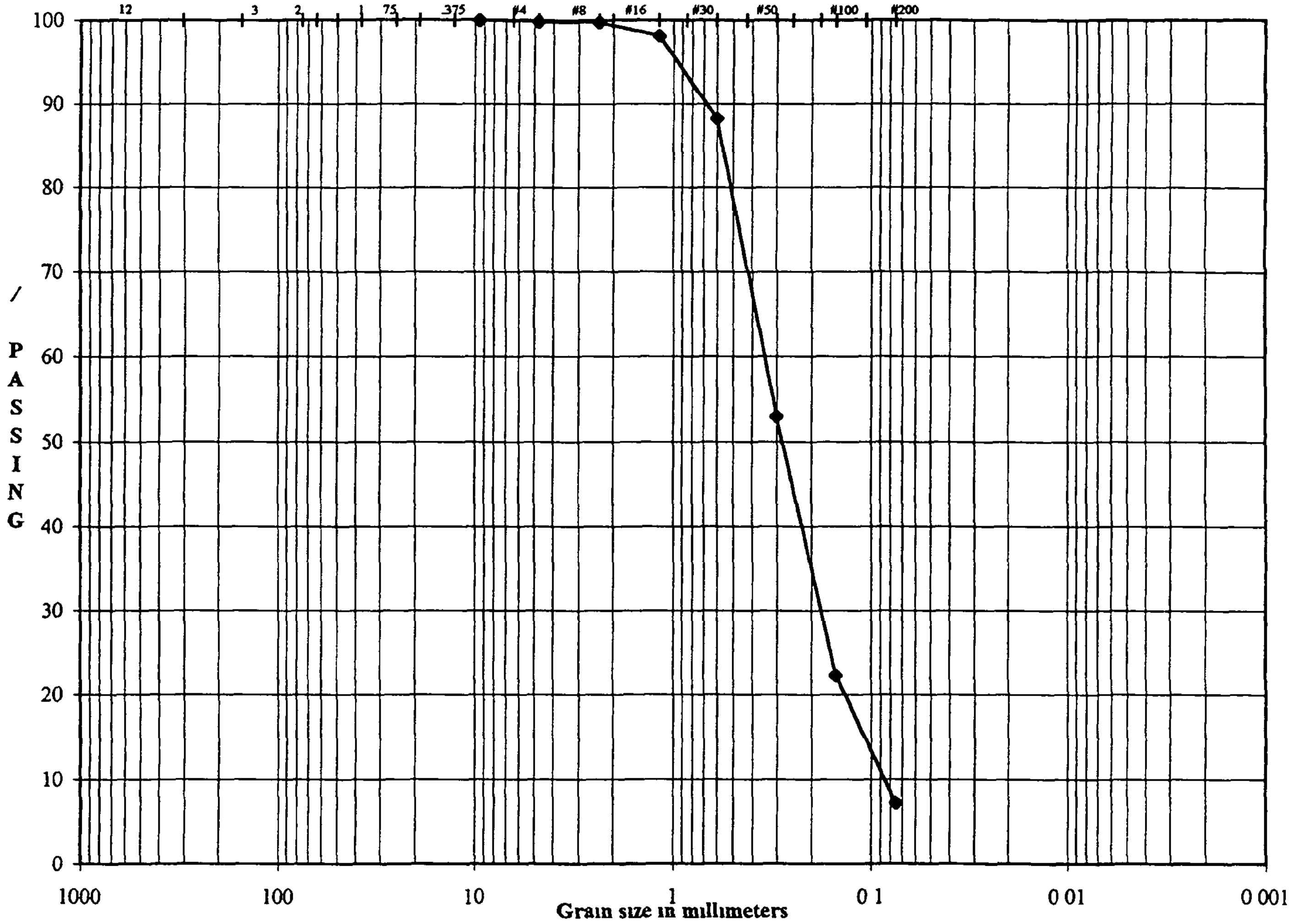
LIQUID LIMIT (Wl)	36 17	36
PLASTIC LIMIT (Wp)	14 54	15
PLASTICITY INDEX (Ip)		21
LIQUIDITY INDEX (I)		0 06
MOISTURE CONTENT		15 77

DESCRIPTION: Olive Brown and Gray SILTY CLAY and medium to fine sand, trace fine gravel

USCS: CL

TECH	JR
DATE	6/1/98
CHECK	
REVIEW	

PARTICLE SIZE DISTRIBUTION
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	GB 1 SA 15
SAMPLE TYPE	Bag
SAMPLE DEPTH	70 0 72 5

LL	
PL	
PI	

DESCRIPTION Brownish Yellow MEDIUM TO FINE SAND little silt, trace fine gravel.

USCS SP-SM

Cu = D60/D10 = 0.24/0 085 = 2 82 < 6

Cc = D30^2/(D60*D10) = 0 17^2/(0 24*0 085) = 1 42 > 1

GSL/ 986-1083 ENVIROGEN/ IA
IC3 3808

TECH	TF
DATE	6/1/98
CHECK	GW
REVIEW	PWM

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	GSL/ 986-1083 ENVIROGEN/ IA	**SAMPLE ID**	GB 1 SA 15
PROJECT NO	IC3 3808	**SAMPLE TYPE**	Bag
REMARKS		**SAMPLE DEPTH**	70 0 72 5

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1 w2)	
Weight of Dry Soil (gm)	(w5=w2 w3)	
Moisture Content (%)	(w4/w5)*100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	1117 94
	Tare Weight (gm)	114 12
(W6)	Total Dry Weight (gm)	1003 82

SIEVE ANALYSIS

Tare Weight: 0 00

	Wt Ret +Tare	(Wt Tare)	Cumulative (%Retained) {(wt ret/w6) 100}	% PASS (100-%ret)	SIEVE	
12 0					12 0	cobbles
3 0					3 0	coarse gravel
2 5					2 5	coarse gravel
2 0					2 0	coarse gravel
1 5					1 5	coarse gravel
1 0					1 0	coarse gravel
0 75					0 75	fine gravel
0 50					0 50	fine gravel
0 375	0 00	0 00	0 00	100 00	0 375	fine gravel
#4	1 29	1 29	0 13	99 87	#4	coarse sand
#8	1 79	1 79	0 18	99 82	#8	coarse sand
#16	18 32	18 32	1 83	98 17	#16	medium sand
#30	118 03	118 03	11 76	88 24	#30	medium sand
#50	471 72	471 72	46 99	53 01	#50	fine sand
#100	779 92	779 92	77 70	22 30	#100	fine sand
#200	931 37	931 37	92 78	7 22	#200	fines
PAN	1003 18	1003 18	99 94	0 06	PAN	

% COBBLES	0 00
% C GRAVEL	0 00
% F GRAVEL	0 13
% C SAND	0 44
% M SAND	28 72
% F SAND	63 50
% FINES	7 22
% TOTAL	100 00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	
PL	
PI	
Gs	2 694

DESCRIPTION Brownish Yellow MEDIUM TO FINE SAND little silt, trace fine gravel.

USCS SP-SM

TECH	TF
DATE	6/1/98
CHECK	GM
REVIEW	PWM

SPECIFIC GRAVITY OF SOILS
ASTM D 854
PYCNOMETER METHOD

PROJECT TITLE	GSL / 986-1083 ENVIROGEN / IA		
PROJECT NUMBER	IC3 3808	**SAMPLE ID**	GB 1 | SA 15
		SAMPLE TYPE	Bag
TESTED FOR	SPECIFIC GRAVITY	**SAMPLE DEPTH**	70 0 72.5

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare Inital (gm)	(W1)	100 24
Weight Soil and Tare Final (gm)	(W2)	100 19
Weight Of Tare (gm)	(W3)	51 93
Weight Of Moisture (gm)	(W4=W1 W2)	0 05
Weight Of Dry Soil (gm)	(W5=W2 W3)	48 26
Hygroscopic Moisture In (%)	(HM=(W4/W5) 100)	0 1%

AIR REMOVAL METHOD

VACUUM

Trial		1	2	3
Pycnometer Number		7	8	19
Weight Pycnometer Empty (gm)	(Mf)	173 99	178 91	176 37
Weight of Soil & Pycnometer (gm)		204 24	212 76	209 14
Weight of Soil Water & Pycnometer (gm)	(Mb)	691 25	698.28	695 02
Observed Temperature (Tb) for (Mb) In Degrees C		24 5	24 5	24 5
Observed Temperature (Ta) for (Ma) In Degrees C		24 00	24 50	23 00
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	672 31	677 15	674 46
Relative Density of Water @ (Ta)		0 99732	0 99720	0 99757
Relative Density of Water @ (Tx)		0 99720	0 99720	0 99720
Correction Factor due to Temperature @Tx	(K)	0 9990	0 9990	0 9990
Weight of Soil (gm)		30 25	33 85	32 77
Weight of Dry Soil (gm)	(Mo)	30 22	33 81	32 74
Weight of Pycnometer & Water (gm)	(Ma)	672 25	677 15	674.28

SPECIFIC GRAVITY

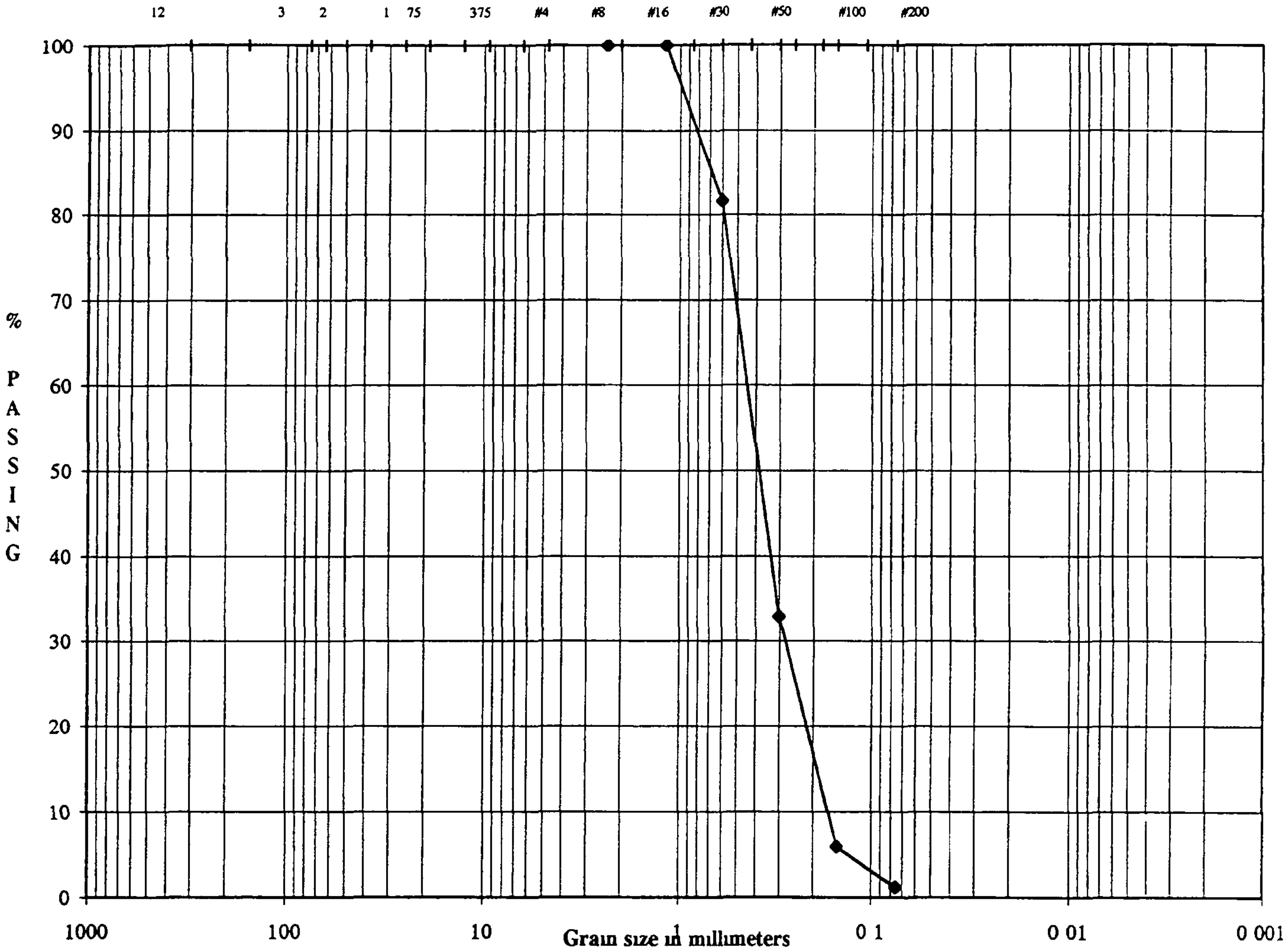
				Gs Average
G @ 20 degrees C = [Mo/(Mo+((Ma Mb))]*(K)	2 691	2 663	2 727	2 694

Correction Values Due To Temperature

Temp (C)	Rel Density	Corr (K)	Temp (C)	Rel Density	Corr (K)
16 00	0 99897	1 0007	23 50	0 99745	0 9992
16 50	0 99889	1 0007	24 00	0 99732	0 9991
17 00	0 99880	1 0006	24 50	0 99720	0 9990
17 50	0 99871	1 0005	25 00	0 99707	0 9988
18 00	0 99862	1 0004	25 50	0 99694	0 9987
18 50	0 99853	1 0003	26 00	0 99681	0 9986
19 00	0 99843	1 0002	26 50	0 99668	0 9984
19 50	0 99833	1 0001	27 00	0 99654	0 9983
20 00	0 99823	1 0000	27 50	0 99640	0 9982
20 50	0 99812	0 9999	28 00	0 99626	0 9980
21 00	0 99802	0 9998	28 50	0 99612	0 9979
21 50	0 99791	0 9997	29 00	0 99597	0 9977
22 00	0 99780	0 9996	29 50	0 99582	0 9976
22 50	0 99768	0 9995	30 00	0 99567	0 9974
23 00	0 99757	0 9993			

TECH	TF
DATE	6/3/98
CHECK	
REVIEW	

PARTICLE SIZE DISTRIBUTION
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID 161
SAMPLE TYPE Bag
SAMPLE DEPTH

LL
PL
PI

DESCRIPTION MEDIUM TO FINE MASTER BUILDERS IRON FILINGS (COLUMN TEST SAMPLE)

USCS SP

Cu = D60/D10 = 0 45/0 18 = 2 5 < 6
Cc = D30 2/(D60*D10) = 0 3 2/(0 45*0 18) = 1 11 > 1

GSL/986-1083 ENVIROGEN /IA
IC3 3808

TECH LB
DATE 6/23/98
CHECK
REVIEW

Golder Construction Services Inc

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	GSL/986-1083 ENVIROGEN /IA	**SAMPLE ID**	161
PROJECT NO	IC3 3808	**SAMPLE TYPE**	Bag
REMARKS		**SAMPLE DEPTH**	

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1 w2)	
Weight of Dry Soil (gm)	(w5=w2 w3)	
Moisture Content (%)	(w4/w5)*100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	425 30
	Tare Weight (gm)	0 00
(W6)	Total Dry Weight (gm)	425 30

SIEVE ANALYSIS

Tare Weight

0 00

	Wt Ret +Tare	(Wt Tare)	Cumulative (% Retained) ((wt ret/w6) 100	% PASS (100-% ret)	SIEVE	
12 0					12 0	cobbles
3 0					3 0	coarse gravel
2 5					2 5	coarse gravel
2 0					2 0	coarse gravel
1 5					1 5	coarse gravel
1 0					1 0	coarse gravel
0 75					0 75	fine gravel
0 50					0 50	fine gravel
0 375					0 375	fine gravel
#4					#4	coarse sand
#8	0 00	0 00	0 00	100 00	#8	coarse sand
#16	0 03	0 03	0 01	99 99	#16	medium sand
#30	78 01	78 01	18 34	81 66	#30	medium sand
#50	285 57	285 57	67 15	32 85	#50	fine sand
#100	399 85	399 85	94 02	5 98	#100	fine sand
#200	419 97	419 97	98 75	1 25	#200	fines
PAN	425 30	425 30	100 00	0 00	PAN	

% COBBLES	0 00
% C GRAVEL	0 00
% F GRAVEL	0 00
% C SAND	0 00
% M SAND	42 62
% F SAND	56 12
% FINES	1 25
% TOTAL	100 00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c m)
< 10% coarse (m f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c f)

LL	
PL	
PI	
Gs	6 953

DESCRIPTION MEDIUM TO FINE MASTER BUILDERS IRON FILINGS (COLUMN TEST SAMPLE)

USCS SP

TECH	LB
DATE	6/23/98
CHECK	
REVIEW	

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	GSL / 986-1083 ENVIROGEN / IA		
PROJECT NUMBER	IC3-3808	**SAMPLE ID**	161
		SAMPLE TYPE	Bag
TESTED FOR	SPECIFIC GRAVITY	**SAMPLE DEPTH**	

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare Inital (gm)	(W1)	34 02
Weight Soil and Tare Final (gm)	(W2)	34 01
Weight Of Tare (gm)	(W3)	3 17
Weight Of Moisture (gm)	(W4=W1 W2)	0 01
Weight Of Dry Soil (gm)	(W5=W2 W3)	30 84
Hygroscopic Moisture In (%)	(HM=(W4/W5) 100)	0 0%

