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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

NOV 25 1992

REPLY TO THE ATTENTION OF:

Waste Management
of Wisconsin, Inc.
c/o Ms. Lisa S. Seglin
Environmental Counsel
3003 Butterfield Road
Oak Brook, IL 60521

RE: Hagen Farm Superfund Site,
Groundwater Control Operable Unit
Unilateral Administrative Order
Remedial Design/Remedial Action

Dear Ms. Seglin:

Enclosed please find a Unilateral Administrative Order issued by the U.S. Environmental Protection Agency under Section 106 of the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1886 (CERCLA), 42 U.S.C. § 9601, et seq.

Please note that the order allows an opportunity for a conference if requested within ten (10) calendar days after issuance of the Order; and specifies a date and location for the conference, if requested.

If you have any questions regarding the Order, feel free to contact Jeff Cahn, Office of Regional Counsel, at (312) 886-6670.

Sincerely yours,

Wm. E. Muno

William E. Muno. Acting Director
Waste Management Division

Enclosure

cc: Paul Kozol
Wisconsin Department of Natural Resources

Printed on Recycled Paper

bcc: Jim Mayka
Mary Pat Tyson
Jeffrey A. Cahn, ORC
Steven Padovani
Sue Pastor, Public Affairs
Ernie Watkins, Office of Waste Programs Enforcement

CERTIFICATE OF SERVICE

I, Jeffrey A. Cahn, hereby certify that I caused copies of the accompanying "Unilateral Administrative Order" entered in Docket No. V-W-92-C-172 to be served via United States Mail, First Class and certified - return receipt requested, postage prepaid, on this 30 day of November, 1992, upon the following:

Ms. Lisa Seglin
Environmental Counsel
Waste Management of Wisconsin, Inc.
3003 Butterfield Road
Oak Brook, Illinois
60521

Jeffrey A. Cahn
Assistant Regional Counsel
Office of the Regional Counsel
United States Environmental
Protection Agency, Region V
77 West Jackson Blvd.
Chicago, Illinois 60604

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION V

IN MATTER OF: HAGEN FARM SUPERFUND SITE DANE COUNTY, WISCONSIN RESPONDENT: WASTE MANAGEMENT OF WISCONSIN, INCORPORATED.	ADMINISTRATIVE ORDER PURSUANT TO SECTION 106 OF THE COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT OF 1980, AS AMENDED V-W-92-C-172

ADMINISTRATIVE ORDER
FOR REMEDIAL DESIGN AND REMEDIAL ACTION

I. INTRODUCTION AND JURISDICTION

1. This Order directs Respondent to perform a remedial design for the remedy described in the Record of Decision for the Hagen Farm site, operable unit No. 2, dated September 30, 1992, and to implement the design by performing a remedial action. The Record of Decision for operable unit No. 2, dated September 30, 1992, is the final Record of Decision for the Hagen Farm site. This Order is issued to Respondent by the United States Environmental Protection Agency ("EPA") under the authority vested in the President of the United States by Section 106(a) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended ("CERCLA"), 42 U.S.C. § 9606(a). This authority was delegated to the Administrator of EPA on January 23, 1987, by Executive Order 12580 (52 Fed. Reg. 2926), and was further delegated to the Regional Administrator on September 13, 1987 by EPA Delegation No. 14-14 and 14-14A, and to the Director, Waste Management Division, Region V, by delegation 14-14B.

II. PARTIES BOUND

2. This Order shall apply to and be binding upon the Respondent identified in paragraph 9 and its successors and assigns. The Respondent is jointly and severally responsible for carrying out all activities required by this Order. No change in the ownership, corporate status, or other control of the Respondent shall alter any of the Respondent's responsibilities under this Order.

3. The Respondent shall provide a copy of this Order to any prospective owners or successors before a controlling interest in Respondent's assets, property rights, or stock are transferred to the prospective owner or successor. Respondent shall provide a copy of this Order to each contractor, sub-contractor, laboratory, or consultant retained to perform any Work under this Order, within five days after the Effective Date of this Order or on the date such services are retained, whichever is later. Respondent shall also provide a copy of this Order to any person acting on behalf of Respondent with respect to the Site or the Work and shall ensure that all contracts and subcontracts entered into hereunder require performance under the contract to be in conformity with the terms and Work required by this Order. With regard to the activities undertaken pursuant to this Order, each contractor and subcontractor shall be deemed to be related by contract to the Respondent within the meaning of Section

107(b)(3) of CERCLA, 42 U.S.C. § 9607(b)(3). Notwithstanding the terms of any contract, the Respondent is responsible for compliance with this Order and for ensuring that its contractors, subcontractors, and agents perform all Work in accordance with this Order.

4. Not later than thirty (30) days prior to any transfer of any interest in any real property included within the Site, Respondent shall submit a true and correct copy of the transfer documents to EPA, and shall identify the transferee by name, principal business address and effective date of the transfer.

III. DEFINITIONS

5. Unless otherwise expressly provided herein, terms used in this Order which are defined in CERCLA or in regulations promulgated under CERCLA shall have the meaning assigned to them in the statute or its implementing regulations. Whenever terms listed below are used in this Order or in the documents attached to this Order or incorporated by reference into this Order, the following definitions shall apply:

a. "CERCLA" shall mean the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, 42 U.S.C. §§ 9601 *et seq*.

b. "Day" shall mean a calendar day unless expressly stated to be a working day. In computing any period of time under this Order, where the last day would fall on a Saturday, Sunday, or Federal holiday, the period shall run until the end of the next working day.

c. "EPA" shall mean the United States Environmental Protection Agency.

d. "WDNR" shall mean the Wisconsin Department of Natural Resources.

e. "National Contingency Plan" or "NCP" shall mean the National Contingency Plan promulgated pursuant to Section 105 of CERCLA, 42 U.S.C. § 9605, codified at 40 C.F.R. Part 300, and any amendments thereto.

f. "Paragraph" shall mean a portion of this Order identified by an Arabic numeral.

g. "Performance Standards" shall mean those cleanup standards, standards of control, and other substantive requirements, criteria or limitations, identified in the Record of Decision and Statement of Work, that the Remedial Action and Work required by this Order must attain and maintain.

h. "Record of Decision" or "ROD" shall mean the EPA Record of Decision relating to the Site, Operable Unit No. 2, signed on September 30, 1992, by the Regional Administrator, EPA Region V, and all attachments thereto, which is attached hereto and made a part hereof as Attachment 1.

i. "Statement of Work" or "SOW" shall mean the statement of work for implementation of the Remedial Design, Remedial Action, and Operation and Maintenance at the Site, as set forth in Attachment 2 to this Order. The Statement of Work is incorporated into this Order and is an enforceable part of this Order.

j. "Section" shall mean a portion of this Order identified by a Roman numeral and includes one or more paragraphs.

k. "Section 106 Administrative Record" shall mean the Administrative Record which includes all documents considered or relied upon by EPA in preparation of this Order. The Section 106 Administrative Record Index is a listing of all documents included in the Section 106 Administrative Record, and is attached hereto as Appendix 1.

l. "Site" shall mean the Hagen Farm Superfund Site, encompassing approximately 28 acres, located at 2318 County Highway A, approximately one mile east of the City of Stoughton

in Dane County, Wisconsin, as described in the Record of Decision, and includes, but is not limited to, all property which has been contaminated as a result of a release from the Facility.

m. "State" shall mean the State of Wisconsin.

n. "United States" shall mean the United States of America.

o. "Work" shall mean all activities Respondent is required to perform under this Order to implement the ROD for Operable Unit No. 2, including Remedial Design, Remedial Action and Operation and Maintenance for Operable Unit No. 2 and any other related activities required to be undertaken pursuant to this Order.

