SUPPLEMENTAL FEASIBILITY STUDY REPORT
ROBESON INDUSTRIES SITE
SITE #9-61-008
CASTILE (T), NEW YORK

Prepared for:

NYS DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF ENVIRONMENTAL REMEDIATION
WORK ASSIGNMENT D003825-6.5

DRAFT

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1.0 INTRODUCTION

1.1 Scope

This Supplemental Feasibility Study (SFS) presents the evaluation of three alternatives for remediation at the Robeson Industries Site (Site No. 9-61-008). This work is being performed for the New York State Department of Environmental Conservation (NYSDEC) under Task 15 of Work Assignment D003825-6.5.

1.2 Current Remediation

The Robeson site remediation construction was completed by the Tyree Organization in February 1998. Tyree operated the remediation systems from February 1998 to February 1999. URS has operated the system from February 1999 to the present.

The remediation, installed in 1998, includes a Soil Vapor Extraction/Treatment (SVET) system and Groundwater Extraction/Treatment (GWET) system. Major components of the SVET system include the following: 1) eleven vapor extraction wells with total depths ranging from 9.5 to 17 feet; 2) an air/moisture separator; 3) two ten-horsepower vacuum blowers for extracting soil gas; 4) carbon adsorption units for air treatment; and 5) associated piping and instrumentation. The major components of the GWET system include the following: 1) ten 4-inch diameter groundwater extraction wells constructed to depths ranging from 39 to 56 feet with pumps; 2) an approximately 1,200 gallon storage tank that is used to store water pumped from the wells prior to treatment; 3) a chemical addition system that adds a sequestering agent (Calsperse) to reduce scale build-up on equipment and piping; 4) two air strippers to remove VOCs – each with a capacity of 20 gallons per minute; 5) a catalytic oxidizer to treat air emissions from the air strippers; and 6) process pumps, piping, and instrumentation.

The number of soil vapor extraction wells used to extract soil gas has been reduced over the operating period because operating data showed that some areas of the vadose zone were clean. Currently, only two wells (I-4 and I-5) are being used to extract soil gas (See Figure 2-1).

Air emissions control units, both the catalytic oxidizer and carbon adsorption units, were taken off line in June 2000 because the quantity of contaminants removed by the SVET and

GWET systems decreased. URS performed an analysis showing that air emissions were in compliance without any air emissions control. On this basis, the Department directed URS to take the air emissions control units off line.

Although there are two air strippers on site, only one air stripper has been used. The total groundwater extraction rate has never exceeded 10 gallons per minute, so one air stripper has been adequate for treatment.

A summary of operating data for the period of February 1998 to February 2004 (the date of the last operating report) is presented below. Data for the GWET system is summarized as follows:

1. About 8.1 million gallons of contaminated groundwater were extracted over the period.

2. The average extraction rate over the entire (six year) period was 2.6 gallons per minute.

3. Generally, the extraction rate was the highest during the first month of operation. The extraction during this period was about 8 gallons per minute.

4. Over the six year period, about 320 pounds (4.4 lbs./month) of VOCs were removed. About 98% of the VOC mass removed was trichloroethene (TCE). Mass removal estimates were based on analysis of VOCs in samples from the groundwater extraction wells and groundwater flow measurements.

Data for the SVET system is summarized as follows:

1. Approximately 3,500 pounds of VOCs were removed over the six year period. About 94% of the VOC mass removed was TCE. Mass removal estimates were based on analysis of VOCs in samples of extracted soil gas from SVET system extraction wells and soil gas flow measurements.

2. Removal rates have decreased over time. About 150 lbs/month of VOCs were removed during the first year of operation. About 25 lbs/month of VOCs were removed during the sixth year of operation.

3. Removal rates have decreased partly because data has shown that some areas of treatment were clean. Eleven extraction wells were used from February 1998 to May 2002, six wells were used from May 2002 to October 2003, and two wells have been used since October 2003.

The system performance has also been evaluated by monitoring downgradient (west of the onsite building) monitoring wells and the seep (Figure 2-2). Over the period, the data has shown, that in general, the downgradient groundwater quality has remained relatively static while the seep water quality has improved with respect to VOC concentrations.

1.3 Remedial Goals

The remedial goals for the site stated in the March 1995 Record of Decision (ROD) include the following: "1) eliminate the threat of surface water by eliminating any future discharges of contaminated groundwater (e.g. seeps) from the site; 2) mitigate the impacts of contaminated groundwater to the environment; 3) eliminate the potential for direct human or animal contact with the contaminated soils and groundwater on-site which act as a source of contamination to groundwater and surface water leaving the site; and 4) provide to the extent practicable attainment of Standards, Criteria, and Guidance (SCGs) for groundwater quality."

1.4 Approach

As stated in Section 1.2, Remediation at the Robeson site began in 1998. In accordance with NYSDEC policy, the site must undergo a five-year review to evaluate remedial progress. As part of the review process, a meeting was held in the NYSDEC Albany office on January 27, 2005. One of the purposes of this meeting, was to discuss and select alternatives to the existing remedy that could improve remedial progress. As a result of this meeting, five alternatives will be evaluated as follows:

1. Minor Modifications to Existing Remediation. The existing system will be modified to make it more efficient and less costly to operate.

2. Enhancement of Existing Remediation: A trench will be installed to dewater the seep. Additional wells will be installed in the contaminated area under the building. These wells will be used to lower the water table and to extract soil gas from the

zone dewatered by pumping from the wells. A total of 40 gallons per minute of groundwater will be extracted from existing extraction wells, and the new trench and wells. The extracted water will be treated in the existing treatment system.

3. In-Situ Chemical Oxidation (ISCO): A chemical oxidant (sodium permanganate) will be injected into the saturated zone in the source area to destroy contamination including contamination in groundwater, adhering to soil, and in the form of DNAPL (See Section 2.0 for a discussion of DNAPL).

4. No Action: The existing remediation will cease and the site will continue to be monitored.

5. Source Removal: The existing building will be demolished and soil in the source area will be excavated to a depth of approximately 50 feet. Soil will be disposed of offsite.

As agreed to in the meeting of January 27, alternatives 4 and 5 will be evaluated by NYSDEC while URS will evaluate alternatives 1, 2 and 3. A final evaluation of all alternatives will be performed by NYSDEC and they will select the preferred remedial alternative. URS's evaluation of the three alternatives is presented in Sections 3.0 and 4.0.

2.0 EXTENT OF CONTAMINATION

Design of the existing remediation system was based on data presented in the Design Analysis Report (URS 1997). The conceptual model developed from this data included the following: 1) an approximately 26,000 square foot area (Figure 2-1) of soil contamination in the unsaturated zone (extending about 15 feet below the floor of the on-site building); and 2) a dissolved phase groundwater plume extending about 400 – 500 feet downgradient (west) of the vadose zone soil contamination considered the source area of contamination (Figure 2-2).

Data collected during the remediation and a recent (September 2004) supplemental investigation indicate that the extent of the source contamination is greater than that used to design the existing remediation system. Six borings were installed in September 2004 (Figure 2-3) to further define the extent of the contamination source. The data from these borings are summarized on Table 2-1. The data show that there is significant contamination below the water table. Furthermore, elevated (above 100 ppm) PID readings from these borings (Appendix A) along with TCE concentrations (Table 2-2) in groundwater near or above 1% of the solubility limit of 12,800 µg/L (USEPA 2005) suggest that there is residual DNAPL in the saturated zone.

Since the recent investigation was limited in scope, the extent of soil contamination and residual DNAPL is unknown. It is expected that the extent of contamination in the saturated zone would be at least the extent of contamination identified in the unsaturated zone (Figure 2-1). Since DNAPL is subjected to the forces of groundwater flow once it reaches the saturated zone it is likely that the DNAPL has migrated downgradient, and/or sidegradient from the original source area. For the purpose of this SFS, it is assumed that the contamination in the saturated zone is somewhat larger than in the unsaturated zone, as shown on Figure 2-4.

The quantity of contamination in the saturated zone is nearly impossible to estimate accurately since DNAPL can exist in seams or pools that may never be detected by conventional drilling techniques. However, using data from the recent investigation, it seems possible that upwards of 5,000 pounds of contamination (mainly trichloroethylene) could be present in the saturated zone at the Robeson site (Appendix B).

The SVET system has been operating for seven years. During that time over 3,500 pounds of contamination has been removed from the vadose zone. Removal rates have decreased over time. Currently, the SVET system is removing about 10 – 20 pounds of contamination per month. Based on air and soil sampling the vadose zone (to a depth of 15 feet) is relatively clean. Remaining soil contamination in the vadose zone seems to be limited to the area around SVET extraction wells I-4 and I-5 (Figure 2-1).

3.0 EVALUATION OF ALTERNATIVES

3.1 Alternative 1 – Minor Modifications to Existing Remediation

3.1.1 Description

Under this alternative, the remediation system would remain largely the same. Some small modifications would be implemented to reduce the operator time on site, and thus reduce operating cost. Proposed modifications include the following:

1. Revise PLC programming so that all groundwater pumps operate on a timer/flow cycle rather than on signals from the in-well level transducer. This will reduce maintenance costs associated with the level transducers.
2. Replace discharge pumps with a gravity discharge line.
3. Reinstitute the use of Calsperse, a proprietary chemical sequesterant, to reduce mineral deposition on air stripper trays. This will reduce maintenance time for cleaning trays.
4. Redevelop wells on regular basis. This will reduce pump maintenance and sustain a higher pumping rate in the wells.

In addition, to the above sampling frequencies and parameters would be reduced to further reduce O&M costs.

3.1.2 Technical Analysis

In the first six years of operation, about 320 pounds of contamination (53/lbs/year) were removed by groundwater extraction. By making system improvements and increasing the frequency of extraction well cleaning, the rate of contaminant extraction could be increased to 100 to 150 pounds per year – assuming that the average extraction rate will double or triple and that the concentration of VOCs in extracted groundwater remains the same. However, although the amount of contamination in the saturated zone is unknown, it is likely that several thousand pounds of contamination are present in the saturated zone. On this basis, it will take several decades (50 – 100 years) to effectively remove the source contamination in the saturated zone.

This estimate is in keeping with the original estimate (60 years) presented in the Design Analysis Report (URS 1997).

Based on data collected over six years of operation, groundwater contamination does not appear to be migrating, and the groundwater quality at the seep has improved. The existing remediation system is generally meeting the site remedial objectives except that the system has not effectively eliminated the seep located downgradient (west) of the site.

The effectiveness of alternative 1 is summarized as follows:

1. Alternative 1 is reducing the volume of contamination over time, but only very slowly. Residual contamination will remain onsite for several decades.
2. Alternative 1 is containing groundwater contamination.
3. Alternative 1 is generally meeting the remedial objectives for the site, except it has not effectively eliminated the downgradient seep. It has, however, improved water quality at the seep.

3.1.3 Cost

Cost analysis for Alternative 1 is presented in Appendix C. The capital cost for Alternative 1 is estimated at $18,000, and the estimated O&M cost is $69,000 per year. Assumptions with regard to capital cost were as follows: 1) the existing discharge forcemain is not sufficient in size or slope for gravity discharge so an entire new gravity discharge line will be installed; and 2) PLC programming and reinstating the Calsperse chemical addition system will be completed with monies already appropriated under the existing contract so no cost is included in the SFS. For O&M costs, it is assumed that SVE operations will be terminated in the near future so no air analysis costs were included in the SFS estimate. A comparison of costs for Alternative 1 to other alternatives is presented in Section 4.7.

3.2 Alternative 2 – Enhancement of Existing Remediation

3.2.1 Description

Under this alternative, the existing remediation system would remain in-place; however, significant new components would be added to the remediation. Additional components would include the following:

1. Seep Dewatering System: A system would be installed at the seep located downgradient (west) of the site to dewater the seep and better meet remedial objective 1 (Section 1.3) for the site (Appendix D). The system would include the following: (a) Collection Trench: A trench consisting of a small slot size well screen surrounded by compatible sand pack material. The estimated, dimensions are 100' long x 2.5' wide x 15' deep. (b) Collection Sump: A twenty foot deep sump consisting of a 4 foot diameter concrete manhole, dual-submersible pumps on guiderails with control panel, and (c) Forcemain: A 2" diameter buried PVC forcemain estimated at 400 feet in length. A design extraction rate from the seep is estimated at 10 gallons per minute (Appendix D). Because the gradient is seep and the permeability is low, a trench was considered more feasible than wells for the FS. A pump test in the seep area would be used to evaluate the feasibility of extraction using wells in the seep area. The pump test could be performed during design, if this alternative is implemented at the site. Using wells instead of a collection trench would probably reduce the capital cost of Alternative 2 by $20,000 to $40,000.

2. Enhanced Extraction System: Twelve additional wells would be installed in the building to further lower the water table and enhance remediation by using soil vapor extraction in the dewatered zone (Appendix E). The new wells would be approximately 50 feet deep and would be used to extract groundwater and soil vapor. The total estimated extraction rate from the twelve new wells is 20 gallons per minute. The estimated drawdown using these wells is 5 feet.

3.2.2 Technical Analysis

Installing a trench in the seep will effectively dewater the seep and completely meet remediation objective 1 for the site. To date, extracting groundwater upgradient of the seep near the building has not effectively dewatered the seep, although data indicate the contaminant concentrations at the seep have been reduced. It is expected that dewatering the seep will have little effect on improving groundwater quality at the site since it will not be removing contamination at the source under the building.

The enhanced extraction system in the building should have a positive impact on groundwater quality. Contamination will be removed by both groundwater extraction and soil vapor extraction. In addition, control of contaminant migration will be greatly enhanced. During the first six years of operation, the existing soil vapor extraction system removed over 3,500 pounds of contaminants in the 15 to 20 foot deep vadose zone. It is expected that additional hundreds, if not more, pounds of contaminants can be removed by soil vapor extraction system once the water table is lowered below the current level.

The effectiveness of Alternative 2 is summarized as follows:

1. Alternative 2 will further reduce the source of contamination. Contamination now within the top 5 feet of the saturated zone will be removed by soil vapor extraction after the area is dewatered. However, contamination (both DNAPL and soil contamination) in the remainder of the saturated zone will remain largely intact. It will be removed slowly over time by dissolution into the groundwater. It is expected that several decades would still be required to meet groundwater standards.

2. Alternative 2 includes additional wells to more effectively contain the source and prevent groundwater contaminant migration.

3. Alternative 2 will eliminate the downgradient seep.

4. Alternative 2 meets all the site remedial objectives.

3.2.3 <u>Cost</u>

Cost analysis for Alternative 2 is presented in Appendix C. The estimated capital cost for Alternative 2 is $330,000. The capital cost is based on the assumption there will be no capital improvements to the existing treatment equipment. Two annual O&M costs have been calculated for Alternative 2. It is assumed that the twelve additional SVE/groundwater extraction wells located in the building will be operated only for 5 years. It is assumed, that after 5 years, remediation by SVE will be complete-meaning the 12 new wells inside the building will cease operation. During the first 5 years of operation, the estimated O&M cost is $140,000 per year. After the first 5 years, it is assumed that only the ten existing extraction wells outside the building, and the proposed seep collection trench will continue to operate. The estimated O&M cost for years 6 and beyond is $74,000 per year. A comparison of costs for Alternative 2 to other alternatives is presented in Section 4.7.

3.3 <u>Alternative 3 – In-Situ Chemical Oxidation (ISCO)</u>

3.3.1 <u>Description</u>

Under this alternative, sodium permanganate will be injected into the saturated zone to destroy contaminants. More specifically, this alternative would include the following:

- Injection of sodium permanganate solution at approximately 552 injection points (based on a 5 foot radius of influence).
- Injection of about 70 gallons of 40% sodium permanganate solution along with approximately 800 gallons of dilution water at each injection point.
- Soil and groundwater sampling and analysis both before and after injection.

More details regarding this alternative are provided in Appendix F.

3.3.2 <u>Technical Analysis</u>

Theoretically, oxidation will destroy all or most contamination at source under the buildings. If this is accomplished, groundwater quality should be returned to pre-spill conditions very quickly. It would probably take 6 months to a year to complete the oxidation program.

However, actual successful remediation by oxidation is limited by a number of factors which are discussed briefly below.

1. <u>Subsurface Heterogeneity</u>: Oxidation is dependent on achieving adequate contact between oxidants (in this case sodium permanganate) and contaminants. Subsurface heterogeneities (such as found at the Robeson site), preferential flow paths, and poor mixing in the subsurface can result in extensive pockets of untreated contaminants.

2. Natural Oxidation Demand (NOD): Oxidizing reagents such as sodium permanganate are consumed by other oxidizable substrates (e.g. natural organic compounds or dissolved iron), limiting the efficiency of treatment by oxidation. In the estimate for the Robeson site (Appendix F), most of the sodium permanganate to be injected is consumed by the NOD. It should be noted that the NOD was approximated, and that installation of additional borings, and soil sampling and analysis would be required to accurately determine a value for NOD necessary for design. A value of 5 g/kg was assumed for NOD at the Robeson site. The NOD was measured at another Superfund site in New York – the Hillcrest site in the Town of Frenton, Broome County. At the Hillcrest site, the NOD was estimated to be between 0.7 and 2.2 g/kg.

3. Experience: In-situ chemical oxidation (ISCO) technology has been commercially practiced for about 10 years. Although the technology is becoming better understood, it is still evolving. Because of the relative lack of experience with ISCO, greater amounts of time are required for site investigations, and bench or pilot-scale are recommended prior to implementing this technology.

The effectiveness of Alternative 3 is summarized as follows:

- Successful implementation of ISCO would allow remedial objectives to be met quickly so a "clean" site closure would be possible.
- There are many uncertainties associated with implementation of ISCO. Success is not guaranteed. Additional remedial measures might have to be implemented if ISCO is unsuccessful.

3.3.3 Cost

Cost analysis for Alternative 3 is presented in Appendix C. The estimated cost for implementing ISCO is $2,200,000. The cost is based on the assumption that dilution water can be obtained from the onsite production well. If this is not possible, the cost would be increased by about $50,000 to $100,000.

As mentioned above, the amount of sodium permanganate, and therefore, the cost of ISCO depends on the NOD of the soil. If a NOD of 2 g/kg, similar to Hillcrest is assumed, the cost of ISCO is reduced to about $1,200,000 (Appendix C).

The NOD could be higher than 5 g/kg which would increase cost. The cost would also increase if retreatment of some areas were required because of complicated geology or unexpectedly high levels of contamination or NOD. Under these scenarios, the cost of ISCO could escalate to $3,000,000 or more.

Uncertainties associated with implementing ISCO lead to uncertainties in estimating the cost. The estimated range of cost for ISCO is $1,000,000 to $3,000,000. A value of $2,200,000 was used for this SFS which represents a mid range estimate of the cost. This estimate assumes that all or nearly all contamination is oxidized. If only partial success is achieved, additional remediation (e.g. continued pump and treat) would be required which would increase the cost.

4.0 COMPARISON OF ALTERNATIVES

This section includes a comparison of the three alternatives discussed in Section 3.0 which are Alternative 1 – Minor Modifications to the Existing Remediation, Alternative 2 – Enhancement of Existing Remediation, and Alternative 3 – In Situ Chemical Oxidation. The comparison is based on the criteria for evaluating alternatives described in 6 NYCRR Part 375.

4.1 Overall Protection of Human Health and the Environment

All three alternatives are protective of human health and the environment. Alternative 1 meets all remedial objectives except with regard to eliminating the downgradient seep. Although the existing system has not effectively dewatered this seep, concentrations of VOCs at the seep have been greatly reduced. Because of this reduction, the threat to public health and the environment is minimal.

Alternative 2 includes measures to dewater the seep and remove additional contamination from the source using soil vapor extraction. This alternative eliminates potential exposure at the seep and reduces the residual contamination remaining on site.

Alternative 3 eliminates or significantly reduces the source of contamination in about 1 year. In this way, it is more effective than the other alternatives which will require several decades or longer to eliminate the source of contamination.

4.2 Compliance with SCGs

Theoretically, Alternative 3 will comply with SCGs very quickly. Alternatives 1 and 2 will take several decades if not longer to achieve SCGs. However, there are uncertainties associated with ISCO which is included in Alternative 3. It is highly likely that not all contamination will be removed by this technology. Therefore, compliance with SCGs could still take many years. Nevertheless, by removing the majority of contamination at the source, Alternative 3 will significantly reduce the time required to achieve SCGs.

4.3 Short-Term Impacts and Effectiveness

Alternative 1 includes very little construction so short term impacts will be minimal. Alternative 2 includes well and trench construction so there are some small potential impacts to workers from VOCs; however, these should easily be controlled by a properly administered health and safety program. Alternative 3 includes the most intrusive work so potential short-term impacts are the greatest with this alternative. The potential short-term impacts are primarily for workers and not the community since the site is in an isolated rural area. As with Alternative 2, potential impacts from Alternative 3 could be controlled by a properly administered health and safety program.

4.4 Long-Term Effectiveness and Permanence

Both Alternatives 1 and 2 require many decades of operation so they are not short-term permanent remedies. However, both include hydraulic control of contamination using mostly existing infrastructure. Based on existing data, these systems will be effective in managing the contamination remaining in place. Alternative 3 includes removal or at least significant reduction of source contamination; therefore, it, is a more permanent remedy.

4.5 Reduction of Toxicity, Mobility and Volume (TMV)

The reduction of Toxicity, Mobility, and Volume (TMV) is the greatest for Alternative 3. Oxidation will destroy contaminants. The effectives of oxidation depends on many factors, e.g. site geology, however, it is believed that oxidation will remove between 50 and 100% of the contamination. Alternative 2 includes additional soil vapor extraction after lowering the water table. Alternative 2 will remove additional contamination rather quickly, but reduction of TMV by Alternative 2 will be significantly less than Alternative 3 because it addresses only about 15 – 20% of the contaminated saturated zone. Alternative 1 reduces TMV very slowly over time as contamination dissolves into the groundwater.

4.6 Implementability

Alternative 1 includes very little construction and would be easy to implement. Alternative 2 would be somewhat more difficult to implement because well construction for soil vapor and groundwater extraction is necessary; however, the technologies for alternative 2 are well understood. Construction should be completed within about a month. Alternative 3 would be much more difficult to implement than the other two alternatives. Although oxidation has been commercially available for about 10 years, actual experience with this technology is limited and the technology is not completely understood. At the Robeson site, further field investigations and a pilot scale study would probably be required before implementing ISCO at the site. As with other in-situ technologies, the quantity of bidders on the project would be small because not many companies would have the experience to qualify for the bid. It is also possible that ISCO would not be successful on the first try, and that the Contractor would have to remobilize and retreat portions of the site where contaminant concentration did not reach acceptable levels.

4.7 Cost

A summary of costs for all three alternatives is presented in Table 3-1. On the basis of total present worth cost, Alternative 1 – Minor Modifications to the Existing Remediation is the least costly alternative. Alternative 2 – Enhancement of Existing Remediation is about 50% more costly than Alternative 1, and Alternative 3 – ISCO is about 100% more costly than Alternative 1.

The present worth cost is comprised of capital and O&M costs. Alternatives 1 and 2 are low in capital cost, but higher in O&M cost since the systems will continue to operate for many years. For Alternative 3, the cost is incurred in a short period of time (approximately 1 year).

The costs presented in Table 3-1 are based on an O&M period of 30 years – the conventional time period used for feasibility studies. Table 3-2 presents costs on a present worth basis for an O&M period of 100 years since it is possible that systems included in Alternatives 1 and 2 would need to continue to operate well beyond 30 years (Sections 3.1.2 and 3.2.2). When using a 100 year O&M period, Alternative 3 is still the most costly alternative. On a present worth basis, Alternative 3 is about 50% more costly then Alternative 1 and about 5% more costly than Alternative 2.

5.0 SUMMARY

In this summary, the three alternatives are evaluated with respect to the three fundamental evaluation criteria, namely, effectiveness, implementability (constructability), and cost. The evaluation is based on a five-year period of operation. A five-year period is used because budget uncertainties as well as potential modifications to the superfund program could impact the evaluation of the site remediation at the next 5 year review.

1. Effectiveness: Alternatives 1 and 2 will meet remedial objectives and contain contamination, but will be less effective than Alternative 3 in removing contamination. Over a 5 year period, contaminant reduction will probably be 5 – 10% or less with Alternative 1, 15 – 25% with Alternative 2, and probably 50% or greater with Alternative 3.
2. Implementability (Constructability): Alternatives 1 and 2 are conventional approaches to remediation, and there is little uncertainty with respect to their constructability or cost. Alternative 3 includes a technology (ISCO) which is not well understood and would be more difficult to implement.
3. Cost: Based on a 5 year period of operation, Alternative 1 will cost $320,000 Alternative 2 will cost $940,000, and Alternative 3 will cost $2,200,000.

It should be noted, that because Alternative 3 includes ISCO, which is a less well understood than the other remedial approaches considered, there is a higher degree of uncertainty with regard to effectiveness and cost than for other two alternatives.

REFERENCES

URS Consultants, Inc., 1997. Design Analysis Report. Robeson Industries Site.

USEPA, 2005. Toxicity and Chemical Specific Factors Data Base. http://risk.lsd.ornl.gov.