AIR REMOVAL METHOD

VACUUM

Trial		1	2	3
Pycnometer Number		16		
Weight Pycnometer Empty (gm)	(Mf)	178 80		
Weight of Soil & Pycnometer (gm)		232.39		
Weight of Soil Water & Pycnometer (gm)	(Mb)	722 90		
Observed Temperature (Tb) for (Mb) In Degrees C		24 0		
Observed Temperature (Ta) for (Ma) In Degrees C		23 00		
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	677 15		
Relative Density of Water @ (Ta)		0 99757		
Relative Density of Water @ (Tx)		0 99732		
Correction Factor due to Temperature @Tx	(K)	0 9991		
Weight of Soil (gm)		53 59		
Weight of Dry Soil (gm)	(Mo)	53 57		
Weight of Pycnometer & Water (gm)	(Ma)	677 03		

SPECIFIC GRAVITY

G @ 20 degrees C = [Mo/(Mo+((Ma Mb))]*(K)	6 953			**Gs Average** 6 953

Correction Values Due To Temperature

Temp (C)	Rel Density	Corr (K)	Temp (C)	Rel Density	Corr (K)
16 00	0 99897	1 0007	23 50	0 99745	0 9992
16 50	0 99889	1 0007	24 00	0 99732	0 9991
17 00	0 99880	1 0006	24 50	0 99720	0 9990
17 50	0 99871	1 0005	25 00	0 99707	0 9988
18 00	0 99862	1 0004	25 50	0 99694	0 9987
18 50	0 99853	1 0003	26 00	0 99681	0 9986
19 00	0 99843	1 0002	26 50	0 99668	0 9984
19 50	0 99833	1 0001	27 00	0 99654	0 9983
20 00	0 99823	1 0000	27 50	0 99640	0 9982
20 50	0 99812	0 9999	28 00	0 99626	0 9980
21 00	0 99802	0 9998	28 50	0 99612	0 9979
21 50	0 99791	0 9997	29 00	0 99597	0 9977
22 00	0 99780	0 9996	29 50	0 99582	0 9976
22 50	0 99768	0 9995	30 00	0 99567	0 9974
23 00	0 99757	0 9993			

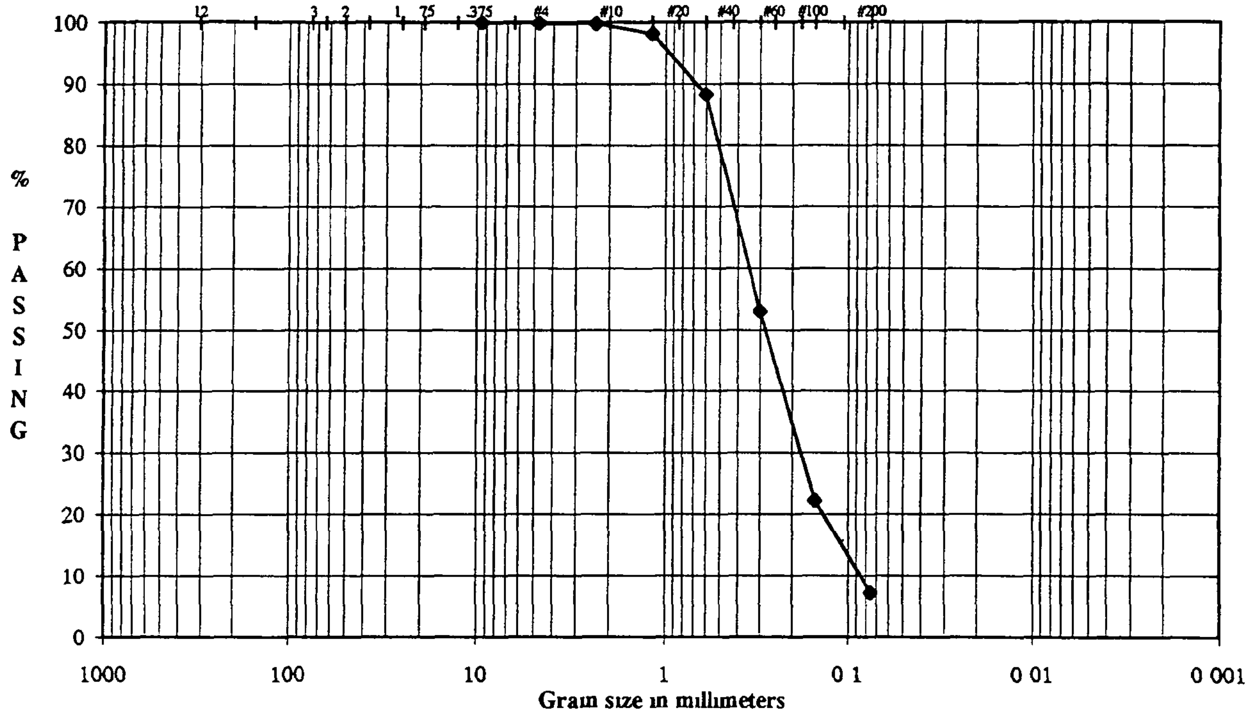
TECH	LB
DATE	6/23/98
CHECK	
REVIEW	

JUNE 1998 IC3 3808

GEOTECHNICAL TEST RESULTS

PROJECT NAME	GSL /986-1083 ENVIROGEN / IA
PROJECT NUMBER	IC3 3808
SAMPLE ID	GB 1 / SA 15 @ 25 psi
DEPTH	70 0 72 5

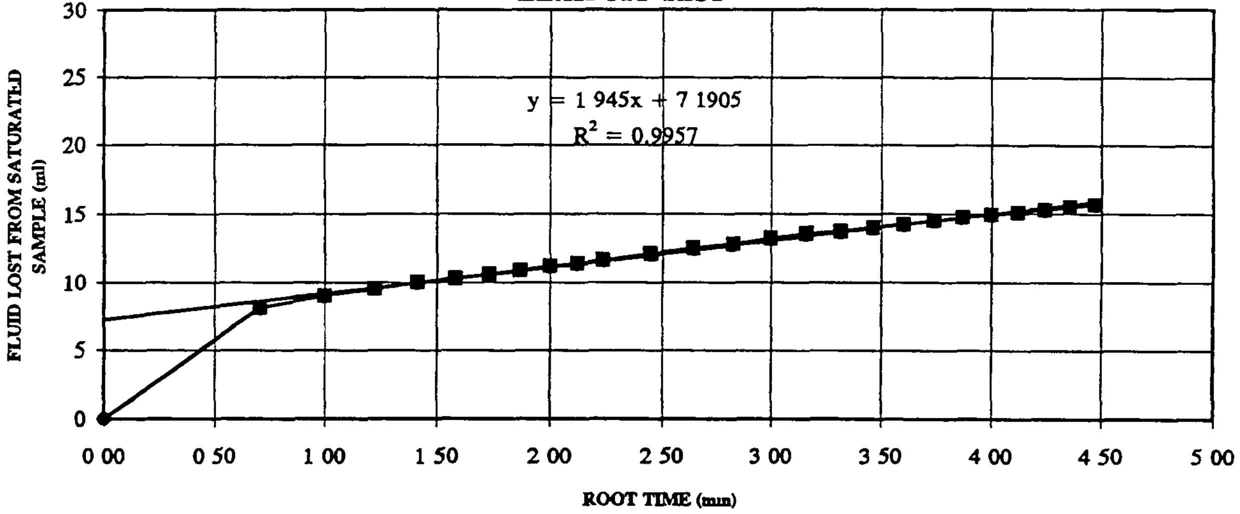
PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422 US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	C	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

NOTES	Sample GB-1 / SA 15 was reconstructed Sample was saturated at a vertical effective stress of 30 psi Some fines lost during saturation
SOIL DESCRIPTION	Brownish Yellow MEDIUM TO FINE SAND little silt trace fine gravel
USCS	SP SM
FLUID DESCRIPTION	Frac Fluid 48lb Guar/1000 gal water

LEAK OFF TEST



LEAK OFF COEFFICIENT Cw (cm/min$^{1/2}$) = 0 02
(Tested under 25 psi)
SPURT VALUE (cm) = 0 09

TECH	TF
DATE	6/12/98
CHECK	TF
REVIEW	

GEOTECHNICAL TEST RESULTS

PROJECT NAME	**GSL /986-1083 ENVIROGEN / IA**
PROJECT NUMBER	**IC3 3808**
SAMPLE ID	**GB 1 / SA 15 @ 25 psi**
DEPTH	**70 0 72 5**

PARTICLE SIZE DISTRIBUTION

Tare Weight	0 00
Total Dry Weight	1003 82

	Wt Ret +Tare	(Wt Tare)	Cumulative (%Retained) {(wt ret/w6) 10	% PASS (100-%ret)	SIEVE	
12 0					12 0	cobbles
3 0					3 0	coarse gravel
2 5					2 5	coarse gravel
2 0					2 0	coarse gravel
1 5					1 5	coarse gravel
1 0					1 0	coarse gravel
0 75					0 75	fine gravel
0 50					0 50	fine gravel
0 375	0 00	0 00	0 00	100 00	0 375	fine gravel
#4	1 29	1 29	0 13	99 87	#4	coarse sand
#8	1 79	1 79	0 18	99 82	#8	coarse sand
#16	18 32	18 32	1 83	98 17	#16	medium sand
#30	118 03	118 03	11 76	88 24	#30	medium sand
#50	471 72	471 72	46 99	53 01	#50	fine sand
#100	779 92	779 92	77 70	22 30	#100	fine sand
#200	931 37	931 37	92 78	7 22	#200	fines
PAN	1003 18	1003 18	99 94	0 06	PAN	

NOTES	Sample GB-1 / SA 15 was reconstructed Sample was saturated at a vertical effective stress of 30 psi Some fines lost during saturation
SOIL DESCRIPTION	Brownish Yellow MEDIUM TO FINE SAND little silt trace fine gravel
USCS	SP SM
FLUID DESCRIPTION	Frac Fluid 48lb Guar/1000 gal water

LEAK OFF TEST

SAMPLE PREPARATION

Sample weight g	224 9
Sample height cm	3 2
Sample Diameter cm	7 11
Area cm²	39 70
Volume cm³	127 05
Dry Density pcf	110 45
Porosity %	34 2

TIME (min)	TIME ROOT (min)	VOLUME OF WATER DISPLACED FROM SAMPLE (ml)
0	0 00	0 00
0 5	0 71	8 10
1	1 00	9 0
1 5	1 22	9 5
2	1 41	10 0
2 5	1 58	10 3
3	1 73	10 6
3 5	1 87	10 9
4	2 00	11 2
4 5	2 12	11 4
5	2 24	11 6
6	2 45	12 1
7	2 65	12 5
8	2 83	12 8
9	3 00	13 2
10	3 16	13 5
11	3 32	13 7
12	3 46	14 0
13	3 61	14 2
14	3 74	14 5
15	3 87	14 7
16	4 00	14 9
17	4 12	15 1
18	4 24	15 3
19	4 36	15 5
20	4 47	15 7

FILTER CAKE THICKNESS (cm)

0 2

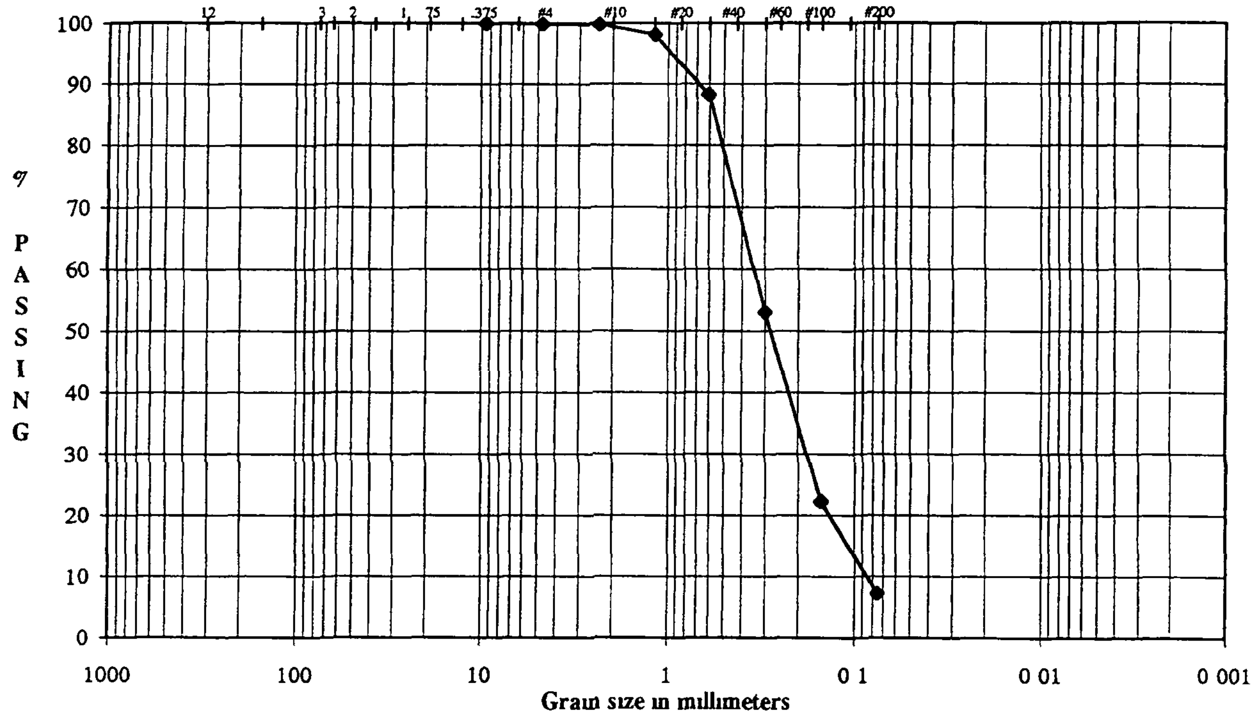
TECH	TF
DATE	6/12/98
CHECK	
REVIEW	

JUNE 1998 IC3 3808

GEOTECHNICAL TEST RESULTS

PROJECT NAME GSL /986-1083 ENVIROGEN / IA
PROJECT NUMBER. IC3 3808
SAMPLE ID GB 1 / SA 15 @ 50 psi **DEPTH** 70 0 72 5

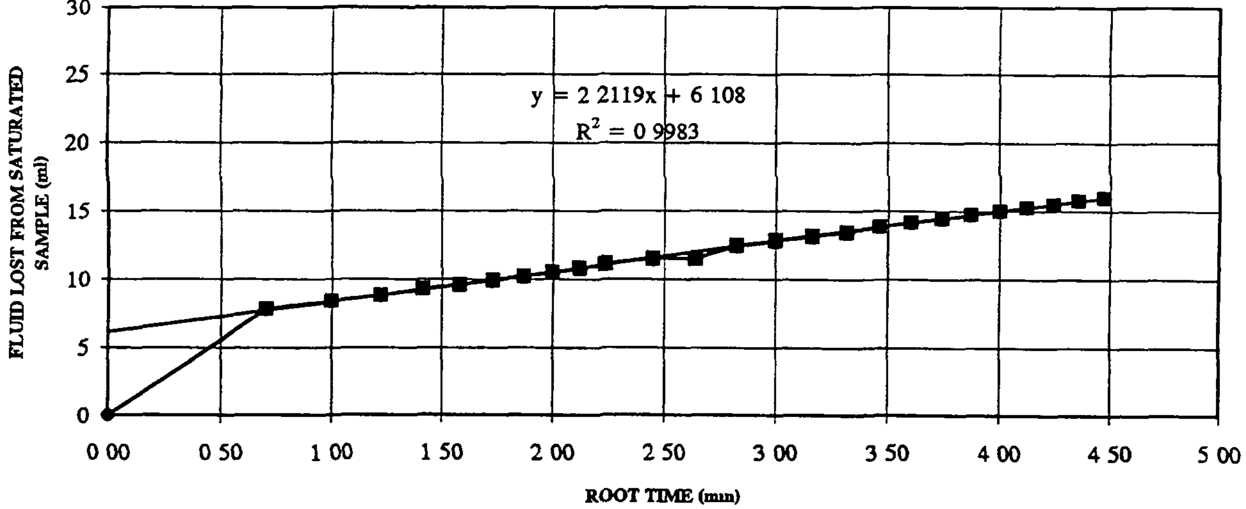
PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422 US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	C	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

NOTES	Sample GB-1 / SA 15 was reconstructed Sample was saturated at a vertical effective stress of 30 psi Some fines lost during saturation
SOIL DESCRIPTION	Brownish Yellow MEDIUM TO FINE SAND little silt trace fine gravel
USCS	SP SM
FLUID DESCRIPTION	Frac Fluid 48lb Guar/1000 gal water

LEAK OFF TEST



LEAK OFF COEFFICIENT Cw (cm/min$^{1/2}$) = 0 03
(Tested under 50 psi)
SPURT VALUE (cm) = 0 08