IV. DETERMINATIONS

6. The Hagen Farm Site is located at 2318 County Highway A, Dane County, Wisconsin. The Hagen Farm Site consists of a total of approximately 28 acres in an area of rural surrounding that is dominated largely by sand and gravel mining and agriculture. Soil and gravel mining operations are located northwest, northeast and south of the landfill site. The Stoughton Airfield is located adjacent to the northwest corner of the landfill site. County Highway "A" passes just south of the landfill site. The

landfill site was operated as a sand and gravel pit prior to the late 1950s. The gravel pit then was used for disposal of waste material from the late 1950s to the mid-1960s. The landfill operator accepted municipal wastes, waste solvents, and other various organic materials including acetone, butyl acetate, 1-2-dichloroethylene, tetrahydrofuran, solid vinyl, sludge material containing methylethyl ketone and xylenes, and toluene. In a 103(c) notification submitted to the U.S. EPA by Uniroyal, Inc., in June 1981, Uniroyal indicated that F003 and F005 wastes, which are hazardous wastes within the meaning of the Resource Conservation and Recovery Act ("RCRA"), 42 U.S.C. 6901, also were disposed of at the landfill.

7. During the period that the landfill was operated as a disposal facility, the property was owned by Nora Sundby, who is now deceased. The landfill was operated by City Disposal Corporation ("City Disposal"), a predecessor corporation of Respondent, Waste Management of Wisconsin, Inc. ("WMWI"). City Disposal also was the transporter of much of the waste that was disposed of at the landfill. On November 30, 1977, the landfill site property was conveyed by the estate of Ms. Sundby to Orrin N. and Ida Mae Hagen.

8. Beginning in November 1980, in response to complaints received from local residents, the WDNR began conducting groundwater sampling at nearby private water supply wells.

Sampling of the on-Site monitoring wells during the period 1980-1986 indicated certain organic compounds were present in the groundwater, including benzene, ethylbenzene, tetrahydrofuran, xylenes, and toluene. In addition, nearby private water supplies on adjacent properties have also shown detectable levels of volatile organic compounds (VOCs). The private wells located on the Site had been impacted by acetone, tetrahydrofuran, vinyl chloride, xylene, trans 1,2-dichloroethene, and trichloroethylene.

9. On February 24, 1987, Orrin Hagen conveyed ownership of the landfill site property to Respondent. Respondent, Waste Management of Wisconsin, Inc., is now, and has been since on or about February 27, 1987, the owner of the landfill site property.

10. On February 23, 1987, U.S. EPA, pursuant to Section 122 of CERCLA, 42 U.S.C. § 9622, notified Waste Management of Wisconsin, Inc., that it had determined that it was a potentially responsible party for the release or threatened release of hazardous substances at the Hagen Farm Site. WMWI was offered the opportunity to conduct a Remedial Investigation and Feasibility Study ("RI/FS").

11. On July 22, 1987, (52 Fed. Reg. 27620), pursuant to section 105 of CERCLA, 42 U.S.C. § 9605, EPA placed the Hagen Farm Site

on the National Priorities List ("NPL"), set forth at 40 C.F.R. Part 300, Appendix B.

12. Subsequently, WMWI and Uniroyal, Inc., entered into an Administrative Order by Consent (U.S. EPA Docket No. VW 87-C-016, dated September 14, 1987) (the "Consent Order") with the U.S. EPA and the WDNR. In the Consent Order, WMWI and Uniroyal agreed to conduct the RI/FS at the Site. Accordingly, in July of 1988, upon U.S. EPA approval, in consultation with the WDNR, of the required Work Plans, fieldwork at the Site commenced.

13. Two operable units, which are being conducted concurrently, have been defined for the Site. Operable Unit No. 1, which is the Source Control Operable Unit ("SCOU"), addresses waste refuse and sub-surface soils ("Waste/sub-Soils") at disposal area A and two smaller disposal areas, areas B and C, which are all located within the landfill site property. Operable Unit No. 2, which is the Groundwater Control Operable Unit ("GCOU"), addresses the contaminated groundwater at the Site. The Operable Unit approach was agreed upon after discussions among U.S. EPA, WDNR, and the PRPs during the early phase of the implementation of the Work Plan for the RI. This Order addresses Operable Unit No. 2.

14. The Technical Memorandum for the SCOU was completed in early 1989. The RI for the GCOU was initiated in July 1989 and the final RI for GCOU was submitted to U.S. EPA in November 1991.

15. In June of 1990, U.S. EPA provided the FS and the Proposed Plan for the SCOU remedial action to the public. An opportunity for public comments was provided. Comments were to be submitted in writing to the U.S. EPA by August 10, 1990, or orally at the public meeting held in Stoughton, Wisconsin on August 2, 1990. The Respondent was allowed to submit comments on the Proposed Plan for the SCOU during this public comment period.

16. Considering the Proposed Plan for SCOU remedial action and the public comments received, U.S. EPA, with concurrence by the State, selected a source control remedy for remediation of on-site waste and sub-surface soils the Facility. U.S. EPA's decision for Operable Unit No. 1 is summarized in the Record of Decision signed by the U.S. EPA Administrator, Region V, on September 17, 1990. An Explanation of Significant Differences ("ESD") relating to the selected remedy for Operable Unit No. 1 was issued by U.S. EPA in April of 1991. The SCOU ROD and the SCOU ESD are attached as Appendix 2.

17. On October 31, 1990, U.S. EPA issued Special Notice, pursuant to Section 122(e)(1) of CERCLA, to WMWI and Uniroyal, Inc. The purpose of issuance of Special Notice was to initiate a period for negotiating an agreement with U.S. EPA for the cleanup of the Hagen Farm Site. At the outset of the initial negotiation session, WMWI (and Uniroyal, Inc.) unequivocally refused to enter into a civil Consent Decree to settle issues relating to the

Hagen Farm Site, but stated that they would perform cleanup activities pursuant to the terms of a unilateral Administrative Order. Accordingly, on March 7, 1991, U.S. EPA issued a unilateral Administrative Order, pursuant to Section 106 of CERCLA, ordering WMWI and Uniroyal, Inc., to undertake SCOU cleanup activities at the Hagen Farm Site.

18. Pursuant to the terms of the ROD and ESD for Operable Unit No. 1, and the March 7, 1991, Administrative Order, sub-areas B and C were consolidated into the disposal area A and the construction of the Landfill Cover over the main disposal area A, which is one of the components of the selected remedy for Operable Unit No. 1, was completed in May 1992. The implementation of In-Situ Vapor Extraction, which is also part of the selected remedy for Operable Unit No. 1, was initiated in May 1992.

19. The RI for the GCOU was initiated by WMWI in July 1989 and the final RI report was submitted in November 1991. An Alternatives Array was prepared in July 1991, which provided a preliminary description of the technical methods under consideration for cleaning up the groundwater. Based on the evaluation and screening of technical methods available for addressing the groundwater contamination in the Alternatives Array, a draft Feasibility Study ("FS") report was submitted in October 1991. The draft FS was revised in order to include off-

property contaminated groundwater in January 1992, and finalized in April 1992. The FS Report for Operable Unit No. 2 outlined the final alternatives under consideration for correcting contamination problems found in the groundwater, and provided a thorough evaluation of each alternative.

20. Pursuant to section 117 of CERCLA, 42 U.S.C. § 9617, EPA published notice of the completion of the FS and of the proposed plan for remedial action in May of 1992, and provided opportunity for public comment on the proposed remedial action. Similarly, Respondent was given an opportunity to comment on the proposed plan for remedial action and to supplement the Administrative Record regarding a decision for selection of the final plan for remedial action.

21. The decision by EPA on the remedial action to be implemented at the Hagen Farm Site, Operable Unit No. 2, is embodied in a Record of Decision ("ROD"), executed on September 30, 1992, on which the State has given its concurrence. Operable Unit No. 2 (the Groundwater Control Operable Unit), addresses the contaminated on- and off-property groundwater at the Site. The ROD defines "on-property groundwater" as contaminated groundwater on and in the immediate vicinity of the main waste disposal area and "off-property groundwater" as contaminated groundwater at any location within the plume other than in the area defined as on-property groundwater. The ROD is an enforceable part of this

Order and is attached hereto as Attachment 1. The ROD is supported by an Administrative Record which contains the documents and information upon which EPA based the selection of the response action. The U.S. EPA's selected response action set out in the ROD has been determined to provide adequate protection of public health, welfare and the environment; meet all Federal and State environmental laws; and be cost effective. The Operable Unit No. 2 ROD, together with the Operable Unit No. 1 ROD, constitutes the final remedy for the Hagen Farm Site.