TABLE 2-1

ANALYTICAL RESULTS SUMMARY

FOR SEPTEMBER 2004 INVESTIGATION

BORING LOCATION AND DEPTH	TRICHLOROETHENE CONCENTRATION (µg/kg)	VOC CONCENTRATION (µg/kg)
DB-1 (25 - 27')	11,000	11,094
DB-2 (25 - 27')	170	195
DB-2 (30 – 32')	6,100	6,157
DB-2 (35 - 37)	43,000	45,724
DB-3 (15 - 17')	1,500	1,521
DB-3 (25 - 27')	8,100	8,129
DB-4 (10 – 12')	41	46
DB-4 (25 –27')	3,400	3,436
DB-5 (25 – 27')	6,300	6,348
DB-5 (30 – 32')	6,100	6,148
DB-5 (40 – 42')	19,000	20,457
DB-6 (20 – 22')	3,500	4,368
DB-6 (30 – 32')	18,000	19,112

TABLE 2-2

TCE CONCENTRATIONS IN GROUNDWATER

NEAR OR ABOVE 1% OF THE SOLUBILITY LIMIT

Location (1)	Date	Concentration (µg/L)
GWEW-05 and 09	8/10/00	14,000
GWEW-08	1/22/02	12,000
GWEW-05 and 09	5/29/03	27,000
GWEW-05 and 09	9/18/03	17,000
GWEW-05 and 09	12/10/03	20,000
GWEW-05 and 09	10/13/04	10,000
GWEW-05 and 09	12/16/04	25,000

Notes:

1. Locations are shown on Figure 2-1.

TABLE 3-1

COST SUMMARY FOR

ALL ALTERNATIVES 30 YEAR O&M PERIOD

Alternative	Capital Cost	Annual O&M Cost	Present Worth of O&M (1)	Total Present Worth
1. Minor Modifications to Existing Remediation	$18,000	$69,000	$1,100,000	$1,100,000
2. Enhancement of Existing Remediation	$330,000	$140,000^(2) $74,000^(2)	$1,400,000	$1,700,000
3. In-Situ Chemical Oxidation (ISCO)	$2,200,000	$0	$0	$2,200,000

Notes:

(1) Present Worth of O&M based on a 5% discount rate and a 30 year O&M period.

(2) Annual O&M cost for Alternative 2 is $140,000 for first 5 years and $74,000 for remaining 25 years of O&M period.

TABLE 3-2

COST SUMMARY FOR ALL ALTERNATIVES

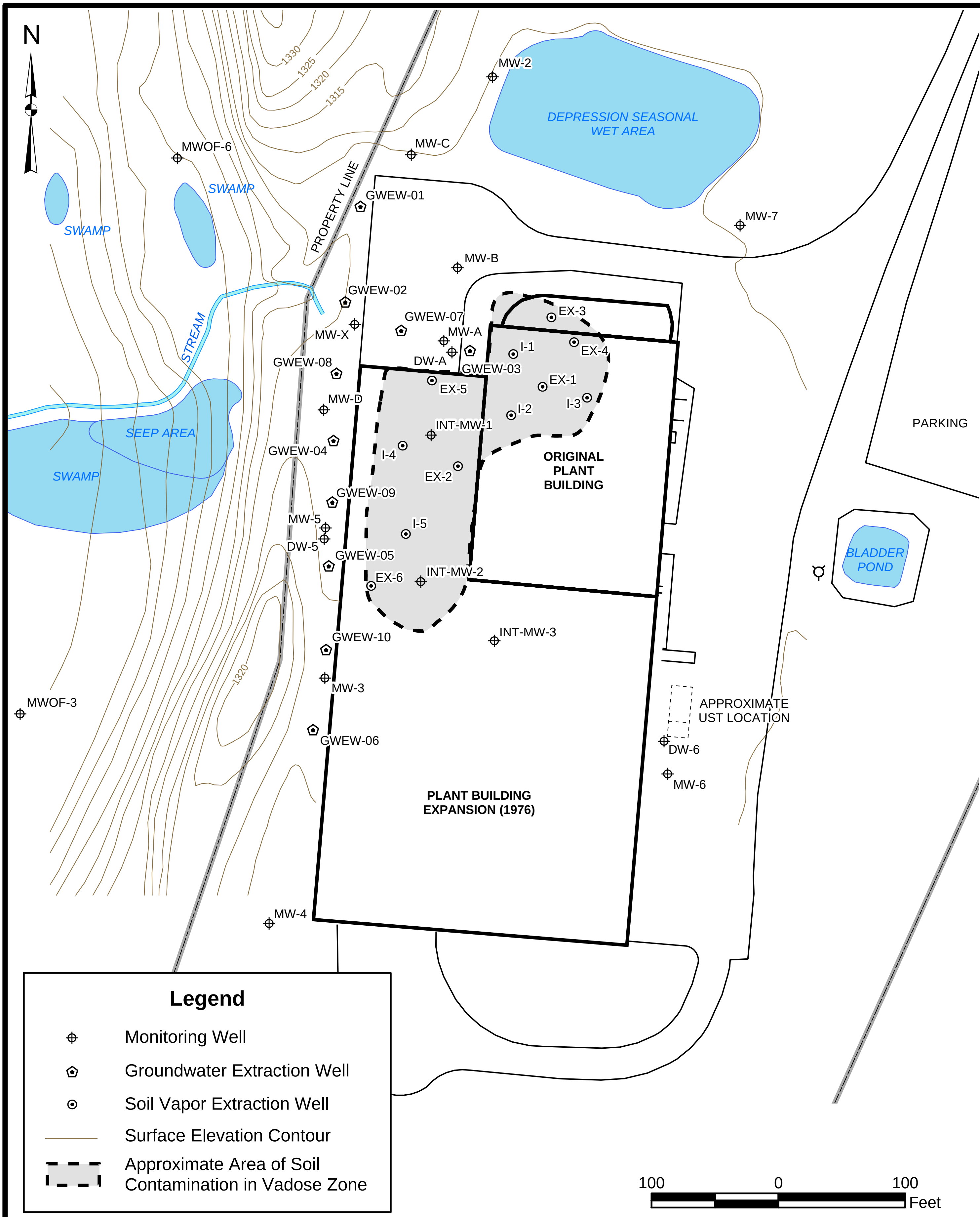
100 YEAR O&M PERIOD

Alternative	**Capital Cost**	**Annual O&M Cost**	**Present Worth of O&M (1)**	**Total Present Worth**
1. Minor Modifications to Existing Remediation	$18,000	$69,000	$1,400,000	$1,400,000
2. Enhancement of Existing Remediation	$330,000	$140,000[(2)] $74,000[(2)]	$1,800,000	$2,100,000
3. In-Situ Chemical Oxidation (ISCO)	$2,200,000	$0	$0	$2,200,000

Notes:

(1) Present Worth of O&M based on a 5% discount rate and a 100 year O&M period.

(2) Annual O&M cost for Alternative 2 is $138,000 for first 5 years and $70,000 for first 5 years and $70,000 remaining 95 years of O&M period.

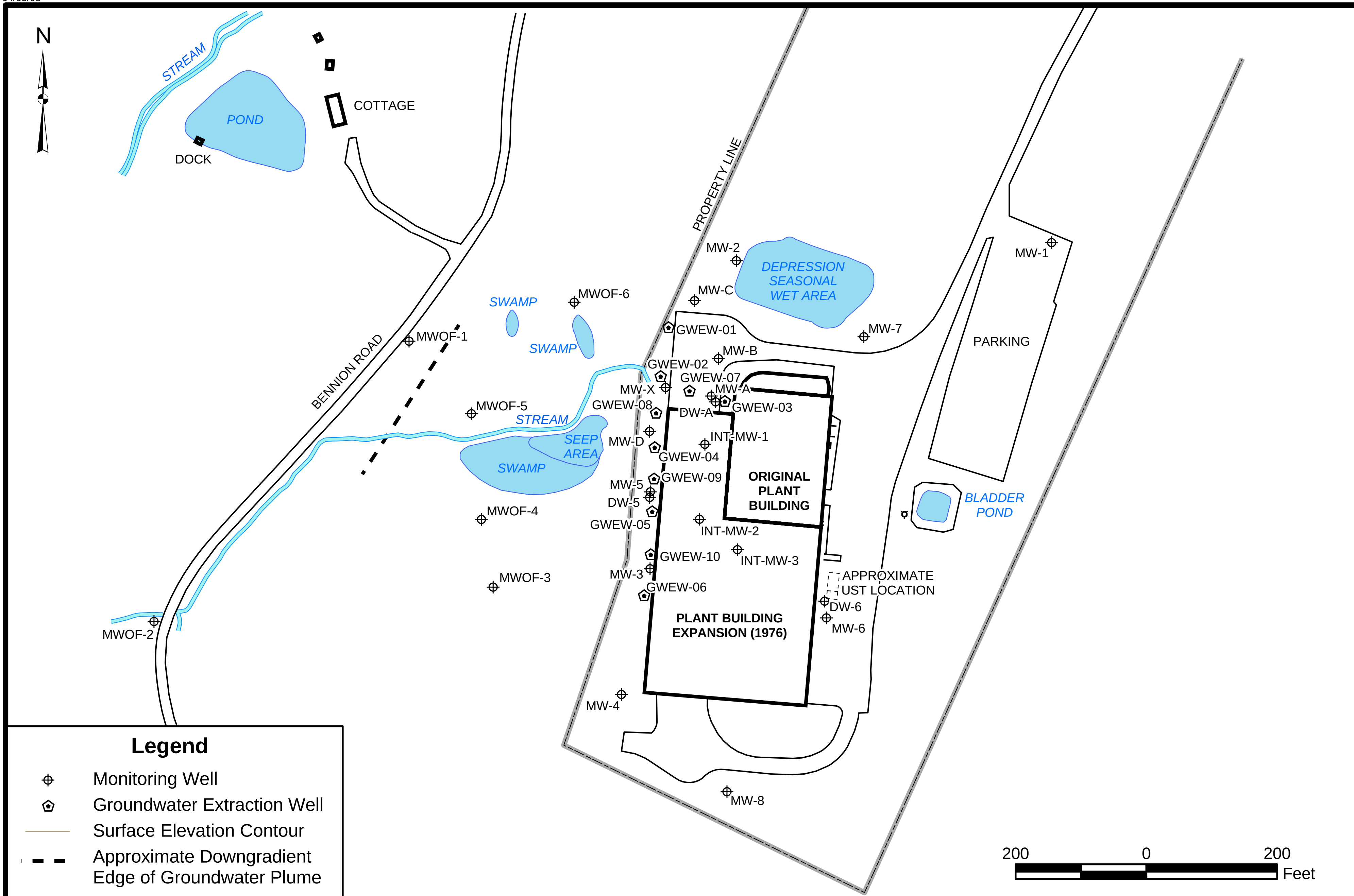


URS

ROBESON INDUSTRIES - TOWN OF CASTILE
EXTENT OF CONTAMINATION IN VADOSE ZONE

FIGURE 2-1

N:\11173790.00000\DB\GIS\EXTENT OF GROUNDWATER CONTAMINATION.mxd
04/05/05



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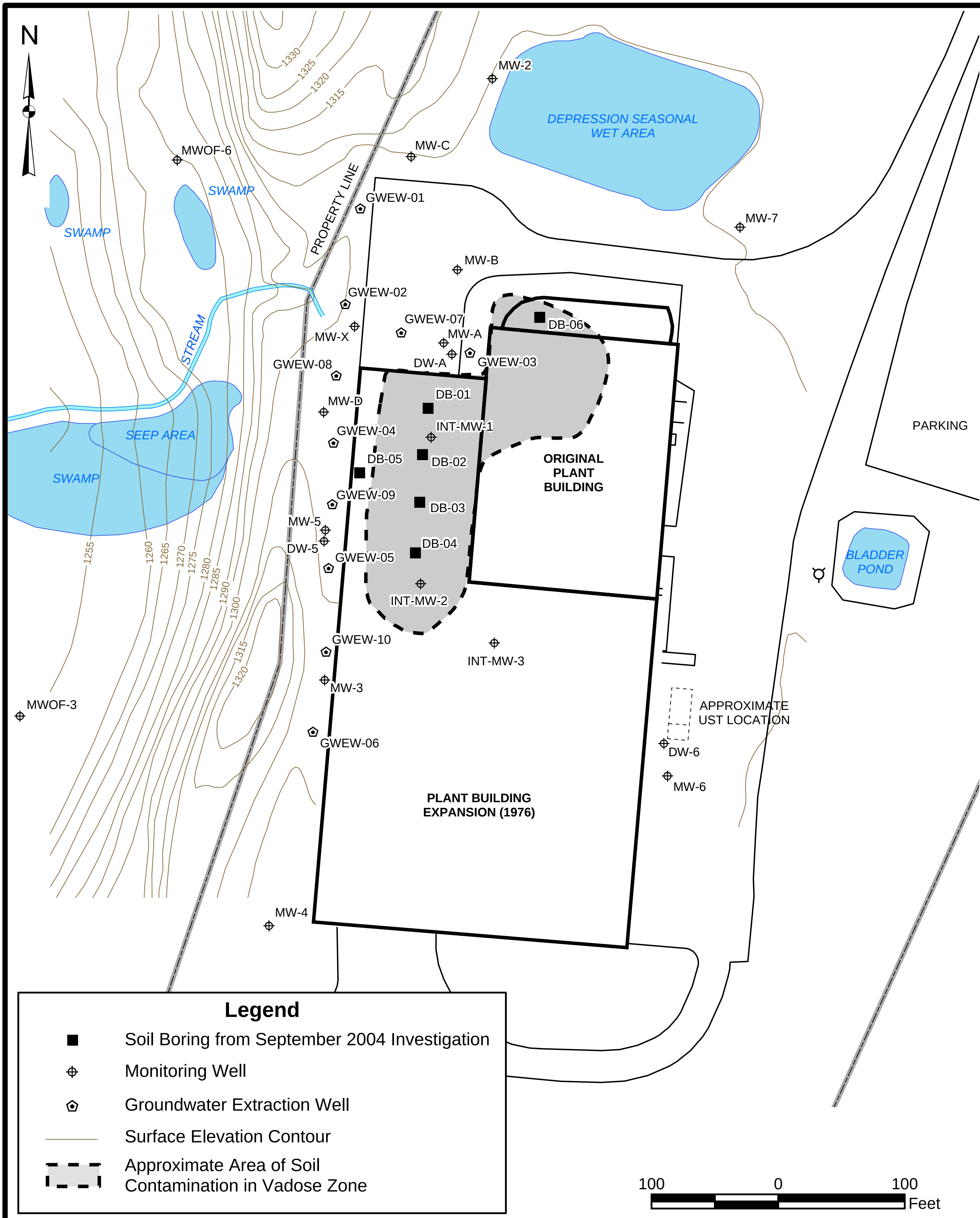
ROBESON INDUSTRIES - TOWN OF CASTILE
EXTENT OF GROUNDWATER CONTAMINATION

FIGURE 2-2

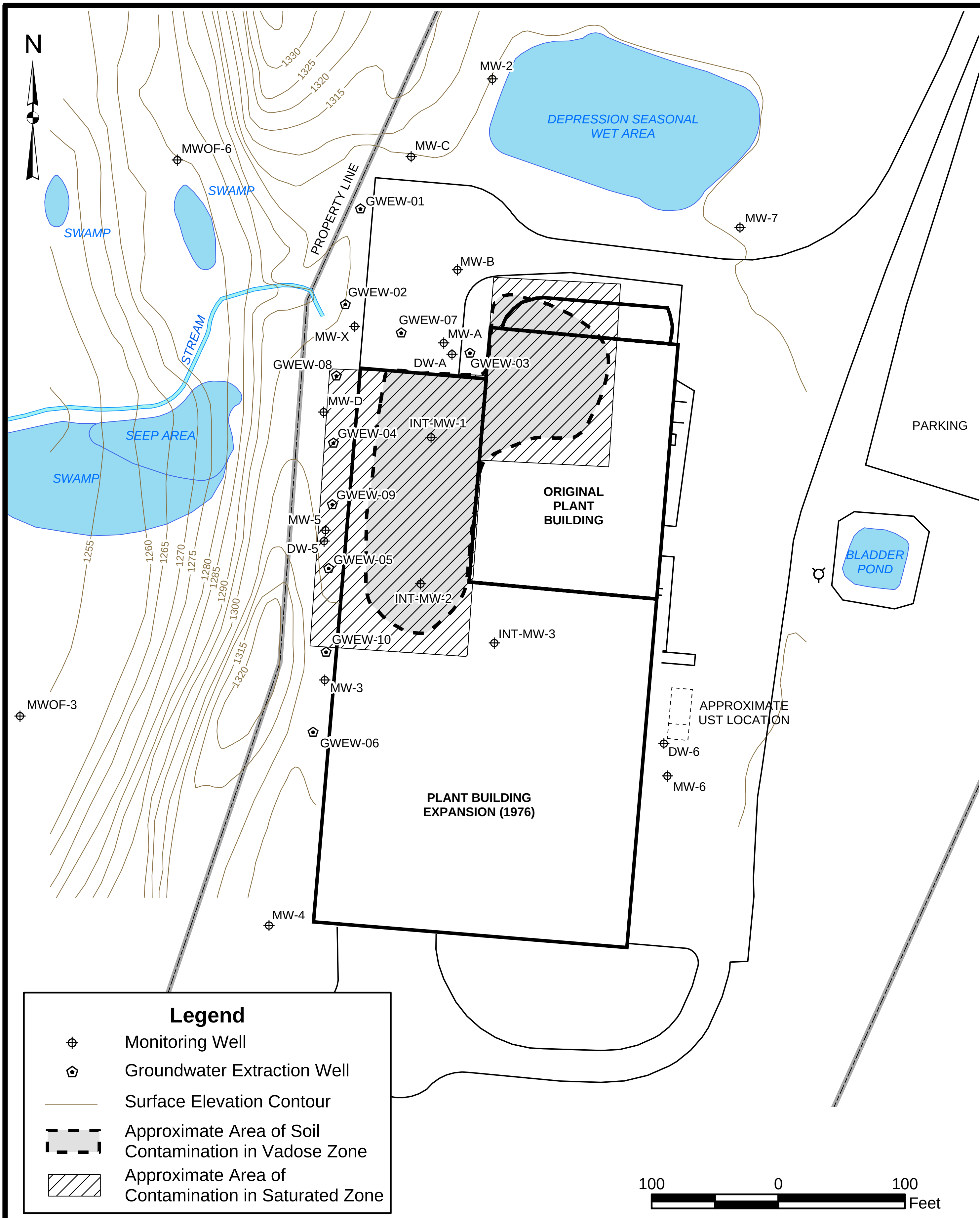


URS

ROBESON INDUSTRIES - TOWN OF CASTILE
BORING LOCATIONS FOR SEPTEMBER 2004 INVESTIGATION

FIGURE 2-3

N:\11173790.00000\DB\GIS\BORING LOCATIONS FOR SEPTEMEBER 2004 INVESTIGATION.mxd
04/28/05



URS

ROBESON INDUSTRIES - TOWN OF CASTILE
EXTENT OF CONTAMINATION IN SATURATED ZONE

FIGURE 2-4

N:\11173790.00000\DB\GIS\EXTENT OF CONTAMINATION IN SATURATED ZONE.mxd
04/28/05

APPENDIX A

PID DATA FROM SEPTEMBER 2004 INVESTIGATION

URS

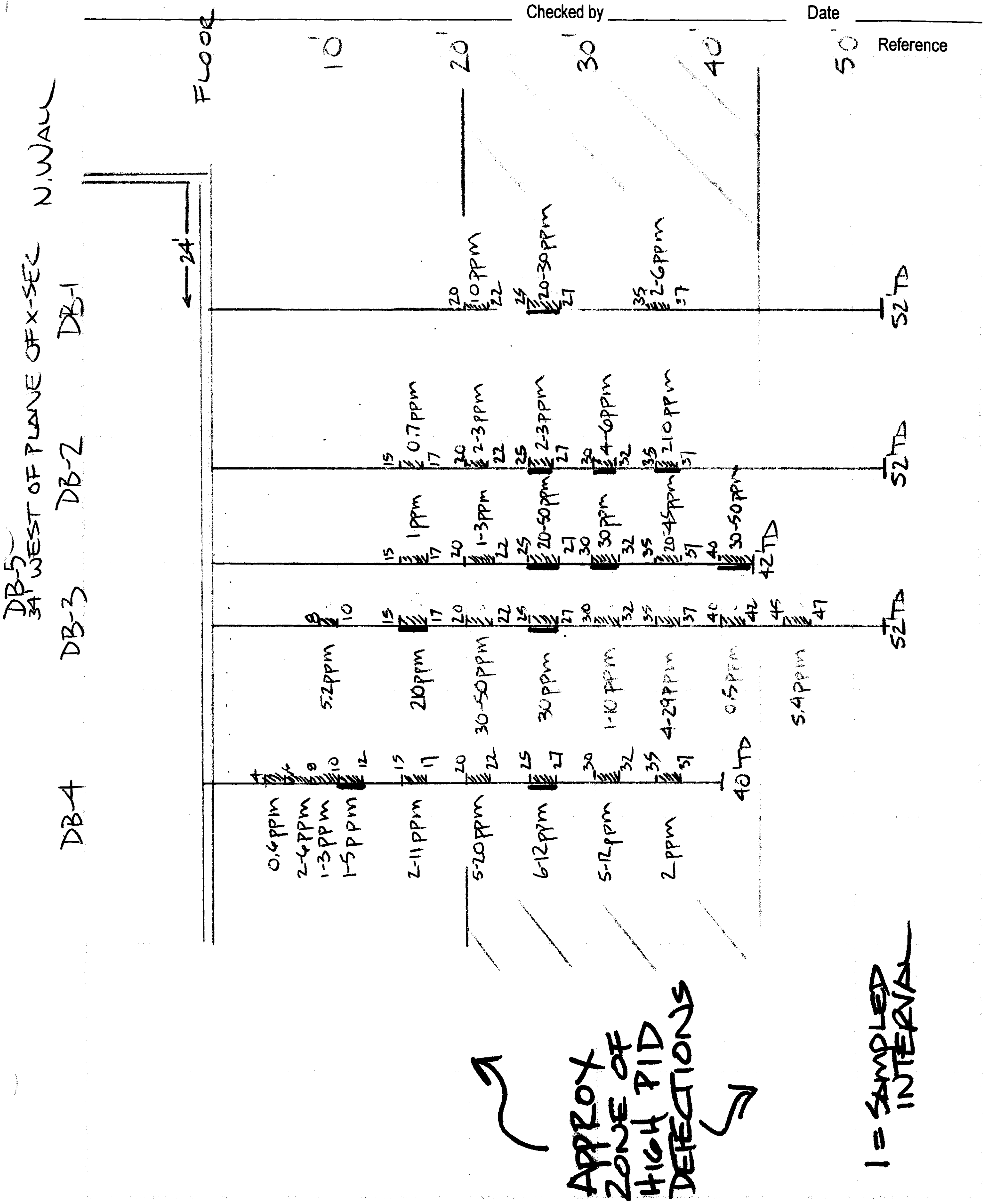
Job ROBESON SATURATED ZONE INVESTIGATION   Project No. ______   Page ____ of ____

Sheet ____ of ____

Description ______   Computed by ______   Date ______

Checked by ______   Date ______

Reference



URS Corporation	**TEST BORING LOG**
	BORING NO: DB-1
PROJECT: Robeson Site	**SHEET: 1 of 2**
CLIENT: New York State Department of Environmental Conservation	**JOB NO.:** 11173791
BORING CONTRACTOR: Nothnagle Drilling	**LOCATION: 24' so.of north wall, 49' east of w. wall**

GROUNDWATER:					**CAS.**	**SAMPLER**	**TUBE**	**GROUND ELEVATION:**
DATE	**TIME**	**LEVEL**	**TYPE**	**TYPE**		Split-spoon		**DATE STARTED:9/10/04**
				DIA.		2"		**DATE FINISHED: 9/10/04**
				WT.		140#		**DRILLER: Neil Short**
				FALL		30"		**GEOLOGIST: Tim Burmeier**
								REVIEWED BY: Duane Lenhardt

DEPTH FEET	**STRATA**	**SAMPLE "S" NO.**	**"N" NO.**	**BLOWS PER 6"**		**REC%**	**COLOR**	**CONSISTENCY HARDNESS**	**MATERIAL DESCRIPTION**	**PID**	**REMARKS**
1		1	22	x	11	60%	Medium Brown	Medium Dense	Concrete floor (0-0.5') Fill: Regraded local material-silty fine to coarse sand and gravel	0	Slightly Moist
				11	12						
		2	32	12	15	70%		Dense		0	Moist
				17	12						
5		3	33	13	17	45%				0	
				16	14						
		4	17	10	9	70%		Medium Dense	Silty fine sand with faint layering and fine round gravel	0	
				8	8						
		5	15	5	7	75%				0	
10				8	10						
15											
		6	18	14	10	55%	Light Gray Brown		-predominantly fine gravel (15-16')	0	
				8	4						Wet at 16'
20											
		7	26	6	12	95%	Medium Brown		Silty fine sand with trace fine gravel	10	
				14	15						
25											
		8	28	6	13	80%			Sandy silt-very fine sand	20-30	
				15	16						
30											
		9	24	6	10	100%			Fine sand, well graded salt and pepper appearance	0	
				14	14						
									Silty very fine-fine sand		
35		10	23	WOR	WOH	100%		Very Loose	(continues on page 2)	2-6	

COMMENTS: Boring advanced with Gus Pech 750 rig using 2 1/4" ID hollow-stem augers.
Sampling with 2-inch diameter split spoon samplers. All samples were screened inside plastic baggies with a Mini-Rae 2000 PID. WOR=weight of rods, WOH = weight of hammer
Sampled 25-27' for VOCs analysis