TECH	TF
DATE	6/7/98
CHECK	TF
REVIEW	

GEOTECHNICAL TEST RESULTS

PROJECT NAME	GSL /986-1083 ENVIROGEN / IA
PROJECT NUMBER	IC3 3808
SAMPLE ID	GB 1 / SA 15 @ 50 psi DEPTH 70 0 72 5

PARTICLE SIZE DISTRIBUTION

Tare Weight
0 00

Total Dry Weight
1003 82

	Wt Ret +Tare	(Wt Tare)	Cumulative (%Retained) ((wt ret/w6) 10	% PASS (100 %ret)	SIEVE	
12 0					12 0	cobbles
3 0					3 0	coarse gravel
2 5					2 5	coarse gravel
2 0					2 0	coarse gravel
1 5					1 5	coarse gravel
1 0					1 0	coarse gravel
0 75					0 75	fine gravel
0 50					0 50	fine gravel
0 375	0 00	0 00	0 00	100 00	0 375	fine gravel
#4	1 29	1 29	0 13	99 87	#4	coarse sand
#8	1 79	1 79	0 18	99 82	#8	coarse sand
#16	18 32	18 32	1 83	98 17	#16	medium sand
#30	118 03	118 03	11 76	88 24	#30	medium sand
#50	471 72	471 72	46 99	53 01	#50	fine sand
#100	779 92	779 92	77 70	22 30	#100	fine sand
#200	931 37	931 37	92 78	7 22	#200	fines
PAN	1003 18	1003 18	99 94	0 06	PAN	

NOTES	Sample GB-1 / SA 15 was reconstructed Sample was saturated at a vertical effective stress of 30 psi Some fines lost during saturation
SOIL DESCRIPTION	Brownish Yellow MEDIUM TO FINE SAND little silt trace fine gravel
USCS	SP SM
FLUID DESCRIPTION	Frac Fluid 48lb Guar/1000 gal water

LEAK OFF TEST

SAMPLE PREPARATION

Sample weight g	224 9
Sample height cm	3 2
Sample Diameter cm	7 11
Area cm²	39 70
Volume cm³	125 07
Dry Density pcf	112 22
Porosity %	33 1

TIME (min)	TIME ROOT (min)	VOLUME OF WATER DISPLACED FROM SAMPLE (ml)
0	0 00	0 00
0 5	0 71	7 80
1	1 00	8 4
1 5	1 22	8 8
2	1 41	9 3
2 5	1 58	9 6
3	1 73	9 9
3 5	1 87	10 2
4	2 00	10 5
4 5	2 12	10 8
5	2 24	11 1
6	2 45	11 5
7	2 65	11 5
8	2 83	12 4
9	3 00	12 8
10	3 16	13 1
11	3 32	13 4
12	3 46	13 8
13	3 61	14 1
14	3 74	14 4
15	3 87	14 7
16	4 00	15 0
17	4 12	15 3
18	4 24	15 5
19	4 36	15 8
20	4 47	16 0

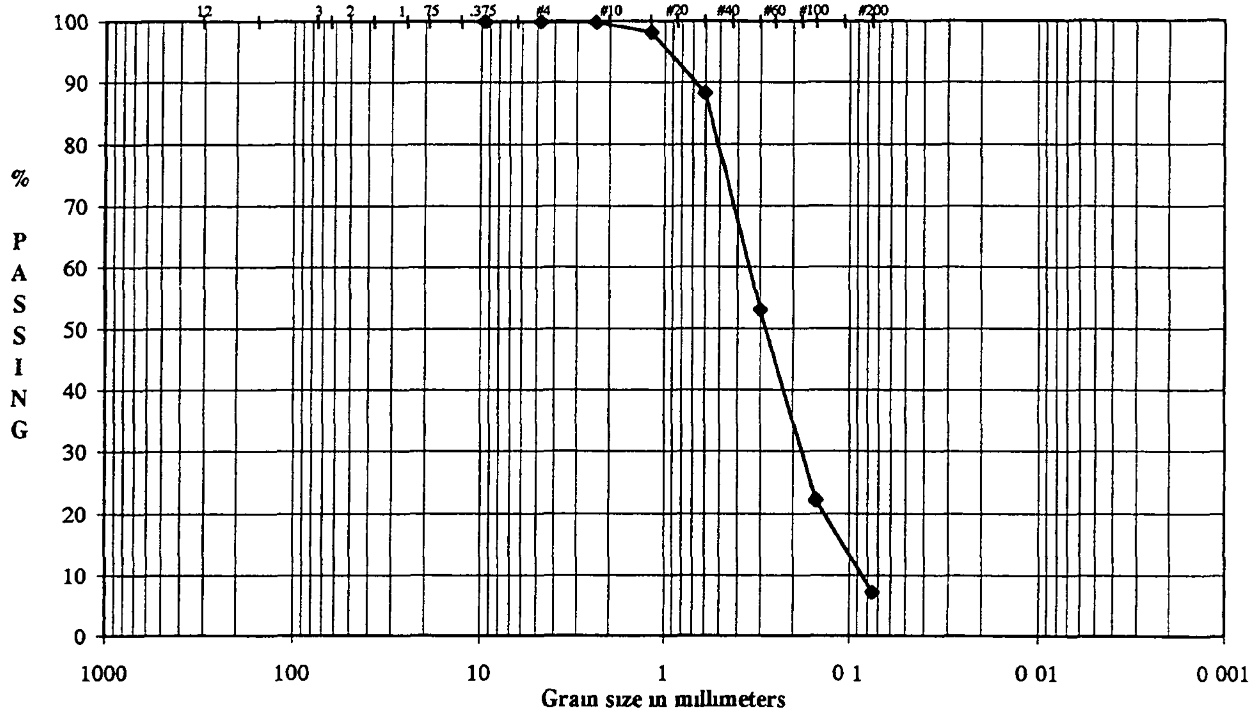
FILTER CAKE THICKNESS (cm)
0.3

TECH	TF
DATE	6/7/98
CHECK	TF
REVIEW	

GEOTECHNICAL TEST RESULTS

PROJECT NAME GSL /986-1083 ENVIROGEN / IA
PROJECT NUMBER IC3 3808
SAMPLE ID GB 1 / SA 15 @ 100 psi **DEPTH** 70 0 72 5

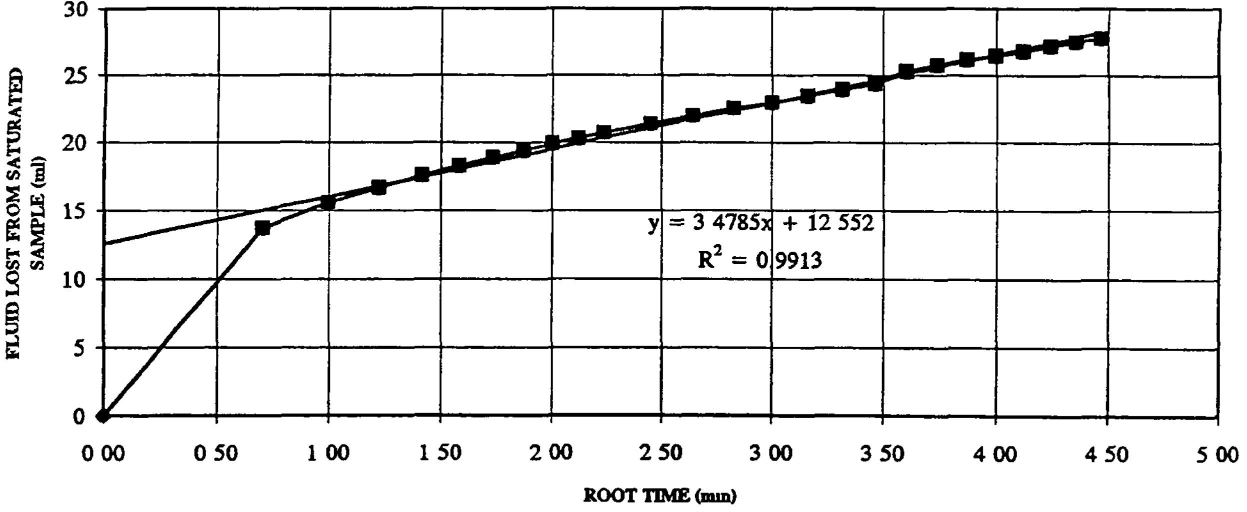
PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422 US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	C	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

NOTES Sample GB-1 / SA 15 was reconstructed Sample was saturated at a vertical effective stress of 30 psi Some fines lost during saturation
SOIL DESCRIPTION Brownish Yellow MEDIUM TO FINE SAND little silt trace fine gravel
USCS SP SM
FLUID DESCRIPTION Frac Fluid 48lb Guar/1000 gal water

LEAK OFF TEST



LEAK OFF COEFFICIENT Cw (cm/min$^{1/2}$) = 0 04
(Tested under 100 psi)
SPURT VALUE (cm) = 0 16

TECH	TF
DATE	6/10/98
CHECK	
REVIEW	

GEOTECHNICAL TEST RESULTS

PROJECT NAME	GSL /986-1083 ENVIROGEN / IA
PROJECT NUMBER	IC3 3808
SAMPLE ID	GB 1 / SA 15 @ 100 psi DEPTH 70 0 72 5

PARTICLE SIZE DISTRIBUTION

Tare Weight
0 00

Total Dry Weight
1003 82

	Wt Ret +Tare	(Wt Tare)	Cumulative (%Retained) ((wt ret/w6) 10	% PASS (100 %ret)	SIEVE	
12 0					12 0	cobbles
3 0					3 0	coarse gravel
2 5					2 5	coarse gravel
2 0					2 0	coarse gravel
1 5					1 5	coarse gravel
1 0					1 0	coarse gravel
0 75					0 75	fine gravel
0 50					0 50	fine gravel
0 375	0 00	0 00	0 00	100 00	0 375	fine gravel
#4	1 29	1 29	0 13	99 87	#4	coarse sand
#8	1 79	1 79	0 18	99 82	#8	coarse sand
#16	18 32	18 32	1 83	98 17	#16	medium sand
#30	118 03	118 03	11 76	88 24	#30	medium sand
#50	471 72	471 72	46 99	53 01	#50	fine sand
#100	779 92	779 92	77 70	22 30	#100	fine sand
#200	931 37	931 37	92 78	7 22	#200	fines
PAN	1003 18	1003 18	99 94	0 06	PAN	

NOTES	Sample GB-1 / SA 15 was reconstructed Sample was saturated at a vertical effective stress of 30 psi Some fines lost during saturation
SOIL DESCRIPTION	Brownish Yellow MEDIUM TO FINE SAND little silt trace fine gravel
USCS	SP-SM
FLUID DESCRIPTION	Frac Fluid 48lb Guar/1000 gal water

LEAK OFF TEST

SAMPLE PREPARATION

Sample weight g	225 0
Sample height cm	3 1
Sample Diameter cm	7 11
Area cm²	39 70
Volume cm³	123 08
Dry Density pcf	114 07
Porosity %	34 1

TIME (min)	TIME ROOT (min)	VOLUME OF WATER DISPLACED FROM SAMPLE (ml)
0	0 00	0 00
0 5	0 71	13 70
1	1 00	15 6
1 5	1 22	16 7
2	1 41	17 6
2 5	1 58	18 3
3	1 73	18 9
3 5	1 87	19 4
4	2 00	19 9
4 5	2 12	20 3
5	2 24	20 7
6	2 45	21 4
7	2 65	22 0
8	2 83	22 6
9	3 00	23 0
10	3 16	23 5
11	3 32	24 0
12	3 46	24 4
13	3 61	25 3
14	3 74	25 7
15	3 87	26 1
16	4 00	26 4
17	4 12	26 7
18	4 24	27 1
19	4 36	27 4
20	4 47	27 7

FILTER CAKE THICKNESS (cm)

0.4

TECH	TF
DATE	6/10/98
CHECK	
REVIEW	

RESISTIVITY OF SOIL
ASTM G-57 AND U S DOT FP-85

PROJECT TITLE	GSL/986-1083 ENVIROGEN/IA	**SAMPLE ID**	GB 1	SA 9
PROJECT NO	IC3-3808	**SAMPLE TYPE**	Bag	
REMARKS		**SAMPLE DEPT**	41 0 43 2	

SAMPLE PREPARATION Sieved through the #8 Sieve No

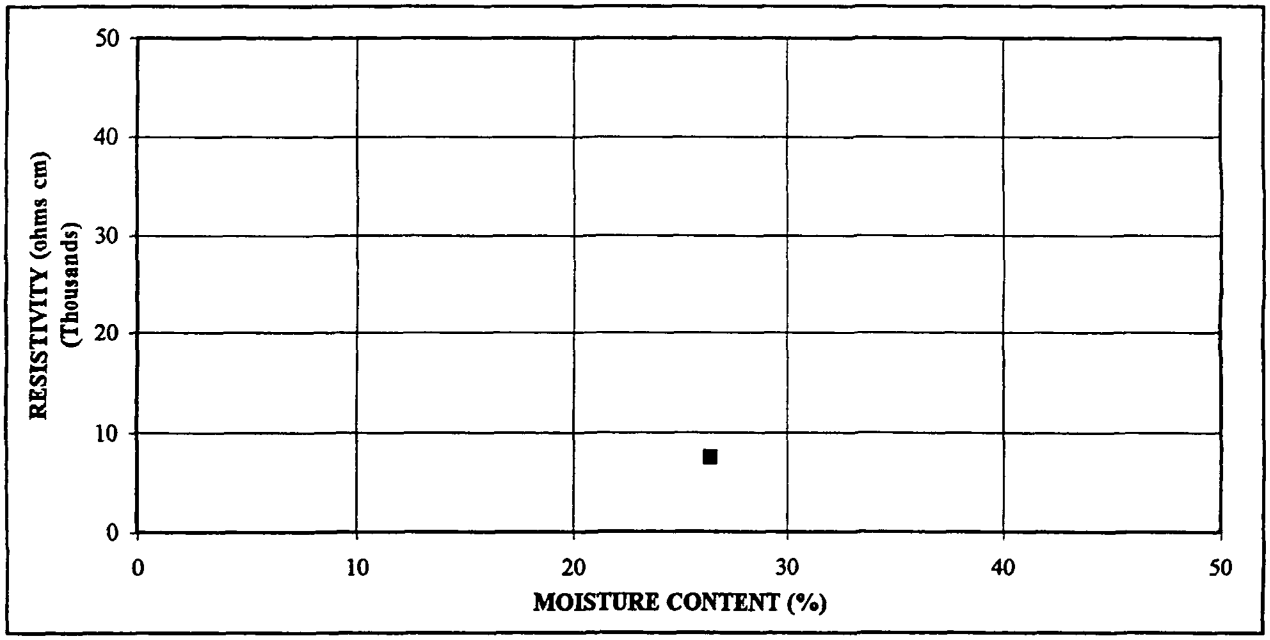
TEST APPARATUS Miller Soilbox and Nilsson 400 Soil Resistance Meter

Identification SATURATED

SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	6 550			
TEMP DEGREES (C)	22.0			
RESISTIVITY @ 15 5 C (ohms-cm)	7 614			

MOISTURE CONTENT

WET WEIGHT & TARE	457 80			
DRY WEIGHT & TARE	372.85			
TARE WEIGHT	51 38			
WEIGHT OF MOISTURE (gm)	84 95			
WEIGHT OF DRY SOIL (gm)	321 47			
MOISTURE CONTENT (%)	26 43			



Description	Brownish Yellow FINE SAND trace silt
USCS	SP

TECH	TF
DATE	6/1/98
CHECK	
REVIEW	

Golder Construction Services, Inc

RESISTIVITY OF SOIL
ASTM G-57 AND U S DOT FP-85

PROJECT TITLE	GSL/ 986-1083 ENVIROGEN/ IA	SAMPLE ID	GB 1	SA 10
PROJECT NO	IC3-3808	SAMPLE TYPE	Bag	
REMARKS		SAMPLE DEPT	45 0 48.0	

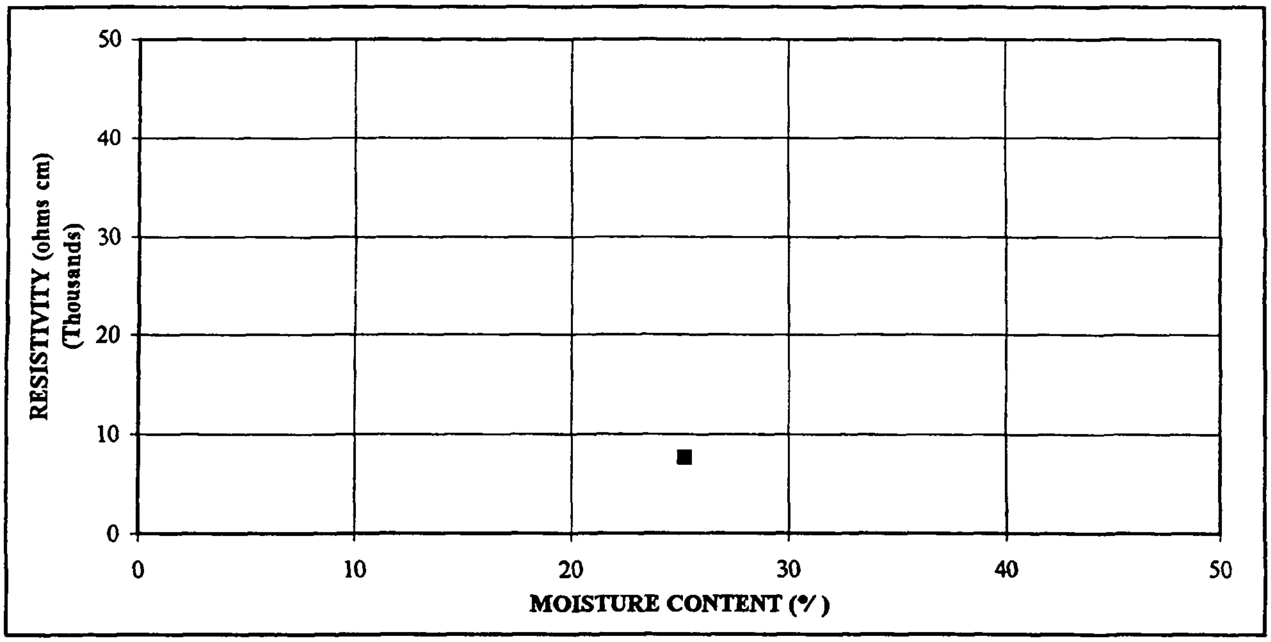
SAMPLE PREPARATION	Sieved through the #8 Sieve	No
TEST APPARATUS	Miller Soilbox and Nilsson 400 Soil Resistance Meter	