22. Groundwater contamination at the Hagen Farm Site poses a current and potential future threat to public health and the environment by chemicals in the groundwater originating at, or migrating from the Facility. Groundwater contamination is the result of on-Site waste disposal. Wastes disposed of at the Facility included waste solvents and other various organic materials including acetone, butyl acetate, 1-2-dichloroethylene, tetrahydrofuran, solid vinyl, sludge material containing methyl ethyl ketone and xylenes, and toluene. Contamination from the wastes disposed of at the Facility subsequently migrated into the groundwater.

23. Sampling of the on-Site monitoring wells during the period 1980-1986 indicated certain organic compounds are present in the groundwater, including benzene, ethylbenzene, tetrahydrofuran ("THF"), xylenes, and toluene. In addition, nearby private water

supplies on adjacent properties also contained detectable levels of volatile organic compounds ("VOCs"). The private wells located on adjacent properties had been impacted by acetone, THF, vinyl chloride, xylene, trans-1,2-dichloroethene, and trichloroethylene. The private wells located at the Site were abandoned in accordance with NR 112 and are no longer in use. Presently, no one is drinking contaminated groundwater associated with the Site.

24. In November 1991, an RI Report for the GCOU was completed under the guidance and oversight of U.S. EPA and WDNR. The RI supplied information supporting the conclusion that there is a release of hazardous substances at the Site and provided a determination of the hazardous substances' nature and extent. The RI indicated that the contaminants causing the most concern are VOCs. In general, there are high VOC concentrations in groundwater in and near the Facility. Relatively lower concentrations of VOCs (primarily THF) were detected downgradient of the Site. A THF plume originates from the south section of the Facility and extends downgradient (south) approximately 3600 feet. Elevated levels of VOCs detected in wells near the Facility include THF (630,000 ppb), ethylbenzene (4,400 ppb), toluene (2,700 ppb), and xylenes (37,000 ppb). These levels exceed MCLs and/or State Preventative Action Limits ("PALs") by orders of magnitude.

25. Groundwater contamination at the Site is primarily due to leaching of contaminants from the waste mass and the vadose zone under the waste mass to the groundwater via infiltration of precipitation. The first phase of the cleanup plan at the Hagen Farm Site, referred to as the Source Control Operable Unit, involved capping the landfill and operating an in-situ vapor extraction ("ISVE") unit. The landfill cap is expected to be effective in preventing the leaching of contaminants into the groundwater by preventing the infiltration of precipitation and the ISVE system is a system designed to remove contaminants in the waste mass and vadose zone. VOCs have yet to be detected in private wells determined to be potential receptors. However, at least two private wells appear to be within 500 feet downgradient of the leading edge of the plume. In general, three private wells are located approximately 1000 feet west of the Site and eight private wells are located within 4000 feet downgradient from the Site.

26. Populations at risk include current and future residents using private wells which have been impacted by contaminated groundwater from the Hagen Farm Site. Routes of exposure include ingestion of groundwater and inhalation of volatiles from showering with groundwater. A risk assessment conducted during the RI for Operable Unit No. 2 indicated that the highest risk is from the future ingestion of on-property groundwater, assuming that residential housing would be developed around the Facility.

Under this scenario a carcinogenic risk of 2×10^{-3} and a hazard index ratio of 6,000 were calculated. U.S. EPA considers these risks unacceptable. Drinking groundwater from wells on the property next to the Facility could result in a significant increase in an individual's risk of developing cancer and/or could result in non-cancerous health effects, such as organ impairment due to the toxicity of the contaminants.

27. As provided in CERCLA and the NCP, and based upon the evaluation of the RI/FS and the nine criteria, U.S. EPA, in consultation with the WDNR, selected groundwater extraction and treatment, with discharge of the treated groundwater to either an adjacent wetland or the Yahara River as the groundwater control remedial action at the Hagen Farm Site. The main elements of the groundwater control remedial action as selected in the ROD are as follows: (1) Monitoring of all private wells located around the Site; (2) pre-treatment of extracted on- and off-property groundwater; (3) extraction and treatment of groundwater; (4) treatment of on-property groundwater using Activated Sludge Biological Treatment; (5) treatment of off-property groundwater using a treatment technology to be determined during the design phase; (6) discharge of treated groundwater to adjacent wetlands or the Yahara River; (7) treatment and disposal of sludges generated from the groundwater treatment and treatment of off-gas emitted from the treatment process; (8) deed and access restrictions to prevent installation of drinking water wells

within the vicinity of the disposal areas and off-property; and (9) implementation of a bench scale study to determine the effect of nutrients and/or oxygen on contaminated groundwater. If the bench scale study shows positive results, a pilot study shall be conducted with the ultimate goal of enhancing the selected remedy with an in-situ groundwater bioremediation.

28. The selected remedy will provide adequate protection of human health and the environment. Risks posed by groundwater contamination will be reduced and controlled by the operation of a groundwater extraction and treatment system. Access restrictions will prevent direct contact with contaminated groundwater until groundwater cleanup standards are met. No unacceptable short-term risks will be caused by implementation of the remedy. Standard safety programs, such as fencing, use of protective equipment, monitoring, and off-gas treatment, should mitigate any short-term risks.

29. The Hagen Farm Site is a "facility" as defined in section 101(9) of CERCLA, 42 U.S.C. § 9601(9).

30. Respondent is a "person" as defined in section 101(21) of CERCLA, 42 U.S.C. § 9601(21).

31. Respondent is a liable party as defined in section 107(a) of CERCLA, 42 U.S.C. § 9607(a), and is subject to this Order under section 106(a) of CERCLA, 42 U.S.C. § 9606(a).

32. "Hazardous substances" as defined in section 101(14) of CERCLA, 42 U.S.C. § 9601(14) are present at the Site.

33. These hazardous substances are being "released" from the Facility as that term is defined in section 101(22) of CERCLA, 42 U.S.C. § 9601(22).

34. The past disposal and migration of hazardous substances from the Facility constitutes a "release". The potential for future migration of hazardous substances from the Site poses a threat of a "release" as defined in section 101(22) of CERCLA, 42 U.S.C. § 9601(22).

35. The release of one or more hazardous substances from the Facility is or may be presenting an imminent and substantial endangerment to the public health or welfare or the environment.

V. NOTICE TO THE STATE

36. Prior to issuing this Order, EPA notified the State of Wisconsin's Department of Natural Resources, that EPA intended to issue this Order. EPA will consult with the State and the State

will have the opportunity to review and comment to EPA regarding all work to be performed, deliverables, and any other issues which arise while the Order remains in effect.

VI. ORDER

37. Based on the foregoing, Respondent is hereby ordered to comply with all of the provisions of this Order, including but not limited to all Attachments to this Order, all documents incorporated by reference into this Order, and all schedules and deadlines contained in this Order, attached to this Order, or incorporated by reference into this Order.

VII. WORK TO BE PERFORMED

38. Within five (5) days after the effective date of this Order, Respondent shall record Notice of and/or a copy of this Order in the appropriate governmental office where land ownership and transfer records are filed or recorded, and shall ensure that the recording of said notice and/or Order is indexed to the title of each and every parcel of property owned by said Respondent at the Site, so as to provide notice to third parties of the issuance and terms of this Order with respect to those properties. Respondent shall, within 15 days after the effective date of this Order, send notice of such recording and indexing to EPA.

39. All materials removed from the Site shall be disposed of or treated at a facility approved in advance of removal by EPA's RPM and in accordance with Section 121(d)(3) of CERCLA, 42 U.S.C. § 9621(d)(3); with the U.S. EPA "Revised Off-Site Policy," OSWER Directive 9834.11, November 13, 1987; and with all other applicable Federal, State, and local requirements. Prior to any off-site shipment of hazardous substances from the Site to an out-of-state waste management facility, Respondent shall provide written notification to the appropriate state environmental official in the receiving state and to EPA's Remedial Project Manager ("RPM") of such shipment of hazardous substances. However, the notification of shipments to the state shall not apply to any off-Site shipments when the total volume of all shipments from the Site to the state will not exceed ten (10) cubic yards.

a. The notification shall be in writing, and shall include the following information, where available: (1) the name and location of the facility to which the hazardous substances are to be shipped; (2) the type and quantity of the hazardous substances to be shipped; (3) the expected schedule for the shipment of the hazardous substances; and (4) the method of transportation. Respondent shall notify the receiving state of major changes in the shipment plan, such as a decision to ship the hazardous substances to another facility within the same state, or to a facility in another state.

b. All hazardous substances removed from the Facility or vicinity shall be disposed of or treated at a Facility approved by EPA's RPM, and in compliance with the Resource Conservation and Recovery Act of 1976, 42 U.S.C. Section 9601, et seq., as amended; the EPA Revised Off-Site Policy; and all other applicable Federal, State, and local requirements. The identity of the receiving facility and state will be determined by Respondent following the award of the contract for Remedial Action construction. Respondent shall provide all relevant information, including information under the categories noted in paragraph 44(a) above, on the off-Site shipments as soon as practicable after the award of the contract and before the hazardous substances are actually shipped.