Boring No.
DB-1

URS Corporation	TEST BORING LOG
	BORING NO: DB-1
PROJECT: Robeson Site	SHEET: 2 of 2
CLIENT: New York State Department of Environmental Conservation	JOB NO.: 11173791
BORING CONTRACTOR: Nothnagle Drilling	LOCATION: 24' so.of north wall, 49' east of w. wall

GROUNDWATER:					CAS.	SAMPLER	TUBE	GROUND ELEVATION:
DATE	TIME	LEVEL	TYPE	TYPE		Split-spoon		DATE STARTED:9/10/04
				DIA.		2"		DATE FINISHED: 9/10/04
				WT.		140#		DRILLER: Neil Short
				FALL		30"		GEOLOGIST: Tim Burmeier
								REVIEWED BY: Duane Lenhardt

DEPTH FEET	STRATA	"S" NO.	"N" NO.	BLOWS PER 6"	REC%	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	PID	REMARKS
36		10	23	5 10	100%	Light Brown	Medium Dense	Silty very fine-fine quartz sand	2-6	Wet
40										
		11	43	6 18 / 25 22	100%		Dense	Very fine sandy silt	0	
45										
		12	19	WOR 5 / 14 15	100%		Medium Dense		0	
50										
		13	12	4 5 / 7 5	90%				0	
								End of boring at 52 feet		
55										
60										
65										
70										

COMMENTS: Boring advanced with Gus Pech 750 rig using 2 1/4" ID hollow-stem augers.
Sampling with 2-inch diameter split spoon samplers. All samples were screened inside plastic baggies
with a Mini-Rae 2000 PID. WOR=weight of rods, WOH = weight of hammer
Sampled 25-27' for VOCs analysis

Boring No.
DB-1

URS Corporation	**TEST BORING LOG**
	BORING NO: DB-2
PROJECT: Robeson Site	**SHEET: 1 of 2**
CLIENT: New York State Department of Environmental Conservation	**JOB NO.:** 11173791
BORING CONTRACTOR: Nothnagle Drilling	**LOCATION: 60' so.of north wall, 49' east of w. wall**

GROUNDWATER:					CAS.	SAMPLER	TUBE	GROUND ELEVATION:
DATE	TIME	LEVEL	TYPE	TYPE		Split-spoon		DATE STARTED:9/13/04
				DIA.		2"		DATE FINISHED: 9/13/04
				WT.		140#		DRILLER: Neil Short
				FALL		30"		GEOLOGIST: Tim Burmeier
								REVIEWED BY: Duane Lenhardt

DEPTH FEET	STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC%	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	PID	REMARKS
1		1	28	x	15	40%	Medium Brown	Medium Dense	Concrete floor (0-0.5') Fill: Regraded local material-silty sandy gravel	0	Slightly Moist
				13	15						
		2	37	14	16	40%		Dense		0	Moist
				21	22						
5		3	24	13	13	45%		Medium Dense		0	
				11	11						
		4	27	11	11	50%				0	
				16	15				Silty sand fine to medium with fine gravel		
		5	36	10	20	60%		Dense	-gravel becomes fine to coarse	0	
10				16	20						
15									Fine to coarse sandy gravel		
		6	29	19	18	50%	Light Gray Brown	Medium Dense	-predominantly fine gravel (15-16')	0.7	Wet at 16'
				11	10						
20											
		7	5	2	2	20%	Medium Brown	Loose	Silty coarse gravel	2-3	
				3	4						
25											
		8	24	9	11	85%		Medium Dense	Silt	2-3	
				13	15						
30											
		9	29	9	13	70%	Gray			4-16	
				16	19						
									- trace gravel		
35		10	20	3	8	100%			(continues on page 2)	210	

COMMENTS: Boring advanced with Gus Pech 750 rig using 2 1/4" ID hollow-stem augers.
Sampling with 2-inch diameter split spoon samplers. All samples were screened inside plastic baggies
with a Mini-Rae 2000 PID. WOR=weight of rods, WOH = weight of hammer
Sampled 25-27' , 30-32' and 35-37'for VOCs analysis

Boring No.
DB-2

URS Corporation	**TEST BORING LOG**
	BORING NO: DB-2
PROJECT: Robeson Site	**SHEET: 2 of 2**
CLIENT: New York State Department of Environmental Conservation	**JOB NO.:** 11173791
BORING CONTRACTOR: Nothnagle Drilling	**LOCATION: 24' so.of north wall, 49' east of w. wall**

GROUNDWATER:					**CAS.**	**SAMPLER**	**TUBE**	**GROUND ELEVATION:**
DATE	**TIME**	**LEVEL**	**TYPE**	**TYPE**		Split-spoon		**DATE STARTED:9/13/04**
				DIA.		2"		**DATE FINISHED: 9/13/04**
				WT.		140#		**DRILLER: Neil Short**
				FALL		30"		**GEOLOGIST: Tim Burmeier**
								REVIEWED BY: Duane Lenhardt

DEPTH FEET	**SAMPLE: STRATA**	**"S" NO.**	**"N" NO.**	**BLOWS PER 6"**		**REC%**	**DESCRIPTION: COLOR**	**CONSISTENCY HARDNESS**	**MATERIAL DESCRIPTION**	**PID**	**REMARKS**
36		10	23	12	12	100%	Gray	Medium Dense	Silty fine sand	210	Wet
40											
		11	20	5	9	100%	Gray Brown		Silty very fine-fine sand	0.5	
				11	19						
45											
		12	24	6	13	75%	Gray		Silty fine to coarse angular gravel	5.4	
				11	11						
50											
		13	21	7	11	35%			Silty fine sand	0	
				10	10						
									End of boring at 52 feet		
55											
60											
65											
70											

COMMENTS: Boring advanced with Gus Pech 750 rig using 2 1/4" ID hollow-stem augers.
Sampling with 2-inch diameter split spoon samplers. All samples were screened inside plastic baggies
with a Mini-Rae 2000 PID. WOR=weight of rods, WOH = weight of hammer
Sampled 25-27' , 30-32' and 35-37'for VOCs analysis

Boring No.
DB-2

URS Corporation	**TEST BORING LOG**
	BORING NO: DB-3
PROJECT: Robeson Site	**SHEET: 1 of 2**
CLIENT: New York State Department of Environmental Conservation	**JOB NO.:** 11173791
BORING CONTRACTOR: Nothnagle Drilling	**LOCATION: 98' so.of north wall, 49' east of w. wall**

GROUNDWATER:					**CAS.**	**SAMPLER**	**TUBE**	**GROUND ELEVATION:**
DATE	**TIME**	**LEVEL**	**TYPE**	**TYPE**		Split-spoon		**DATE STARTED :9/14/04**
				DIA.		2"		**DATE FINISHED: 9/14/04**
				WT.		140#		**DRILLER: Neil Short**
				FALL		30"		**GEOLOGIST: Tim Burmeier**
								REVIEWED BY: Duane Lenhardt

DEPTH FEET	**STRATA**	**"S" NO.**	**"N" NO.**	**BLOWS PER 6"**		**REC%**	**COLOR**	**CONSISTENCY HARDNESS**	**MATERIAL DESCRIPTION**	**PID**	**REMARKS**
1		1	21	x	9	70%	Medium Brown	Medium Dense	Concrete floor (0-0.5') Fill: Regraded local material-silty sandy gravel	0	Slightly Moist
				12	13						
		2	43	15	19	65%		Dense		0	Moist
				24	29						
5		3	22	11	11	35%		Medium Dense		0	
				11	9						
		4	30	12	15	50%				0	
				15	15						
		5	20	15	11	75%			Silty fine sand, trace fine-coarse gravel	5.2 (peak)	
10				9	9						
15											
		6	53	9	23	85%		Very Dense	Fine to coarse gravel with silty sand	210 (peak)	
				30	32						
20											
		7	23	3	10	55%		Medium Dense		30-50	Wet at 20'
				13	13						
25											
		8	28	9	14	85%			Silt with very fine sand	30 (peak)	
				14	16						
30											
		9	19	5	9	75%	Gray		Silty fine sand	1-10	
				10	11						
35		10	6	2	2	100%		Loose	(continues on page 2)	4-29	

COMMENTS: Boring advanced with Gus Pech 750 rig using 2 1/4" ID hollow-stem augers.
Sampling with 2-inch diameter split spoon samplers. All samples were screened inside plastic baggies
with a Mini-Rae 2000 PID. WOR=weight of rods, WOH = weight of hammer
Sampled 15-17' and 25-27' for VOCs analysis

Boring No.
DB-3

URS Corporation	**TEST BORING LOG**
	BORING NO: DB-3
PROJECT: Robeson Site	**SHEET: 2 of 2**
CLIENT: New York State Department of Environmental Conservation	**JOB NO.:** 11173791
BORING CONTRACTOR: Nothnagle Drilling	**LOCATION: 24' so.of north wall, 49' east of w. wall**

GROUNDWATER:					**CAS.**	**SAMPLER**	**TUBE**	**GROUND ELEVATION:**
DATE	**TIME**	**LEVEL**	**TYPE**	**TYPE**		Split-spoon		**DATE STARTED:9/13/04**
				DIA.		2"		**DATE FINISHED: 9/13/04**
				WT.		140#		**DRILLER: Neil Short**
				FALL		30"		**GEOLOGIST: Tim Burmeier**
								REVIEWED BY: Duane Lenhardt

DEPTH FEET	**SAMPLE STRATA**	**"S" NO.**	**"N" NO.**	**BLOWS PER 6"**		**REC%**	**DESCRIPTION COLOR**	**CONSISTENCY HARDNESS**	**MATERIAL DESCRIPTION**	**PID**	**REMARKS**
36		10	6	4	7	100%	Gray	Loose	Silty very fine - fine sand	4-29	Wet
40											
		11	9	wh	3	100%				0.5	
				6	7						
45											
		12	25	9	12	60%		Medium Dense	Fine sandy silt with fine gravel	5.4	
				13	13						
50											
		13	50	33	39	85%		Dense		0	
				11	100/2						
									End of boring at 52 feet		
55											
60											
65											
70											

COMMENTS: Boring advanced with Gus Pech 750 rig using 2 1/4" ID hollow-stem augers.
Sampling with 2-inch diameter split spoon samplers. All samples were screened inside plastic baggies
with a Mini-Rae 2000 PID. WOR=weight of rods, WOH = weight of hammer
Sampled 15-17' and 25-27' for VOCs analysis

Boring No.
DB-3

URS Corporation	TEST BORING LOG
	BORING NO: DB-4
PROJECT: Robeson Site	SHEET: 1 of 2
CLIENT: New York State Department of Environmental Conservation	JOB NO.: 11173791
BORING CONTRACTOR: Nothnagle Drilling	LOCATION: 137' s.of n. wall, 49' east of w. wall

GROUNDWATER:					CAS.	SAMPLER	TUBE	GROUND ELEVATION:
DATE	TIME	LEVEL	TYPE	TYPE		Split-spoon		DATE STARTED : 9/14/04
				DIA.		2"		DATE FINISHED: 9/15/04
				WT.		140#		DRILLER: Neil Short
				FALL		30"		GEOLOGIST: Tim Burmeier
								REVIEWED BY: Duane Lenhardt

DEPTH FEET	STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC%	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	PID	REMARKS
1		1	20	x	5	55%	Medium Brown	Medium Dense	Concrete floor (0-0.5') Fill: Regraded local material- sandy silt with gravel	0	Slightly Moist
				15	9						
		2	29	13	13	50%				0	
				16	16						
5		3	32	13	15	80%		Dense		0.6 (peak)	
				17	19						
		4	56	23	27	80%		Very Dense	Silt with fine sand and fine gravel	2-6	
				29	30						
		5	38	12	17	80%		Dense		1-3	Moist
10				21	22						
		6	44	11	18	75%				1-5	
				26	30						
15											
		7	42	12	20	55%			Silty fine to coarse sand and fine to coarse gravel	2-11	
				22	15						
20											
		8	36	13	16	85%			Silt, trace gravel	5-20	
				20	10						
25											
		9	24	6	12	75%	Gray	Medium Dense	Silt with very fine sand	6-12	
				12	10						
30											
		10	10	3	4	60%			Silty fine sand	5-12	
				6	8						
35		11	4	1	1	90%		Loose	(continues on page 2)	2	

COMMENTS: Boring advanced with Gus Pech 750 rig using 2 1/4" ID hollow-stem augers.
Sampling with 2-inch diameter split spoon samplers. All samples were screened inside plastic baggies
with a Mini-Rae 2000 PID. WOR=weight of rods, WOH = weight of hammer
Sampled 10-12' and 25-27' for VOCs analysis

Boring No.
DB-4

URS Corporation	TEST BORING LOG
	BORING NO: DB-4
PROJECT: Robeson Site	SHEET: 2 of 2
CLIENT: New York State Department of Environmental Conservation	JOB NO.: 11173791
BORING CONTRACTOR: Nothnagle Drilling	LOCATION: 137' s.of n. wall, 49' east of w. wall

GROUNDWATER:					CAS.	SAMPLER	TUBE	GROUND ELEVATION:
DATE	TIME	LEVEL	TYPE	TYPE		Split-spoon		DATE STARTED: 9/14/04
				DIA.		2"		DATE FINISHED: 9/15/04
				WT.		140#		DRILLER: Neil Short
				FALL		30"		GEOLOGIST: Tim Burmeier
								REVIEWED BY: Duane Lenhardt

DEPTH FEET	SAMPLE STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC%	DESCRIPTION COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	PID	REMARKS
36		11	4	3	5	90%	Gray	Loose	Sand- very fine - fine with 'salt and pepper appearance	4-29	Wet
40											
									Ended boring at 40 feet due to heaving sand problem		
45											
50											
55											
60											
65											
70											

COMMENTS: Boring advanced with Gus Pech 750 rig using 2 1/4" ID hollow-stem augers.
Sampling with 2-inch diameter split spoon samplers. All samples were screened inside plastic baggies
with a Mini-Rae 2000 PID. WOR=weight of rods, WOH = weight of hammer
Sampled 10-12' and 25-27' for VOCs analysis

Boring No.
DB-4

URS Corporation	**TEST BORING LOG**
	BORING NO: DB-5
PROJECT: Robeson Site	**SHEET: 1 of 2**
CLIENT: New York State Department of Environmental Conservation	**JOB NO.:** 11173791
BORING CONTRACTOR: Nothnagle Drilling	**LOCATION: 137' s.of n. wall, 49' east of w. wall**

GROUNDWATER:					**CAS.**	**SAMPLER**	**TUBE**	**GROUND ELEVATION:**
DATE	**TIME**	**LEVEL**	**TYPE**	**TYPE**		Split-spoon		**DATE STARTED : 9/15/04**
				DIA.		2"		**DATE FINISHED: 9/15/04**
				WT.		140#		**DRILLER: Neil Short**
				FALL		30"		**GEOLOGIST: Tim Burmeier**
								REVIEWED BY: Duane Lenhardt

DEPTH FEET	**SAMPLE** STRATA	**"S" NO.**	**"N" NO.**	**BLOWS PER 6"**		**REC%**	**DESCRIPTION** COLOR	**CONSISTENCY HARDNESS**	**MATERIAL DESCRIPTION**	**PID**	**REMARKS**
1		1	19	x	3	65%	Medium Brown	Medium Dense	Concrete floor (0-0.5') Fill: Regraded local material- sandy silt with gravel	0*	Moist
				16	60						
		2	22	10	11	55%				0*	
				11	11						
5		3	11	7	6	90%				0*	
				5	6						
		4	19	3	7	50%			Fine sand	0*	
				12	17						
		5	34	16	16	55%		Dense	- becomes silty	0*	
10				18	25				- with fine to coarse gravel at 8.5'		
										0*	
15											
		6	19	11	10	5%		Medium Dense	Silty fine to coarse sand and fine to coarse gravel	1	
				9	9						
20											
		7	22	6	13	35%			Silty gravel	1-3	Wet at 20'
				9	9						
25											
		8	33	14	15	85%		Dense	Silt	20-50	
				18	18						
30											
		9	26	9	14	75%	Gray	Medium Dense	Silty fine sand	30	
				12	11						
35		10	31	7	14	75%		Dense	(continues on page 2)	20-45	

COMMENTS: Boring advanced with Gus Pech 750 rig using 2 1/4" ID hollow-stem augers.
Sampling with 2-inch diameter split spoon samplers. All samples were screened inside plastic baggies
with a Mini-Rae 2000 PID. WOR=weight of rods, WOH = weight of hammer
Sampled 25-27', 30-32' and 40-42' for VOCs analysis

Boring No.
DB-5

URS Corporation	**TEST BORING LOG**
	BORING NO: DB-5
PROJECT: Robeson Site	**SHEET: 2 of 2**
CLIENT: New York State Department of Environmental Conservation	**JOB NO.:** 11173791
BORING CONTRACTOR: Nothnagle Drilling	**LOCATION: 81' s.of n. wall, 15' east of w. wall**

GROUNDWATER:					**CAS.**	**SAMPLER**	**TUBE**	**GROUND ELEVATION:**
DATE	**TIME**	**LEVEL**	**TYPE**	**TYPE**		Split-spoon		**DATE STARTED: 9/15/04**
				DIA.		2"		**DATE FINISHED: 9/15/04**
				WT.		140#		**DRILLER: Neil Short**
				FALL		30"		**GEOLOGIST: Tim Burmeier**
								REVIEWED BY: Duane Lenhardt

DEPTH FEET	**SAMPLE** STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC%	**DESCRIPTION** COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	**PID**	**REMARKS**
36		10	31	17	19	75%	Gray	Dense	Very fine - fine sand, fluid, heaving consistency	20-45	Wet
40											
		11	2	WOR / 2	WOR / 2	100%		Loose		30-50	
									Ended boring at 42 feet due to heaving sand problem		
45											
50											
55											
60											
65											
70											

COMMENTS: Boring advanced with Gus Pech 750 rig using 2 1/4" ID hollow-stem augers.
Sampling with 2-inch diameter split spoon samplers. All samples were screened inside plastic baggies
with a Mini-Rae 2000 PID. WOR=weight of rods, WOH = weight of hammer
Sampled 25-27', 30-32' and 40-42' for VOCs analysis

Boring No.
DB-5

URS Corporation	**TEST BORING LOG**
	BORING NO: DB-6
PROJECT: Robeson Site	**SHEET: 1 of 2**
CLIENT: New York State Department of Environmental Conservation	**JOB NO.:** 11173791
BORING CONTRACTOR: Nothnagle Drilling	**LOCATION: 11' n.of n. wall, 42' east of w.cor.**

GROUNDWATER:					**CAS.**	**SAMPLER**	**TUBE**	**GROUND ELEVATION:**
DATE	**TIME**	**LEVEL**	**TYPE**	**TYPE**		Split-spoon		**DATE STARTED : 9/16/04**
				DIA.		2"		**DATE FINISHED: 9/16/04**
				WT.		140#		**DRILLER: Neil Short**
				FALL		30"		**GEOLOGIST: Tim Burmeier**
								REVIEWED BY: Duane Lenhardt

DEPTH FEET	**STRATA**	**"S" NO.**	**"N" NO.**	**BLOWS PER 6"**		**REC%**	**COLOR**	**CONSISTENCY HARDNESS**	**MATERIAL DESCRIPTION**	**PID**	**REMARKS**
1		1	11	8	7	70%	Medium Brown	Medium Dense	Asphalt paving (0-0.2') Fill: Regraded local material- sandy silt with gravel	0.5 (peak)	Moist
				4	3						
		2	5	3	2	80%		Loose		0	
				3	5						
5		3	19	14	10	70%		Medium Dense		0	
				9	5						
		4	30	8	14	70%				0	
				16	17						
		5	28	9	16	65%			Silty fine sand with fine-coarse gravel	0	
10				12	8						
15											
		6	15	3	5	10%				40-115	Wet
				10	10						
20											
		7	14	3	4	80%			Silt	20-50	
				10	6						
25											
		8	10	3	4	85%				20-54	
				6	7						
30											
		9	18	4	9	85%	Gray			50-177	
				9	9						
35		10	11	1	4	80%			(continues on page 2)	0	

COMMENTS: Boring advanced with Gus Pech 750 rig using 2 1/4" ID hollow-stem augers.
Sampling with 2-inch diameter split spoon samplers. All samples were screened inside plastic baggies
with a Mini-Rae 2000 PID. WOR=weight of rods, WOH = weight of hammer
Sampled 25-27' for VOCs analysis

Boring No.
DB-6

URS Corporation	TEST BORING LOG
	BORING NO: DB-6
PROJECT: Robeson Site	**SHEET: 2 of 2**
CLIENT: New York State Department of Environmental Conservation	**JOB NO.:** 11173791
BORING CONTRACTOR: Nothnagle Drilling	**LOCATION: 11' n.of n. wall, 42' east of w.cor.**

GROUNDWATER:					**CAS.**	**SAMPLER**	**TUBE**	**GROUND ELEVATION:**
DATE	**TIME**	**LEVEL**	**TYPE**	**TYPE**		Split-spoon		**DATE STARTED: 9/16/04**
				DIA.		2"		**DATE FINISHED: 9/16/04**
				WT.		140#		**DRILLER: Neil Short**
				FALL		30"		**GEOLOGIST: Tim Burmeier**
								REVIEWED BY: Duane Lenhardt

DEPTH FEET	**STRATA**	**"S" NO.**	**"N" NO.**	**BLOWS PER 6"**		**REC%**	**COLOR**	**CONSISTENCY HARDNESS**	**MATERIAL DESCRIPTION**	**PID**	**REMARKS**
36		10	6	7	7	80%	Gray	Loose	Silt	0	Wet
40											
		11	12	WOR	5	100%	Brown	Medium Dense	Silty very fine sand with fluid heaving consistency	0	
				7	8						
45											
		12	1	WOR	WOR	100%		Loose	Fine sandy silt with fine gravel	0	
				1	1						
50											
		13	13	5	6	100%		Medium Dense	Fine sandy silt with fine to coarse gravel	0	
				7	4						
									End of boring at 52 feet		
55											
60											
65											
70											

COMMENTS: Boring advanced with Gus Pech 750 rig using 2 1/4" ID hollow-stem augers.
Sampling with 2-inch diameter split spoon samplers. All samples were screened inside plastic baggies
with a Mini-Rae 2000 PID. WOR=weight of rods, WOH = weight of hammer
Sampled 20-22' and 30-32' for VOCs analysis

Boring No.
DB-6

APPENDIX B

ESTIMATE OF CONTAMINATION IN SATURATED ZONE

CALCULATION COVER SHEET

Client: NYSDEC Project Name: ROBESON

Project/Calculation Number: 11173792

Title: ESTIMATE OF CONTAMINATION IN SATURATED ZONE

Total Number of Pages (including cover sheet): 2

Total Number of Computer Runs: 0

Prepared by: CRAIG PAWLEWSKI Date: 4/7/05

Checked by: Marek Ostrowski Date: 4/14/05

Description and Purpose: TO ESTIMATE QUANTITY OF CONTAMINATION IN SATURATED ZONE.

Design Basis/References/Assumptions SEE TEXT

Remarks/Conclusions/Results: GREATER THAN 5,000 LBS. PRESENT

Calculation Approved by: Craig W. Pawlewski 4/18/05
Project Manager/Date

Revision No.:	Description of Revision:	Approved by:

Project Manager/Date

PURPOSE: Estimate the quantity of contamination in the saturated zone at the Robeson site.

CONTAMINATION IN SOIL:

Area of Contamination (Figure 2-4) $\cong$ 43,600 Ft.^{2}

Depth of Contamination (Appendix A) $\cong$ 30 Ft.

Volume of Contamination = 43,600 Ft.^{2} x 30 Ft.
= 1,308,000 Ft.^{3}

Avg. Conc. In Saturated Zone $\cong$ 10 ppm (Table 2-1)

Quantity of Contamination = $1{,}308{,}000\,\mathrm{Ft}^3 \; \mathrm{x}\, 100\, \frac{\mathrm{Lb}}{\mathrm{Ft}^3}\, \mathrm{x}\, 10\, x 10^{-6} = 1{,}308\,\mathrm{Lb}$

Residual DNAPL Contamination:

Assume Porosity = 0.4

Pore Volume = 0.4 x 1,308,000 Ft.^{3}
= 523,200 Ft.^{3}

Assume Residual DNAPL Occupies 10 ppm to 1,000 ppm (0.001 – 0.1%) of the Pore Volume

DNAPL Volume $\cong$ 5 – 500 Ft.^{3}

Assume Contamination is all TCE Density TCE = 1.46 g/cm^3 = 91.1 Lb/Ft.^{3}

Quantity of Contamination = 5 – 500 Ft.^{3} x 91.1 Lb/Ft.^{3}
= 455.5 – 45,555 Lb.

Total Contamination
= 1,308 Lb + (450 – 45,000 Lb)
$\cong$ 1,750 Lb – 46,300 Lb.

To date about 3,000 Lb has been removed from the vadose zone by SVE. It is likely that more contamination is present in the saturated zone than in the vadose zone.

If it is assumed the quantity of residual contamination in the saturated zone is in the mid range (100 ppm – 200 ppm), the total amount of contamination in the saturated zone would be estimated in the range of 5,000 – 10,000 Lb.

APPENDIX C

COST ESTIMATES

URS

EXHIBIT 4.7-2

CALCULATION COVER SHEET

Client: NYSDEC Project Name: ROBESON

Project/Calculation Number: 11173792

Title: FEASIBILITY STUDY COST ESTIMATE

Total Number of Pages (including cover sheet): 10

Total Number of Computer Runs: 0

Prepared by: PAT BAUER Date: 3/25/05

Checked by: CRAIG PAWLEWSKI Date: 4/12/05

Description and Purpose: ESTIMATE CAPITAL COSTS FOR ALTERNATIVES 1 and 2.