Identification SATURATED

SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	6 650			
TEMP DEGREES (C)	21 5			
RESISTIVITY @ 15 5 C (ohms-cm)	7 648			

MOISTURE CONTENT

WET WEIGHT & TARE	495 31			
DRY WEIGHT & TARE	406 13			
TARE WEIGHT	51 76			
WEIGHT OF MOISTURE (gm)	89 18			
WEIGHT OF DRY SOIL (gm)	354 37			
MOISTURE CONTENT (%)	25 17			



Description	Brownish Yellow FINE SAND little silt
USCS	SP-SM

TECH	TF
DATE	6/1/98
CHECK	
REVIEW	

RESISTIVITY OF SOIL
ASTM G-57 AND U S DOT FP-85

PROJECT TITLE	GSL/ 986-1083 ENVIROGEN/ IA	SAMPLE ID	GB 1	SA 15
PROJECT NO	IC3-3808	SAMPLE TYPE	Bag	
REMARKS		SAMPLE DEPT	70 0 72 5	

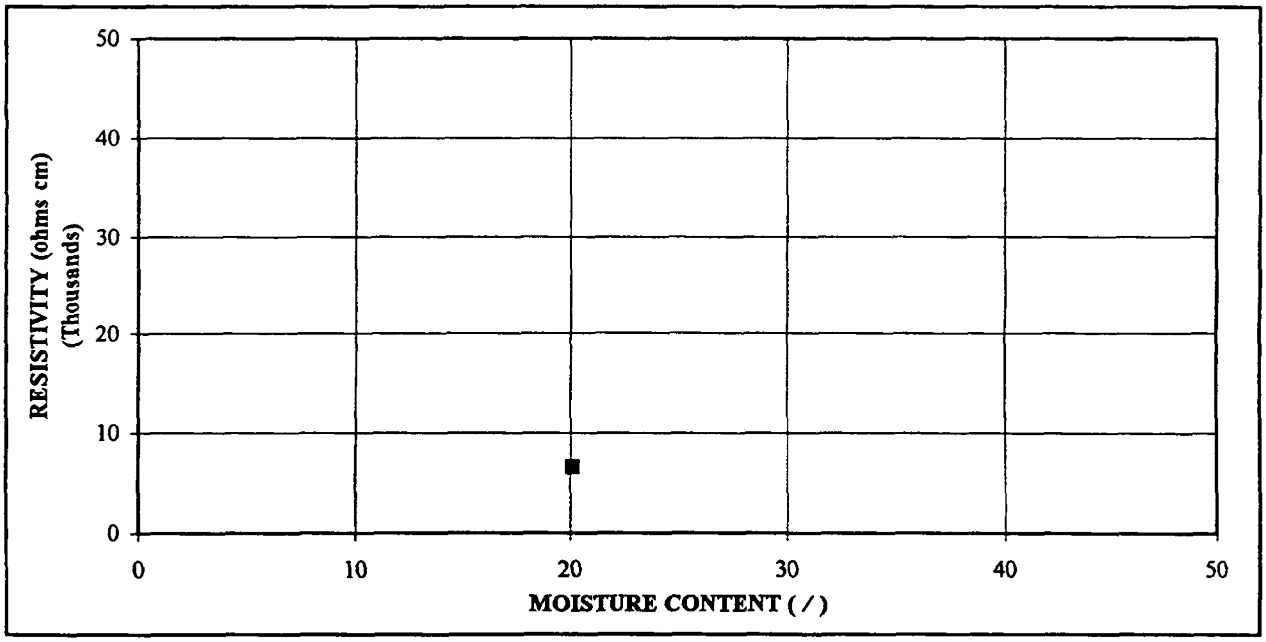
SAMPLE PREPARATION	Sieved through the #8 Sieve	No
TEST APPARATUS	Miller Soilbox and Nilsson 400 Soil Resistance Meter	

Identification SATURATED

SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	5 750			
TEMP DEGREES (C)	21 5			
RESISTIVITY @ 15 5 C (ohms-cm)	6 613			

MOISTURE CONTENT

WET WEIGHT & TARE	538 88			
DRY WEIGHT & TARE	457 22			
TARE WEIGHT	51 60			
WEIGHT OF MOISTURE (gm)	81 66			
WEIGHT OF DRY SOIL (gm)	405 62			
MOISTURE CONTENT (/)	20 13			



Description	Brownish Yellow MEDIUM TO FINE SAND little silt, trace fine gravel
USCS	SP-SM

TECH	TF
DATE	6/1/98
CHECK	
REVIEW	

Golder Construction Services, Inc

Iron Bearing Fracture Fluid Preparation

1) 1 L water

2) Raise pH to 9 5 with basic solution

3) Stir water in blender without entraining air Slowly sprinkle 5 8 g Golder B1 and 0 12 g Golder-BE1 into the water (to avoid lumps)

4) Mix slowly for 10 minutes

5) Drop mix pH to 6 5 with acidic solution

6) Mix without entraining air for at least 15 minutes

7) Add 1900 g of Master Builder fine to medium iron Mixer speed should be increased to maintain iron in suspension

8) Add 5 ml Golder BC1 mix thoroughly without entraining air for a short duration until mix is consistent

Notes

1) Fracturing fluid can be mixed in smaller/larger batches by maintaining the above ratios

Revised 05/04/98

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inc

Method Detection Limits (MDL) and Detection Limits (DL), Bench Scale Tests, Centerville, Iowa Site

Organic Compounds	**MDL (µg/L)**
Tetrachloroethene	1 4
Trichloroethene	1 2
1 1 1-Trichloroethane	1 3
Trichloromethane	1 2
Dichloromethane	3 5
1 1-Dichloroethane	6 0
1 2 Dichloroethane	4 1
cis-1 2 Dichloroethene	7 8
trans 1 2 Dichloroethene	1 9
1 1 Dichloroethene	3 2
Vinyl Chloride	0 70
Inorganic Compounds	**DL (mg/L)**
Calcium	0 05
Iron Total	0 01
Magnesium	0 05
Manganese	0 005
Potassium	1 0
Silica, Reactive	0 05
Sodium	0 1
Chloride	0 05
Sulphate	0 05
Alkalinity (as $CaCO_3$)	1 0
Total Dissolved Solids	2

Treatability Test
Iowa

Column Identification	251
Column Composition	100 / Granular Iron (UW#161)
Pore Volume (PV)	260
Porosity	0 46
Column Length	1 64 ft (50 cm)
Column Diameter	1 5 in (3 81 cm)
Flow Velocity	2 ft/day (61 cm/day)

Column Distance (ft)			0 0	0 08	0 16	0 33	0 50	0 66	1 0	1 3	1 6		
Residence Time (hr)			0 0	1 0	1 9	4 0	6 0	7 9	12 0	15 7	19 7		
	PV	RN	Influent			Organic Concentration (ug/L)					Effluent	HL	r2
PCE													
	6	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	10	a	1 1	1 7	2 4	nd	nd	nd	nd	nd	nd		
	16	a	nd	nd	nd	nd	3	nd	2	nd	nd		
	21	a	1 3	2.4	10	nd	nd	nd	nd	nd	nd		
	31	a	4 5	11	1 0	1 0	nd	nd	nd	nd	nd		
	38	b	1 1	nd	nd	nd	nd	nd	nd	nd	nd		
	43	b	2 1	nd	nd	nd	nd	nd	nd	nd	nd		
TCE													
	6	a	7428	416	124	nd	nd	nd	nd	nd	nd		
	10	a	7811	321	141	nd	nd	nd	nd	nd	nd		
	16	a	7324	280	99	4 4	1 3	nd	nd	nd	nd		
	21	a	7211	227	131	nd	nd	nd	nd	nd	nd		
	31	a	6850	199	76	6 9	nd	nd	nd	nd	nd	0 4	0 910
	38	b	5865	217	53	1 5	nd	nd	nd	nd	nd	0 3	0 973
	43	b	4730	231	40	3 1	nd	nd	nd	nd	nd	0 4	0 955
111TCA													
	10	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	16	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	21	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	31	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	38	b	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	43	b	nd	nd	nd	nd	nd	nd	nd	nd	nd		
TCM													
	10	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	16	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	21	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	38	b	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	43	b	nd	nd	nd	nd	nd	nd	nd	nd	nd		
DCM													
	10	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	16	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	21	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		

nd = not detected
na = not applicable
RN = reservoir number
HL = half life
r2 = coefficient of variation
BOLD = peak concentration

Treatability Test	Column Identification	251
Iowa	Column Composition	100 / Granular Iron (UW#161)
	Pore Volume (PV)	260
	Porosity	0 46
	Column Length	1 64 ft (50 cm)
	Column Diameter	1 5 in (3 81 cm)
	Flow Velocity	2 ft/day (61 cm/day)

Column Distance (ft)			0 0	0 08	0 16	0 33	0 50	0 66	1 0	1 3	1 6		
Residence Time (hr)			0 0	1 0	1 9	4 0	6 0	7 9	12 0	15 7	19 7		
	PV	RN	Influent				Organic Concentration (ug/L)				Effluent	HL	r2
11DCA													
	10	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	16	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	38	b	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	43	b	nd	nd	nd	nd	nd	nd	nd	nd	nd		
12DCA													
	10	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	16	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	38	b	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	43	b	nd	nd	nd	nd	nd	nd	nd	nd	nd		
cDCE													
	5	a	17	28	11	0 8	nd	nd	nd	nd	nd		
	9	a	19	44	28	7 5	nd	nd	nd	nd	nd		
	13	a	10	16	11	6 8	nd	nd	nd	nd	nd		
	16	a	12	51	28	8 6	nd	nd	nd	nd	nd		
	20	a	12	**43**	32	7 1	nd	nd	nd	nd	nd	1 1	0 968
	29	a	41	**89**	64	24	7 1	nd	nd	nd	nd	1 3	0 991
	42	b	39	**62**	44	15	nd	nd	nd	nd	nd	1 4	0 990
tDCE													
	5	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	9	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	13	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	16	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	20	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	29	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	42	b	nd	nd	nd	nd	nd	nd	nd	nd	nd		
11DCE													
	5	a	nd	2 3	0 9	nd	nd	nd	nd	nd	nd		
	9	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	13	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	16	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	20	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	29	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	42	b	nd	nd	nd	nd	nd	nd	nd	nd	nd		

nd = not detected
na = not applicable
RN = reservoir number
HL = half life
r2 = coefficient of variation
BOLD = peak concentration

Treatability Test	Column Identification	251
Iowa	Column Composition	100 / Granular Iron (UW#161)
	Pore Volume (PV)	260
	Porosity	0 46
	Column Length	1 64 ft (50 cm)
	Column Diameter	1 5 in (3 81 cm)
	Flow Velocity	2 ft/day (61 cm/day)

Column Distance (ft)			0 0	0 08	0 16	0 33	0 50	0 66	1 0	1 3	1 6		
Residence Time (hr)			0 0	1 0	1 9	4 0	6 0	7 9	12 0	15 7	19 7		
	PV	RN	Influent				Organic Concentration (ug/L)				Effluent	HL	r2
VC													
	5	a	nd	6 9	1 1	3 3	nd	nd	nd	nd	nd		
	9	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	13	a	nd	3 2	nd	3 2	nd	nd	nd	nd	nd		
	16	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	20	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	29	a	nd	nd	nd	nd	nd	nd	nd	nd	nd		
	42	b	nd	nd	nd	nd	nd	nd	nd	nd	nd		
			pH Along Column										
pH													
	3	a	7 5	9 0	9 2	9.2	9 4	9 6	9 8	9 1	10 1		
	8	a	7 8	9 0	9 2	9 3	9 3	9 5	9 6	9 6	9 8		
	14	a	7 9	9 1	9 2	9 3	9 4	9 3	9 4	9 8	9 9		
	22	a	8 0	9 1	9 2	9 2	9 3	9 3	9 6	9 5	9 9		
	30	a	7 5	8 5	8 7	9 0	9 1	9 5	9 6	na	9 8		
	46	b	7 9	9 0	9 0	9 1	9 1	9 2	9 2	9 6	10 0		
			Redox Potential Along Column (mV)										
Eh													
	3	a	374	0	104	271	286	261	29	64	71		
	8	a	384	-346	399	362	289	231	292	337	116		
	14	a	391	-407	-405	356	-358	382	386	-423	192		
	22	a	249	-456	-461	-485	-473	-476	-81	-483	-455		
	30	a	404	-381	-373	-413	252	374	502	na	-466		
	46	b	305	-406	372	385	-424	-426	-430	520	523		

nd = not detected
na = not applicable
RN = reservoir number
HL = half life
r2 = coefficient of variation
BOLD = peak concentration

eof//

PHILIP SERVICES

30-Jun-98

UNIVERSITY OF WATERLOO
Institute for Groundwater Research
University of Waterloo
N2L 3G1

Page: 8
Copy 1 of 2
Set 2

Attn: Wayne Noble
Project:
PO #
Received 19-Jun 98 15:41

Job 9854504 **Status. Final**

Water Samples

Sample Id	Ag ICAP mg/L	Al ICAP mg/L	As ICAP mg/L	B ICAP mg/L	Ba ICAP mg/L	Be ICAP mg/L	Bi ICAP mg/L	Ca ICAP mg/L
UW-180 influent	<0 003	0 03	<0 1	<0 01	0 157	<0 0005	<0 1	64 4
UW-181 effluent col 251 319 pv RNB	<0 003	<0 03	<0 1	0 23	<0 005	<0 0005	<0 1	2 46
Blank	<0 003	<0 03	<0 1	<0 01	<0 005	<0 0005	<0 1	<0 05
QC Standard (found)	0 024	9 33	1.1	0 18	0 995	0 979	1 0	49 7
QC Standard (expected)	0 030	10 0	1 0	0 20	1 00	1 00	1 0	51 0
Repeat UW-180	<0 003	0 04	<0 1	0 02	0 157	<0 0005	<0 1	64 3

PHILIP SERVICES

30-Jun-98

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University of Waterloo
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Attn: Wayne Noble
Project:
PO #
Received 19-Jun 98 15:41

Job: 9854504
Status Final

Water Samples

Sample Id	Cd ICAP mg/L	Co ICAP mg/L	Cr ICAP mg/L	Cu ICAP mg/L	Fe ICAP mg/L	K ICAP mg/L	Mg ICAP mg/L	Mn ICAP mg/L
UW 180 nfluent	<0 005	<0 005	<0 005	<0 003	0 01	1	18 5	<0 005
UW-181 eff col 251, 319pv RNB	<0 005	<0 005	<0 005	<0 003	0 02	1	0 30	<0 005
Blank	<0 005	<0 005	<0 005	<0 003	<0 01	<1	<0 05	<0 005
QC Standard (found)	0 924	0 944	0 943	0 960	0 91	10	10 8	0 937
QC Standard (expected)	1 00	1 00	1 00	1 00	1 00	10	11 0	1 00
Repeat UW-180	<0 005	<0 005	<0 005	<0 003	0 02	<1	18 6	<0 005

PSC
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30-Jun-98

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Attn: Wayne Noble
Project:
PO #:

Received: 19-Jun 98 15 41

Job: 9854504 Status, Final

Water Samples

Sample Id	Mo ICAP mg/L	Na ICAP mg/L	Ni ICAP mg/L	P ICAP mg/L	Pb GFAAS mg/L	S ICAP mg/L	Sb ICAP mg/L	Se ICAP mg/L
UW-180 influent	0 01	44 5	<0 02	<0 1	<0 001	4 5	<0 1	<0 1
UW-181 eff col 251, 319 pv RNB	0 09	44 2	<0 02	<0 1	<0 001	4 5	<0 1	<0 1
Blank	<0 01	<0 1	<0 02	<0 1	<0 001	<0 1	<0 1	<0 1
QC Standard (found)	1 05	49 7	0 95	2 0	0 024	10 0	0 9	0 9
QC Standard (expected)	1 10	50 0	1 00	2 0	0 025	10 0	1 0	1 0
Repeat UW-180	0 01	44 4	<0 02	<0 1	<0 001	4 5	<0 1	<0 1

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Attn Wayne Noble
Project
PO #:
Received 19-Jun-98 15 41

Job: 9854504
Status: Final

Water Samples

Sample Id	Si ICAP mg/L	Sn ICAP mg/L	Sr ICAP mg/L	Ti ICAP mg/L	V ICAP mg/L	Zn ICAP mg/L	F- SM 4500F mg/L	Cl- SM 4110B mg/L
UW-180 influent	12 1	<0 05	0 199	<0 005	<0 005	<0 005	0 6	1 20
UW-181 eff col 251 31 9 pv RNB	0 76	<0 05	0 020	<0 005	<0 005	<0.005	0 5	6 00
Blank	<0 05	<0 05	<0 001	<0 005	<0 005	<0 005	<0 1	<0 05
QC Standard (found)	2 06	0 96	0 905	0 944	0.944	0 941	1 2	6 10
QC Standard (expected)	2 00	1 00	1 00	1 00	1 00	1 00	1 2	6 00
Repeat UW-180	12 1	<0 05	0 198	<0 005	0 005	<0 005	0 6	1 20