40. Respondent shall cooperate with EPA in providing information regarding the work to the public. When requested by EPA, Respondent shall participate in the preparation of such information for distribution to the public and in public meetings which may be held or sponsored by EPA to explain activities at or relating to the Site.

41. All Workplans and deliverables thereunder, as described throughout this Order, shall be submitted to WDNR and U.S. EPA. All Workplans and deliverables will be reviewed and either approved, approved with modifications, or disapproved by EPA, in consultation with WDNR. In the event of approval or approval

with modifications by EPA, Respondent shall proceed to take any action required by the plan, report, or other item, as approved or modified by EPA. If the Workplan or other deliverable is approved with modifications or disapproved, EPA will provide, in writing, comments or modifications required for approval. Respondent shall amend the Workplan or other deliverable to incorporate only those comments or modifications required by U.S. EPA. Within thirty (30) days after the date of EPA's written notification of approval with modifications or disapproval, Respondent shall submit an Amended Workplan or other deliverable. EPA shall review the Amended Workplan or deliverable and either approve or disapprove it. Failure to submit a Workplan, Amended Workplan or other deliverable shall constitute noncompliance with this Order. Submission of an Amended Workplan or other deliverable which fails to incorporate all of EPA's required modifications, or which includes other unrequested modifications, shall also constitute noncompliance with this Order. Approval by EPA of the (Amended) Workplan or other deliverable shall cause said approved (Amended) Workplan or other deliverable to be incorporated herein as an enforceable part of this Order. If any (Amended) Workplan or other deliverable is not approved by EPA, Respondent shall be deemed to be in violation of this Order.

A. Remedial Design

42. Within sixty (60) days after the effective date of this Order, Respondent shall submit a workplan for the remedial design at the Site ("Remedial Design Workplan" or "RD Workplan") to EPA

for review and approval. The RD Workplan shall include a detailed step-by-step plan for completing the remedial design for the remedy selected in the ROD, and for attaining and maintaining all requirements and performance standards identified in the ROD and Statement of Work. The RD Workplan must describe in detail the tasks and deliverables Respondent will complete during the remedial design phase, and a schedule for completing the tasks and deliverables in the RD Workplan. The RD Workplan shall be consistent with, and shall provide for implementing the Statement of Work, and shall comport with EPA's "Superfund Remedial Design and Remedial Action Guidance, OSWER Directive 9355.0-4A."

43. Upon approval of the (Amended) RD Workplan by U.S. EPA, Respondent shall implement the (Amended) RD Workplan and submit all design deliverables according to the schedule in the approved (Amended) RD Workplan. Any noncompliance with the approved (Amended) RD Workplan shall be a violation of this Order.

44. Upon EPA approval, the final design is incorporated into this Order as an enforceable part of this Order.

B. Remedial Action

45. As part of the final design, Respondent shall submit a Remedial Action Workplan ("RA Workplan") for review and approval. The RA Workplan shall be developed in accordance with the ROD, and the attached Statement of Work, and shall be consistent with the final design as approved by EPA.

46. Upon approval of the (Amended) RA Workplan by EPA, Respondent shall implement the (Amended) RA Workplan according to the schedules in the (Amended) RA Workplan. Unless otherwise directed by EPA, Respondent shall not commence remedial action at the Site prior to approval of the (Amended) RA Workplan. Any noncompliance with the approved (Amended) RA Workplan shall be a violation of this Order.

47. Notwithstanding any action by EPA or the State, Respondent shall remain fully responsible for achievement of the performance standards in the Record of Decision and Statement of Work. Nothing in this Order, or in EPA's approval of any (amended) work plan or other deliverable, shall be deemed to constitute a warranty or representation of any kind by EPA that full performance of the Remedial Design or Remedial Action will achieve the performance standards set forth in the ROD and in the Statement of Work. Respondent's compliance with such approved documents does not foreclose EPA from seeking additional work to achieve the applicable performance standards.

VIII. ADDITIONAL RESPONSE ACTIONS

48. In the event that EPA, in its sole discretion, determines that additional work or modifications to work are necessary to meet applicable performance standards, or that modifications to work are necessary to maintain consistency with the final remedy,

EPA will notify Respondent that additional response actions are necessary. EPA may also require Respondent to modify any plan, design, or other deliverable required by this Order, including any approved modifications.

49. Within sixty (60) days after receipt of notice from EPA that additional response activities are necessary, Respondent shall submit for approval an Additional RD/RA Workplan pursuant to paragraph 34 herein. The Additional RD/RA Workplan shall conform to this Order's applicable requirements for RD and RA Workplans. Upon EPA's approval of the (Amended) Additional RD/RA Workplan, the (Amended) Additional RD/RA Workplan shall become an enforceable part of this Order, and Respondent shall implement the (Amended) Additional RD/RA Workplan for additional response activities in accordance with the standards, specifications, and schedule contained therein. Failure to submit an Additional Workplan shall constitute noncompliance with this Order.

50. Within thirty (30) days after Respondent concludes that the Remedial Action has been fully performed, Respondent shall so notify EPA and shall schedule and conduct a pre-certification inspection to be attended by Respondent and EPA. The pre-certification inspection shall be followed by a written report submitted within thirty (30) days after the inspection by a registered professional engineer and Respondent's Project Coordinator certifying that the Remedial Action has been

completed in full satisfaction of the requirements of this Order. If, after completion of the pre-certification inspection and receipt and review of the written report, EPA determines that the Remedial Action or any portion thereof has not been completed in accordance with this Order, EPA shall notify Respondent in writing of the activities that must be undertaken to complete the Remedial Action and shall set forth in the notice a schedule for performance of such activities. Respondent shall perform all activities described in the notice in accordance with the specifications and schedules established therein. If EPA concludes, following the initial or any subsequent certification of completion by Respondent that the Remedial Action has been fully performed in accordance with this Order, EPA may notify Respondent that the Remedial Action has been fully performed. EPA's notification shall be based on present knowledge and Respondent's certification to EPA, and shall not limit EPA's right to perform periodic reviews pursuant to section 121(c) of CERCLA, 42 U.S.C. § 9621(c), or to take or require any action that in the judgment of EPA is appropriate at the Site, in accordance with 42 U.S.C. §§ 9604, 9606, or 9607.

IX. EPA PERIODIC REVIEW

51. Under section 121(c) of CERCLA, 42 U.S.C. § 9621(c), and any applicable regulations, EPA may review the Site to assure that the work performed pursuant to this Order adequately protects

human health and the environment. Until such time as EPA certifies completion of the work, Respondent shall conduct the requisite studies, investigations, or other response actions as determined necessary by EPA in order to permit EPA to conduct the review under section 121(c) of CERCLA. As a result of any review performed under this paragraph, Respondent may be required to perform additional Work or to modify work previously performed.

X. ENDANGERMENT AND EMERGENCY RESPONSE

52. In the event of any event during the performance of the work which causes or threatens to cause a release of a hazardous substance or which may present an immediate threat to public health or welfare or the environment, Respondent shall immediately take all appropriate action to prevent, abate, or minimize the threat, and shall immediately notify EPA's RPM or alternate RPM. If neither of these persons is available Respondent shall notify the EPA Emergency Response Section, Region V. Respondent shall take further action in consultation with EPA's RPM and in accordance with all applicable provisions of this Order, including but not limited to the Health and Safety Plan and the Contingency Plan. In the event that Respondent fails to take appropriate response action as required by this paragraph, and EPA takes that action instead, Respondent shall reimburse EPA for all costs of the response action not inconsistent with the NCP. Respondent shall pay the response

costs in the manner described in Section XX of this Order, within thirty (30) days after EPA's demand for payment.