Design Basis/References/Assumptions SEE TABLES.

Remarks/Conclusions/Results: SEE SUMMARY TABLES

Calculation Approved by: Craig W. Pawlowski 4/13/05
Project Manager/Date

Revision No.:	Description of Revision:	Approved by:

Project Manager/Date

CALCULATION COVER SHEET

Client: NYSDEC Project Name: ROBESON

Project/Calculation Number: 1117379 2

Title: FEASIBILITY STUDY COST ESTIMATE

Total Number of Pages (including cover sheet): 7

Total Number of Computer Runs: 0

Prepared by: CRAIG W. PAWLEWSKI Date: 4/7/05

Checked by: DONALD A. McCALL DAM Date: 4.18.05

Description and Purpose: ESTIMATE O+M COSTS FOR ALTERNATIVES 1 and 2.

Design Basis/References/Assumptions SEE TABLES.

Remarks/Conclusions/Results: SEE SUMMARY TABLES.

Calculation Approved by: Craig W. Pawlewski 4/18/05
Project Manager/Date

Revision No.:	Description of Revision:	Approved by:

Project Manager/Date

URS **EXHIBIT 4.7-2**

CALCULATION COVER SHEET

Client: NYSDEC Project Name: ROBESON

Project/Calculation Number: 1117 3792

Title: FEASIBILITY STUDY COST ESTIMATE

Total Number of Pages (including cover sheet): 5

Total Number of Computer Runs: 0

Prepared by: KEVIN SHANAHAN Date: 3/16/05

Checked by: CRAIG W. PAWLEWSKI Date: 4/7/05

Description and Purpose: TO ESTIMATE COST OF ALTERNATIVE 3 (ISCO) USING A NATURAL OXIDANT DEMAND OF 2 AND 5.

Design Basis/References/Assumptions SEE APPENDIX F. OF FS.

Remarks/Conclusions/Results: SEE SUMMARY TABLES

Calculation Approved by: Craig W. Pawlewski 4/14/05
Project Manager/Date

Revision No.:	Description of Revision:	Approved by:

Project Manager/Date

NYSDEC
ROBESON INDUSTRIES SITE
FEASIBILITY STUDY

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	P. Baker	Date:	25-Mar-05
Description:	Feasibility Study	Checked By:	C. Pawlewski	Date:	12-Apr-05

SUMMARY

DESCRIPTION	ESTIMATED COST
Alternative 1-Capital Cost	
Gravity Discharge Line	**$12,167**
Mobilization / Demobilization(10%)	**$1,217**
Design and Construction Management(15%)	**$1,825**
Contingency(25%)	**$3,042**
TOTAL	**$18,250**

URS CORPORATION
CONSTRUCTION COST ESTIMATE
ESTIMATED UNIT COST

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	P. Baker	Date:	25-Mar-05
Title:	Feasibility Study - Alternative 1 Gravity Discharge Line	Checked By:	C. Pawlewski	Date:	12-Apr-05

ITEM	DESCRIPTION	QTY.	UNITS	UNIT COST	TOTAL COST
1	Clear and Grub (Means: 02230-100-200/250)	0.1	acre	$7,550.00	$755
2	Trench excavation (Means: 01590-200-0100)	1	day	$459.00	$459
3	Bedding stone (Means: 02315-640-0050)	33	cy	$30.50	$1,007
4	Compaction (Means: 02315-640-0500)	33	cy	$4.00	$132
5	Pipe - 10" diameter, PVC Sched. 80 (Means:15108-520-2580)*	250	lf	$35.73	$8,933
6	Backfill excavation spoils (Means:01590-200-0100)	0.5	day	$459.00	$230
7	Backfill compaction (Means: 02315-640-0500)	83	cy	$4.00	$332
8	Seeding (Means: 02920-320-5400)	5	msf	$64.00	$320
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11	Note: * adjusted to delete pipe hanger				
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	TOTAL COST:				**$12,167**

NYSDEC
ROBESON INDUSTRIES SITE
FEASIBILITY STUDY

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	P. Baker	Date:	25-Mar-05
Description:	Feasibility Study	Checked By:	C. Pawlewski	Date:	12-Apr-05

SUMMARY

DESCRIPTION	ESTIMATED COST
Alternative 2-Capital Cost	
Collection Trench	**$35,752**
Collection Sump	**$18,395**
Force Main	**$12,030**
Wells (in building)	**$71,353**
Submersible Well Pumps	**$68,350**
Connecting Pipe for SVE	**$11,746**
SUBTOTAL	**$217,625**
Mobilization/Demobilization(10%)	**$21,763**
Design and Construction Management(15%)	**$32,644**
Contingency(25%)	**$54,406**
TOTAL	**$326,438**

URS CORPORATION
CONSTRUCTION COST ESTIMATE
ESTIMATED UNIT COST

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	P. Baker	Date:	4-Apr-05
Title:	Feasability - Study Alternative 2 Collection Trench	Checked By:	C. Pawlewski	Date:	4/12.2005

ITEM	DESCRIPTION	QTY.	UNITS	UNIT COST	TOTAL COST
	Collection Trench				
1	Clear and Grub(Means; 02230-100-200/250)	0.3	acre	$7,550.00	$2,265
2	Trench excavation (Means: 01590-200-0100)	1	day	$459.00	$459
3	Collection pipe - 6" diameter PVC well screen (Means: 02520-510-8360)	100	lf	$10.20	$1,020
4	Moire sand backfill (Means: 33 23 1403*)	252	ton	$125.07	$31,518
5	Spread trench excavation spoils parallel to trench - Allow:	140	cy	$3.50	$490
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	TOTAL COST:				**$35,752**

URS CORPORATION
CONSTRUCTION COST ESTIMATE
ESTIMATED UNIT COST

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	P. Baker	Date:	4-Apr-05
Title:	Feasability - Study Alternative 2 Collection Sump	Checked By:	C. Pawlewski	Date:	12-Apr-05

ITEM	DESCRIPTION	QTY.	UNITS	UNIT COST	TOTAL COST
	Collection Sump				
1	Excavation (Means: 01590-200-0100)	1	day	$459.00	$459
2	Precast concrete manhole - 4' diameter x 20 vlf (Means: 02630-400-1110)	1	each	$5,143.00	$5,143
3	Manhole slab top (Means: 02630-400-1300)	1	each	$345.00	$345
4	Base stone - 12" deep - Allow:	5	ton	$25.00	$125
5	Manhole ladder rungs (Means: 02630-400-4000)	20	each	$27.50	$550
6	Manhole frame and cover (Means: 02630-110-1900)	1	each	$365.00	$365
7	Spread manhole excavation spoils - Allow:	30	cy	$3.50	$105
8	Sump pumps - duplex system (Means: 15440-800-1100)	1	ls	$2,650.00	$2,650
9	Sump pumps - 3 level control (Means: 15440-800-3340)	1	ls	$825.00	$825
10	Sump pumps - alternator, mercury switch activated (Means: 15440-800-3380)	1	ls	$1,050.00	$1,050
11	Sump pump system - electrical connection - Allow:	1	ls	$6,500.00	$6,500
12	Backfill excavation (Means:01590-200-0100)	0.5	day	$459.00	$230
13	Backfill compaction (Means: 02315-640-0500)	12	cy	$4.00	$48
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	TOTAL COST:				**$18,395**

URS CORPORATION
CONSTRUCTION COST ESTIMATE
ESTIMATED UNIT COST

Client:	NYSDEC	Project Number:	11173792	
Project:	Robeson Industries Site	Calculated By:	P. Baker	Date: 4-Apr-05
Title:	Feasability - Study Alternative 2 Force Main	Checked By:	C. Pawlewski	Date: 12-Apr-05

ITEM	DESCRIPTION	QTY.	UNITS	UNIT COST	TOTAL COST
	Forcemain				
1	Clear and Grub (Means: 02230-100-200/250)	0.2	acre	$7,550.00	$1,510
2	Trench excavation (Means: 01590-200-0100)	1	day	$459.00	$459
3	Force main pipe - 2" dia. Sch. 80 PVC (Means: 15108-520-5910)*	400	lf	$17.45	$6,980
4	Bedding stone (Means: 02315-640-0050)	60	cy	$30.50	$1,830
5	Backfill excavation spoils (Means:01590-200-0100)	90	cy	$3.50	$315
6	Backfill compaction (Means: 02315-640-0500)	90	cy	$4.00	$360
7	Seeding (Means: 02920-320-5400)	9	msf	$64.00	$576
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10	NOTE: * adjusted to delete hangers				
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	TOTAL COST:				**$12,030**

URS CORPORATION
CONSTRUCTION COST ESTIMATE
ESTIMATED UNIT COST

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	P. Baker	Date:	4-Apr-05
Title:	Feasability - Study Alternative 2	Checked By:	C. Pawlewski	Date:	14-Apr-05
	Wells (in building)				

ITEM	DESCRIPTION	QTY.	UNITS	UNIT COST	TOTAL COST
	Wells				
1	Well - boring - 6" dia. X 50' deep x 12 each (Means: 02520-510-100)	600	lf	$45.00	$27,000
2	Well - casing - PVC	600	lf	$23.20	$13,920
3	Well - screen - 4" dia. PVC	540	lf	$28.00	$15,120
4	Well - riser - 4" dia. PVC	60	lf	$22.42	$1,345
5	Well - pack Moire sand	540	lf	$25.20	$13,608
6	Well - grout annular seal	60	lf	$6.00	$360
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	TOTAL COST:				**$71,353**

URS CORPORATION
CONSTRUCTION COST ESTIMATE
ESTIMATED UNIT COST

Client: NYSDEC
Project: Robeson Industries Site
Title: Feasability - Study Alternative 2
Submersible Well Pumps

Project Number: 11173792
Calculated By: P. Baker   Date: 4-Apr-05
Checked By: C. Pawlewski   Date: 12-Apr-05

ITEM	DESCRIPTION	QTY.	UNITS	UNIT COST	TOTAL COST
	Submersible Well Pump				
1	Submersible Well Pump - 4", head < 240', 1/2 hp	12	each	$1,000.00	$12,000
2	Pipe - 2" dia. PVC (Means: 15108-520-1910)*	700	lf	$10.25	$7,175
3	Instrumentation and controls - Allow:	1	ls	$30,000.00	$30,000
4	Electrical conduit, wiring - Allow:	800	lf	$12.00	$9,600
5	Electrical panels, disconnects - Allow:	1	ls	$3,800.00	$3,800
6	Heat trace system - 115v, 5 watts / lf (Means: 15760-250-4030)	700	lf	$8.25	$5,775
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10	NOTE: * adjusted to delete hangers				
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	TOTAL COST:				**$68,350**

URS CORPORATION
CONSTRUCTION COST ESTIMATE
ESTIMATED UNIT COST

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	P. Baker	Date:	4-Apr-05
Title:	Feasability - Study Alternative 2	Checked By:	C. Pawlewski	Date:	12-Apr-05
	Connecting Pipe for SVE				

ITEM	DESCRIPTION	QTY.	UNITS	UNIT COST	TOTAL COST
	Connecting Pipe for SVE				
1	Pipe - 6" dia. Sch. 80 PVC - (Means: 15108-520-2560)*	700	lf	$16.78	$11,746
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4	Note: * adjusted to delete hangers				
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	TOTAL COST:				**$11,746**

NYSDEC
ROBESON INDUSTRIES SITE
FEASIBILITY STUDY

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	C. Pawlewski	Date:	7-Apr-05
Description:	Feasibility Study	Checked By:	D. McCall	Date:	15-Apr-05

SUMMARY

DESCRIPTION	ESTIMATED COST
Alternative 1-Annual O&M Cost	
On-Site Labor	**$22,500**
Office Labor	**$17,000**
Maintenance and Repair-Direct Costs	**$5,000**
Scale Control Chemical	**$2,200**
Well Cleaning	**$10,000**
Water Analysis	**$5,000**
Electricity	**$1,000**
Contingency	**$6,270**
TOTAL	**$68,970**

URS CORPORATION
CONSTRUCTION COST ESTIMATE
ESTIMATED UNIT COST

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	C. Pawlewski	Date:	7-Apr-05
Title:	Feasibility Study - Alternative 1 Annual O&M Costs	Checked By:	D. McCall	Date:	15-Apr-05

ITEM	DESCRIPTION	QTY.	UNITS	UNIT COST	TOTAL COST
1	On-Site Labor	300	HR	$75.00	$22,500
2	Office Labor	200	HR	$85.00	$17,000
3	Maintenance and Repair-Direct Costs	1	LS	$5,000.00	$5,000
4	Scale Control Chemical	2	Drum	$1,100.00	$2,200
5	Well Cleaning	1	LS	$10,000.00	$10,000
6	Water Analysis	50	EA	$100.00	$5,000
7	Electricity	1	LS	$1,000.00	$1,000
8	Contingecy(10%)				$6,270
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	TOTAL COST:				**$68,970**

NYSDEC
ROBESON INDUSTRIES SITE
FEASIBILITY STUDY

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	C. Pawlewski	Date:	7-Apr-05
Description:	Feasibility Study	Checked By:	D. McCall	Date:	15-Apr-05

SUMMARY

DESCRIPTION	ESTIMATED COST
Alternative 2-Annual O&M Cost-First 5 Years	
On-Site Labor	**$37,500**
Office Labor	**$25,500**
Maintenance and Repair-Direct Costs	**$10,000**
Scale Control Chemical	**$11,000**
Well Cleaning	**$30,000**
Water Analysis	**$7,500**
Air Analysis	**$3,000**
Electricity	**$2,000**
Contingency	**$12,650**
TOTAL	**$139,150**

URS CORPORATION
CONSTRUCTION COST ESTIMATE
ESTIMATED UNIT COST

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	C. Pawlewski	Date:	7-Apr-05
Title:	Feasibility Study - Alternative 2 Annual O&M Costs-First 5 Years	Checked By:	D. McCall	Date:	15-Apr-05

ITEM	DESCRIPTION	QTY.	UNITS	UNIT COST	TOTAL COST
1	On-Site Labor	500	HR	$75.00	$37,500
2	Office Labor	300	HR	$85.00	$25,500
3	Maintenance and Repair-Direct Costs	1	LS	$10,000.00	$10,000
4	Scale Control Chemical	10	Drum	$1,100.00	$11,000
5	Well Cleaning	1	LS	$30,000.00	$30,000
6	Water Analysis	75	EA	$100.00	$7,500
7	Air Analysis	12	EA	$250.00	$3,000
8	Electricity	1	LS	$2,000.00	$2,000
9	Contingecy(10%)				$12,650
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	TOTAL COST:				**$139,150**

NYSDEC
ROBESON INDUSTRIES SITE
FEASIBILITY STUDY

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	C. Pawlewski	Date:	7-Apr-05
Description:	Feasibility Study	Checked By:	D. McCall	Date:	15-Apr-05

SUMMARY

DESCRIPTION	ESTIMATED COST
Alternative 2-Annual O&M Cost-Years 6-30	
On-Site Labor	**$22,500**
Office Labor	**$17,000**
Maintenance and Repair-Direct Costs	**$7,500**
Scale Control Chemical	**$4,400**
Well Cleaning	**$10,000**
Water Analysis	**$5,000**
Electricity	**$1,200**
Contingency	**$6,760**
TOTAL	**$74,360**

URS CORPORATION
CONSTRUCTION COST ESTIMATE
ESTIMATED UNIT COST

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	C. Pawlewski	Date:	7-Apr-05
Title:	Feasibility Study - Alternative 2 Annual O&M Costs-Years 6-30	Checked By:	D. McCall	Date:	15-Apr-05

ITEM	DESCRIPTION	QTY.	UNITS	UNIT COST	TOTAL COST
1	On-Site Labor	300	HR	$75.00	$22,500
2	Office Labor	200	HR	$85.00	$17,000
3	Maintenance and Repair-Direct Costs	1	LS	$7,500.00	$7,500
4	Scale Control Chemical	4	Drum	$1,100.00	$4,400
5	Well Cleaning	1	LS	$10,000.00	$10,000
6	Water Analysis	50	EA	$100.00	$5,000
7	Electricity	1	LS	$1,200.00	$1,200
8	Contingecy(10%)				$6,760
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	TOTAL COST:				**$74,360**

NYSDEC
ROBESON INDUSTRIES SITE
FEASIBILITY STUDY

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	K. Shanahan	Date:	16-Mar-05
Description:	Feasibility Study	Checked By:	C. Pawlewski	Date:	7-Apr-05

SUMMARY

DESCRIPTION	ESTIMATED COST
Alternative 3-NOD 5	
Sodium Permanganate	**$1,020,234**
Chemical Injection by Geoprobe	**$298,500**
Groundwater Monitoring Wells	**$8,000**
Soil Borings	**$27,000**
Sample Analysis	**$21,600**
Pilot Test in Field	**$100,000**
SUBTOTAL	**$1,475,334**
Mobilization / Demobilization(10%)	**$147,533**
Design and Construction Management(15%)	**$221,300**
Contingency(25%)	**$368,834**
TOTAL	**$2,213,001**

URS CORPORATION
CONSTRUCTION COST ESTIMATE
ESTIMATED UNIT COST

Client: NYSDEC
Project: Robeson Industries Site
Title: Feasibility Study - Alternative 3

Project Number: 11173792
Calculated By: K. Shanahan — Date: 16-Mar-05
Checked By: C. Pawlewski — Date: 17-Apr-05

ITEM	DESCRIPTION	QTY.	UNITS	UNIT COST	TOTAL COST
1	Sodium Permanganate(See Appendix F)	451431	pounds	$2.26	$1,020,234
2	Chemical Injection by Geoprobe(See Appendix F)	199	day	$1,500.00	$298,500
3	Groundwater Monitoring Wells(See Appendix F)	4	each	$2,000.00	$8,000
4	Soil BoringsSee Appendix F)	36	each	$750.00	$27,000
5	Sample Analysis(See Appendix F)	108	each	$200.00	$21,600
6	Pilot Test in Field	1	each	$100,000.00	$100,000
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	TOTAL COST:				**$1,475,334**

NYSDEC
ROBESON INDUSTRIES SITE
FEASIBILITY STUDY

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	K. Shanahan	Date:	16-Mar-05
Description:	Feasibility Study	Checked By:	C. Pawlewski	Date:	7-Apr-05

SUMMARY

DESCRIPTION	ESTIMATED COST
Alternative 3-NOD of 2	
Sodium Permanganate	**$494,260**
Chemical Injection by Geoprobe	**$144,000**
Groundwater Monitoring Wells	**$8,000**
Soil Borings	**$27,000**
Sample Analysis	**$21,600**
Pilot Test in Field	**$100,000**
SUBTOTAL	**$794,860**
Mobilization / Demobilization(10%)	**$79,486**
Design and Construction Management(15%)	**$119,229**
Contingency(25%)	**$198,715**
TOTAL	**$1,192,290**

URS CORPORATION
CONSTRUCTION COST ESTIMATE
ESTIMATED UNIT COST

Client:	NYSDEC	Project Number:	11173792		
Project:	Robeson Industries Site	Calculated By:	K. Shanahan	Date:	16-Mar-05
Title:	Feasibility Study - Alternative 3-NOD 0f 2	Checked By:	C. Pawlewski	Date:	17-Apr-05

ITEM	DESCRIPTION	QTY.	UNITS	UNIT COST	TOTAL COST
1	Sodium Permanganate	218699	pounds	$2.26	$494,260
2	Chemical Injection by Geoprobe	96	day	$1,500.00	$144,000
3	Groundwater Monitoring Wells	4	each	$2,000.00	$8,000
4	Soil Borings	36	each	$750.00	$27,000
5	Sample Analysis	108	each	$200.00	$21,600
6	Pilot Test in Field	1	each	$100,000.00	$100,000
7					
8					
9					
10					
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	TOTAL COST:				**$794,860**

APPENDIX D

SEEP DEWATERING

URS

EXHIBIT 4.7-2

CALCULATION COVER SHEET

Client: NYSDEC Project Name: Robeson

Project/Calculation Number: 11173792

Title: Dewatering of the Seep West of the Site

Total Number of Pages (including cover sheet): 11 (10 + cover)

Total Number of Computer Runs: 0

Prepared by: Marek Ostrowski Date: 1 March 05

Checked by: Craig Taylor Date: 1 Mar 05

Description and Purpose: To evaluate feasibility of dewatering the seep west of the site.

Design Basis/References/Assumptions: See text.

Remarks/Conclusions/Results: Flow into the seep estimated at 1 to 10 gpm. Testing required to evaluate feasibility of wells. Trench can be used. See summary on pg 3

Calculation Approved by: Craig W. Pawlewski 4/18/05
Project Manager/Date

Revision No.:	Description of Revision:	Approved by:

Project Manager/Date

MADE BY: M.O. DATE: March 1, 2005
CHKD. BY: C.T. DATE: March 1, 2005

PROJECT: Robeson
SUBJECT: Dewatering of the Seep West of the Site

1. PURPOSE

The purpose of this calculation is to evaluate the feasibility of dewatering the seep located west of the site.

2. GENERAL

The site is located over an unconfined water-bearing zone, consisting of relatively low-permeability brown till and gray sandy silt. An underlying layer of dense gray till is thought to form a low-permeability lower limit to the vertical extent of the water-bearing zone. In the flat area of the site, the saturated thickness is approximately 25 to 50 feet. To the west of the site, the ground surface drops at a steep slope and the saturated thickness decreases. See reference 1.

A ground water seep has been identified west of the site. The seep appears to be located downgradient of a low-lying area, which most likely serves as a source of water for the seep. See Figure 3-4 of reference 1.

Hydraulic conductivity of the water-bearing zone is thought to be between approximately $5*10^{-5}$ and $5*10^{-4}$ cm/s (0.14 and 1.4 ft/d). See reference 1.

3. CALCULATIONS

Based on Figure 3-4 of reference 1, the hydraulic gradient between the seep and the potential source of water is approximately 10 ft over 300 feet (i = 1/30). The saturated thickness varies, assume H_0 = 50 feet, which is likely a maximum value. Use hydraulic conductivity of K = 1.4 ft/d, a likely maximum value. The width of the low-lying area is approximately 200 feet, the width of the seep is approximately 100 feet. Conservatively, use the width of flow area of W = 400 feet (two times the source width). Based on that, the flow at the seep can be estimated as:

$$Q = H_0 \; W \; i \; K$$

$$Q = 50*400*(1/30)*1.4 = 933 \text{ ft}_3\text{/d} = 5 \text{ gpm}$$

The likely flow into the seep is on the order of 1 to 10 gpm.

The hydraulic gradient at the seep location is substantial, because ground water flows on a steep incline. Aquifer permeability is low. Under such circumstances, the utility of using extraction wells as a means of dewatering is generally low. It would be difficult to assess whether wells can accomplish the dewatering. Most likely, a pumping test would be required to verify the feasibility of using wells.

Assume that the flow is collected in a horizontal trench. The materials at the site are generally very fine-grained. It may not be possible to find an appropriate filter fabric. Instead of a typical trench consisting of filter fabric, gravel and perforated pipe, use a small-slot well screen, surrounded by a compatible sand pack material. The pipe would slope into a sump, where the ground water would collect and be pumped out of the trench.

The length of the trench would be the same as the length of the seep, approximately 100 feet. The thickness of the saturated zone at the seep is not known; however, based on Figure 3D of reference 1, it may be assumed to be approximately 20 feet. Assume that the trench would penetrate approximately 15 feet into the saturated zone. This would also be the total depth of the trench, as water table at that location is expected to be essentially at the ground surface. The minimum volume of excavation for the trench, assuming a 2.5-foot wide bucket, would be approximately 100*15*2.5 = 3,750 ft^3 or 139 cubic yards.

As an alternative way of collecting water, the seep could be excavated to below the frost depth (approximately 5 feet), and a drainage blanket consisting of a layer of sand and a synthetic drain and pipes could be used. However, the volume of excavation in this case would be higher, because the seep area may be up to approximately 100 by 50 feet (Figure 3-4 of reference 1) - 100*50*5 = 25,000 ft^3 or 926 cubic yards.

MADE BY: M.O. DATE: March 1, 2005
CHKD. BY: C.T. DATE: March 1, 2005

PROJECT: Robeson
SUBJECT: Dewatering of the Seep West of the Site

4. SUMMARY

It appears that the extraction rate required dewater the seep located west of the site would be between 1 and 10 gpm. It is not clear whether the dewatering can be accomplished by means of extraction wells. An aquifer test would be required to determine that. If wells can not be used, a 100-foot long, 15-foot deep trench could be installed, with a well screen, and a sand pack material as bedding.