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Attn: Wayne Noble
Project
PO #

Received 19-Jun-98 15 41

Job: 9854504 Status Final

Water Samples

Sample Id	NO2-N SM 4110B mg/L	PO4-3 SM 4110B mg/L	Br- SM 4110B mg/L	NO3-N SM 4110B mg/L	SO4= SM 4110B mg/L	pH SM 4500B pH Units	Alk @ 3 SM 2320B mg CaCO3/L
UW-180 influent	<0 1	<0 5	<0 5	0 8	13 6	8 17	<1
UW-181 eff, col 251 319 pv RNB	<0 1	<0 5	<0 5	<0 2	13 5	9 76	<1
Blank	<0 1	<0 5	<0 5	<0 2	<0 05	--	2
QC Standard (found)	0 9	3 7	0 5	3 3	6 10	9 06	125
QC Standard (expected)	1 0	3 7	0 6	3 0	6 00	9 00	125
Repeat UW-180	<0 1	<0 5	<0 5	0 8	13 6	-	-

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30-Jun 98

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Attn: Wayne Noble
Project
PO #
Received 19-Jun-98 15 41

Job: 9854504
Status: Final

Water Samples

Sample Id	Alk 4 2 SM 2320B mg CaCO3/L	NH3-N SM 4500H mg/L	DOC SM 5310C mg/L	Th TDS Calc mg/L	pHs Calc pH Units	CAB Calc %	Hard(Calc) SM 2340B mg CaCO3/L
UW-180 influent	325	0 02	0 6	339	7 14	1 11	237 4
UW-181 eff col 251, 319 pv, RNB	76	0 12	1 6	113	9.11	-2 94	7 4
Blank	<1	<0 02	<0 2	2	12 61	-1 68	0 3
QC Standard (found)	240	0 29	5 4	277	7 37	-4 33	168 8
QC Standard (expected)	250	0 30	5 0	284	7 34	-3 46	172 6
Repeat UW-180	321	0 02	0 7	336	7 15	0 62	237 6

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30-Jun-98

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University of Waterloo
N2L 3G1

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Attn: Wayne Noble
Project:
PO #
Received 19-Jun-98 15 41

Job. 9854504
Status: Final

Water Samples

Sample Id	CO3= Calc mg/L	HCO3- Calc mg/L	L I Calc None	A I Calc None	R S I Calc None	Colour SM 2120B TCU	Turb SM 2130B NTU	Sp Cond SM 2510B umhos/cm
UW-180 influent	1	393 9	1 0	13 06	6 1	<1	0 5	569
UW-181 eff, col 25/ 31 9pv, RNB	0	93 7	0.6	12 51	8 5	<1	0 5	216
Blank	nan	nan	nan	nan	nan	<1	<0 1	<1
QC Standard (found)	75	0 0	1 7	13 67	5 7	10	1 8	683
QC Standard (expected)	75	0 6	1 7	13 64	5 7	10	1 8	718
Repeat UW-180	nan	nan	nan	nan	nan	---	- -	--

PSC
PHILIP SERVICES

30-Jun-98

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University of Waterloo
N2L 3G1

Page: 15
Copy. 1 of 2

Attn: Wayne Noble
Project
PO #:
Received 19-Jun-98 15 41

Job 9854504
Status: Final

All work recorded herein has been done in accordance with normal professional standards using accepted testing methodologies and QA/QC procedures Philip Analytical is limited in liability to the actual cost of the pertinent analyses done Your samples will be retained by PASC for a period of 30 days following reporting or as per specific contractual arrangements

Job approved by:

Signed:

Ralph Siebert, B Sc
Project Manager

ENVIROGEN

New Solutions to Hazardous Waste Problems

Princeton Research Center

4100 Quakerbridge Road
Lawrenceville New Jersey 08648
Tel 609/936-9300
Fax 609/936-9221

Limited Chemistry Deliverables

Prepared for

University of Waterloo/Golders/Iowa

Lab ID

2317

Samples Received

10 Jun-98

Reported

14-Jul 98

NJDEP Certified Lab 11001

2317

ENVIROGEN - Chain-of-Custody

Client, Contact & Project Name: University of Waterloo /Golders / Iowa

Phone: (519) 885 1211 x3159

Project No:

Envirogen Contact:

Page of

Turnaround: NORMAL RAPID

EPA ID No:

Phone: ( )

Sampler (Print/Sign): GREG FRIDAY

Sampling Method:

ANALYSIS

Request analysis by method number

Laboratory ID No	Sample ID Location	Date	Time	Sample Matrix	Number Bottles	Volume Bottles	Preservative
01	251 - influent	6/29/98	9 00		1	1L	—
	251 - influent	6/23/98	9 00		1	1L	—
	251 influent	6/22/98	9 30		1	250ml	H2SO4
	251 - influent	6/22/98	9:30		1	120ml	NaOH
	251 - influent	6/22/98	9:30		4	40ml	—
02	251 - effluent	6/29/98	9 00		1	1L	—
	251 - effluent	6/23/98	9 00		1	1L	—
	251 - effluent	6/22/98	9 30		1	250ml	H2SO4
	251 effluent	6/22/98	9 30		1	120ml	NaOH
	251 effluent	6/22/98	9 30		4	40ml	—

Comment

2 ltr Bottles were broken along with one 40ml vial during transport

1 ltr eff

1 ltr inf

1 40ml eff

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	DATE	TIME
	6/29/98	1 00			
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	DATE	TIME
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	DATE	TIME

SAMPLE COLLECTOR

ENVIROGEN
4100 Quakerbridge Road
Lawrenceville NJ 08648
609 936 9300

Method of Shipment:

Shipped by (Signature)

Received for Laboratory by: (Signature)

6/30/98
1105

11°C

11/98

ENVIROGEN
Analytical and Treatability Laboratories

Princeton Research Center
4100 Quakerbridge Road
Lawrenceville, New Jersey 08648
Tel 609/936 9300
Fax 609/936-9221

Sample Information

Lab ID	~~2317-01~~	**Date Received**	6/30/98
Sample ID	251 Influent	**Matrix**	*Aqs*

Limited Chemistry

Parameter	*Concentration*	*Units*	*Practical Quantitation Limit*	*Dilution Factor*	*Method Code*
Chloride(1)	1 5	mg/L	<0 2	1	300 0
Nitrate as N	0 7	mg/L	<0 2	1	300 0
Nitrite as N	u	mg/L	<0.2	1	300 0
Sulfate as SO4	13	mg/L	<2 0	10	300 0
Alkalinity as CaCO3	260	mg/L	<20	10	310 1
Hardness as CaCo3 (1,applied)	240	mg/L	<2	1	130 2
Carbon Dioxide(2)	5 1	mg/L	<2 0	1	S4500-CO2
Methane(2)	0 002	mg/L	<0 002	1	8015m
Ethane(2)	0 002	mg/L	<0 002	1	8015m
Ethane(2)	u	mg/L	<0 002	1	8015m
Biological Oxygen Demand	5	mg/L	<2	1	405 1
Chemical Oxygen Demand(1,applied)	u	mg/L	<10	1	410 4
Phosphate, total as P	u	mg/L	<0 05	1	365 2
Sulfide (1,applied)	u	mg/L	<0 01	1	376.2

7-14-98

Allen F Thomas
Laboratory Director

Date

Envirogen NJDEP certified Lab ID 11001
(1) Not listed as Envirogen Certified parameters under the NJDEP lab certification program.
(2) Not available as a certified parameter under the NJDEP lab certification program.
(u) Compound not detected above method detection limit

ENVIROGEN
Analytical and Treatability Laboratories

Princeton Research Center
4100 Quakerbridge Road
Lawrenceville, New Jersey 08648
Tel 609/936 9300
Fax 609/936-9221

Sample Information

Lab ID	2317-02	**Date Received**	6/30/98
Sample ID	251 Effluent	**Matrix**	Aqs

Limited Chemistry

Parameter	Concentration	Units	Practical Quantitation Limit	Dilution Factor	Method Code
Chloride(1)	6 2	mg/L	<0 2	1	300 0
Nitrate as N	u	mg/L	<0 2	1	300 0
Nitrite as N	0 2	mg/L	<0 2	1	300 0
Sulfate as SO4	17	mg/L	<2.0	10	300 0
Alkalinity as CaCO3	69	mg/L	<20	10	310 1
Hardness as CaCo3 (1 applied)	60	mg/L	<2	1	130 2
Carbon Dioxide(2)	u	mg/L	<2	1	S4500-CO2
Methane(2)	0 002	mg/L	<0 002	1	8015m
Ethene(2)	0 020	mg/L	<0 002	1	8015m
Ethane(2)	0 014	mg/L	<0 002	1	8015m
Biological Oxygen Demand	6	mg/L	<2	1	405 1
Chemical Oxygen Demand(1,applied)	u	mg/L	<10	1	410.4
Phosphate total as P	u	mg/l	<0 05	1	365.2
Sulfide (1 applied)	u	mg/L	<0 01	1	376 2

7-14-98

Allan F Thomas — Date
Laboratory Director

Envirogen NJDEP certified Lab ID 11001
(1) Not listed as Envirogen Certified paramaters under the NJDEP lab certification program.
(2) Not available as a certified parameter under the NJDEP lab certification program.
(u) Compound not detected above method detection limit

TOTAL P 05

RECRA
LabNet
a division of Recra Environmental Inc
Virtual Laboratories Everywhere

July 1 1998

Ms Jennifer Whitney
Envirogen
7707 Rickle Road
Lansing, MI 48917

RE Cooper Analytical Report

Dear Ms Whitney

The enclosed analytical report is for the project and lot number listed above If you have any questions please contact me at 708-534-5200

Sincerely

Recra LabNet - Chicago

Jeffrey A James

Jeffrey A. James
Project Manager

sj

Enclosures

Approved By

Michael K Healy
Vice President

The results presented in this report relate only to the analytical testing and conditions of sample at receipt. This report pertains to only those samples actually tested. All pages of this report are integral parts of the analytical data. Therefore, this report should be reproduced only in its entirety

EPA 8260 25 ML PURGE VOAS

Client Sample ID Job No & Lab Sample ID	251 EFFLUENT P98 1315 P8131502	251 INFLUENT P98 1315 P8131501	TRIP BLANK P98 1315 P8131503		
Sample Date	06/15/98 13 00	06/15/98 13 00	06/15/98		
Received Date	06/19/98 09 35	06/19/98 09 35	06/19/98 09 35		
Extraction Date					
Analysis Date	06/22/98 22 15	06/22/98 22 47	06/22/98 21 43		
Extraction HT Met?					
Analytical HT Met?	YES	YES	YES		
Sample Matrix	WATER	WATER	WATER		
Dilution Factor	1 0	100 0	1 0		
Sample Wt/vol	0 025 LITERS	0 025 LITERS	0 025 LITERS		
% Dry					

NA Not Applicable

RECRA LABNET UNIVERSITY PARK
QC SAMPLE CHRONOLOGY

EPA 8260 25 ML PURGE VOAS

Client Sample ID Job No & Lab Sample ID	LCS22 P98 1315 P8131505	Method Blank(VBLK22) P98 1315 P8131504			
Sample Date					
Received Date					
Extraction Date					
Analysis Date	06/22/98 19 37	06/22/98 21 12			
Extraction HT Met?					
Analytical HT Met?					
Sample Matrix	WATER	WATER			
Dilution Factor	1 0	1 0			
Sample Wt/vol	0 025 LITERS	0 025 LITERS			
% Dry					

NA Not Applicable

Date 06/25/98 16 49
Jobno P98 1315

RECRA LABNET UNIVERSITY PARK
SAMPLE CHRONOLOGY /

Rept AN03

Lab ID	Sample ID	Units	Analyte	Method	Dilution Factor	Sample Date	Receive Date	TCLP Date	THT	Analysis Date	AHT	Matr
P8131502	251 EFFLUENT	MG/L	Iron Total	200 7	1 00	06/15/98 13 00	06/19 09 35	NA	NA	06/23	Yes	WATE
P8131501	251 INFLUENT	MG/L	Iron Total	200 7	1 00	06/15/98 13 00	06/19 09 35	NA	NA	06/23	Yes	WATE

AHT Analysis Holding Time Met
THT TCLP Holding Time Met
NA = Not Applicable

Recra LabNet

Date 06/25/98 16 49
Jobno P98 1315

RECRA LABNET UNIVERSITY PARK
QC CHRONOLOGY

Rept AN03

Lab ID	Sample ID	Units	Analyte	Method	Dilution Factor	Sample Date	Receive Date	TCLP Date	THT	Analysis Date	AHT	Matri
P880172302	Matrix Spike Blank	MG/L	Iron Total	200 7	1 00		09 35	NA	NA	06/23	Yes	WATER
P880172301	Method Blank	MG/L	Iron Total	200 7	1 00		09 35	NA	NA	06/23	Yes	WATER

AHT Analysis Holding Time Met
THT TCLP Holding Time Met
NA = Not Applicable

Date 06/25/98
Time 09 00 55

Recra Labnet University Park
Envirogen
Sample Summary Excluding Internal Standards/Surrogates
Recra LabNet

Sample ID 251 INFLUENT
Lab ID P8131501
Date Collected 06/15/98
Time Collected 13 00

Date Received 06/19/98
Project No PABA7515
Client No LB0259
P O No

Parameter	Result	Flag	Detection Limit	Units	Method	Date/Time Analyzed	Analyst
EPA 8260 (25 ML PURGE) VOAS							
Benzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Bromodichloromethane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Dichlorodifluoromethane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Bromoform	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Bromomethane	<100	U	100	UG/L	8260/25ML	06/22/9822 47	JRB
Carbon Tetrachloride	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Chlorobenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Chloroethane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Chloroform	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Chloromethane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Dibromochloromethane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 2 Dichlorobenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 3 Dichlorobenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 4-Dichlorobenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 1 Dichloroethane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 2 Dichloroethane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 1 Dichloroethene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
cis 1 2 Dichloroethene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
trans 1 2 Dichloroethene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 2 Dichloropropane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
cis 1 3 Dichloropropene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
trans 1 3 Dichloropropene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Ethylbenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Methylene chloride	<100	U	100	UG/L	8260/25ML	06/22/9822 47	JRB
Styrene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 1 1 2 Tetrachloroethane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 1 2 2 Tetrachloroethane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Tetrachloroethene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Trichlorofluoromethane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 2 3 Trichloropropane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Toluene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 1 1 Trichloroethane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 1 2 Trichloroethane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Trichloroethene	3500		50	UG/L	8260/25ML	06/22/9822 47	JRB
Vinyl chloride	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 3 Dichloropropane	<100	U	100	UG/L	8260/25ML	06/22/9822 47	JRB
2 2 Dichloropropane	<100	U	100	UG/L	8260/25ML	06/22/9822 47	JRB
1 2 Dibromo 3 chloropropane	<100	U	100	UG/L	8260/25ML	06/22/9822 47	JRB
1 2 Dibromoethane	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Bromochloromethane	<100	U	100	UG/L	8260/25ML	06/22/9822 47	JRB
Dibromomethane	<100	U	100	UG/L	8260/25ML	06/22/9822 47	JRB
1 1 Dichloropropene	<500	U	500	UG/L	8260/25ML	06/22/9822 47	JRB
m/p Xylenes	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
o Xylene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 2 3 Trichlorobenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 2 4 Trichlorobenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 2 4 Trimethylbenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
1 3 5 Trimethylbenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Bromobenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Hexachlorobutadiene							

Date 06/25/98
Time 09 00 55

Recra Labnet University Park
Envirogen
Sample Summary Excluding Internal Standards/Surrogates
Recra LabNet

Page
Rept AN101

Sample ID 251 INFLUENT
Lab ID P8131501
Date Collected 06/15/98
Time Collected 13 00

Date Received 06/19/98
Project No PA8A7515
Client No L80259
P O No

Parameter	Result	Flag	Detection Limit	Units	Method	Date/Time Analyzed	Analyst
Isopropylbenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
n Butylbenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
n Propylbenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Naphthalene	<100	U	100	UG/L	8260/25ML	06/22/9822 47	JRB
o Chlorotoluene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
p Chlorotoluene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
p Cymene	<50	U	50	UG/L	8260/25ML	06/22/9822:47	JRB
sec Butylbenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
tert Butylbenzene	<50	U	50	UG/L	8260/25ML	06/22/9822 47	JRB
Metals Analysis							
Iron Total	0 98		0 050	MG/L	200 7	06/23/98	MLG

Date 06/25/98
Time 09 00 55

Recra Labnet University Park
Envirogen
Sample Summary Excluding Internal Standards/Surrogates
Recra LabNet

Page 3
Rept AN1010

Sample ID 251 EFFLUENT
Lab ID P8131502
Date Collected 06/15/98
Time Collected 13 00