53. Nothing in the preceding paragraph shall be deemed to limit any authority of the United States to take, direct, or order all appropriate action to protect human health and the environment or to prevent, abate, or minimize an actual or threatened release of hazardous substances on, at, or from the Site.

XI. PROGRESS REPORTS

54. In addition to the other deliverables set forth in this Order, Respondent shall provide monthly progress reports to EPA with respect to actions and activities undertaken pursuant to this Order. The progress reports shall be submitted on or before the tenth day of each month following the effective date of this Order. Respondent's obligation to submit progress reports continues until EPA gives Respondent written notice under paragraph 92 of this Order. At a minimum these progress reports shall: (1) describe the actions which have been taken to comply with this Order during the prior month; (2) include all results of sampling and tests and all other data received by Respondent and not previously submitted to EPA; (3) describe all work planned for the next 90-days with schedules relating such work to the overall project schedule for RD/RA completion; and (4) describe all problems encountered and any anticipated problems,

any actual or anticipated delays, and solutions developed and implemented to address any actual or anticipated problems or delays.

XII. QUALITY ASSURANCE, SAMPLING AND DATA ANALYSIS

55. Respondent shall use the quality assurance, quality control, and chain of custody procedures described in the "EPA NEIC Policies and Procedures Manual," May 1978, revised May 1986, EPA-330/9-78-001-R; EPA's "Guidelines and Specifications for Preparing Quality Assurance Program Documentation," June 1, 1987; EPA's "Data Quality Objective Guidance," (EPA/540/G87/003 and 004), and any amendments to these documents, while conducting all sample collection and analysis activities required herein by any plan. To provide quality assurance and maintain quality control, Respondent shall:

a. Prior to the commencement of any sampling and analysis under this Order, Respondent shall submit a Quality Assurance Project Plan ("QAPP") to the U.S. EPA that is consistent with the SOW, the Amended Workplan, and EPA's "Interim Guidelines and Specifications For Preparing Quality Assurance Project Plans" (QAM-005/80) and any subsequent amendments.

b. Prior to the development and submittal of a QAPP, Respondent shall attend a pre-QAPP meeting sponsored by EPA to identify all monitoring and data quality objectives. U.S. EPA, after review of the submitted QAPP, will either approve, conditionally approve, or disapprove the QAPP. Upon notification of conditional or disapproval, Respondent shall make all required modifications to the QAPP within twenty-one (21) days of receipt of such notification.

c. Use only laboratories which have a documented Quality Assurance Program that complies with EPA guidance document QAMS-005/80 and subsequent amendments.

d. Ensure that the laboratory used by the Respondent for analyses, performs according to a method or methods deemed satisfactory to EPA and submits all protocols to be used for analyses to EPA at least 30 days before beginning analysis.

e. Ensure that EPA personnel and EPA's authorized representatives are allowed access to the laboratory and personnel utilized by the Respondent for analyses.

56. Respondent shall notify EPA not less than fourteen (14) days in advance of any sample collection activity. At the request of EPA, Respondent shall allow split or duplicate samples to be taken by EPA or its authorized representatives, of any samples

collected by Respondent with regard to the Site or pursuant to the implementation of this Order. In addition, EPA shall have the right to take any additional samples that EPA deems necessary.

XIII. COMPLIANCE WITH APPLICABLE LAWS

57. All activities by Respondent pursuant to this Order shall be performed in accordance with the requirements of all Federal and State laws and regulations. EPA has determined that the activities contemplated by this Order are consistent with the National Contingency Plan ("NCP").

58. Except as provided in section 121(e) of CERCLA and the NCP, no permit shall be required for any portion of the Work conducted entirely on-Site. Where any portion of the Work requires a Federal or State permit, Respondent shall submit timely applications and take all other actions necessary to obtain and to comply with all such permits or approvals.

59. This Order is not, and shall not be construed to be, a permit issued pursuant to any Federal or State statute or regulation.

XIV. REMEDIAL PROJECT MANAGER

60. All communications, whether written or oral, from Respondent to EPA shall be directed to EPA's Remedial Project Manager. Respondent shall submit to EPA ten (10) copies of all documents, including plans, reports, and other correspondence, which are developed pursuant to this Order, and shall send these documents by specify certified mail, return receipt requested.

EPA's Remedial Project Manager is:

Steven J. Padovani
Remedial Project Manager
Mail Code HSRW-6J
77 W. Jackson Boulevard
Chicago, Illinois 60604

EPA's Alternate Remedial Project Manager is:

Mary Pat Tyson, Chief
Michigan/Wisconsin Section II
Mail Code HSRW-6J
77 W. Jackson Boulevard
Chicago, Illinois 60604

61. EPA may change its Remedial Project Manager or Alternate Remedial Project Manager. If EPA changes its Remedial Project Manager or Alternate Remedial Project Manager, EPA will inform Respondent in writing of the name, address, and telephone number of the new Remedial Project Manager or Alternate Remedial Project Manager.

62. EPA's RPM and Alternate RPM shall have the authority lawfully vested in a Remedial Project Manager ("RPM") and On-Scene Coordinator ("OSC") by the National Contingency Plan, 40

C.F.R. Part 300. EPA's RPM or Alternate RPM shall have authority, consistent with the National Contingency Plan, to halt any work required by this Order, and to take any necessary response action.

XV. PROJECT COORDINATOR AND CONTRACTORS

63. All aspects of the Work to be performed by Respondent pursuant to this Order shall be under the direction and supervision of a Project Coordinator qualified to undertake and complete the requirements of this Order. The Project Coordinator shall be the RPM's primary point of contact with the Respondent and shall possess sufficient technical expertise regarding all aspects of the Work. Within fifteen (15) days after the effective date of this Order, Respondent shall notify EPA in writing of the name and qualifications of the Project Coordinator, including primary support entities and staff, proposed to be used in carrying out Work under this Order.

64. Within thirty (30) days after EPA approves the RA Workplan, Respondent shall identify a proposed construction contractor and notify EPA in writing of the name, title, and qualifications of the construction contractor proposed to be used in carrying out work under this Order. EPA reserves the right to disapprove the proposed construction contractor. In the event that EPA disapproves the proposed construction contractor, Respondent

shall submit the name, title and qualifications of a new proposed contractor within fifteen (15) days of EPA's disapproval of the contractor previously proposed.

65. Respondent shall submit a copy of the construction contractor solicitation documents to EPA not later than five (5) days after publishing the solicitation documents. Upon EPA's written request, Respondent shall submit complete copies of all bid packages received from all contract bidders when Respondent notifies EPA of the identity of the proposed construction contractor.

66. At least seven (7) days prior to commencing any work at the Site pursuant to this Order, Respondent shall submit to EPA a certification that Respondent or its contractors and subcontractors have adequate insurance coverage or have indemnification for liabilities for injuries or damages to persons or property which may result from the activities to be conducted by or on behalf of Respondent pursuant to this Order. Respondent shall ensure that such insurance or indemnification is maintained for the duration of the Work required by this Order.

67. EPA retains the right to disapprove of the Project Coordinator and any contractor, including but not limited to remedial design contractors and construction contractors retained by the Respondent. In the event EPA disapproves a Project

Coordinator or contractor, Respondent shall retain a new project coordinator or contractor to perform the work, and such selection shall be made within fifteen (15) days following the date of EPA's disapproval. If at any time Respondent propose to use a new project coordinator or contractor, Respondent shall notify EPA of the identity of the new project coordinator or contractor at least fifteen (15) days before the new project coordinator or contractor performs any work under this Order.

XVI. SITE ACCESS AND DOCUMENT AVAILABILITY

68. In the event that the Site, the off-Site area that is to be used for access, property where documents required to be prepared or maintained by this Order are located, or other property subject to or affected by this response action, is owned in whole or in part by parties other than those bound by this Order, Respondent will obtain, or use its best efforts to obtain, site access agreements from the present owner(s) within sixty (60) days after the effective date of this Order. Said agreements shall provide access for EPA, its contractors and oversight officials, the State and its contractors, and Respondent or Respondent's authorized representatives and contractors. Said agreements shall specify that Respondent is not EPA's representative with respect to liability associated with Site activities. Copies of such agreements shall be provided to EPA prior to Respondent's initiation of field activities.