5. REFERENCES

1. Limited Site Data
   Robeson Industries Site (Site No. 9-61-008)
   URS March 1997

LIMITED SITE DATA
ROBESON INDUSTRIES SITE
SITE NO. 9-61-008

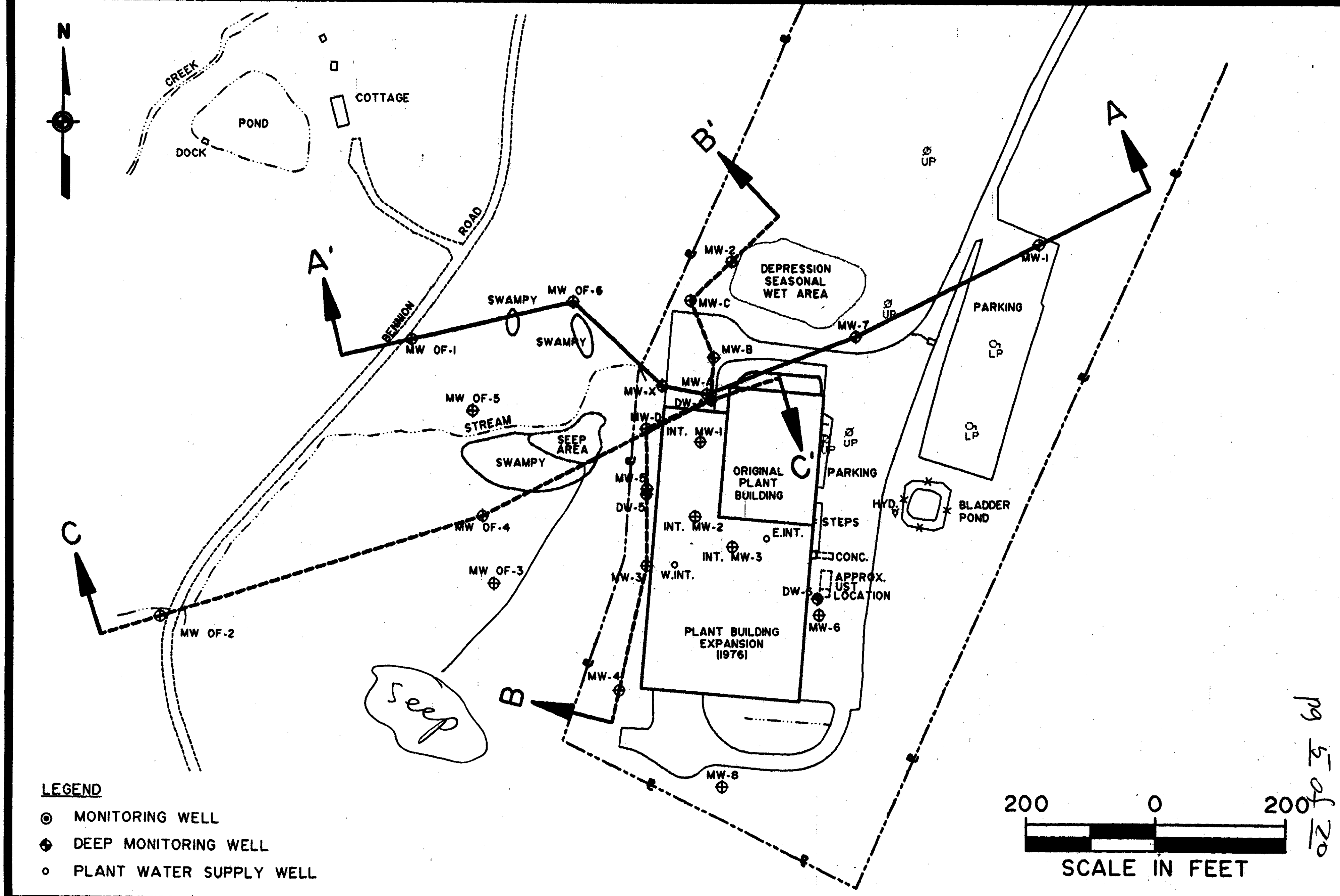
This document is NOT part of the Contract Documents for the Remedial Action at the Robeson Industries Site. The Department neither represents that the characteristics of the contaminated media at the site will be the same as in the attached document nor considers the attached document as being a comprehensive and actual listing of contaminants which may be detected. The Contractor shall be responsible for the accurate and comprehensive characterization of contaminated media to be properly treated, removed, transported or disposed of.

MARCH 1997

Reference 1

AC-5509A

\35438\CAD\ 1=200 9/1/96 SLS



URS CONSULTANTS, INC.

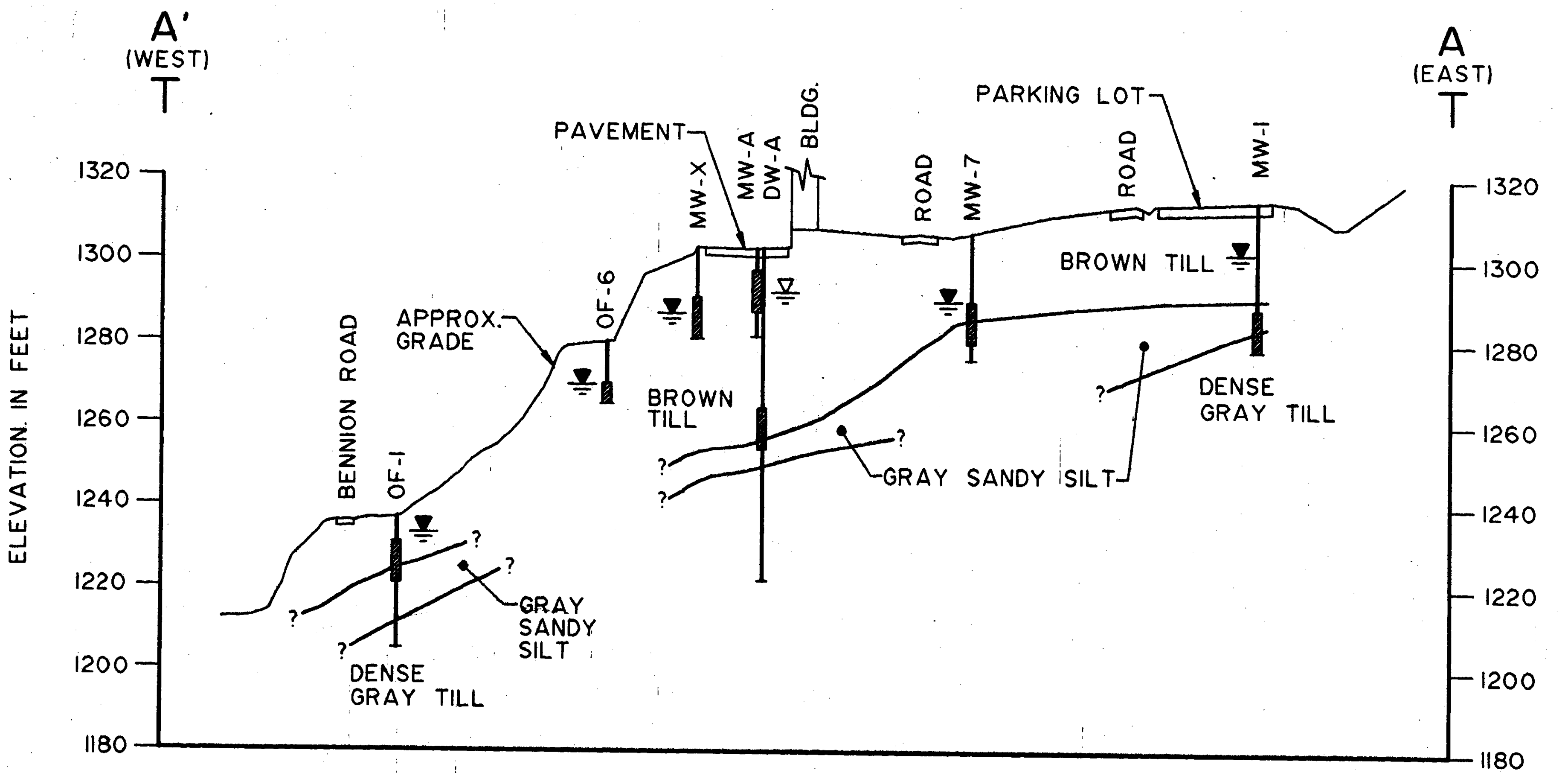
ROBESON INDUSTRIAL CORPORATION
CASTILE, NEW YORK
NYSDEC SITE No. 961008

CROSS SECTION LOCATIONS

FIGURE 3A

AC-5514A

\35438\CAD\ 1=1 9/1/96 SLS



LEGEND

MW-7 BORING AND MONITORING WELL NUMBER

WATER LEVEL 1/13/94

SCREENED INTERVAL OF MONITORING WELL

BOTTOM OF BORING

VERTICAL SCALE: 40 — 0 — 40 SCALE IN FEET

HORIZONTAL SCALE: 200 — 0 — 200 SCALE IN FEET

pg 6 of 20

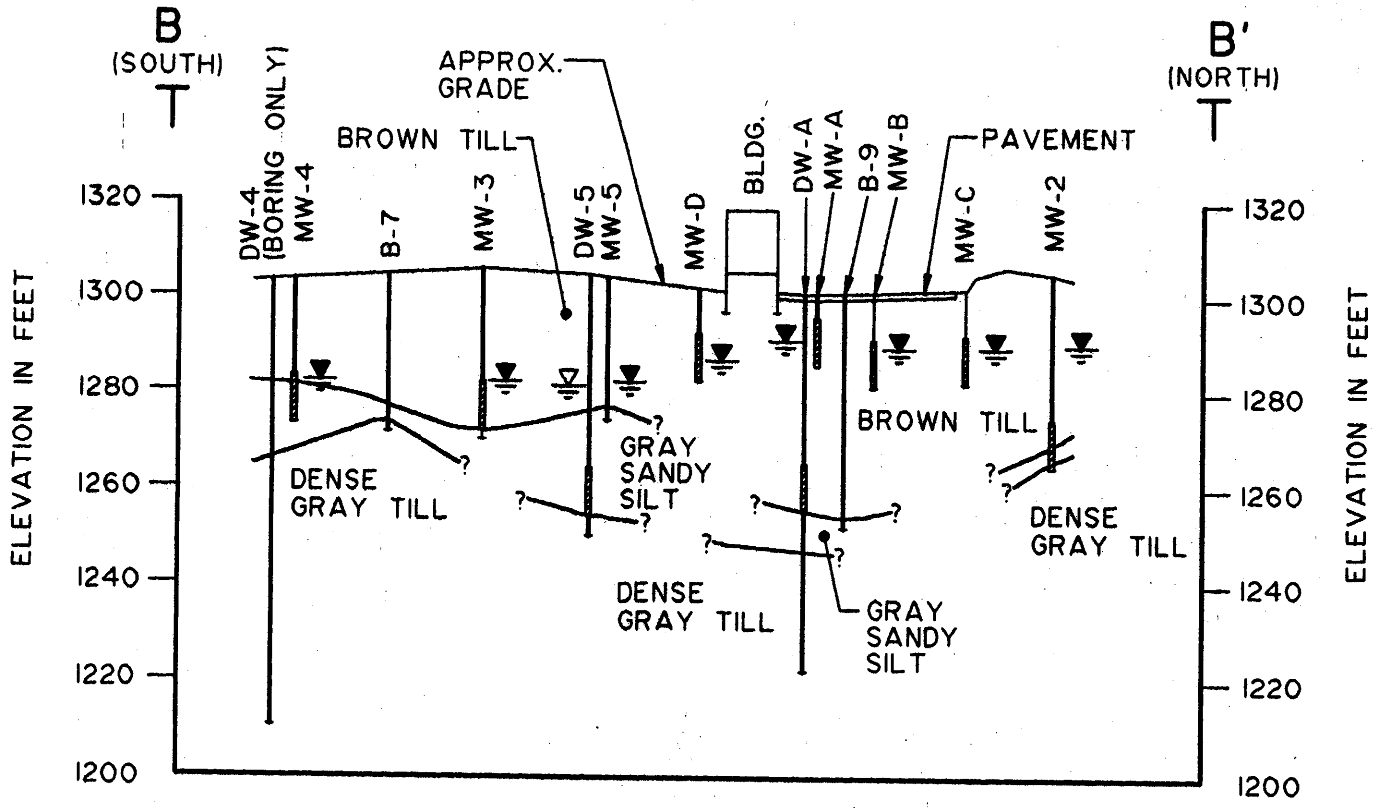
URS CONSULTANTS, INC.

CROSS SECTION A-A' (EAST-WEST)

FIGURE 3B

AC-5558A

\35438\CAD I=I 9/1/96 SLS



LEGEND

MW-5 BORING AND MONITORING WELL NUMBER

WATER LEVEL 1/13/94

SCREENED INTERVAL OF MONITORING WELL

BOTTOM OF BORING

VERTICAL SCALE 40 0 40 SCALE IN FEET

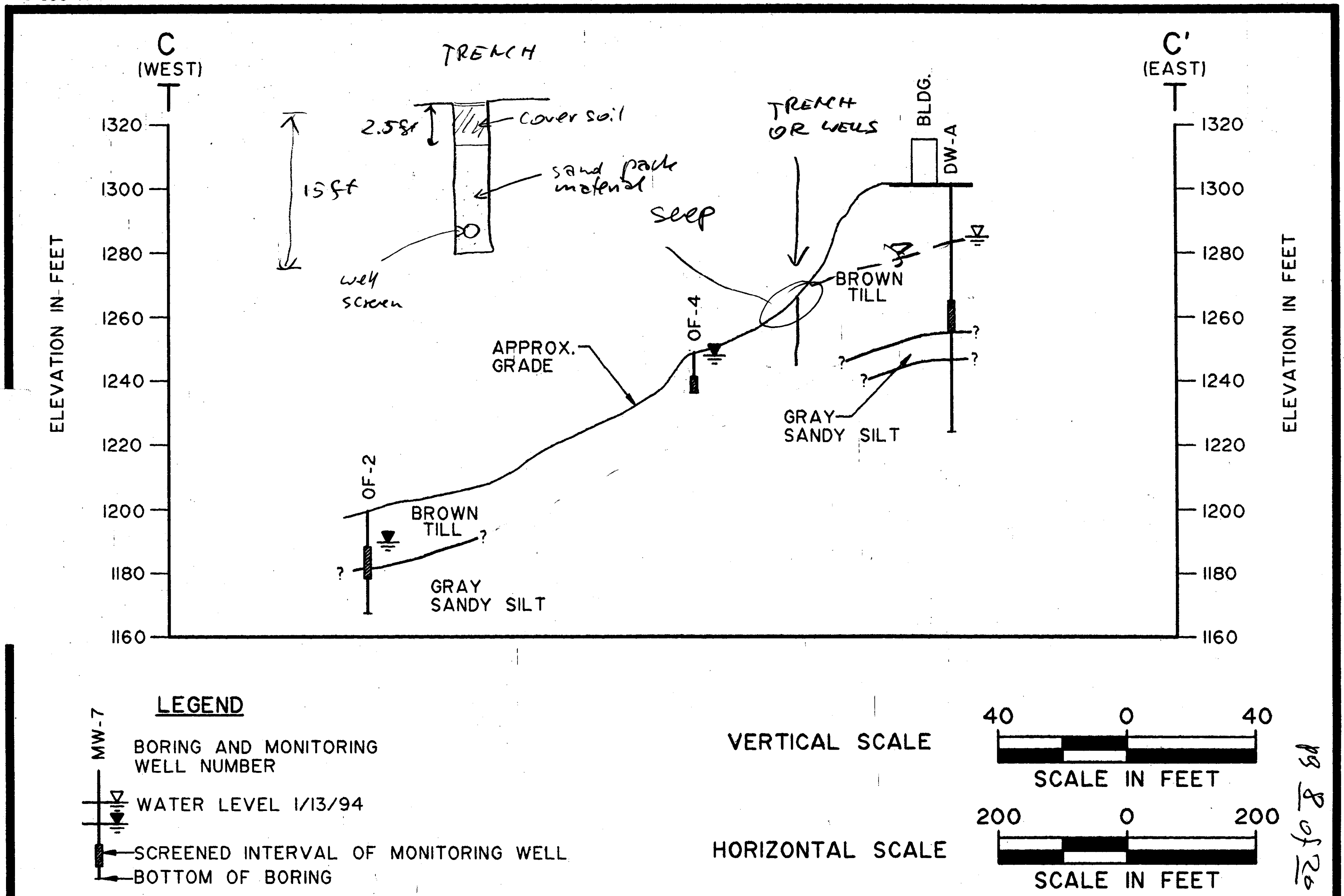
HORIZONTAL SCALE 200 0 200 SCALE IN FEET

pg 7 of 20

URS CONSULTANTS, INC.

CROSS SECTION B-B' (SOUTH-NORTH)

FIGURE 3C



pg 8 of 26

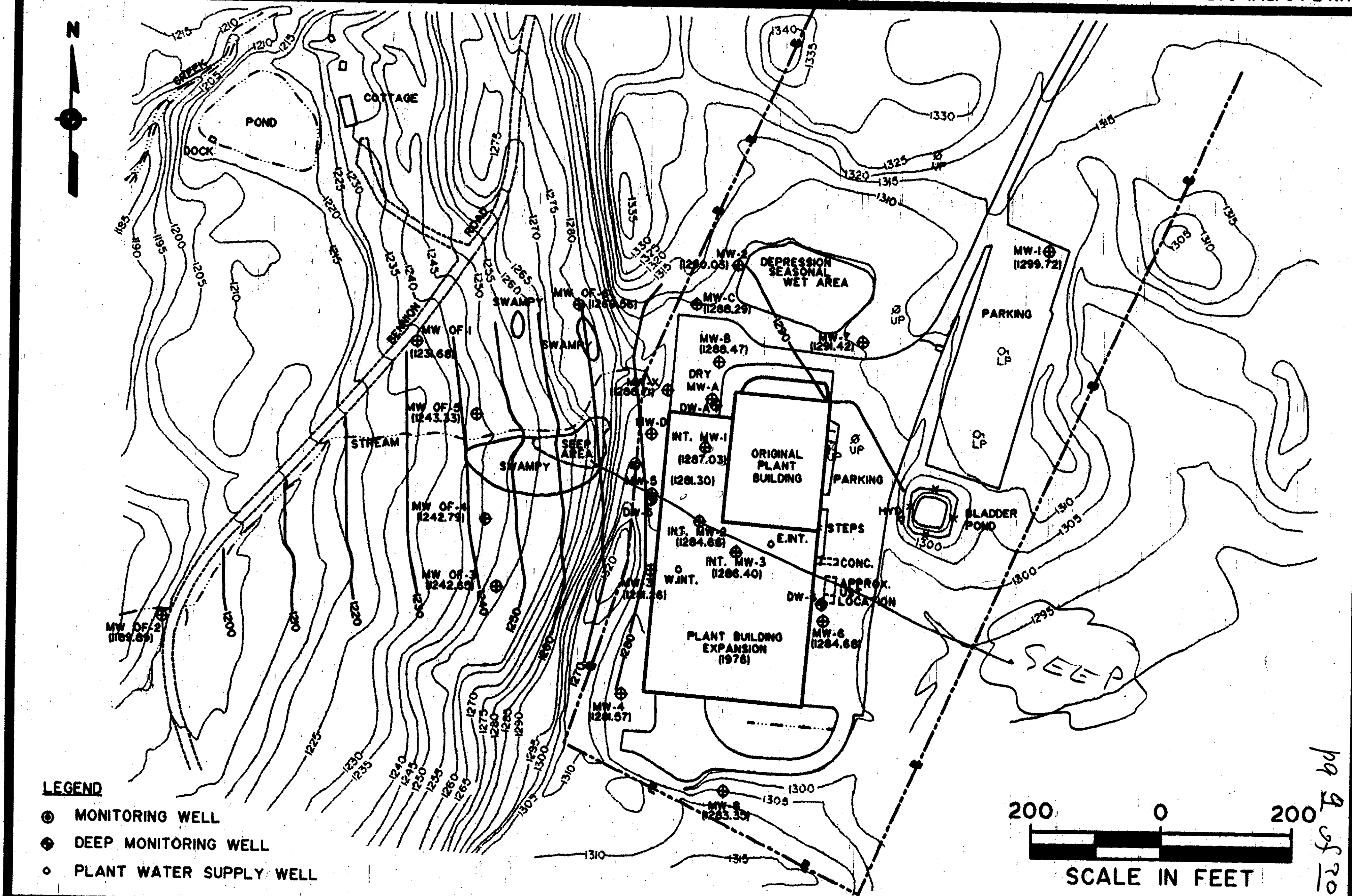
URS CONSULTANTS, INC.

CROSS SECTION C-C' (EAST-WEST)

FIGURE 3D

AC-5564

\35243.06\ I=200 1/18/94-2-RAL



pg 9 of 20

URS CONSULTANTS, INC.

GROUNDWATER CONTOUR MAP

FIGURE 3-4

Robeson Industries Corporation

Aquifer/Slug Testing Results

Well	Testing Method	Hydraulic Conductivity (ft/sec)
MW-A	Slug Testing	1.00E-04
DW-A	Slug/Pumping Test	3.3E-4 / 1.89E-5
MW-B	Slug Testing	3.05E-04
MW-C	Slug Testing	8.10E-05
MW-D	Slug Testing	*
MW-X	Slug Testing	6.10E-05
MW-3	Slug Testing	6.10E-04
MW-4	Slug Testing	3.60E-04
MW-5	Slug Testing	3.10E-04
DW-5	Slug/Pumping Test	9.5E-5 / 1.04E-5
MW-6	Pumping Test	1.07E-04
MW-7	Pumping Test	*
MW-8	Pumping Test	*

Note: * - Data could not be interpreted for quantitative results

Obtained by using a confined aquifer model. The aquifer is unconfined, and these values are not used.

APPENDIX E

LOWERING WATER TABLE BENEATH THE BUILDING

URS **EXHIBIT 4.7-2**

CALCULATION COVER SHEET

Client: NYSDC Project Name: Robeson

Project/Calculation Number: 111 73 792

Title: Dewatering of Soil Contamination Area

Total Number of Pages (including cover sheet): 21 (20 + cover)

Total Number of Computer Runs: 0

Prepared by: Marek Ostrowski Date: 1 March 05

Checked by: Craig Taylor Date: 1 Mar 05

Description and Purpose: To investigate feasibility of lowering the water table within soil contamination area.

Design Basis/References/Assumptions See text.

Remarks/Conclusions/Results: See summary on pg 4.

Calculation Approved by: Craig W. Pawlewski 4/18/05
Project Manager/Date

Revision No.:	Description of Revision:	Approved by:

Project Manager/Date

MADE BY: M.O. DATE: March 1, 2005
CHKD. BY: C.T DATE: March 1, 2005

PROJECT: Robeson
SUBJECT: Dewatering of Soil Contamination Area

1. PURPOSE

The purpose of this calculation is to evaluate the feasibility of lowering the water table in the soil contamination area by means of ground water extraction.

2. GENERAL

The site is located over an unconfined water-bearing zone, consisting of relatively low-permeability brown till and gray sandy silt. An underlying layer of dense gray till is thought to form a low-permeability lower limit to the vertical extent of the water-bearing zone. In the area of soil contamination, the saturated thickness is approximately 25 to 50 feet. See reference 1.

Several 4-inch diameter ground water extraction wells have been operating at the site, providing approximately 1 gpm per well on the average. Actual extraction rates vary from very low to approximately 3 gpm.

Hydraulic conductivity of the water-bearing zone is thought to be between approximately $5*10^{-5}$ and $5*10^{-4}$ cm/s (0.14 and 1.4 ft/d). See reference 1.

3. CALCULATIONS

Assume that the maximum drawdown that can be maintained in an extraction well is half of the saturated thickness. Energy losses at the screen can probably be neglected, because the flow rates considered here are very low. The relationship between the saturated thickness at well face and the flow rate is (equations 8-12 and 8-23 of reference 2, formula for "R" is empirical in units of "meters" and "seconds"):

$$H_0^2 - h_w^2 = (Q_w/\pi K)\ \ln[575(H_0-h_w)(H_0K)^{1/2}/r_w]$$

$$h_w = 0.5\ H_0$$

$$H_0^2 - (0.5H_0)^2 = (Q_w/\pi K)\ \ln[575(H_0-0.5H_0)(H_0K)^{1/2}/r_w]$$

$$0.75H_0^2 = (Q_w/\pi K)\ \ln[575(0.5H_0)(H_0K)^{1/2}/r_w]$$

$$Q_w = (0.75H_0^2\pi K)\ /\ \ln[288H_0(H_0K)^{1/2}/r_w]$$

Or:

$$Q_w = (0.75H_0^2\pi K) / \ln(R_{1/2}/r_w)$$

Where $R_{1/2}$ is the radius of influence corresponding to well drawdown of half of the saturated thickness.

$$R_{1/2} = 288\ H_0\ (H_0K)^{1/2}$$

This flow rate is substituted to equation 8-24 of reference 3:

$$H_0^2 - h^2 = (Q_w/\pi K)\ \ln(R_{1/2}/r)$$

$$H_0^2 - h^2 = \{[(0.75H_0^2\pi K)/\ln(R_{1/2}/r_w)]/\pi K\}\ \ln(R_{1/2}/r)$$

$$H_0^2 - h^2 = 0.75H_0^2[\ln(R_{1/2}/r)/\ln(R_{1/2}/r_w)]$$

Assume 4 wells placed at vertices of a square area. See sketch on page 5. Dewatering at the center of the square area, which is equidistant from all wells, can be calculated by superimposing quantity ($H_0^2 - h^2$) from all four wells (reference 2, equation 8-142).

$$H_0^2 - h^2 = 4*0.75H_0^2[\ln(R_{1/2}/r)/\ln(R_{1/2}/r_w)]$$

$$H_0^2 - h^2 = 3H_0^2[\ln(R_{1/2}/r)/\ln(R_{1/2}/r_w)]$$

The required distance to the wells can be calculated, corresponding to the desired degree of dewatering.

$$H_0^2 - h_{req}^2 = 3H_0^2[\ln(R_{1/2}/r)/\ln(R_{1/2}/r_w)]$$

$$\ln[R_{1/2}/r] = [(H_0^2 - h_{req}^2)/(3H_0^2)]\ \ln(R_{1/2}/r_w)$$

$$R_{1/2}/r = \mathrm{EXP}\{[(H_0^2 - h_{req}^2)/(3H_0^2)]\ \ln(R_{1/2}/r_w)\}$$

$$r = R_{1/2}/\ \mathrm{EXP}\{[(H_0^2 - h_{req}^2)/(3H_0^2)]\ \ln(R_{1/2}/r_w)\}$$

The spacing between wells, or the side of the square area created by the wells, is:

$$a = r\ 2^{1/2}$$

Four cases are investigated (see page 6). Required dewatering at the center is assumed to be 5 feet.