Date Received 06/19/98
Project No PABA7515
Client No L80259
P O No

Parameter	Result	Flag	Detection Limit	Units	Method	Date/Time Analyzed	Analyst
EPA 8260 (25 ML PURGE) VOAS							
Benzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Bromodichloromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Dichlorodifluoromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Bromoform	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Bromomethane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9822 15	JRB
Carbon Tetrachloride	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Chlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Chloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Chloroform	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Chloromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Dibromochloromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 2 Dichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 3 Dichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 4 Dichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 1 Dichloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1,2 Dichloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 1 Dichloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
cis 1 2 Dichloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
trans 1 2 Dichloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 2 Dichloropropane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
cis 1 3 Dichloropropene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
trans 1 3 Dichloropropene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Ethylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Methylene chloride	2 1		1 0	UG/L	8260/25ML	06/22/9822 15	JRB
Styrene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 1 1 2 Tetrachloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 1 2 2 Tetrachloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Tetrachloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Trichlorofluoromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 2 3 Trichloropropane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Toluene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 1 1 Trichloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 1 2 Trichloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Trichloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Vinyl chloride	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 3 Dichloropropane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9822 15	JRB
2 2 Dichloropropane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9822 15	JRB
1 2 Dibromo-3 chloropropane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9822 15	JRB
1 2 Dibromoethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Bromochloromethane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9822 15	JRB
Dibromomethane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9822 15	JRB
1 1 Dichloropropene	<5 0	U	5 0	UG/L	8260/25ML	06/22/9822 15	JRB
m/p Xylenes	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
o Xylene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 2 3 Trichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 2 4 Trichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 2 4 Trimethylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
1 3 5 Trimethylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Bromobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Hexachlorobutadiene							

Date 06/25/98
Time 09:00 55

Recra Labnet University Park
Envirogen
Sample Summary Excluding Internal Standards/Surrogates
Recra LabNet

Sample ID 251 EFFLUENT
Lab ID P8131502
Date Collected 06/15/98
Time Collected 13 00

Date Received 06/19/98
Project No PA8A7515
Client No L80259
P O No

Parameter	Result	Flag	Detection Limit	Units	Method	Date/Time Analyzed	Analyst
Isopropylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
n Butylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
n-Propylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Naphthalene	<1 0	U	1 0	UG/L	8260/25ML	06/22/9822 15	JRB
o Chlorotoluene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
p Chlorotoluene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
p Cymene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
sec Butylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
tert Butylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9822 15	JRB
Metals Analysis							
Iron Total	<0 050	U	0 050	MG/L	200 7	06/23/98	MLG

Sample Summary Excluding Internal Standards/Surrogates
Recra LabNet

Sample ID TRIP BLANK
Lab ID P8131503
Date Collected 06/15/98
Time Collected

Date Received 06/19/98
Project No PABA7515
Client No L80259
P O No

Parameter	Result	Flag	Detection Limit	Units	Method	Date/Time Analyzed	Analyst
EPA 8260 (25 ML PURGE) VOAS							
Benzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Bromodichloromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Dichlorodifluoromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Bromoform	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Bromomethane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 43	JRB
Carbon Tetrachloride	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Chlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Chloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Chloroform	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Chloromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Dibromochloromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 2 Dichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 3 Dichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 4 Dichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 1 Dichloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 2 Dichloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 1 Dichloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
cis 1 2-Dichloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
trans 1 2 Dichloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 2 Dichloropropane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
cis 1 3 Dichloropropene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
trans 1 3 Dichloropropene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Ethylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Methylene chloride	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 43	JRB
Styrene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 1 1 2 Tetrachloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 1 2 2 Tetrachloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Tetrachloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Trichlorofluoromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 2 3 Trichloropropane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Toluene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 1 1 Trichloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 1 2 Trichloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Trichloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Vinyl chloride	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 3 Dichloropropane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 43	JRB
2 2 Dichloropropane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 43	JRB
1 2 Dibromo 3 chloropropane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 43	JRB
1 2 Dibromoethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Bromochloromethane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 43	JRB
Dibromomethane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 43	JRB
1 1 Dichloropropene	<5 0	U	5 0	UG/L	8260/25ML	06/22/9821 43	JRB
m/p Xylenes	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
o Xylene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 2 3 Trichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1,2 4 Trichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 2 4 Trimethylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
1 3 5 Trimethylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Bromobenzene	<0 50	U	0 50				

Recra Labnet University Park
Envirogen
Sample Summary Excluding Internal Standards/Surrogates
Recra LabNet

Sample ID	TRIP BLANK	Date Received	06/19/98
Lab ID	P8131503	Project No	PA8A7515
Date Collected	06/15/98	Client No	L80259
Time Collected		P O	No

Parameter	Result	Flag	Detection Limit	Units	Method	Date/Time Analyzed	Analyst
Isopropylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
n Butylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
n Propylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
Naphthalene	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 43	JRB
o-Chlorotoluene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
p-Chlorotoluene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
p Cymene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
sec Butylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB
tert Butylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 43	JRB

Date 06/25/98
Time 09 00 55

Recra Labnet University Park
Envirogen
Sample Summary Excluding Internal Standards/Surrogates
Recra LabNet

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Rept AN101

Sample ID Method Blank(VBLK22)
Lab ID P8131504
Date Collected
Time Collected

Date Received
Project No PA8A7515
Client No L80259
P O No

Parameter	Result	Flag	Detection Limit	Units	Method	Date/Time Analyzed	Analyst
EPA 8260 (25 ML PURGE) VOAS							
Benzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Bromodichloromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821:12	JRB
Dichlorodifluoromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Bromoform	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Bromomethane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 12	JRB
Carbon Tetrachloride	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Chlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Chloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Chloroform	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Chloromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Dibromochloromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 2 Dichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 3 Dichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 4 Dichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 1 Dichloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 2 Dichloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 1 Dichloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
cis 1 2 Dichloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
trans 1 2 Dichloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 2 Dichloropropane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
cis 1 3 Dichloropropene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
trans-1 3 Dichloropropene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Ethylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Methylene chloride	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 12	JRB
Styrene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 1 1 2 Tetrachloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 1 2 2-Tetrachloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Tetrachloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Trichlorofluoromethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 2 3 Trichloropropane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Toluene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 1 1 Trichloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 1 2 Trichloroethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Trichloroethene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Vinyl chloride	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 3 Dichloropropane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 12	JRB
2 2 Dichloropropane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 12	JRB
1 2 Dibromo 3 chloropropane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 12	JRB
1 2 Dibromoethane	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Bromochloromethane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 12	JRB
Dibromomethane	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821:12	JRB
1 1 Dichloropropene	<5 0	U	5 0	UG/L	8260/25ML	06/22/9821 12	JRB
m/p Xylenes	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
o Xylene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 2 3 Trichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 2 4 Trichlorobenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 2 4 Trimethylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
1 3 5 Trimethylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Bromobenzene	<0 50	U	0 50				

Recra Labnet University Park
Envirogen
Sample Summary Excluding Internal Standards/Surrogates
Recra LabNet

Sample ID	Method Blank(VBLK22)	Date Received	
Lab ID	P8131504	Project No	PA8A7515
Date Collected		Client No	L80259
Time Collected		P O No	

Parameter	Result	Flag	Detection Limit	Units	Method	Date/Time Analyzed	Analyst
Isopropylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
n Butylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
n Propylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
Naphthalene	<1 0	U	1 0	UG/L	8260/25ML	06/22/9821 12	JRB
o Chlorotoluene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
p Chlorotoluene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
p Cymene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
sec Butylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB
tert Butylbenzene	<0 50	U	0 50	UG/L	8260/25ML	06/22/9821 12	JRB

Date 06/25/98
Time 09 00 55

Recra Labnet University Park
Envirogen
Sample Summary Excluding Internal Standards/Surrogates
Recra LabNet

Page
Rept AN101

Sample ID LCS22
Lab ID P8131505
Date Collected
Time Collected

Date Received
Project No PA8A7515
Client No L80259
P O No

Parameter	Result	Flag	Detection Limit	Units	Method	Date/Time Analyzed	Analyst
EPA 8260 (25 ML PURGE) VOAS							
Benzene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Bromodichloromethane	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Dichlorodifluoromethane	9 9		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Bromoform	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Bromomethane	11		1 0	UG/L	8260/25ML	06/22/9819 37	JRB
Carbon Tetrachloride	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Chlorobenzene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Chloroethane	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Chloroform	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Chloromethane	9 2		0 50	UG/L	8260/25ML	06/22/9819:37	JRB
Dibromochloromethane	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 2 Dichlorobenzene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 3 Dichlorobenzene	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 4 Dichlorobenzene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 1 Dichloroethane	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 2 Dichloroethane	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 1 Dichloroethene	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
cis 1 2 Dichloroethene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
trans 1 2 Dichloroethene	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 2 Dichloropropane	11		0 50	UG/L	8260/25ML	06/22/9819:37	JRB
cis 1 3 Dichloropropene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
trans 1 3 Dichloropropene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Ethylbenzene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Methylene chloride	8 7		1 0	UG/L	8260/25ML	06/22/9819 37	JRB
Styrene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 1 1 2 Tetrachloroethane	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 1 2 2 Tetrachloroethane	12		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Tetrachloroethene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Trichlorofluoromethane	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 2 3 Trichloropropane	12		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Toluene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 1 1 Trichloroethane	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 1 2 Trichloroethane	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Trichloroethene	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Vinyl chloride	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 3 Dichloropropane	11		1 0	UG/L	8260/25ML	06/22/9819 37	JRB
2 2 Dichloropropane	10		1 0	UG/L	8260/25ML	06/22/9819 37	JRB
1 2 Dibromo 3 chloropropane	12		1 0	UG/L	8260/25ML	06/22/9819 37	JRB
1 2 Dibromoethane	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Bromochloromethane	11		1 0	UG/L	8260/25ML	06/22/9819 37	JRB
Dibromomethane	11		1 0	UG/L	8260/25ML	06/22/9819 37	JRB
1 1 Dichloropropene	11		5 0	UG/L	8260/25ML	06/22/9819 37	JRB
m/p Xylenes	22		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
o Xylene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 2 3 Trichlorobenzene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 2 4 Trichlorobenzene	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 2 4 Trimethylbenzene	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
1 3 5 Trimethylbenzene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Bromobenzene	11						

Recra Labnet University Park
Envirogen
Sample Summary Excluding Internal Standards/Surrogates
Recra LabNet

Sample ID LCS22
Lab ID P8131505
Date Collected
Time Collected

Date Received
Project No PA8A7515
Client No L80259
P O No

Parameter	Result	Flag	Detection Limit	Units	Method	Date/Time Analyzed	Analyst
Isopropylbenzene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
n Butylbenzene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
n Propylbenzene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
Naphthalene	14		1 0	UG/L	8260/25ML	06/22/9819 37	JRB
o Chlorotoluene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
p-Chlorotoluene	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
p Cymene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
sec Butylbenzene	11		0 50	UG/L	8260/25ML	06/22/9819 37	JRB
tert Butylbenzene	10		0 50	UG/L	8260/25ML	06/22/9819 37	JRB

Sample Summary Excluding Internal Standards/Surrogates
Recra LabNet

Sample ID	Method Blank	Date Received	
Lab ID	P880172301	Project No	PABA7515
Date Collected		Client No	L80259
Time Collected		P O No	

Parameter	Result	Flag	Detection Limit	Units	Method	Date/Time Analyzed	Analyst
Metals Analysis							
Iron Total	<0 050	U	0 050	MG/L	200 7	06/23/98	MLG

Recra Labnet University Park
Envirogen
Sample Summary Excluding Internal Standards/Surrogates
Recra LabNet

Sample ID Matrix Spike Blank
Lab ID P8B0172302
Date Collected
Time Collected

Date Received
Project No PA8A7515
Client No L80259
P O No

Parameter	Result	Flag	Detection Limit	Units	Method	Date/Time Analyzed	Analyst
Metals Analysis							
Iron Total	0 89		0 050	MG/L	200 7	06/23/98	NLG

RECRA LABNET UNIVERSITY PARK
EPA 8260 25 ML PURGE VOAS
WATER SURROGATE RECOVERY

Lab Name Recra LabNet Contract ________

Lab Code RECPA Case No ____ SAS No ____ SDG No ____

	Client Sample ID	BFB %REC #	DCE %REC #	TOL %REC #						TOT OUT
1	251 EFFLUENT	112	92	112						0
2	251 INFLUENT	112	92	112						0
3	LCS22	100	99	99						0
4	Method Blank (VBLK22)	109	93	107						0
5	TRIP BLANK	110	91	103						0

		QC LIMITS
BFB	= p-Bromofluorobenzene	(78-114)
DCE	= 1 2-Dichloroethane-D4	(76-130)
TOL	= Toluene-D8	(86-114)

\# Column to be used to flag recovery values
* Values outside of contract required QC limits
D Surrogates diluted out

FORM II - GC/MS VOA

RECRA LABNET UNIVERSITY PARK
EPA 8260 25 ML PURGE VOAS
WATER MATRIX SPIKE BLANK RECOVERY

Lab Name Recra LabNet Contract ________ Lab Samp ID P8131504

Lab Code RECPA Case No _____ SAS No _____ SDG No _____

Matrix Spike - Client Sample No Method Blank (VBLK22)

COMPOUND	SPIKE ADDED UG/L	MSB CONCENTRATION UG/L	MSB % REC #	QC LIMITS REC
1 1-Dichloroethene	10	10	100	63 - 137
Trichloroethene	10	10	100	72 - 128
Benzene	10	11	110	72 - 128
Toluene	10	11	110	72 - 128
Chlorobenzene	10	11	110	72 - 129
Bromodichloromethane	10	10	100	61 - 145
Bromoform	10	10	100	55 - 151
Bromomethane	10	11	110	39 - 154
Carbon Tetrachloride	10	10	100	48 - 164
Chloroethane	10	11	110	38 - 175
Chloroform	10	10	100	67 - 138
Chloromethane	10	9 2	92	34 - 154
Dibromochloromethane	10	11	110	59 - 145
1 2-Dichlorobenzene	10	11	110	61 - 125
1 3-Dichlorobenzene	10	10	100	56 - 127
1,4-Dichlorobenzene	10	11	110	60 - 125
1 1-Dichloroethane	10	11	110	69 - 133
1 2-Dichloroethane	10	11	110	63 - 141
trans-1 2-Dichloroethene	10	10	100	68 - 138
1,2-Dichloropropane	10	11	110	67 - 132
trans-1 3-Dichloropro(1)	10	11	110	67 - 135
cis-1 3-Dichloropropene	10	11	110	64 - 135
Ethylbenzene	10	11	110	65 - 138
Methylene chloride	10	8 7	87	49 - 136
1,1,2 2-Tetrachloroet(2)	10	12	120	70 - 126
Tetrachloroethene	10	11	110	68 - 135
1 1 1-Trichloroethane	10	10	100	61 - 150
1 1 2-Trichloroethane	10	11	110	71 - 127
Trichlorofluoromethane	10	10	100	17 - 231
Vinyl chloride	10	11	110	44 - 147
1,2,3-Trichloropropane	10	12	120	67 - 130
Dibromomethane	10	11	110	75 - 125
cis-1 2-Dichloroethene	10	11	110	75 - 129
Styrene	10	11	110	73 - 129

FORM III GC/MS VOA

RECRA LABNET UNIVERSITY PARK
EPA 8260 25 ML PURGE VOAS
WATER MATRIX SPIKE BLANK RECOVERY

Lab Name Recra LabNet Contract ____________ Lab Samp ID P8131504

Lab Code RECPA Case No _____ SAS No ______ SDG No ______

Matrix Spike - Client Sample No Method Blank (VBLK22)

(1) trans-1 3-Dichloropropene
(2) 1,1 2,2-Tetrachloroethane

Column to be used to flag recovery and RPD values with an asterisk

* Values outside of QC limits

Spike recovery ____0 out of ___34 outside limits

Comments ____

FORM III GC/MS VOA

RECRA LABNET UNIVERSITY PARK
EPA 8260 25 ML PURGE VOAS
METHOD BLANK SUMMARY

Client N

Method Blank (VBLK22)

Lab Name Recra LabNet   Contract ______

Lab Code RECPA   Case No ______   SAS No ______   SDG No ______

Lab File ID E0622018 RR   Lab Sample ID P8131504

Date Analyzed 06/22/98   Time Analyzed 21.12

GC Column DB-624   ID 0 53 (mm)   Heated Purge (Y/N) N

Instrument ID PA-HPMS-5

THIS METHOD BLANK APPLIES TO THE FOLLOWING SAMPLES MS AND MSD

	CLIENT SAMPLE NO	LAB SAMPLE ID	LAB FILE ID	TIME ANALYZED
1	251 EFFLUENT	P8131502	E0622020 RR	22 15
2	251 INFLUENT	P8131501	E0622021 RR	22 47
3	LCS22	P8131505	E0622015 RR	19 37
4	TRIP BLANK	P8131503	E0622019 RR	21 43

Comments ______

FORM IV - GC/MS VOA

Client Sample ID Method Blank Matrix Spike Blank
Lab Sample ID P880172301 P880172302

Analyte	Units of Measure	Concentration Blank Spike	Concentration Spike Amount	% Recovery Blank Spike	QC LIMITS
TOTAL METALS ANALYSIS					
IRON TOTAL WATER	MG/L	0 89	1 0	89	75 125

* Indicates Result is outside QC Limits
NC Not Calculated ND = Not Calculated

RECRA LabNet Use Only

Custody Transfer Record/Lab Work Request

RECRA LabNet

Client
Est. Final Proj Sampling Date
Project #
Project Contact/Phone #
RECRA Project Manager
QC ____ Del ____ TAT ____
Date Rec d ____ Date Due ____
Account #