Respondent's best efforts shall include providing reasonable compensation to any off-Site property owner. If access agreements are not obtained within the time referenced above, Respondent shall immediately notify EPA of its failure to obtain access.

69. If Respondent cannot obtain the necessary access agreements, EPA may exercise non-reviewable discretion and; (1) use its legal authorities to obtain access for the Respondent(s); (2) conduct response actions at the property in question; or (3) terminate this Order. If EPA conducts a response action and does not terminate the Order, Respondent shall perform all other activities not requiring access to that property. Respondent shall integrate the results of any such tasks undertaken by EPA into its reports and deliverables. Respondent shall reimburse EPA, pursuant to Section XX of this Order, for all response costs (including attorney fees) incurred by the United States to obtain access for Respondent.

70. Respondent shall allow EPA and its authorized representatives and contractors to enter and freely move about all property at the Site and off-Site areas subject to or affected by the Work under this Order or where documents required to be prepared or maintained by this Order are located, for the purposes of inspecting conditions, activities, the results of activities, records, operating logs, and contracts related to the

Site or Respondent and its representatives or contractors pursuant to this Order; reviewing the progress of the Respondent in carrying out the terms of this Order; conducting tests as EPA or its authorized representatives or contractors deem necessary; using a camera, sound recording device or other documentary type equipment; and verifying the data submitted to EPA by Respondent. Respondent shall allow EPA and its authorized representatives to enter the Site, to inspect and copy all records, files, photographs, documents, sampling and monitoring data, and other writings related to work undertaken in carrying out this Order. Nothing herein shall limit EPA's right of entry or inspection authority under Federal law.

XVII. RECORD PRESERVATION

71. On or before the effective date of this Order, Respondent shall submit a written certification to EPA that they have not altered, mutilated, discarded, destroyed or otherwise disposed of any records, documents or other information relating to their potential liability with regard to the Site since the time of their notification of potential liability by EPA or the State. Respondent shall not dispose of any such documents without prior approval by EPA. Upon EPA's request, Respondent shall make all such documents available to EPA.

72. Respondent shall provide to EPA upon request, copies of all documents and information within their possession or control or that of any of their contractors or agents relating to activities at the Site or to the implementation of this Order, including but not limited to sampling, analysis, chain of custody records, manifests, trucking logs, receipts, reports, sample traffic routing, correspondence, or other documents or information. Respondent shall also make available to EPA for purposes of investigation, information gathering, or testimony, their employees, agents, or representatives with knowledge of relevant facts concerning the performance of the Work.

73. Until ten (10) years after EPA provides notice pursuant to paragraph 92 of this Order, Respondent shall preserve, and shall instruct their contractors and agents to preserve, all documents, records, and information of whatever kind, nature or description relating to the performance of the Work. Upon the conclusion of this document retention period, Respondent shall notify the United States at least ninety (90) days prior to the destruction of any such records, documents or information, and, upon request of the United States, Respondent shall deliver all such documents, records and information to EPA.

74. Respondent may assert a claim of business confidentiality covering part or all of the information submitted to EPA pursuant to the terms of this Order under 40 C.F.R. § 2.203, provided such

claim is not inconsistent with section 104(e)(7) of CERCLA, 42 U.S.C. § 9604(e)(7) or other provisions of law. This claim shall be asserted in the manner described by 40 C.F.R. § 2.203(b) and substantiated by Respondent at the time the claim is made. Information determined to be confidential by EPA will be given the protection specified in 40 C.F.R. Part 2. If no such claim accompanies the information when it is submitted to EPA, it may be made available to the public by EPA or the state without further notice to the Respondent. Respondent shall not assert confidentiality claims with respect to any data or documents related to Site conditions, sampling, or monitoring.

75. Respondent shall maintain, for the period during which this Order is in effect, an index of documents that Respondent claims contain confidential business information. The index shall contain, for each document, the date, author, addressee, and subject of the document. Upon written request from EPA, Respondent shall submit a copy of the index to EPA.

XVIII. DELAY IN PERFORMANCE

76. Any delay in performance of this Order that, in EPA's judgment, is not properly justified by Respondent under the terms of this section shall be considered a violation of this Order. Any delay in performance of this Order shall not affect

Respondent's obligation to fully perform all obligations under the terms and conditions of this Order.

77. Respondent shall notify EPA of any delay or anticipated delay in performing any requirement of this Order. Such notification shall be made by telephone to EPA's RPM or Alternate RPM within forty eight (48) hours after Respondent first knows or should have known that a delay might occur. Respondent shall adopt all reasonable measures to avoid or minimize any such delay. Within seven (7) days after notifying EPA by telephone, Respondent shall provide written notification fully describing the nature of the delay, any justification for delay, any reason why Respondent should not be held strictly accountable for failing to comply with any relevant requirements of this Order, the measures planned and taken to minimize the delay, and a schedule for implementing the measures that will be taken to mitigate the effect of the delay. Increased costs or expenses associated with implementation of the activities called for in this Order is not a justification for any delay in performance.

XIX. ASSURANCE OF ABILITY TO COMPLETE WORK

78. Respondent shall demonstrate its ability to complete the Work required by this Order and to pay all claims that arise from the performance of the Work by obtaining and presenting to EPA within thirty (30) days after approval of the RD Workplan, one of

the following: (1) a performance bond; (2) a letter of credit; (3) a guarantee by a third party; or (4) internal financial information to allow EPA to determine that Respondent has sufficient assets available to perform the Work. Respondent shall demonstrate financial assurance in an amount no less than the estimate of cost for the remedial design and remedial action contained in the Record of Decision for the Site. If Respondent seeks to demonstrate ability to complete the remedial action by means of internal financial information, or by guarantee of a third party, they shall re-submit such information annually, on the anniversary of the effective date of this Order. If EPA determines that such financial information is inadequate, Respondent shall, within thirty (30) days after receipt of EPA's notice of determination, obtain and present to EPA for approval one of the other three forms of financial assurance listed above.

XX. REIMBURSEMENT OF RESPONSE COSTS

79. Respondent shall reimburse EPA, upon written demand, for all response costs incurred by the United States in overseeing Respondent's implementation of the requirements of this Order. EPA may submit to Respondent on a periodic basis an accounting of all oversight response costs incurred by the United States with respect to this Order. EPA's Itemized Cost Summary Reports, or such other summary as may be certified by EPA, shall serve as the basis for payment demands.

80. Respondent shall, within thirty (30) days after receipt of each EPA accounting, remit a certified or cashier's check for the amount of those costs. Interest shall accrue from the later of the date that payment of a specified amount is demanded in writing or the date of the expenditure. The interest rate is the rate established by the Department of the Treasury pursuant to 31 U.S.C. § 3717 and 4 C.F.R. § 102.13.

81. Checks shall be made payable to the "U.S. EPA Hazardous Substances Superfund" and shall include the name of the Site, the Site identification number, the account number and the title of this Order. Checks shall be forwarded to:

U.S. Environmental Protection Agency
Superfund Accounting
P.O. Box 70753
Chicago, Illinois 60604

Respondent shall send copies of each transmittal letter and check to the EPA's RPM.

XXI. UNITED STATES NOT LIABLE

82. The United States and EPA are not to be construed as parties to, and do not assume any liability for, any contract entered into by the Respondent to carry out the activities pursuant to this Order. The proper completion of the Work under this Order is solely the responsibility of the Respondent. The United States and EPA, by issuance of this Order, also assume no liability for any injuries or damages to persons or property

resulting from acts or omissions by Respondent, or its directors, officers, employees, agents, representatives, successors, assigns, contractors, or consultants in carrying out any action or activity required by this Order.

XXII. ENFORCEMENT AND RESERVATIONS

83. EPA reserves the right to bring an action against Respondent under section 107 of CERCLA, 42 U.S.C. § 9607, for recovery of any response costs incurred by the United States related to this Order and not reimbursed by Respondent. This reservation shall include but not be limited to past costs, direct costs, indirect costs, the costs of oversight, the costs of compiling the cost documentation to support oversight cost demand, as well as accrued interest as provided in section 107(a) of CERCLA.

84. Notwithstanding any other provision of this Order, at any time during the response action, EPA may perform its own studies, complete the response action (or any portion of the response action) as provided in CERCLA and the NCP, and seek reimbursement from Respondent for its costs, or seek any other appropriate relief.