Case 1	Hydraulic Conductivity [cm/s]	Hydraulic Conductivity [m/s]	Saturated Thickness [ft]	Saturated Thickness [m]	Spacing [ft]	Flow Rate [gpm]
1	$5*10^{-4}$	$5*10^{-6}$	50	15	117	5.5
2	$5*10^{-4}$	$5*10^{-6}$	25	8	32	1.6
3	$5*10^{-5}$	$5*10^{-7}$	50	15	40	0.7
4	$5*10^{-5}$	$5*10^{-7}$	25	8	12	0.2

The area to be dewatered is approximately 200 by 80 plus 100 by 100 ft (see page 7). Assume the area dewatered on the outside of the square of wells to be equal to 25% of well spacing. From that, the required number of wells and the total flow are:

$$A = 200*80 + 100*100 = 26,000 \text{ ft}^2$$

$$N = A / 1.25a^2$$

$$Q_{tot} = Q\ N$$

Case	Number of Wells N [-]	Flow Rate Q_{tot} [gpm]
1	2	11
2	20	32
3	16	11
4	144	29

MADE BY: M.O. DATE: March 1, 2005
CHKD. BY: C.T DATE: March 1, 2005

PROJECT: Robeson
SUBJECT: Dewatering of Soil Contamination Area

4. SUMMARY

For Cases 1, 2 and 3, the total number of wells required would be up to 20, and the total extraction rate would be between approximately 10 and 30 gpm. For Case 4, dewatering would not be feasible because of a very large number of wells required.

Due to uncertainty, it is recommended that a phased approach be used. In the initial phase, it is recommended that wells be first installed at a 50-foot grid. Twelve wells would be required, see page 7. This should cover most of possible cases. However, in areas where very low saturated thickness and hydraulic conductivity are encountered, the system may not be effective, and more wells may have to be installed.

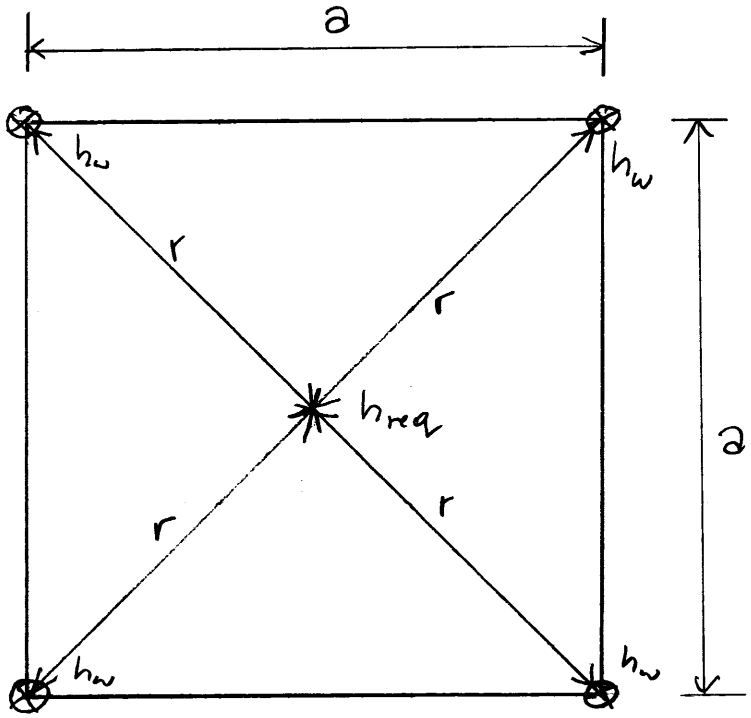
The total expected flow rate would be between 10 and 30 gpm.

5. REFERENCES

1. Limited Site Data
   Robeson Industries Site (Site No. 9-61-008)
   URS March 1997

2. Hydraulics of Groundwater
   J. Bear
   McGraw-Hill, 1979

Job Robeson
Description Dewatering
Project No.
Computed by MO
Date Feb 28, 05
Checked by
Date
Reference



⊗ - Extration well

$$(2r)^2 = a^2 + a^2$$

$$2a^2 = 4r^2$$

$$a^2 = 2r^2$$

$$a = r\sqrt{2}$$

Calculates flow rates and distance between four wells arranged in a square, producing required dewatering at the center of the square. Wells assumed to be identical and create drawdown at well face equal to half of the saturated thickness. Aquifer is unconfined.

$$r = R_{1/2} / \mathrm{EXP}\{[(H_0^2 - h_{req}^2)/(3H_0^2)] \ln(R_{1/2}/r_w)\}$$

$$Q_w = (0.75 H_0^2 \pi K) / \ln(R_{1/2}/r_w)$$

$$R_{1/2} = 288\ H_0\ (H_0 K)^{1/2}$$

$$a = r\ 2^{1/2}$$

Data:

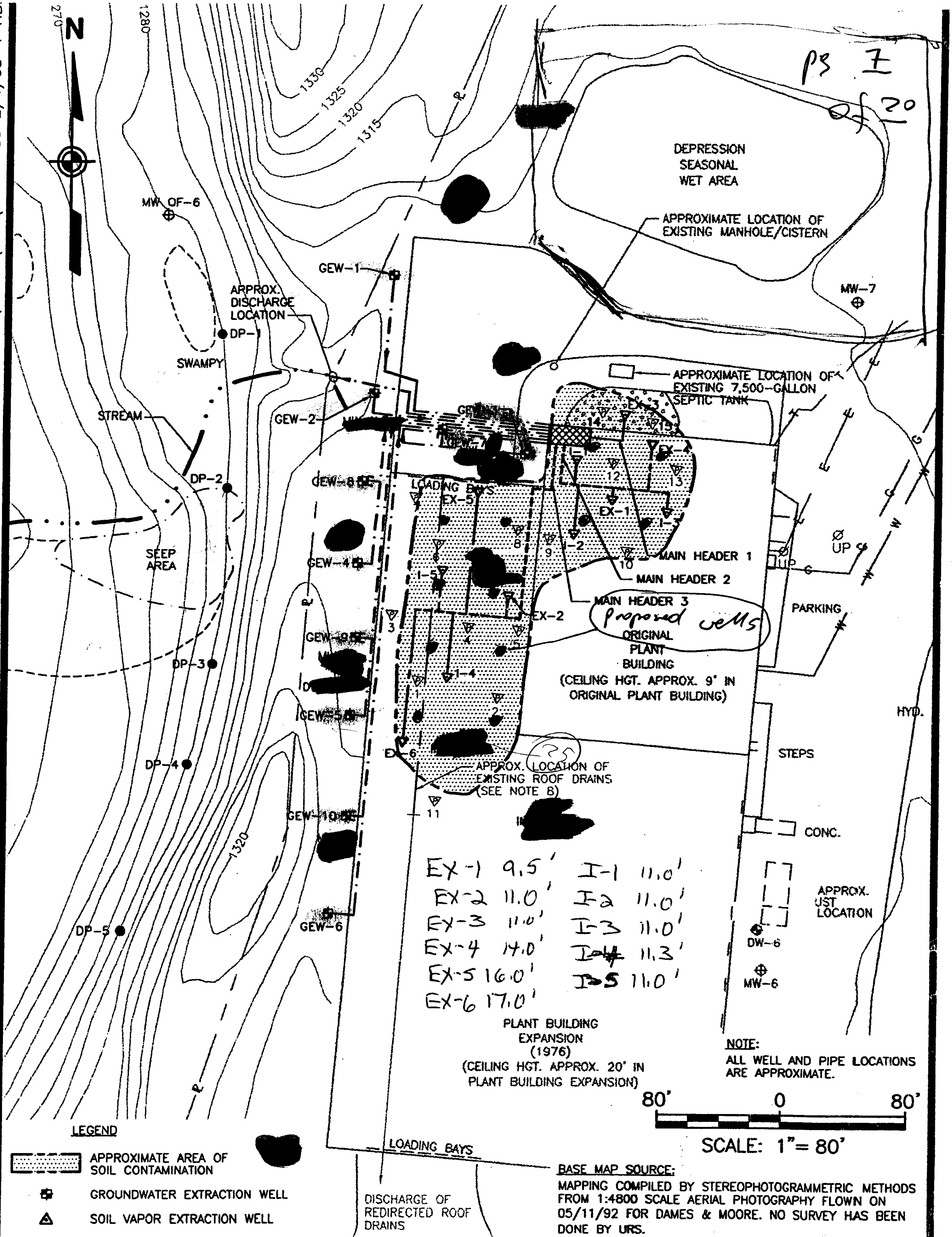
Well diameter	D =	4 in		
Well Radius	r_w =	2 in =	0.051 m =	0.17 ft

Calculate:

Case	Hydraulic Conductivity K			Saturated Thickness H_0		Required Dewatering s_{req}	h_{req} (*)	Radius of Influence $R_{1/2}$		Extraction Rate Q_w		Distance to Center r	Side of Square a
	[cm/s]	[m/s]	[ft/d]	[ft]	[m]	[ft]		[m]	[ft]	[ft^3/d]	[gpm]	[ft]	[ft]
1	5.0E-04	5.0E-06	1.42	50	15.2	5	45	38.3	125.7	1,259	6.5	82.6	117
2	5.0E-04	5.0E-06	1.42	25	7.6	5	20	13.6	44.4	373	1.9	22.7	32
3	5.0E-05	5.0E-07	0.14	50	15.2	5	45	12.1	39.8	152	0.8	28.1	40
4	5.0E-05	5.0E-07	0.14	25	7.6	5	20	4.3	14.1	47	0.2	8.3	12

(*) - $h_{req} = H_0 - s_{req}$

L:\35438\CAD\100 1=80 2/4/03-1 HBI



AC-13335C

URS CONSULTANTS, INC.	ROBESON INDUSTRIES SITE – TOWN OF CASTILE GWET AND SVET WELL LOCATIONS	FIGURE 1–1

LIMITED SITE DATA
ROBESON INDUSTRIES SITE
SITE NO. 9-61-008

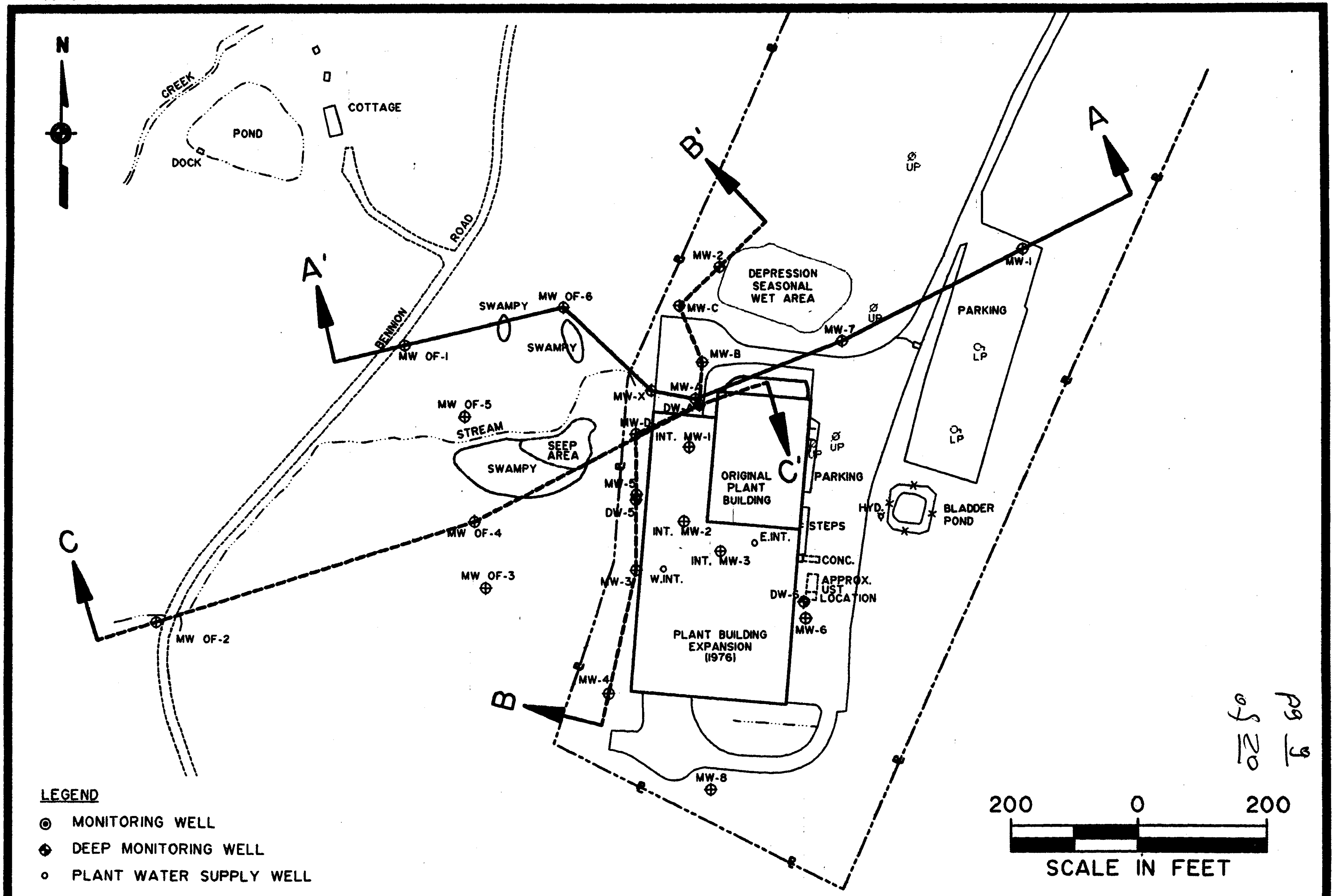
This document is NOT part of the Contract Documents for the Remedial Action at the Robeson Industries Site. The Department neither represents that the characteristics of the contaminated media at the site will be the same as in the attached document nor considers the attached document as being a comprehensive and actual listing of contaminants which may be detected. The Contractor shall be responsible for the accurate and comprehensive characterization of contaminated media to be properly treated, removed, transported or disposed of.

MARCH 1997

Reference 1

AC-5509A

\35438\CAD\ 1=200 9/1/96 SLS

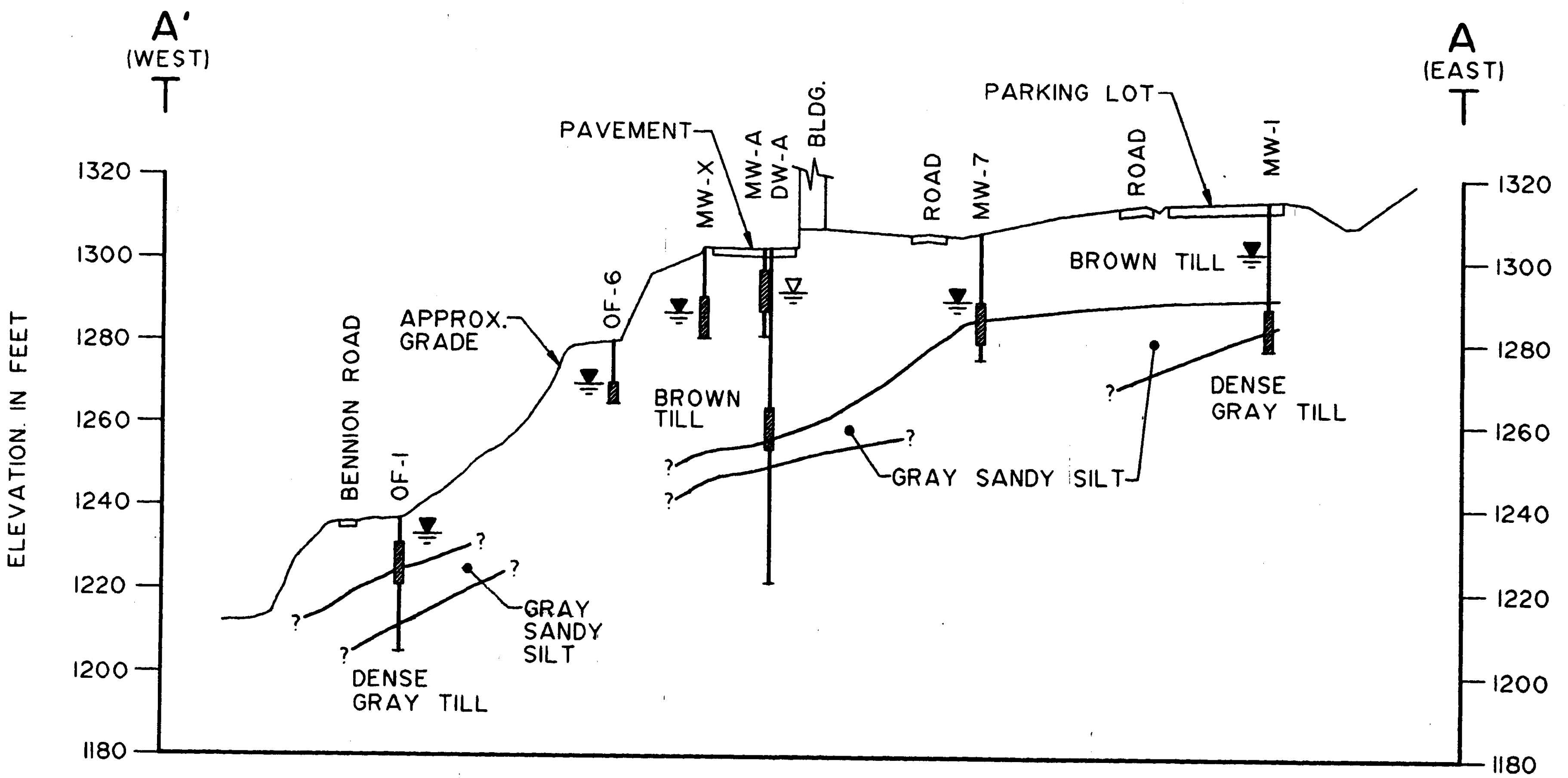


Pg 1 of 20

URS CONSULTANTS, INC.	ROBESON INDUSTRIAL CORPORATION CASTILE, NEW YORK NYSDEC SITE No. 961008	CROSS SECTION LOCATIONS	FIGURE 3A

AC-5514A

\35438\CAD\ 1=1 9/1/96 SLS



LEGEND

VERTICAL SCALE

40 0 40

SCALE IN FEET

HORIZONTAL SCALE

200 0 200

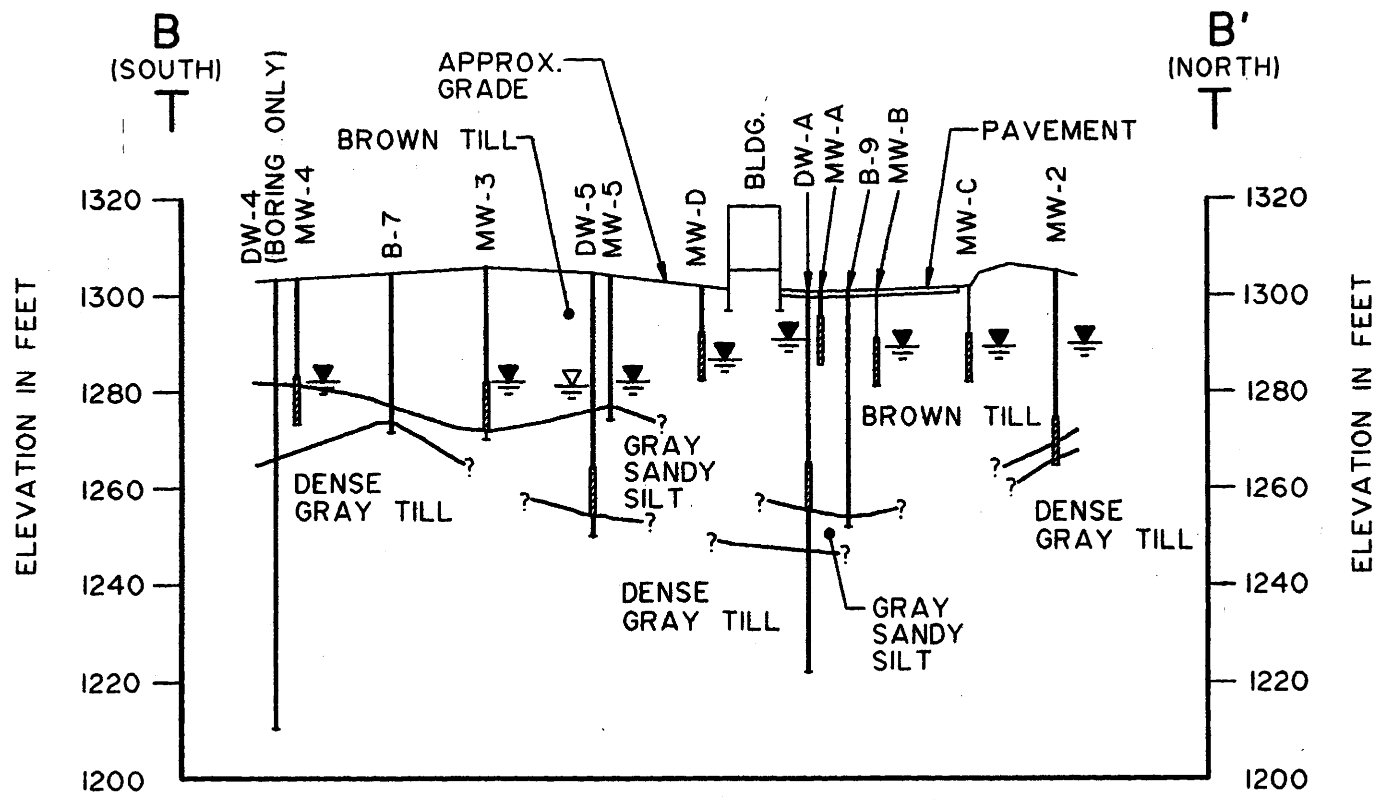
SCALE IN FEET

pg 10
of 26

URS CONSULTANTS, INC.

CROSS SECTION A-A' (EAST-WEST)

FIGURE 3B



LEGEND

MW-5 BORING AND MONITORING WELL NUMBER

WATER LEVEL 1/13/94

SCREENED INTERVAL OF MONITORING WELL

BOTTOM OF BORING

VERTICAL SCALE: 40 0 40 SCALE IN FEET

HORIZONTAL SCALE: 200 0 200 SCALE IN FEET

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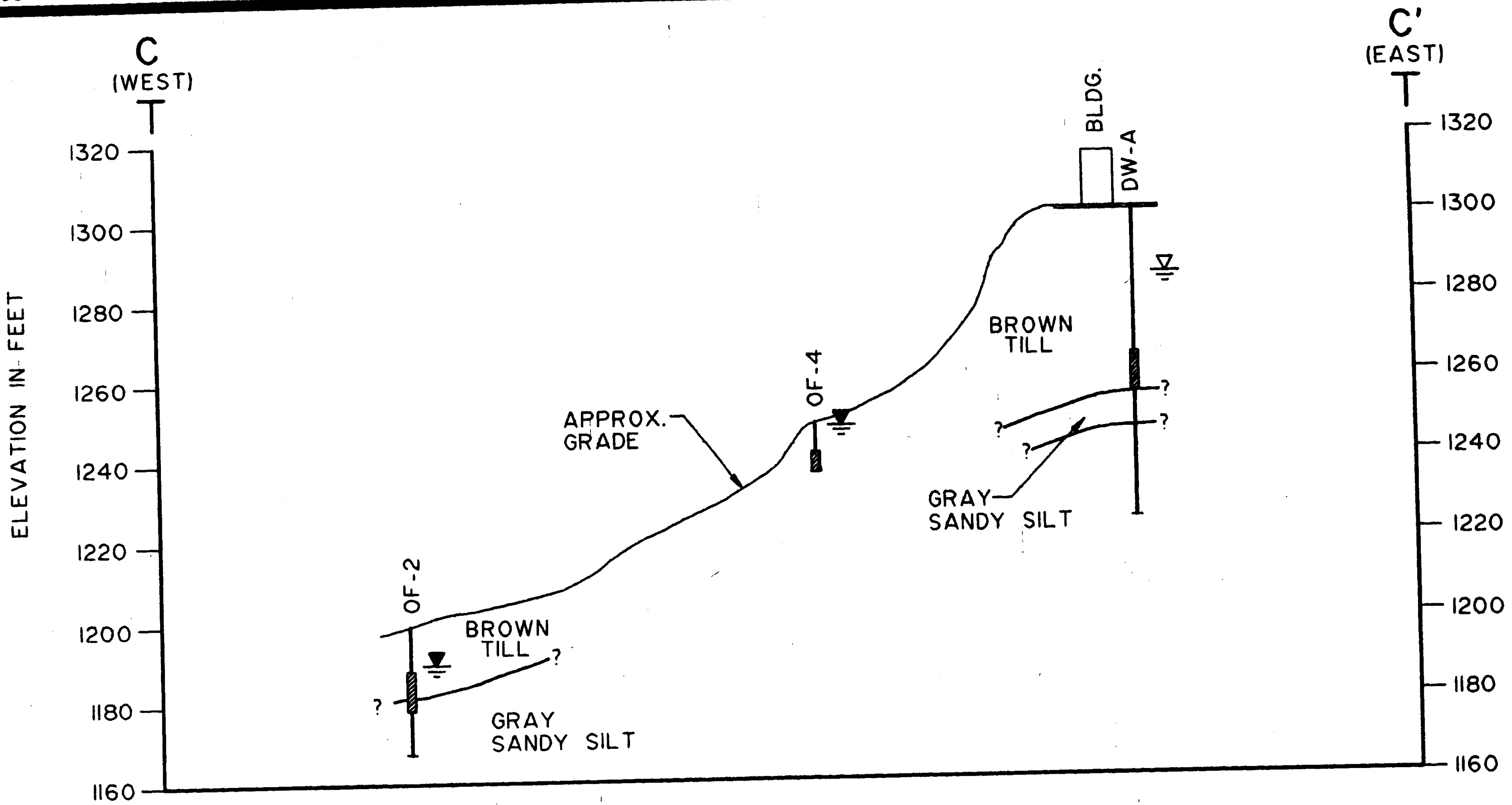
URS CONSULTANTS, INC.