Refrigerator #										
#/Type Container	Liquid									
	Solid									
Volume	Liquid									
	Solid									
Preservatives										
ANALYSES REQUESTED →		ORGANIC				INORG				
		VOA	BNA	Pest/PCB	Herb	Metal	CN			

MATRIX CODES:
S Soil
SE Sediment
SO Solid
SL Sludge
W Water
O Oil
A Air
DS Drum Solids
DL Drum Liquids
L EP/TCLP Leachate
WI Wipe
X Other
F Fish

RECRA LabNet Use Only

Lab ID	Client ID/Description	Matrix QC Chosen (✓) MS	MSD	Matrix	Date Collected	Time Collected	Metal
	251 - influent			W	6/15/98	1:00	✓
	251 - effluent			W	6/15/98	1.00	✓

FIELD PERSONNEL COMPLETE ONLY SHADED AREAS

Special Instructions

DATE/REVISIONS
1
2
3
4
5
6

RECRA LabNet Use Only

Samples were
1) Shipped ___ or Hand Delivered ___
Airbill # ____
2) [✓ Ambient] or Chilled
3) Received in Good Condition Y or N
4) Labels Indicate Properly Preserved Y or N
5) Received Within Holding Times Y or N

COC Tape was
1) Present on Outer Package Y or N
2) Unbroken on Outer Package Y or N
3) Present on Sample Y or N
4) Unbroken on Sample Y or N
COC Record Present Upon Sample Rec t Y or N

Relinquished by	Received by	Date	Time	Relinquished by	Received by	Date	Time
A 7	6/17/98				Chuckleman	6/19/98	0935
					6°C		

Discrepancies Between Samples Lables and COC Record? Y or N
NOTES
Seal 56190

Page ____ of ____

Desorption Test	Matenal	Soil Sampl Golders Iowa GB 1 IC3 3808 976-1083 (30 31 9)
	Column Volume	283 6 cm3
	Porosity	0 34
	Pore Volume	96 mL
	Flow Rate	0 26 mL/min

Sample ID	Volume (mL)	Cummulative Volume (mL)	Pore Volume	Organic Concentration (ug/L) TCE
1	10 86	10 9	0 0	522
2	10 65	21 5	0 1	936
3	10 53	32 0	0 2	1169
4	11 08	43 1	0 3	1097
5	11 76	54 9	0 4	1031
6	10 7	65 6	0 6	986
7	10 92	76 5	0 7	761
8	11 6	88 1	0 8	517
9	11 72	99 8	0 9	484
10	11 45	111 3	1 0	325
11	11 5	122 8	1 2	267
12	11 6	134 4	1 3	169
13	11 61	146 0	1 4	169
14	11 27	157 3	1 5	123
15	11 9	169 2	1 6	95
16	11 42	180 6	1 8	78
17	11 6	192 2	1 9	62
18	11 44	203 6	2 0	61
19	10 76	214 4	2 1	57
20	11 27	225 6	2 2	46
21	11 81	237 5	2 4	49
22	10 69	248 1	2 5	47
23	9 73	257 9	2 6	45
24	11 65	269 5	2 7	33
25	11 48	281 0	2 8	46
26	11 55	292 6	2 9	39
27	10 82	303 4	3 0	31
28	11 64	315 0	3 2	28
29	13 3	328 3	3 3	51
30	11 89	340 2	3 4	25
31	11 79	352 0	3 5	25
32	11 7	363 7	3 7	21
33	11 71	375 4	3 8	14
34	10 42	385 8	3 9	15
35	12 25	398 1	4 0	10
36	11 68	409 8	4 1	11
37	10 73	420 5	4 3	9 9
38	10 5	431 0	4 4	12
39	11 66	442 6	4 5	11
40	11 24	453 9	4 6	12
41	11 62	465 5	4 7	12

Desorption Test

Material Soil Sampl Golders Iowa GB 1 IC3 3808 976 1083 (30 31 9)
Column Volume 283 6 cm3
Porosity 0 34
Pore Volume 96 mL
Flow Rate 0 26 mL/min

Sample ID	Volume (mL)	Cummulative Volume (mL)	Pore Volume	Organic Concentration (ug/L) TCE
42	10 68	476 2	4 8	13
43	12 48	488 7	5 0	9 6
44	12 07	500 7	5 1	10
45	10 46	511 2	5 2	7 9
46	12 61	523 8	5 3	6 0
47	12 71	536 5	5 5	12
48	11 84	548 4	5 6	7 6
49	11 94	560 3	5 7	5 4
50	11 97	572 3	5 8	8 5
51	10 35	582 6	6 0	5 7
52	15 54	598 2	6 1	5 7
53	11 69	609 8	6 2	6 5
54	11 38	621 2	6 4	8 1
55	11 48	632 7	6 5	6 4
56	11 61	644 3	6 6	6 8
57	10 78	655 1	6 7	7 4
58	11 89	667 0	6 8	5 3
59	11 9	678 9	6 9	5 8
60	11 79	690 7	7 1	5 5
61	12 01	702 7	7 2	5 2
62	11 92	714 6	7 3	4 8
63	11 78	726 4	7 4	4 9
64	11 75	738 1	7 6	6 8
65	11 65	749 8	7 7	6 0
66	11 78	761 6	7 8	3 3
67	11 8	773 4	7 9	6 9
68	11 51	784 9	8 1	6 0
69	11 64	796 5	8 2	7 6
70	11 51	808 0	8 3	3 4
71	11 48	819 5	8 4	4 2
72	11 34	830 8	8 5	3 1
73	11 61	842 5	8 7	3 5
74	11 84	854 3	8 8	4 7
75	15 3	869 6	8 9	3 9
76	11 39	881 0	9 1	4 7
77	11 53	892 5	9 2	4 4
78	11 43	903 9	9 3	4 6
79	11 68	915 6	9 4	6 4
80	11 17	926 8	9 5	2 4
81	11 74	938 5	9 7	na
82	11 68	950 2	9 8	6 5
83	10 09	960 3	9 9	5 1

Desorption Test

Material Soil Sampl Golders Iowa GB 1 IC3-3808 976 1083 (30 31 9)
Column Volume 283 6 cm3
Porosity 0 34
Pore Volume 96 mL
Flow Rate 0 26 mL/min

Sample ID	Volume (mL)	Cummulative Volume (mL)	Pore Volume	Organic Concentration (ug/L)
				TCE
84	11 87	972 2	10 0	5 6
85	11 55	983 7	10 1	3 5
86	12 16	995 9	10 2	4 2
87	12 1	1008 0	10 4	5 0
88	12 47	1020 5	10 5	4 2
89	12 2	1032 7	10 6	3 3
90	11 14	1043 8	10 8	3 9
91	37 7	1081 5	10 9	0 7
92	38 11	1119 6	11 3	1 6
93	37 7	1157 3	11 7	2 6
94	37 7	1195 0	12 1	2 0
95	42 38	1237 4	12 4	2 1
96	37 7	1275 1	12 9	2 7
97	37 7	1312 8	13 3	2 6
98	37 7	1350 5	13 7	2 8
99	37 7	1388 2	14 1	1 7
100	36 81	1425 0	14 5	1 7
101	37 7	1462 7	14 8	1 4
102	37 7	1500 4	15 2	1 9
103	37 7	1538 1	15 6	1 9

eof//

ACL

ADVANCED CHEMISTRY LABS, INC

Phone (770) 409 1444
Fax (770) 409 1844
Outside GA (800) 277 0520

3039 Amwiler Road Suite 100 Atlanta GA 30360
P O Box 88610 Atlanta GA 30356
http //www mindspring com/~acl
e mail acl@mindspring com

			Cooper / McGraw Edison / IA
Client	Golder Sierra LLC 3730 Chamblee Tucker Road Atlanta GA 30341	Client Project No	986 1083
		ACL Project No	27200
		Date Received	10 14 98
		Date Reported	10 15 98
Contact	Mr Rafael Ospina		

TOC
(9060) (mg/kg)

Sample ID	ACL #	Matrix	Result	Det Limit	Date Analyzed
GB 1 (45 48)	132957	Soil	410	50 0	10 15 98
GB 1 (41 43)	132958	Soil	BDL	50 0	10 15 98

BDL = Below Detection Limit

John Andros

John Andros, Lab Manager

QUALITY CONTROL SECTION

Client Golder Sierra LLC
3730 Chamblee Tucker Road
Atlanta GA 30341

Contact Mr Rafael Ospina

Cooper / McGraw Edison / IA
Client Project No 986 1083
ACL Project No 27200
Date Received 10 14 98
Date Reported 10 15 98

TOC (9060) QC Data

Method Blank

Station	ACL #	Matrix	TOC (9060) (mg/kg)
	Soil Blank	Soil	< 50 0

QC Ref Std

Station	ACL #	Expected Value (mg/kg)	Actual Value (mg/kg)	Acceptance Range
	QC Std	6250	6551	4690 7810

BDL = Below Detection Limit

ACL

ADVANCED CHEMISTRY LABS, INC

3039 Amwiler Road Suite 100 Atlanta GA 30360 ■ P O Box 88610 Atlanta GA 30356 ■ (770) 409 1444 Fax (770) 409 1844

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Company Name: Golder Sierra LLC

Phone #: (770) 496-1893

Fax #: (770) 934-9476

Company Address: 3730 Chamblee Tucker Rd
Atlanta, GA 30341

Site Location: McGraw Edison Site
Centerville, IA

Project Manager: Rafael Ospina

Client Project (#): 986-1083

(Name): Cooper/McGraw-Edison/IA

I attest that the proper field sampling procedures were used during the collection of these samples

Sampler Name (Print): RAFAEL OSPINA

ANALYSIS REQUEST

Remarks: 24 HOUR TA

Field Sample ID	# Container	Matrix: Water	Matrix: Soil	Matrix: Air	Matrix: Sludge	Matrix: Product	Matrix: Other	Method Preserved: HCl	Method Preserved: HNO_3	Method Preserved: H_2SO	Method Preserved: Ice	Method Preserved: None	Method Preserved: Other	Sampling: Date	Sampling: Time	TOC (EPA 9060)	Remarks
GB-1 (45-48')			☒									☒		5-4-98	—	☒	
GB-1 (41-43')			☒									☒		5 4 98	—	☒	

Special Detection Limits

Remarks: Include all QA/QC

TAT
Priority (24 hr) ☒
Rush (48 hr) ☐
Rush (72 hr) ☐
Normal ☐

Special Handling
ACL Contact ______
Quote # Phone call on 10/14/98
P O ______

Special Reporting Requirements: Need writen (Typed) by 10/15/98 before 5:00 pm
Fax ☐

Lab Use Only
ACL Project # ______

Cooler Temp ______ C

QA/QC Level
Level 1 ☐ Level 2 ☐ Other ☐ ______

CUSTODY RECORD

Relinquished by Sampler: Rafael Ospina	Date: 10/14/98	Time: 17:15	Received by
Relinquished by	Date	Time	Received by
Relinquished by	Date: 10/14/98	Time: 17:15	Received by Laboratory: George [illegible] Waybill #

1D Fate and Transport Transient Model Bear (1979) page 268 269 MathCad V6 1dtce mcd
Ref Bear J (1979) Hydraulics of Groundwater McGraw Hill N Y

McGraw Edison Superfund Site Centerville IA Job 986 1083

$v = 06$ Groundwater velocity ft/day

$t50 = 600$ Half Life for TCE Contaminant in days $\lambda - \frac{0\ 693}{t50}$

$Rf = 1\ 4$ Retardation Coefficient for TCE

$\alpha = 277$ Longitudinal Dispersivity in ft

$Co - 6700$ Source TCE Concentration in ppb

$t \quad 30\ 365$ Time in days

$$\beta - \left(\frac{1}{4\,\alpha^2} + \lambda\,\frac{Rf}{\alpha\,v}\right)^{0\ 5}$$

$$a1 - \left(\frac{v^2}{Rf^2} + 4\,\lambda\,\alpha\,\frac{v}{Rf}\right)^{0\ 5} t$$

$$a2 \quad 2\left(\alpha\,v\,\frac{t}{Rf}\right)^{0\ 5}$$

$i - 0 \quad 19$

$x_i = 50 + i\ 50$

$$C = \frac{Co}{2}\,\exp\left(\frac{x_i}{2\,\alpha}\right)\left(\exp(\ x_i\,\beta)\,\mathrm{erffc}\left(\frac{x_i - a1}{a2}\right) + \exp(x_i\,\beta)\,\mathrm{erffc}\left(\frac{x_i + a1}{a2}\right)\right)$$

Solution for C(x t)

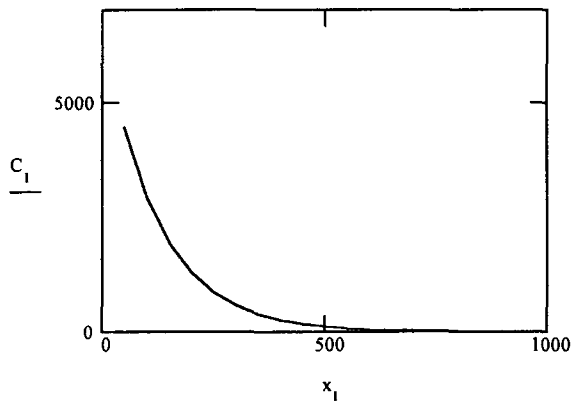
$t - 11\ 365$ Time since Reactive Wall Installed

$$a1 = \left(\frac{v^2}{Rf^2} + 4\,\lambda\,\alpha\,\frac{v}{Rf}\right)^{0\ 5} t \qquad a2 = 2\left(\alpha\,v\,\frac{t}{Rf}\right)^{0\ 5}$$

$$D_i - \frac{Co}{2}\,\exp\left(\frac{x_i}{2\,\alpha}\right)\left(\exp(\ x_i\,\beta)\,\mathrm{erffc}\left(\frac{x_i - a1}{a2}\right) + \exp(x_i\,\beta)\,\mathrm{erffc}\left(\frac{x_i + a1}{a2}\right)\right) + C_i$$

Solution for C(x t)
with Reactive
Wall

TCE Concentration (ppb)



Longitudinal Distance (feet)

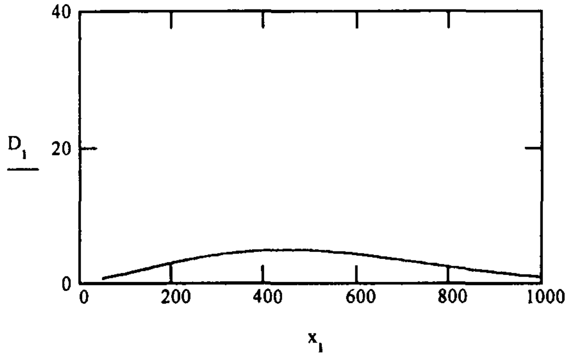
x =

	0
0	50
1	100
2	150
3	200
4	250
5	300
6	350
7	400
8	450
9	500
10	550
11	600
12	650
13	700
14	750

C =

	0
0	4 441 10^3
1	2 944 10^3
2	1 952 10^3
3	1 294 10^3
4	857 698
5	568 573
6	376 91
7	249 856
8	165 631
9	109 797
10	72 785
11	48 249
12	31 985
13	21 202

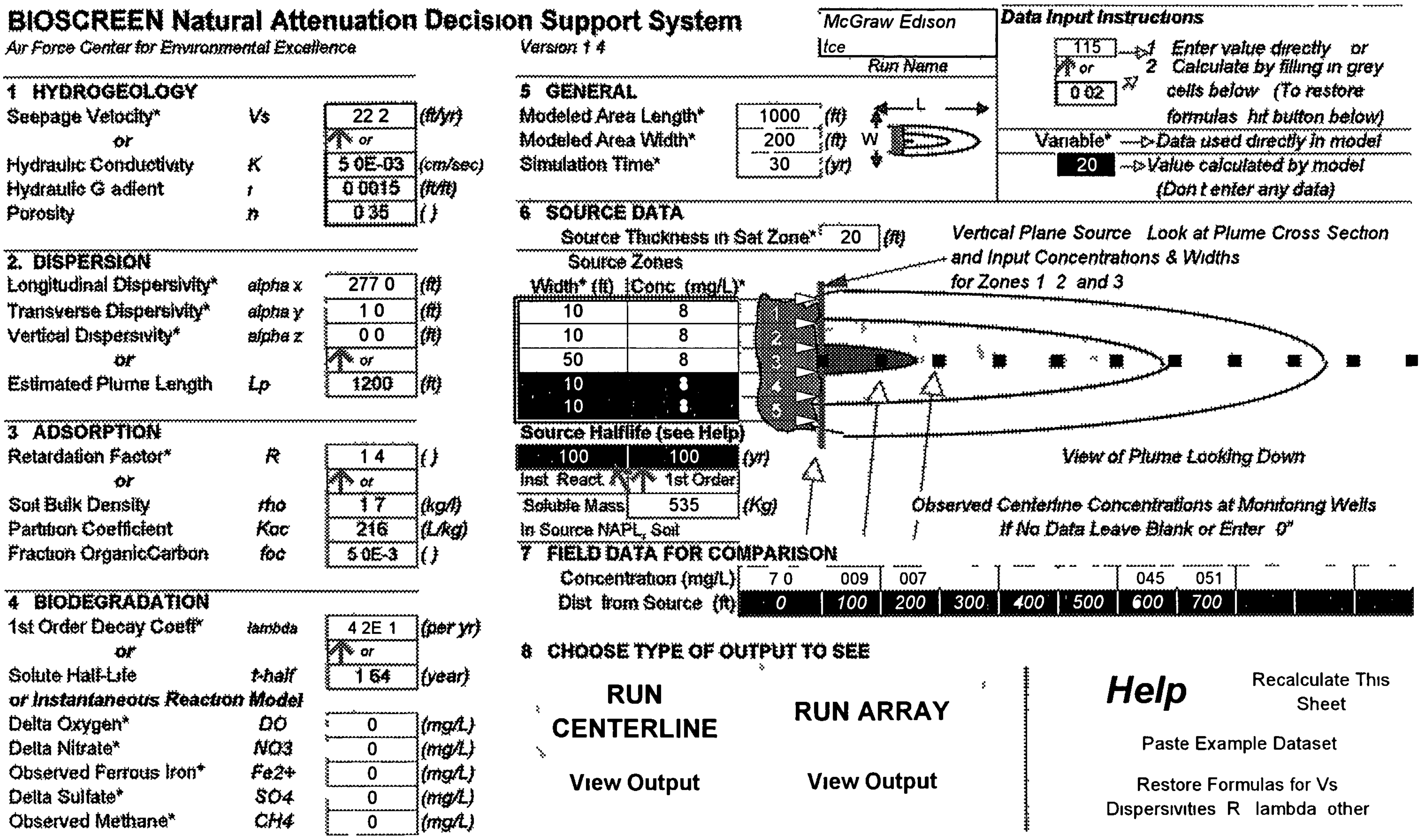
TCE Concentration (ppb)