85. Nothing in this Order shall preclude EPA from taking any additional enforcement actions, including modification of this Order or issuance of additional Orders, and/or additional

remedial or removal actions as EPA may deem necessary, or from requiring Respondent in the future to perform additional activities pursuant to CERCLA, 42 U.S.C. § 9606(a), et seq., or any other applicable law. This Order shall not affect Respondent's liability under CERCLA section 107(a), 42 U.S.C. § 9607(a), for the costs of any such additional actions.

86. Notwithstanding any provision of this Order, the United States hereby retains all of its information gathering, inspection, and enforcement authorities and rights under CERCLA, RCRA, and any other applicable statutes or regulations.

87. Respondent shall be subject to civil penalties under section 106(b) of CERCLA, 42 U.S.C. § 9606(b), of not more than $25,000 for each day in which Respondent violates, or fails or refuses to comply with this Order without cause. In addition, failure to properly provide response action under this Order, or any portion hereof, without sufficient cause, may result in liability under section 107(c)(3) of CERCLA, 42 U.S.C. § 9607(c)(3), for punitive damages in an amount at least equal to, and not more than three times the amount of any costs incurred by the Fund as a result of such failure to take proper action.

88. Nothing in this Order shall constitute or be construed as a release from any claim, cause of action, or demand in law or

equity against any person for any liability it may have arising out of or relating in any way to the Site.

89. If a court issues an order that invalidates any provision of this Order or finds that Respondent has sufficient cause not to comply with one or more provisions of this Order, Respondent shall remain bound to comply with all provisions of this Order not invalidated by the court's order.

XXIII. ACCESS TO ADMINISTRATIVE RECORD

90. The Section 106 Administrative Record is available for review on normal business days between the hours of 9:00 a.m. and 5:00 p.m. at the U.S. EPA, Region V, 77 West Jackson Boulevard Chicago, Illinois. An Index of the Administrative Record is attached hereto as Appendix 1.

XXIV. NOTICE OF INTENT TO COMPLY

91. On or before the effective date of this Order, Respondent must submit to EPA written notice stating its unequivocal intention to comply with all terms of this Order. Respondent's written notice shall describe, using facts that exist on or prior to the effective date of this Order, any "sufficient cause" defenses asserted by Respondent under sections 106(b) and 107(c)(3) of CERCLA. The absence of a response by EPA to the

notice required by this paragraph shall not be deemed to be acceptance of Respondent's assertions. In the event Respondent fails to provide such written notice, then Respondent shall be deemed to have failed to comply with this Order.

XXV. EFFECTIVE DATE AND TERMINATION

92. This Order shall become effective thirty (30) days after the date of signature.

93. Within thirty (30) days after Respondent concludes that all phases of the Work have been fully performed, that the Performance Standards have been attained, and that all Operation and Maintenance activities have been completed, Respondent shall submit to EPA a written report by a registered professional engineer certifying that the Work has been completed in full satisfaction of the requirements of this Order. EPA shall require such additional activities as may be necessary to complete the Work or EPA may, based upon present knowledge and Respondent's certification to EPA, issue written notification to Respondent that the Work has been completed, as appropriate, in accordance with the procedures set forth in Paragraph 41 for Respondent's certification of completion of the Remedial Action. EPA's notification shall not limit EPA's right to perform periodic reviews pursuant to section 121(c) of CERCLA, 42 U.S.C. § 9621(c), or to take or require any action that in the judgment

of EPA is appropriate at the Site, in accordance with 42 U.S.C. §§ 9604, 9606, or 9607.85. The provisions of this Order shall be deemed to be satisfied when EPA notifies Respondent in writing that Respondent has demonstrated, to U.S. EPA's satisfaction, that all terms of the Order have been completed. This notice shall not, however, terminate Respondent's obligation to comply with paragraph 73 of this Order (relating to record preservation).

XXVI. OPPORTUNITY TO CONFER

94. Respondent may, within ten (10) days after the date this Order is signed, request a conference with the EPA to discuss this Order. If requested, the conference shall occur on December 18, 1992, at 77 West Jackson Boulevard, Chicago, Illinois, 60604.

95. The purpose and scope of the conference shall be limited to issues involving the implementation of the response actions required by this Order and the extent to which Respondent intends to comply with this Order. This conference is not an evidentiary hearing, and does not constitute a proceeding to challenge this Order. It does not give Respondent a right to seek review of this Order, or to seek resolution of potential liability. No record of the conference (e.g. stenographic, tape or other physical record) will be made. At any conference held pursuant to Respondent's request, Respondent may appear in person or by an

attorney or other representative. Requests for a conference must be by telephone followed by written confirmation to EPA's RPM.

So Ordered, this 25th day of November, 1992.

BY: Wm. E. Muno (acting)
Director, Waste Management Division

U.S. Environmental Protection Agency, Region V

ATTACHMENT 1

HAGEN FARM SITE, WI
GROUNDWATER CONTROL OPERABLE UNIT

DECLARATION FOR THE RECORD OF DECISION

Site Name and Location

Hagen Farm Site, Groundwater Control Operable Unit
Dane County, Wisconsin

Statement of Basis and Purpose

This decision document represents the selected remedial action for the Hagen Farm Site (the "Site"), in Dane County, Wisconsin, Groundwater Control Operable Unit, which was chosen in accordance with the Comprehensive Environmental Response Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

This decision is based on the Administrative Record for the Hagen Farm site.

The State of Wisconsin concurs with the selected remedy on the condition that, at the time that the proposed treatment design is finalized, the State determines that the proposed effluent discharge limits and discharge location are acceptable to the State.

Assessment of the Site

Actual or threatened releases of hazardous substances from this Site, if not addressed by implementing the response action selected in this Record of Decision (ROD), may present an imminent and substantial endangerment to public health, welfare, or the environment.

Description of Remedy

This Groundwater Control Operable Unit is the second of two operable units for the Site. For purposes of this ROD, the "Site" is defined as the area within the Hagen Farm property boundary and the contaminant plume. The selected remedial action for this operable unit addresses the groundwater contamination by remediation of contaminated groundwater. For purposes of this ROD, "on-property groundwater" is defined as contaminated groundwater on and in the immediate vicinity of the main waste disposal area and "off-property groundwater" is defined as contaminated groundwater

at any location within the plume other than in the area defined as on-property groundwater.

The major components of the selected remedy include:

* Monitoring of all private wells located around the Site;

* Pre-treatment of extracted on- and off-property groundwater;

* Extraction and treatment of groundwater;

* Treatment of on-property groundwater using Activated Sludge Biological Treatment;

* Treatment of off-property groundwater using a treatment technology to be determined during the design phase;

* Discharge of treated groundwater to wetlands or the Yahara River;

* Treatment and disposal of sludges generated from the groundwater treatment and treatment of off-gas emitted from the treatment process;

* Deed and access restrictions to prevent installation of drinking water wells within the vicinity of the disposal areas and off-property; and

* Implementation of a bench scale study to determine the effect of nutrients and/or oxygen on contaminated groundwater. If the bench scale study shows positive results, a pilot study would be conducted, with the ultimate goal of enhancing the selected remedy with an in-situ groundwater bioremediation system.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State environmental requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost effective. This remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable and satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element.

Because this remedy will result in hazardous substances remaining on-site, a review will be conducted within five years after commencement of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

David A. Ullrich

Valdas V. Adamkus
Regional Administrator

9/30/92
Date

RECORD OF DECISION

DECISION SUMMARY

HAGEN FARM SITE

GROUNDWATER CONTROL OPERABLE UNIT

DANE COUNTY, WISCONSIN

Prepared By:

U.S. Environmental Protection Agency

Region V

Chicago, Illinois

September, 1992

ROD SUMMARY
HAGEN FARM SUPERFUND SITE
GROUNDWATER CONTROL OPERABLE UNIT
DANE COUNTY, WISCONSIN

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ROD SUMMARY
HAGEN FARM SUPERFUND SITE
GROUNDWATER CONTROL OPERABLE UNIT
DANE COUNTY, WISCONSIN

I. SITE LOCATION AND DESCRIPTION

The Hagen Farm Site (the Site) is located at 2318 County Highway A, approximately one mile east of the City of Stoughton, Dane County, Wisconsin. The Site is defined as the area within the Hagen Farm property boundary and the contaminant plume. The property is approximately 28 acres in size and is located in the northeast quarter of the southeast quarter of Section 10, Township 5 North, Range 11 East. Within the property boundary is approximately 10 acres of disposal area. The Site, as a whole, is situated in a rural surrounding that is dominated largely by sand and gravel mining and agriculture. Sand and gravel mining operations are located northwest, northeast, and south of the Site. The Stoughton Airfield is located adjacent to the northwest corner of the Site. County Highway "A" passes just south of the property boundary (See Figure 1).