CROSS SECTION B-B' (SOUTH-NORTH)

FIGURE 3C

\35438\CAD 1=1 9/1/96 SLS

AC-5567A



LEGEND

MW-7 BORING AND MONITORING WELL NUMBER

WATER LEVEL 1/13/94

SCREENED INTERVAL OF MONITORING WELL

BOTTOM OF BORING

VERTICAL SCALE 40 0 40 SCALE IN FEET

HORIZONTAL SCALE 200 0 200 S... ...N FEET

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CROSS SECTION C-C' (EAST-WEST)

Robeson Industries Corporation

Aquifer/Slug Testing Results

Well	Testing Method	Hydraulic Conductivity (ft/sec)
MW-A	Slug Testing	1.00E-04
DW-A	Slug/Pumping Test	3.3E-4 / 1.89E-5
MW-B	Slug Testing	3.05E-04
MW-C	Slug Testing	8.10E-05
MW-D	Slug Testing	*
MW-X	Slug Testing	6.10E-05
MW-3	Slug Testing	6.10E-04
MW-4	Slug Testing	3.60E-04
MW-5	Slug Testing	3.10E-04
DW-5	Slug/Pumping Test	9.5E-5 / 1.04E-5
MW-6	Pumping Test	1.07E-04
MW-7	Pumping Test	*
MW-8	Pumping Test	*

Note: * - Data could not be interpreted for quantitative results

Analyzed as recovery in a confined aquifer. The aquifer is unconfined; therefore, these results are not considered.

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BOOK COMPANY

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Reference 2

JACOB BEAR

Department of Civil Engineering
Technion—Israel Institute of Technology
Haifa
Israel

ver

nd

Hydraulics of Groundwater

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By integrating (8-1) from r_w to R, we obtain

$$s_w = H - h_w = \phi(R) - \phi(r_w) = (Q_w/2\pi T)\ln(R/r_w) \tag{8-4}$$

Between any two distances r_1 and $r_2(> r_1)$, we obtain

$$\phi(r_2) - \phi(r_1) = s(r_1) - s(r_2) = (Q_w/2\pi T)\ln(r_2/r_1) \tag{8-5}$$

Equation (8-5) is called the Thiem equation (Thiem, 1906).

Between any two distances r and R, we obtain

$$s(r) = \phi(R) - \phi(r) = (Q_w/2\pi T)\ln(R/r) \tag{8-6}$$

By dividing (8-3) by (8-4), we obtain

$$\phi(r) - h_w = (H - h_w)\frac{\ln(r/r_w)}{\ln(R/r_w)} \tag{8-7}$$

showing that the shape of the curve $\phi = \phi(r)$, given h_w and H at r_w and R, respectively, is independent of Q_w and T.

The distance R in (8-4), (8-6), and (8-7), where the drawdown is zero, is called the *radius of influence of the well*. Since we have established above that steady flow cannot prevail in an infinite aquifer, the distance R should be interpreted as a parameter which indicates the distance beyond which the drawdown is negligible, or unobservable. In general, this parameter has to be estimated from past experience. Fortunately, R appears in (8-6) in the form of $\ln R$ so that even a large error in estimating R does not appreciably affect the drawdown determined by (8-6). The same observation is true also for another parameter—the radius of the well r_w (Sec. 8-1).

Various attempts have been made to relate the radius of influence, R, to well, aquifer, and flow parameters in both steady and unsteady flow in confined and phreatic aquifers. Some relationships are purely empirical, others are semi-empirical. For example (Bear, Zaslavsky, and Irmay, 1968).

Semi-empirical formulas are

Lembke (1886, 1887): $R = H(K/2N)^{1/2}$, (8-8)

Weber (Schultze, 1924): $R = 2.45\,(HKt/n_e)^{1/2}$, (8-9)

Kusakin (Aravin and Numerov, 1953): $R = 1.9\,(HKt/n_e)^{1/2}$ (8-10)

Empirical formulas are

Siechardt (Chertousov, 1962): $R = 3000 s_w K^{1/2}$, (8-11)

Kusakin (Chertousov, 1949): $R = 575 s_w (HK)^{1/2}$ (8-12)

where R, s_w (= drawdown in pumping well), and H are in meters and K in meters per second.

In phreatic aquifers (Sec. 8-3) N, H, and n_e represent accretion from precipitation, the initial thickness of the saturated layer, and the specific yield (or effective porosity) of the aquifer, respectively. In confined aquifers, H and n_e have to be

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By combining (8-15) and (8-16), we obtain

$$-\frac{\partial \phi}{\partial r} = -W\frac{Q_w}{A} + b\frac{Q_w^2}{A^2} = -\frac{WQ_w}{2\pi B}\frac{1}{r} + \frac{bQ_w^2}{4\pi^2 B^2}\frac{1}{r^2} \tag{8-17}$$

Integrating from $r = r_w$, $\phi = \phi_w$ to any distance r, we obtain

$$\phi(r) - \phi_w = \frac{Q_w}{2\pi T}\ln\frac{r}{r_w} + \frac{bQ_w^2}{4\pi^2 B^2}\left(\frac{1}{r_w} - \frac{1}{r}\right) \tag{8-18}$$

Without the second term on its right-hand side, caused by the quadratic term in (8-16), (8-18) is the same as (8-4) based on Darcy's law. One should note, however, that equipotentials are still circles centered at the well.

8-3 STEADY FLOW TO A WELL IN A PHREATIC AQUIFER

Figure 8-6 shows the cone of depression in the vicinity of a well pumping at a rate Q_w from an isotropic phreatic aquifer. The flow is radially symmetric between circular equipotential boundaries at $r = R$ and $r = r_w$. Hence, the potential distribution $\phi = \phi(r, z)$ satisfies the continuity equation

$$\partial^2\phi/\partial r^2 + (1/r)\,\partial\phi/\partial r + \partial^2\phi/\partial z^2 = 0 \tag{8-19}$$

which is the Laplace equation (5-61) for radially symmetric flow. The boundary conditions, assuming no well losses, are

$$\begin{array}{lll}
\phi(R, z) = H_0, & 0 \le z \le H_0, & \text{(equipotential)} \\
\phi(r_w, z) = h_w, & 0 \le z \le h_w, & \text{(equipotential)} \\
\phi(r_w, z) = z, & h_w \le z \le h_s, & \text{(seepage face)} \\
\partial\phi/\partial z = 0, & z = 0;\, r_w \le r \le R, & \text{(impervious bottom)} \\
\left.\begin{array}{l}\phi(r, h) = h, \\ \partial\phi/\partial n = 0,\end{array}\right. & \left.\begin{array}{l} r_w \le r \le R \\ z = h \end{array}\right\} & \text{(phreatic surface)}
\end{array} \tag{8-20}$$

where n is distance measured in the direction of the normal to the phreatic surface. A seepage face (Sec. 5-3) is always present when a phreatic surface approaches a downstream body of liquid continuum (here in the well). The situation is different when the well is cased (=impervious), with a screened (or perforated) section as its lower portion.

Another possible boundary condition at the well is that of constant discharge Q_w = const. Then the second condition is replaced by

$$K\int_0^{h_w} 2\pi r[\partial\phi(r, z)/\partial r]\,dz = Q_w$$

Like other unconfined flow cases, the problem is nonlinear and, in general, cannot be solved analytically. Kirkham (1964) presents an exact solution for the

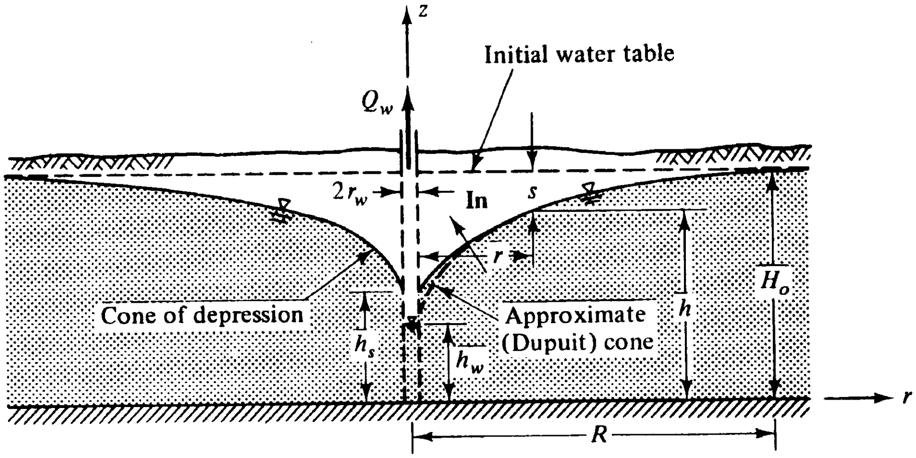

Figure 8-6 Radial flow to a well in a phreatic aquifer.

height of the phreatic surface, h, in the form of an equation which is solvable by iteration.. His potential function is obtained by assuming that a certain fictitious flow exists in the region above the phreatic surface and below the horizontal plane at $z = H_0$, such that the boundary conditions on the phreatic surface are satisfied also by the potential of this flow.

Numerical methods have also been often applied to the solution of the problem as stated by (8-19) and (8-20).

By using the *Dupuit assumptions*, an easily integrable linear continuity equation can be derived. The results are accurate enough for distances $r > 1.5h$ from a well. In this approach, the seepage face is neglected. Hansen (1949) gives graphs of Q/Kr_w^2 as a function of h_s/r_w and h_w/r_w (Fig. 8-7). Boulton (1951) suggests

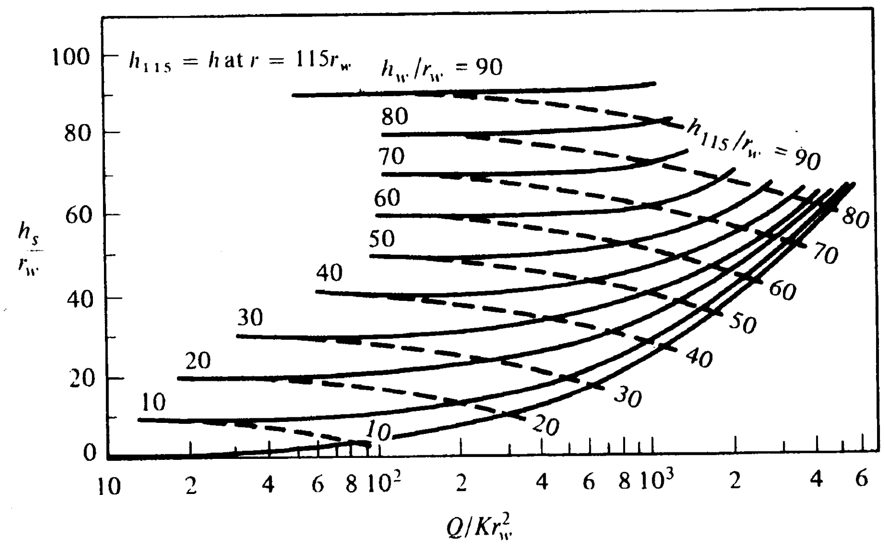

Figure 8-7 Discharge of a well in a phreatic aquifer *(Hansen, 1949)*.

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the relationship

$$h_s - h_w \approx (H_0 - h_w) - 3.75Q_w/2\pi KH_0 \tag{8-21}$$

where 3.75 is replaced by 3.5 if r_w/H_0 is of the order 0.25.

Consider a cylinder of radius r around the well. For the considered steady flow, the Dupuit assumptions lead to

$$Q_w = 2\pi rhq_r = 2\pi rhKdh/dr = 2\pi rK\partial(h^2/2)/\partial r \tag{8-22}$$

where q_r is the specific discharge in the radial direction. Integrating between $h = h_w$ at $r = r_w$ and $h = H_0$ at $r = R$, we obtain

$$H_0^2 - h_w^2 = \frac{Q_w}{\pi K}\ln(R/r_w) \tag{8-23}$$

In this integration, we have completely neglected the seepage face and made h_s identical to h_w. By integrating from some distance r to the external boundary at R, we obtain

$$H_0^2 - h^2 = \frac{Q_w}{\pi K}\ln(R/r) \tag{8-24}$$

Dividing (8-24) by (8-23) gives

$$H_0^2 - h^2 = (H_0^2 - h_w^2)\frac{\ln(R/r)}{\ln(R/r_w)} \tag{8-25}$$

The dashed curve in Fig. 8-6 gives the phreatic surface elevations, $h = h(r)$, as expressed by (8-25). It is interesting to note that neither Q_w nor K appear in (8-25). From (8-24), it follows that as $r \to \infty$, $h \to \infty$, which is obviously impossible. This means that *steady flow is impossible in an infinite aquifer*. The equation is, therefore, valid only in the vicinity of the well.

Equation (8-23) is known as the *Dupuit–Forchheimer well discharge formula*. It is an exact solution of the continuity equation (in polar coordinates) based on the Dupuit assumptions

$$\partial Q/\partial r = 0 = \partial(2\pi rhK\partial h/\partial r)/\partial r = \partial(\pi Kr\partial h^2/\partial r)/\partial r \tag{8-26}$$

or

$$\partial^2(h^2)/\partial r^2 + (1/r)\,\partial(h^2)/\partial r = 0 \tag{8-27}$$

which is linear in h^2.

Equation (8-24) may also be written as

$$H_0 - h = \frac{1}{(H_0 + h)}\frac{Q_w}{\pi K}\ln(R/r) \tag{8-28}$$

For a thick aquifer and small drawdown, $(H_0 - h) \ll H_0$, $H_0 + h \approx 2H_0$, and (8-24) may be approximated by

$$s = \frac{Q_w}{\pi K(H_0 + h)}\ln\frac{R}{r} \quad \text{or} \quad s = \frac{Q_w}{2\pi T}\ln\frac{R}{r} \tag{8-29}$$

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and when both wells are operating, and we assume $\phi_1(P_2) \ll \phi_2^w$ and $\phi_2(P_1) \ll \phi_1^w$. The same procedure can be applied to a larger number of wells.

Muskat (1937) discusses several arrangements of wells in a confined aquifer, and determines in each case the drawdown at the various wells, using (8-131) with $R_j = R =$ const. For example: for two wells of equal drawdown $s_1 = s_2 = s_w$ at a distance L apart, we have

$$Q_1 = Q_2 = \frac{2\pi T s_w}{\ln(R^2/r_w L)} \tag{8-135}$$

The total discharge $(Q_1 + Q_2)$ is that of a single well of radius $(r_w L)^{1/2} \gg r_w$. This shows that a multiple well system is more efficient than a single large well having the same total discharge.

For three wells of equal drawdown forming an equilateral triangle of side L

$$Q_1 = Q_2 = Q_3 = \frac{2\pi T s_w}{\ln(R^3/r_w L^2)} \tag{8-136}$$

In order that a single well of discharge $(Q_1 + Q_2 + Q_3)$ will give the same drawdown s_w, its radius has to be $(r_w L^2)^{1/3}$.

For an infinite *array of wells* at $P_k(ka, 0)$, $k = \ldots, -2, -1, 0, 1, 2, \ldots$ in a confined aquifer in the xy plane, with $Q_k =$ const. $= Q_w$, and $\phi(x, \pm R) =$ const. $= H$; R being an equivalent distance of influence, Muskat (1937) gives

$$s(x, y) \equiv H - \phi(x, y) = \frac{Q_w}{4\pi T} \ln \frac{\cosh 2\pi(y - R)/a - \cos 2\pi x/a}{\cosh 2\pi(y + R)/a - \cos 2\pi x/a} \tag{8-137}$$

Figure 8-20 shows streamlines and equipotentials. At a distance of the order of the mutual spacing, $y > a$, the equipotentials become parallel to the array, as if the latter had been replaced by a continuous line sink.

For a line of three equally spaced wells a distance L apart, all having the same drawdown s_w, the outer wells discharge at

$$Q_1 = Q_3 = \frac{2\pi T s_w \ln(L/r_w)}{2\ln(R/L)\ln(L/R) + \ln(R^2/2r_w L)\ln R/r_w)} \tag{8-138}$$

while the middle well discharges at

$$Q_2 = \frac{2\pi T s_w \ln(L/2r_w)}{2\ln(R/L)\ln(L/R) + \ln(R^2/2r_w L)\ln(R/r_w)} \tag{8-139}$$

Figure 8-21 shows the individual and composite drawdown curves for the three wells for $Q_1 = Q_2 = Q_3$, $s_1 = s_3 \neq s_2$.

The discharge of each of four wells forming a square of side L, all having the same drawdown s_w, is

$$Q_1 = Q_2 = Q_3 = Q_4 = \frac{2\pi T s_w}{\ln(R^4/\sqrt{2} r_w L^3)} \tag{8-140}$$

When N wells are pumping in a phreatic aquifer with a horizontal bottom, and the Dupuit approximation is used to determine the drawdown (steady flow!) in an

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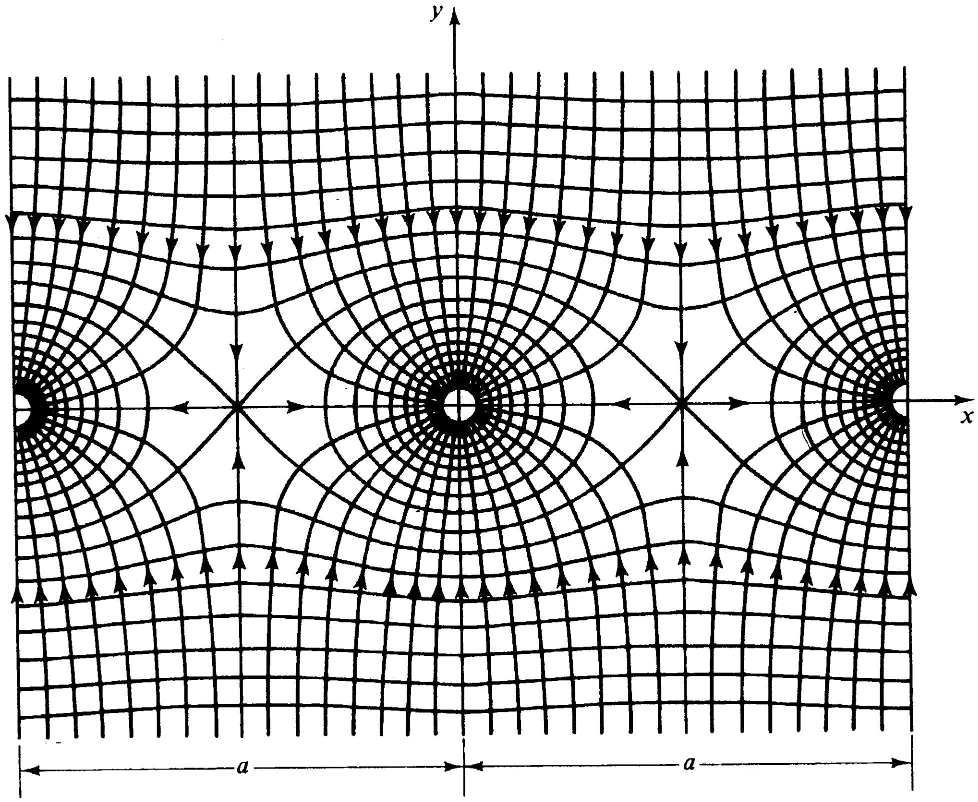

Figure 8-20 Streamlines and equipotentials about an infinite array of wells.

observation well, the principle of superposition (here with respect to h^2) leads to

$$H_0^2 - h_i^2 = \sum_{j=1}^{N} \frac{Q_j}{\pi K} \ln \frac{R_j}{r_{ij}} \tag{8-141}$$

where $H_0 =$ const. is the initial (undisturbed) height of the water table above the impervious bottom, h_i is the height of the water table above the impervious bottom at the observation well (x_i, y_i), and the R_j's are the radii of influence of the pumping wells, (assuming that they are sufficiently large so that drawdown is produced at the observation well). When all R_j's are the same and all Q_j's are equal to Q/N, we obtain from (8-141)

$Q = N \cdot Q_j$

$$H^2 - h_i^2 = \frac{Q}{\pi K} \ln(R/r^*); \qquad r^* = (r_{i1} r_{i2} r_{i3} \cdots r_{iN})^{1/N} \tag{8-142}$$

if $r_{ij} =$ cons $\rightarrow r^* = r$

One should note here that because we have initially the nonhomogeneous conditions $h = H_0$ (and not $h = 0$), the superposition is actually not with respect to h^2. Instead, because initially $H_0^2 - h^2 = 0$ everywhere, the superposition is with respect to the difference $H_0^2 - h^2$. In a similar way, if in a confined aquifer we have initially $\phi_0 \neq 0$, the superposition is with respect to $\phi_0 - \phi$ (i.e., with respect to s!).

APPENDIX F

IN SITU CHEMICAL OXIDATION

URS

EXHIBIT 4.7-2

CALCULATION COVER SHEET

Client: NYSDEC

Project Name: ROBESON

Project/Calculation Number: 11173792

Title: IN-SITU CHEMICAL OXIDATION

Total Number of Pages (including cover sheet):

Total Number of Computer Runs: 0

Prepared by: KEVIN SHANAHAN KHS Date: 4/11/05

Checked by: CRAIG W. PAWLEWSKI / CWP Date: 4/14/05

Description and Purpose: TO ESTIMATE QUANTITY OF OXIDANT (SODIUM PERMAGANATE) REQUIRED FOR SITE REMEDIATION.

Design Basis/References/Assumptions UTILIZED CARUS CHEMICAL COMPANY SPREADSHEET.

Remarks/Conclusions/Results: REQUIRE 39,599 GALLONS OF 40% SODIUM PERMANGANATE SOLUTION AND 437,988 GALLONS OF DILUTION WATER.

Calculation Approved by: Craig W. Pawlowski 4/14/05
Project Manager/Date

Revision No.:	Description of Revision:	Approved by:

Project Manager/Date

1. PURPOSE

The purpose of this conceptual level design is to identify the scope of work and cost to implement site remediation at the Robeson Industries site through in-situ chemical oxidation using sodium permanganate. In order to accomplish this objective, an estimate of the mass of sodium permanganate required to oxidize the volatile organic compounds (VOCs) present in the saturated zone was prepared. In addition to the mass required, an injection grid to deliver the sodium permanganate was developed and the estimated costs to implement the injection of this material and monitor effectiveness were evaluated.

2. PROBLEM STATEMENT

The Robeson Industries site has been impacted by a release of chlorinated solvents while the site was operated as a manufacturing facility between 1953 and 1989. Impacted media primarily include vadose zone soils, saturated soils, and groundwater. Since the mid-1990s remediation of the impacted soil and groundwater has been accomplished using a soil vapor extraction and groundwater extraction and treatment system. Soil and soil gas sampling completed indicate that the vadose zone soil remediation has been successful (approximately 3,000 pounds of VOCs have been removed). However, concentrations of trichloroethene and other VOCs remain significantly above remediation goals in several groundwater monitoring/extraction wells. Therefore, evaluation of the feasibility of in-situ chemical oxidation as an alternative remediation technology for the saturated zone was merited. Remediation of the vadose zone will not be included as part of this chemical oxidation conceptual level design.

3. APPROACH

The approach taken to identifying the scope of work and associated cost of chemical oxidation is summarized below:

1. Determine the contamination and site characteristics such as impacted area, contaminant type and concentration, and aquifer characteristics.

2. Estimate the mass of sodium permanganate required to oxidize the VOCs present using software provided by Carus Chemical Company of Peru, Illinois (Carus is a supplier of sodium permanganate).

3. Determine an injection boring arrangement and injection duration based on the estimated mass of sodium permanganate required, aquifer characteristics, and actual data from the ongoing groundwater extraction system.

4. Identify the components of the baseline and post-injection monitoring program.

5. Estimate the cost to implement the scope of work.

4. DETERMINATION OF MASS OF SODIUM PERMANGANATE REQUIRED

Carus developed software to estimate the mass of sodium permanganate required to oxidize a variety of organic contaminants. The software is intended to be a guide to estimate the mass of sodium permanganate required; however, it should be considered a tool with an uncertain degree of accuracy considering the number of site-specific variables that affect chemical oxidation. The mass of sodium permanganate required is calculated based on a stoichiometric relationship to oxidize the estimated mass of contaminants present in the dissolved-phase. The spreadsheet used to calculate the estimated mass of sodium permanganate required for complete oxidation of the contaminants is presented as Attachment A.