Longitudinal Distance (feet)

D =

	0
0	0 637
1	1 347
2	2 088
3	2 813
4	3 474
5	4 026
6	4 436
7	4 683
8	4 76
9	4 676
10	4 45
11	4 111
12	3 694
13	3 233
14	2 759



BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1 4

McGraw Edison
Ice
Run Name

Data Input Instructions

115	1 *Enter value directly or*
or	
0 02	2 *Calculate by filling in grey cells below (To restore formulas hit button below)*
Variable*	*Data used directly in model*
20	*Value calculated by model (Don t enter any data)*

1 HYDROGEOLOGY

Seepage Velocity*	*Vs*	22 2	*(ft/yr)*
or		or	
Hydraulic Conductivity	*K*	5 0E-03	*(cm/sec)*
Hydraulic Gradient	*i*	0 0015	*(ft/ft)*
Porosity	*n*	0 35	*( )*

2. DISPERSION

Longitudinal Dispersivity*	*alpha x*	277 0	*(ft)*
Transverse Dispersivity*	*alpha y*	1 0	*(ft)*
Vertical Dispersivity*	*alpha z*	0 0	*(ft)*
or		or	
Estimated Plume Length	*Lp*	1200	*(ft)*

3 ADSORPTION

Retardation Factor*	*R*	1 4	*( )*
or		or	
Soil Bulk Density	*rho*	1 7	*(kg/l)*
Partition Coefficient	*Koc*	216	*(L/kg)*
Fraction OrganicCarbon	*foc*	5 0E-3	*( )*

4 BIODEGRADATION

1st Order Decay Coeff*	*lambda*	4 2E 1	*(per yr)*
or		or	
Solute Half-Life	*t-half*	1 64	*(year)*
or Instantaneous Reaction Model			
Delta Oxygen*	*DO*	0	*(mg/L)*
Delta Nitrate*	*NO3*	0	*(mg/L)*
Observed Ferrous Iron*	*Fe2+*	0	*(mg/L)*
Delta Sulfate*	*SO4*	0	*(mg/L)*
Observed Methane*	*CH4*	0	*(mg/L)*

5 GENERAL

Modeled Area Length*	1000	*(ft)*
Modeled Area Width*	200	*(ft)*
Simulation Time*	30	*(yr)*

6 SOURCE DATA

Source Thickness in Sat Zone* 20 *(ft)*

Source Zones

Width* (ft)	Conc (mg/L)*
10	8
10	8
50	8
10	8
10	8

Source Halflife (see Help)

100	100	*(yr)*
Inst React	1st Order	
Soluble Mass	535	*(Kg)*
In Source NAPL, Soil		

Vertical Plane Source Look at Plume Cross Section and Input Concentrations & Widths for Zones 1 2 and 3

View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter 0"

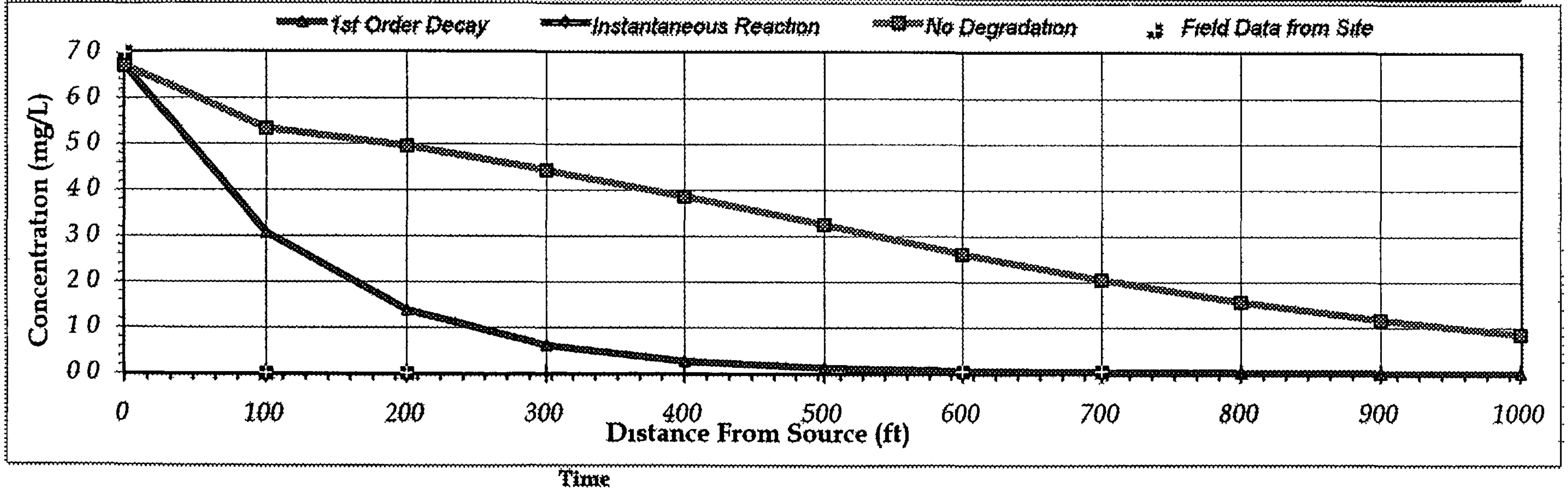
7 FIELD DATA FOR COMPARISON

Concentration (mg/L)	7 0	009	007				045	051			
Dist from Source (ft)	0	100	200	300	400	500	600	700			

8 CHOOSE TYPE OF OUTPUT TO SEE

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

	Distance from Source (ft)										
TYPE OF MODEL	**0**	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**
No Degradation	6 700	5 331	4 959	4 434	3 857	3 250	2 604	2 039	1 557	1 159	0 840
1st Order Decay	6 700	3 067	1 373	0 602	0 263	0 114	0 048	0 020	0 009	0 004	0 002
Inst. Reaction	6 700	5 331	4 959	4 434	3 857	3 250	2 604	2 039	1 557	1 159	0 840
Field Data from Site	7 000	0 009	0 007				0 045	0 051			



Calculate Animation

Time

30 Years

Return to Input

Recalculate This Sheet

DISSOLVED HYDROCARBON CONCENTRATIONS IN PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓	Distance from Source (ft) 0	100	200	300	400	500	600	700	800	900	1000
100	0 000	0 000	0 004	0 008	0 008	0 006	0 003	0 002	0 001	0 000	0 000
50	0 000	1 111	0 565	0 270	0 127	0 059	0 026	0 012	0 005	0 002	0 001
0	6 700	3 067	1 373	0 602	0 263	0 114	0 048	0 020	0 009	0 004	0 002
-50	0 000	1 111	0 565	0 270	0 127	0 059	0 026	0 012	0 005	0 002	0 001
-100	0 000	0 000	0 004	0 008	0 008	0 006	0 003	0 002	0 001	0 000	0 000
MASS FLUX (mg/day)											

Can't calculate mass flux when vertical dispersivity not equal to 0

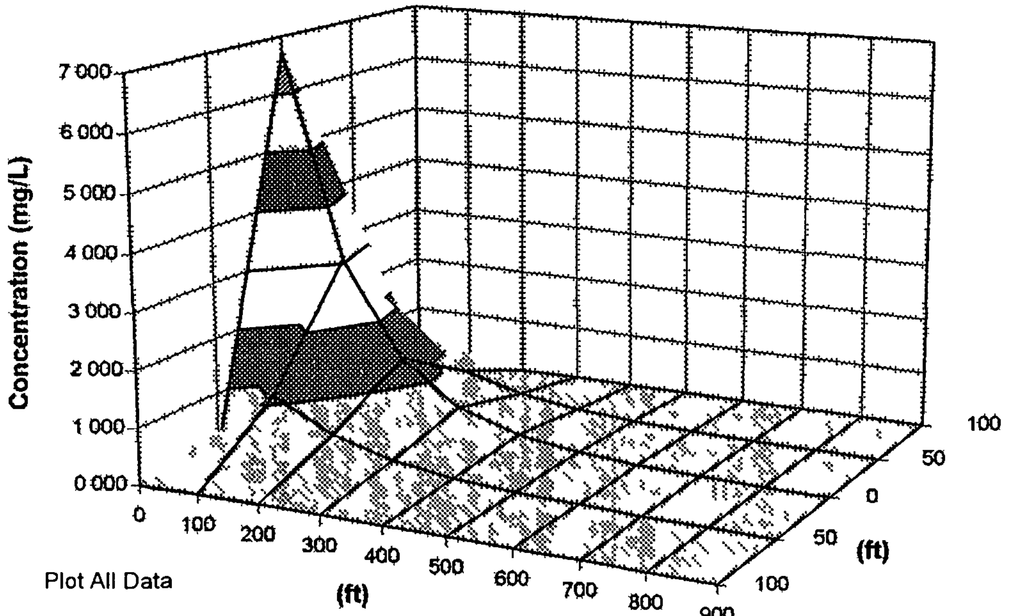
Time **30 Years** Target Level **0 005** mg/L Displayed Model **1st Order Decay**

Model to Display

No Degradation Model

1st Order Decay Model

Instantaneous Reaction Model



Plot All Data

Plot Data > Target

Plume and Source Masses (Order of-Magnitude Accuracy)

Plume Mass If No Biodegradation 86 9 (Kg)

Actual Plume Mass 12 8 (Kg)

= Plume Mass Removed by Biodeg **74 1** (Kg)

(85 %)

Change in Electron Acceptor/Byproduct Masses

Oxygen	*Nitrate*	*Iron II*	*Sulfate*	*Methane*	
na	na	na	na	na	(Kg)

Contam Mass in Source (t=0 Years) 535 0 (Kg)

Contam Mass in Source Now (t=30Years) 448 1 (Kg)

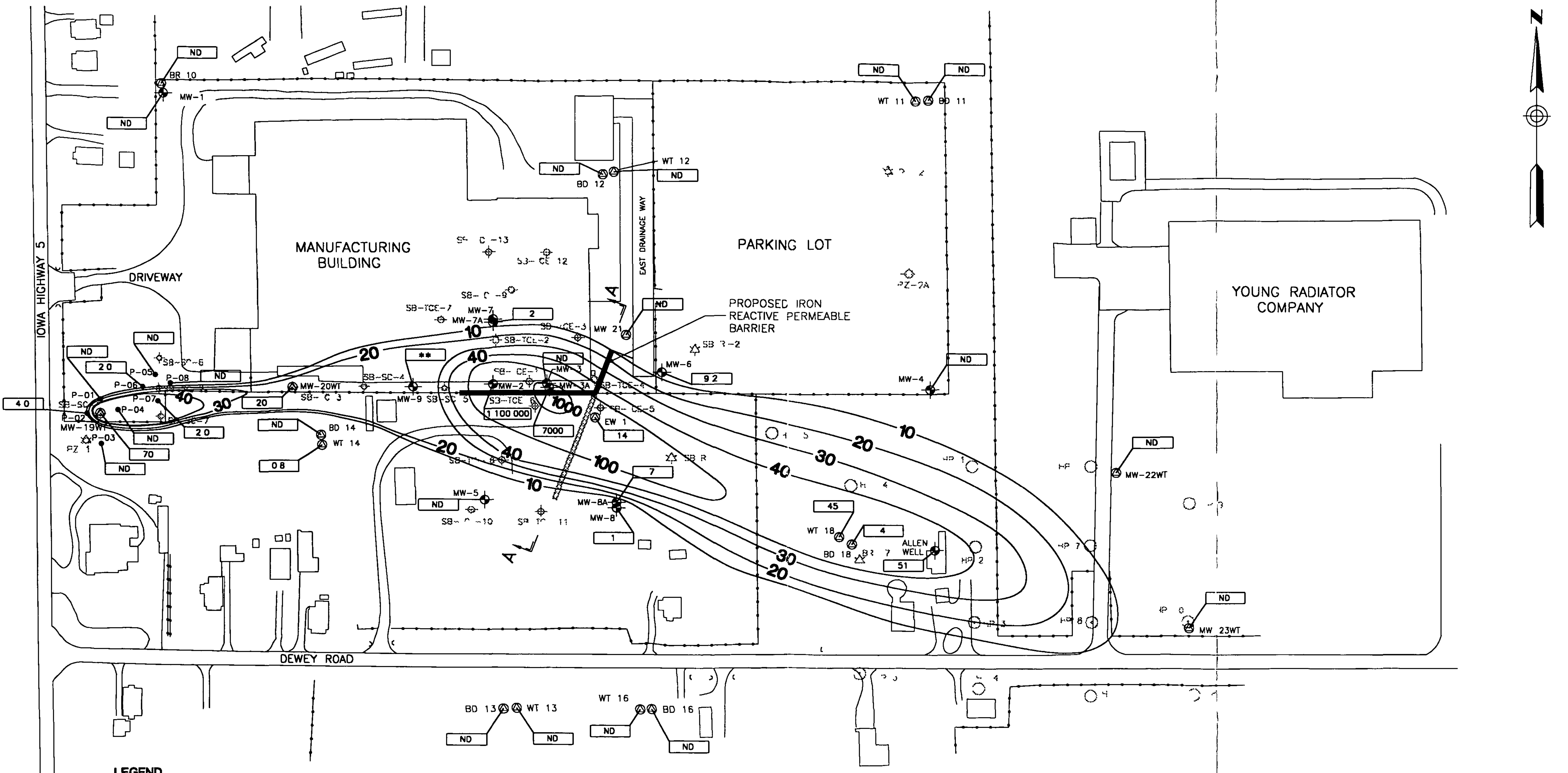
Current Volume of Groundwater in Plume 24 9 (ac ft)

Flowrate of Water Through Source Zone 0 321 (ac ft/yr)

Mass HELP

Recalculate

CommandButton



LEGEND

——•——•—— CHAIN LINK FENCE

BORINGS CONVERTED TO MONITORING WELLS

Ⓐ	WT	TOP OF WATER TABLE BORING
	BD	BASE OF GLACIAL DRIFT BORING
	BR	BEDROCK BORING
	EW	EXTRACTION WELL
☆	SB RI-1 & SB RI-2	SOIL BORING REMEDIAL INVESTIGATION AND BORINGS NOT CONVERTED TO MONITORING WELLS
✡	PZ	PIEZOMETER LOCATIONS
⊕		PREVIOUSLY INSTALLED MONITORING AND SUMP WELLS
P-03 ●		SOIL BORING/SOUTH CULVERT SAMPLE LOCATIONS
▨		PROPOSED LOCATION OF IRON REACTIVE PERMEABLE BARRIER
■		PROPOSED ALTERNATIVE LOCATION OF IRON REACTIVE PERMEABLE BARRIER

NOTE. SEE FIGURE 3 FOR LOCATION OF SOIL BORINGS GB-1 AND GB-1A (MAY 1998)

⊕ SS	SOIL BORING/SOUTH CULVERT SAMPLE LOCATIONS
⊕ SB C	SOIL BORING/TCE STORAGE AREA SAMPLE LOCATIONS
○ HP 5	HYDROPUNCH LOCATION
—40—	GROUND WATER TCE CONCENTRATION CONTOURS (ug/L)
45	TCE DATA (ug/L)
MW-2	SCREENED IN PERCHED WATER TABLE DATA POINT NOT USED FOR CONTOURS
**	WELL NOT SAMPLED DUE TO DEAD ANIMAL

SCALE IN FEET

0 160 320

BASE MAP AND
TCE DATA PROVIDED BY
MWR INCORPORATED
A Division of Envirogen Inc

GOLDER
SIERRA Atlanta, Georgia

CLIENT/PROJECT
McGRAW-EDISON SITE CENTERVILLE, IOWA

TITLE
ALTERNATIVE LOCATION OF PROPOSED
IRON REACTIVE PERMEABLE BARRIER

DRAWN MAT	DATE 7/30/98	JOB NO 986-1083	
CHECKED RIO	SCALE AS SHOWN	DWG NO 1083-D16	REV NO B
REVIEWED	FILE NO 1083-D16	SUBTITLE	FIGURE NO G-1