The following input parameters were used to estimate the mass of sodium permanganate required:

Treatment Area: The impacted area was calculated based on the length and width of the proposed treatment zone. For the purposes of this conceptual level design, the treatment area was based on the estimated extent of soil impacts, but slightly larger (as illustrated in Attachment B). Although there is evidence that the groundwater plume extends further west of the proposed treatment area, this area is not included since it is beyond the limits of the property and the terrain is not conducive to oxidant injection (a steep slope is present). The overall aerial extent of proposed chemical oxidation was estimated to be 43,320 square feet. Although the area is irregularly shaped, it was approximated to be equivalent to a rectangle measuring 285 feet long and 152 feet wide for input parameters to the software.

Treatment Horizon: The treatment horizon was determined through an evaluation of site stratigraphy and groundwater levels. The geologic zone targeted for treatment has been identified as a glacial end moraine unit which is comprised of brown sand/silt tills and grey silty sand/sandy silt soils. The average depth to groundwater beneath the treatment area was assumed to be 18 feet below ground surface based on available water level data. A dense grey till confining unit underlies the water-bearing zone at depths ranging from approximately 40 to 60 feet below ground surface. Since this confining layer was not present at several borings located within or near the proposed remediation area that terminated at depths of 50 feet, it is assumed that this confining layer is present at 55 feet below ground surface (refer to Attachment C for rationale). Therefore, the treatment horizon is assumed to be from 18 to 55 feet below ground surface (a 37 foot thickness).

Porosity: The volume of the groundwater and soil requiring treatment was calculated using the porosity of the aquifer. The porosity was assumed to be 30 percent.

Contaminant Mass: The mass of sodium permanganate required was determined based on a stoichiometeric relationship for the oxidation of the site organic contaminants. The mass of organic contaminants present is assumed to be the dissolved-phase mass plus the non-aqueous phase mass. The average groundwater VOC concentration of 5 milligrams per liter (mg/L) was calculated by averaging the total VOC levels in samples collected from the ten site groundwater extraction wells in December 2004. The mass of organic contaminants in the dissolved-phase was calculated to be 152 pounds and was based on the volume of groundwater requiring treatment (3,597,485 gallons) and the average groundwater concentration (5 mg/L).

The non-aqueous phase mass is assumed to be sorbed to the soil and that from dense non-aqueous phase liquid (DNAPL) present in the pore spaces. The average saturated soil total VOC concentration based on the soil sampling and analysis completed in September 2004 was 9.9 milligrams per kilogram (mg/kg). The sorbed-phase mass of organic contaminants was calculated to be 1,746 pounds and was based on the mass of saturated soils requiring treatment (80,142,000 kg) and the average groundwater concentration (9.9 mg/kg).

There were no investigations completed to evaluate the presence of DNAPL. Therefore, for purposes of this conceptual level design, it was assumed that DNAPL is present in 0.01 percent of the pore volume (or 100 parts per million of volume). The DNAPL mass was calculated to be 4,381 pounds based on the pore volume (3,597,485 gallons) and the density of TCE (91.1 pounds/cubic feet).

In summary, the total mass of organic contaminants present was calculated to be 6,279 pounds and was comprised of 152 pounds from the dissolved phase, 1,746 pounds from the sorbed-phase, and 4,381 pounds from DNAPL.

Natural Oxidant Demand: The natural oxidant demand (NOD) is a measure of the naturally occurring oxygen demand in the aquifer and may be significant if organic matter is present such as a peat layer. This parameter should be determined through sampling and analysis and can vary between 1 and 50. Since NOD was not determined through laboratory analysis, an aquifer NOD of 5 was assumed based on discussions with Carus and a review of boring logs (no significant organic matter was noted). A total natural oxidant demand was calculated to be 88,156 pounds and was based on an effective NOD equal to ten percent of the aquifer NOD. It should be noted that the mass of sodium permanganate required is very sensitive to the NOD and, therefore this calculation has limited accuracy without actual site-specific NOD data.

Average Stoichiometric Oxidant Demand: The average stoichiometeric oxidant demand is based on the stoichiometric relationship corresponding to the oxidation of VOCs in the presence of sodium permanganate. It is assumed that the all of the VOCs present are trichloroethene (the major component of VOCs in site media). Using an average stoichiometeric oxidant demand of 2.3 obtained from the Carus spreadsheet resulted in a theoretical chemical oxidant demand of 14,442 pounds. The resulting theoretical oxidant demand was calculated to be 102,598 pounds (the sum of natural oxidant demand and contaminant oxidant demand).

Factor of Safety: The factor of safety is an arbitrary number between 1 and 10 used to build in a contingency related to uncertainties inherent in the data and assumptions made as well as the general unpredictability of the chemical oxidation process. A factor of safety of 2 was used for this site. The calculated oxidant demand based on a factor of safety of 2 was 205,196 pounds.

Carus recommended that the injection solution be comprised of 5 percent oxidant and 95 percent dilution water. The resulting mass of oxidant required was calculated to be 451,431 pounds of 40 percent sodium permanganate solution (39,599 gallons) with 437,948 gallons of dilution water for a total of 477,547 gallons of oxidant solution.

5. DETERMINE INJECTION BORING ARRANGEMENT

The injection boring arrangement was based on the volume of oxidant required, aquifer characteristics, and actual site-specific groundwater extraction rates. The total volume of sodium permanganate solution and dilution water required was estimated to be 477,547 gallons. Based on data collected during operation of the existing groundwater extraction and treatment system, current extraction rates average between 7 and 8 gallons per minute (gpm). Therefore, for purposes of this conceptual level design it was assumed that the oxidant solution could be pumped into the aquifer at an average rate of 5 gpm.

A radius of influence of 5 feet was selected to maximize the potential for the oxidant to be uniformly distributed into the subsurface. Based on the proposed treatment area of 43,320 square feet and a radius of influence of 5 feet, the total number of injection borings was calculated to be 552.

Assuming a one-time injection event, a total of 866 gallons of oxidant solution will be pumped into each injection boring. The injection time for each boring is calculated to be approximately 3 hours based on a 5 gpm rate. Assuming a 37 foot treatment horizon, the injection time per linear foot of boring is approximately 4.7 minutes. The total number of working days to complete the injection program is calculated to be 199 or approximately 9.5 calendar months (using 5 day work weeks). This time frame is considered conservative since in all likelihood, the contractor will inject into multiple borings simultaneously using a manifold system and two or more direct push drill rigs.

6. BASELINE AND POST-INJECTION MONITORING PROGRAM

A baseline and post-injection monitoring program will be completed to evaluate and document the effectiveness of the sodium permanganate. The primary components of the monitoring program consist of baseline sampling, post-injection monitoring, and reporting.

<u>Baseline Sampling and Analysis</u>: One soil and groundwater sampling and analysis event will be performed to establish baseline conditions prior to oxidant injection. The purpose of the baseline sampling is to document soil and groundwater conditions within the remediation area prior to oxidant injection. The baseline sampling data will allow evaluation of the effect of the oxidant on contaminant levels.

Baseline soil sampling will be completed at four proposed soil borings located within the remediation area (see Attachment D for locations). Each soil boring location will be prepared as a multiple sampling point to enable repeated access (as many as five times) to subsurface soils in that area during post-injection monitoring as shown in (Attachment D). Each boring will be advanced to a depth of 32 feet below ground surface. Continuous soil sampling will be completed during advancement of the baseline soil borings. A geologist will conduct field screening of soil samples retrieved during drilling and prepare a boring log to document subsurface conditions. Volatile organic vapors will be measured using a photoionization detector (PID) and recorded on the boring log as well as physical evidence of petroleum impacts (odors, staining, or free product).

Two soil samples will be collected from each boring from depths of 25 to 27 and 30 to 32 feet below ground surface. These depth intervals were similar to those used during the 2004 soil investigation. Each soil sample will be analyzed for VOCs by USEPA Method 8260.

Four additional two-inch-diameter groundwater monitoring wells will be installed within the remediation area to facilitate collection of baseline and post-injection groundwater samples (see Attachment D). No soil sampling or field screening will be conducted since the wells will be located adjacent to the baseline/post-injection soil boring locations.

Each well will be set at a depth of 60 feet below ground surface and will be constructed of two-inch-diameter, schedule 40 polyvinyl chloride (PVC). The well screen will be 45 feet long with 0.020-inch slots and installed from the bottom of the well to 15 feet below ground surface. A locking flush-mounted protective casing will be installed over the well and set in concrete.

Baseline groundwater samples will be collected from each well and analyzed for VOCs by USEPA Method 8260. In addition, groundwater samples will be analyzed for pH, temperature, oxidation-reduction potential, dissolved-oxygen and sodium permanganate using a hand held spectrophotometer.

Post-Injection Sampling and Analysis: Post-injection sampling and analysis will be conducted to evaluate the effectiveness of the sodium permanganate. Soil and groundwater sampling will be performed after the sodium permanganate injection. The soil and groundwater sampling locations and procedures will be the same as those used during the baseline sampling event.

7. ESTIMATED COST

The estimated costs associated with chemical oxidation by injection of sodium permanganate is comprised of the following major components:

1. Cost for sodium permanganate.
2. Cost for injection of sodium permanganate.
3. Cost for baseline and post-injection monitoring program.
4. Cost for engineering and contractor oversight.

The cost for the sodium permanganate is calculated to be approximately $1,020,234 based on the estimated total reagent requirement of 451,431 pounds and a $2.26/pound cost. The cost for injection is estimated to be $298,500 based on 199 injection days and a daily rig cost of $1,500/day (assuming a direct-push type rig).

The cost for the baseline and post-injection monitoring program consists of drilling and analytical costs. The estimated cost to drill and install four groundwater monitoring wells is $8,000. The estimated cost to drill and sample a total of 36 baseline and post-injection soil borings is $27,000. A total of 108 soil and groundwater samples will be analyzed for VOCs by USEPA method 8260. The estimated cost for sample analyses is $21,600 based on a unit cost of $200/analysis. Therefore, the total cost for the monitoring program is estimated to be $56,600.

ATTACHMENT A

Parameters	Units	Estimates
*** Site Description ***		
Length	Ft.	285
Width	Ft.	152
Area	Sq. Ft.	43,320
Thickness	Ft.	37
Total Volume	Cu. Yd.	59,364
Porosity	%	30
Plume Total Pore Volume	Gal.	3,597,485
Avg. Contaminant Conc. (dissolved phase)	ppm	5
Mass of Dissolved Phase Contaminant	lb.	152
Avg. Contaminant Conc. (saturated soil)	ppm	9.9
Mass of Sorbed-Phase Contaminant	lb.	1,746
Percent DNAPL in Pore Space	%	0.01
Density of Contaminant	lb/ft^3	91.1
Mass of DNAPL Contaminant	lb.	4,381
Total Mass of Contaminant	lb.	6,279
Natural Oxidant Demand (NOD)	g/kg	5
Effective NOD %	10	0.5
NOD	lb/yd3	1.5
NOD Oxidant Demand	lb	88,156
Avg. Stoichiometric Demand	lb/lb	2.3
Contaminant Oxidant Demand	lb.	14,442
Theoritical Oxidant Demand	lb.	102,598
Factor of Safety		2.0
Calculated Oxidant Demand	lb.	205,196
*** Injection Design ***		
Radius of Influence	Ft.	5.0
Number of Injection Points		552
Injection Concentration	% wt/wt	0.05
Flow Rate - Per Injection Point	GPM	5
Number of Wells per Phase		
Total Injection Flow Rate	GPM	5
Estimated Injection Pressure	PSIG	40
Injection Volume/Hole	Gal	866
*** Injection Schedule ***		
Hours per Day	Hrs	8
Days Per Week	Days	5
Number of Inj. Days	Days	199
Number of Inj. Weeks	Weeks	40

40% NaMnO4 Injection Options

Pounds of 40% NaMnO4 Solution	Gallons of 40% Solution	Number of Pails	Number of Drums	Number of Totes	Price per Lb of Solution	Total Cost of Chemical
451,431	39599	7920	825	180	$ 2.26	$1,020,234

Total Gallons of Dillution Water Required	Dillution Water Flow Rate - GPM	NaMnO4 40% Solution Flow Rate - GPM
437,948	4.59	0.41

OR

Dillution Water Gals per Pail	Dillution Water Gals per Drum	Dillution Water Gals per Tote
55.3	530.9	2,433

ATTACHMENT B

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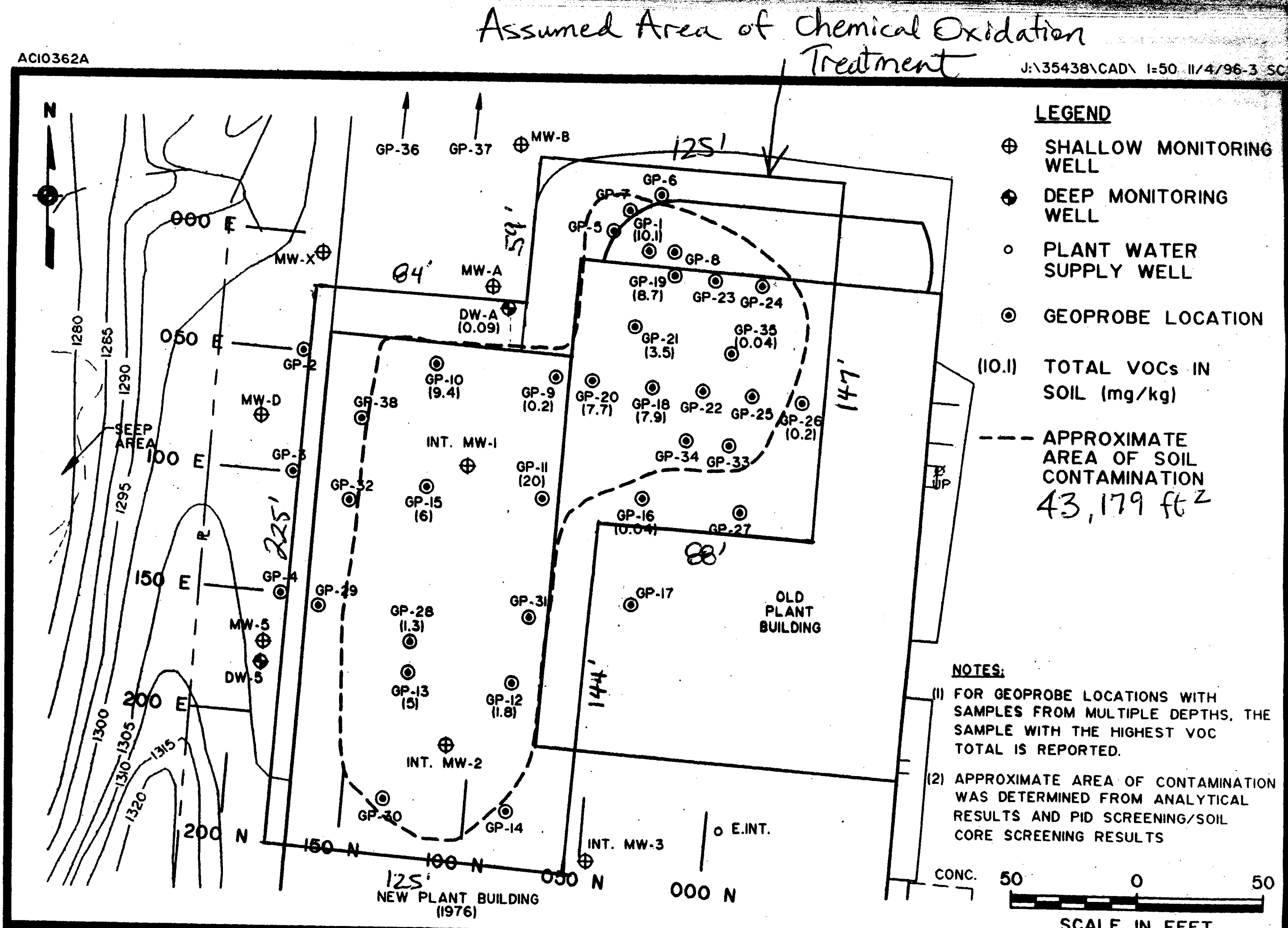

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APPROXIMATE AREA OF SOIL EXCEEDING NYSDEC CLEANUP GUIDELINES

FIGURE 2-2

ATTACHMENT C

RATIONALE FOR ESTIMATING DEPTH TO CONFINING LAYER			
BORING ID	TOTAL DEPTH (FEET)	WAS CONFINING LAYER ENCOUNTERED? (YES/NO)	DEPTH TO CONFINING LAYER (FEET)
B-1	86	YES	35
B-9	46	NO	--
DW-A	78.5	YES	50
DW-4	92	YES	40
DW-5	54	YES	53
DW-6	117	YES	51
GEW-1	51	YES	46
GEW-2	50	NO	--
GEW-3	49	UNKNOWN	--
GEW-4	54	NO	--
GEW-5	56	NO	--
GEW-6	39	NO	--
GEW-7	52	NO	--
GEW-8	54	YES	50
GEW-9	50	UNKNOWN	--
GEW-10	39	NO	--
DB-1	52	NO	--
DB-2	52	NO	--
DB-3	52	YES	50
DB-4	40	NO	--
DB-5	42	NO	--
DB-6	52	NO	--
ASSUME AVERAGE DEPTH TO CONFINING LAYER WITHIN REMEDIATION AREA TO BE 55 FEET.			

ATTACHMENT D

Monitoring Program Locations

Assumed Area of Chemical Oxidation Treatment

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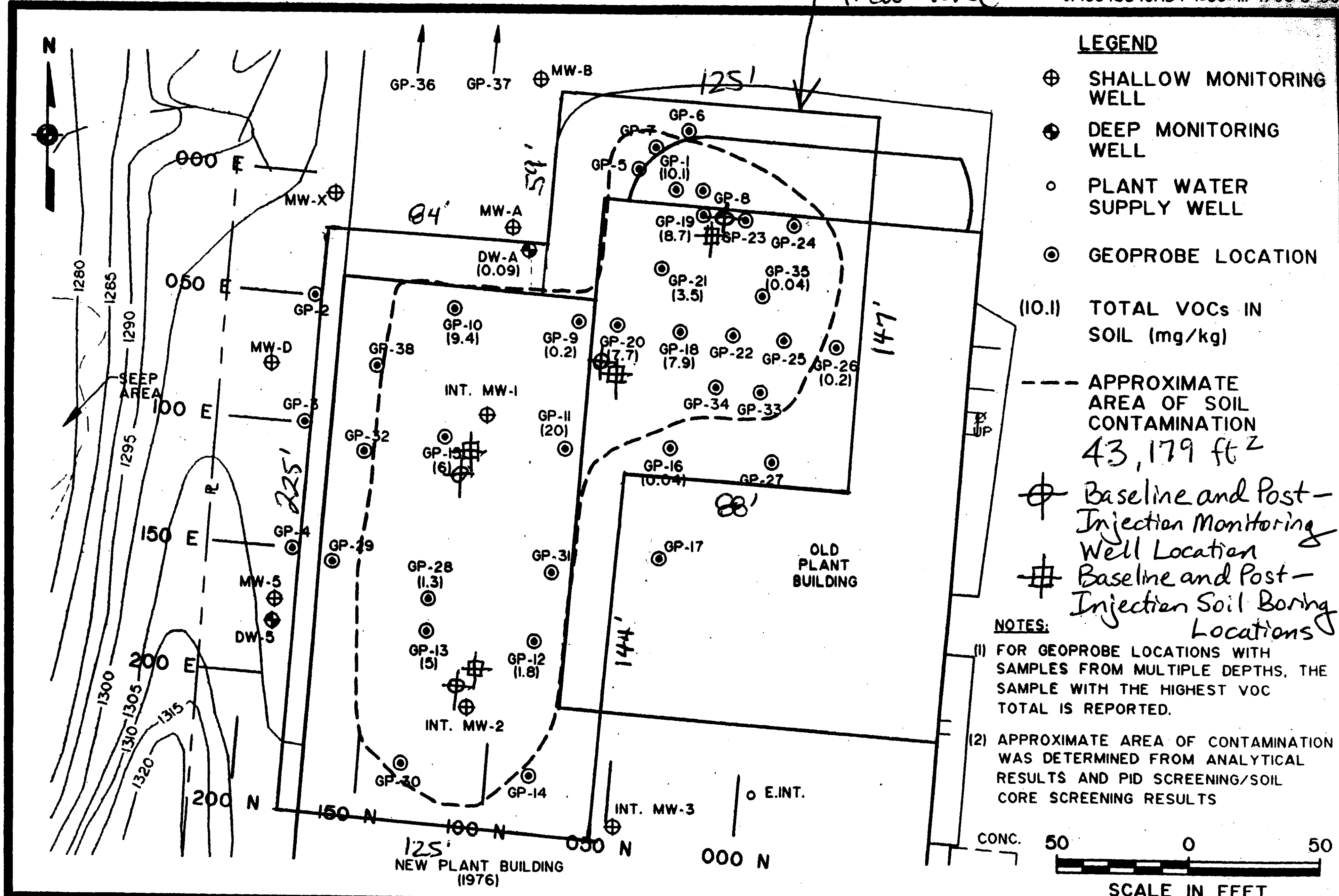
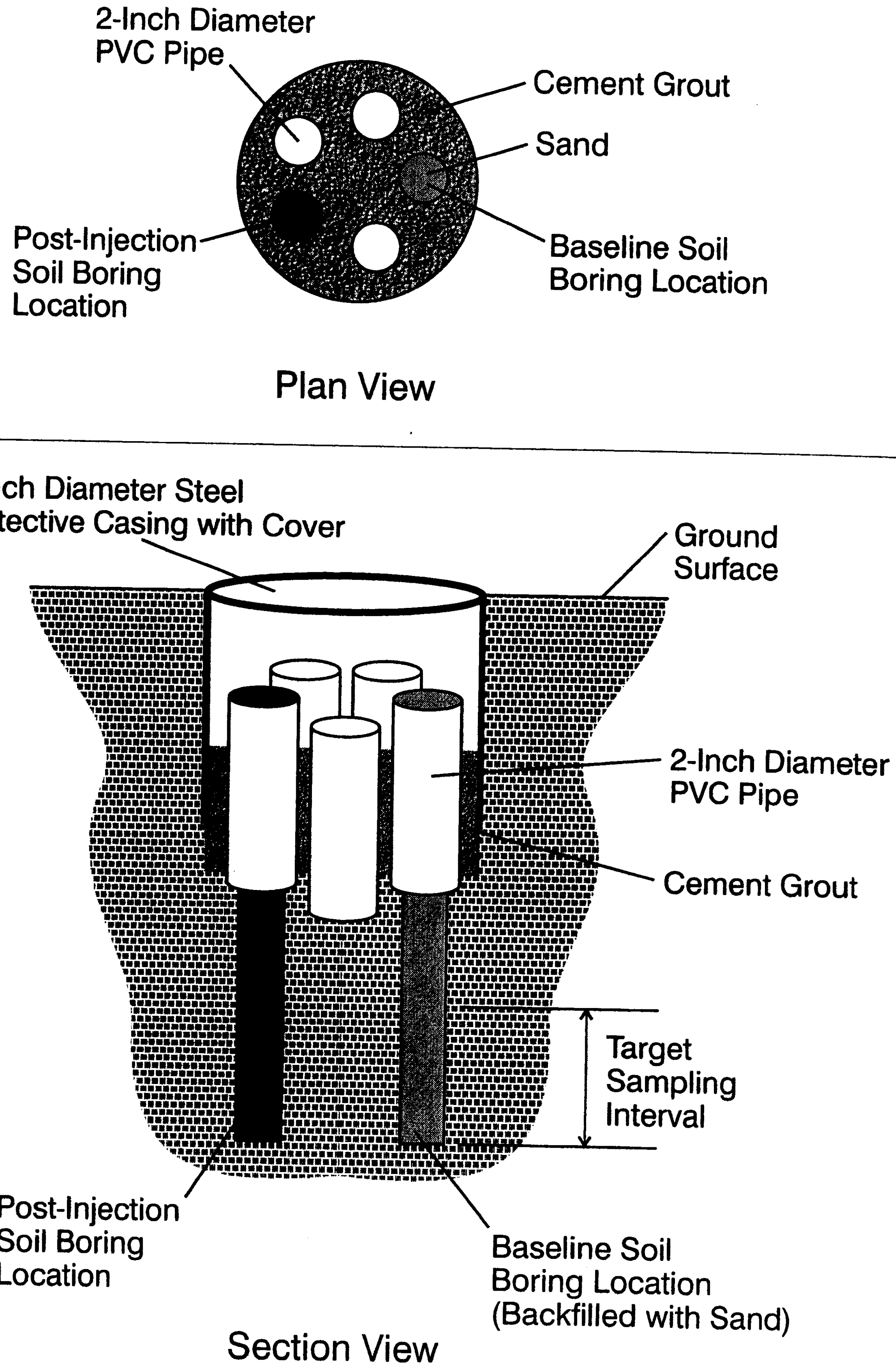


URS CONSULTANTS, INC.

APPROXIMATE AREA OF SOIL EXCEEDING NYSDEC CLEANUP GUIDELINES

FIGURE 2-2



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MULTIPLE SOIL
SAMPLING POINT CONFIGURATION

AG18966-11174037-030405-GCM