The City of Stoughton's municipal wells are located approximately two miles to the west. Three private wells are located approximately 1000 feet west of the Site, and eight private wells are located within 4,000 feet downgradient from the Site based on hydrogeology information obtained during investigation at the Site (See Section V below). The private wells located at the Site were abandoned in accordance with NR 112 and are no longer in use. Approximately 350 people reside within one mile of the Site.

The Site is located in the Yahara River watershed, in an area of flat to gently rolling topography. The Yahara River is located approximately 1.3 miles to the west and flows in a southerly direction. The Site does not lie within the 100-year flood plain. The land surface generally slopes toward the Yahara River from topographically high areas located to the northeast and east. Surface-water drainage in the area is generally poorly developed, apparently due to permeable surface soils. The only substantial surface water bodies in the area are Sundby's pond located approximately 1/2 mile south of the Site and the Yahara River. An on-Site ditch is located at the southeast corner of the property which flows to a wetland. This wetland is located directly south of the Site. There is no designated Wisconsin State significant habitat, or historic landmark site directly or potentially affected. No endangered species are known to inhabit the Site.

The Site is located in an area dominated by glacial outwash deposits, which extend approximately one-half mile to the northeast. These deposits are dominated by sand and gravel. Beyond this, ground moraine and occasional drumlins are encountered. Lacustrine deposits associated with Glacial Lake

Figure 1
Site Location Map
Hagen Farm Site
Dunkirk Township, Wisconsin

Prepared by Jacobs Engineering Group Inc. Chicago
for the U.S. Environmental Protection Agency, 7/22/90

Drawn AH
Checked DS

Yahara are located approximately one-eighth of a mile south. Bedrock, primarily sandstone and dolomite, underlie the glacial deposits in this area. Bedrock generally slopes from the west to southwest, toward a preglacial valley associated with the Yahara River. The depth to bedrock ranges from 50 to 80 feet near the Site. Groundwater is present approximately 10 to 40 feet below ground surface near the Site. Groundwater flow is predominantly to the south-southwest, toward the Yahara River, a regional groundwater discharge zone. Estimated groundwater velocities ranged from 1.2 ft/yr to 145 ft/yr.

The current Site topography is the result of sand and gravel mining and waste disposal activities. Prior to these activities, the ground surface probably sloped from the existing topographically high area located west and northwest toward the southeast and east. The excavated area in the northwest corner of the property is flat. This flat area is separated by a ridge from the water-filled depression located to the northeast.

Within the Site's "area of contamination" (AOC), waste disposal took place within three subareas. These subareas are A (6 acres, located in the southern portion of the property), B and C (1.5 acres each, located in the northeastern portion) (See Figure 2). All three subareas reside within the Site's formally defined AOC. Subareas B and C have been consolidated into the disposal area A. Disposal area A has been capped and vegetated. These consolidation and capping activities were conducted as part of the Source Control Operable Unit (see ROD in this matter dated September 17, 1990).

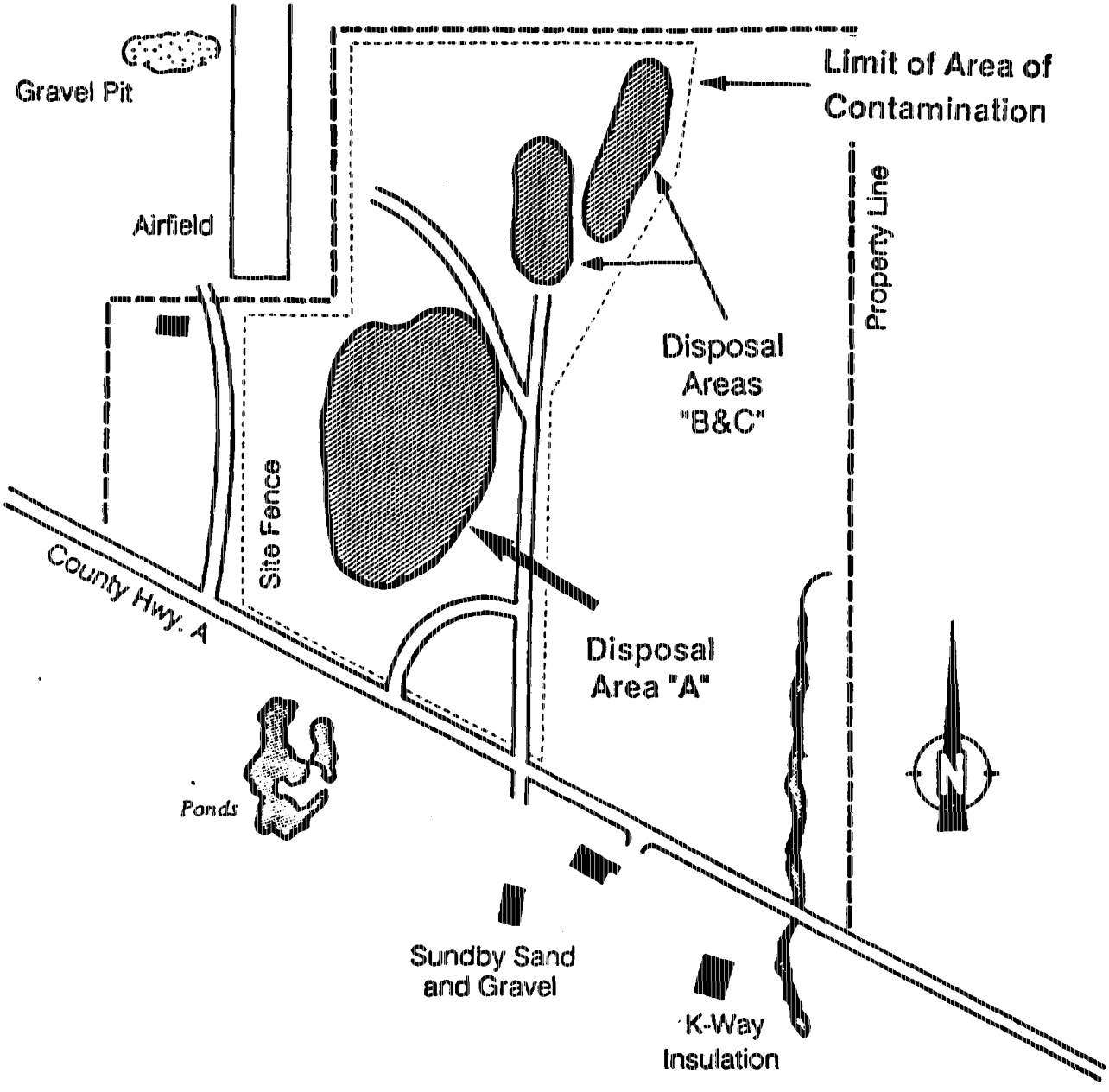
II. SITE HISTORY AND ENFORCEMENT ACTIVITIES

The Site was operated as a sand and gravel pit prior to the late 1950s. Observations suggest gravel operations encompassed an area bounded by the current access road to the east, the former Schroeter property boundary to the west, and the current property boundary to the north (See Figure 2). Mining operations reportedly terminated approximately 14 to 18 feet below ground surface. Excavation may have ceased at this depth due to the presence of groundwater, more fine grained materials, or a change in sand and gravel quality.

The gravel pit was then used for disposal of waste materials from the late 1950s to the mid-1960s. During the period that the Site was operated as a disposal facility, the property was owned by Nora Sundby, since deceased. The property was then purchased from Nora Sundby by Orrin Hagen in November 1977. The Site is currently owned by Waste Management of Wisconsin, Incorporated (WMWI). The Site was operated by City Disposal Corporation. City Disposal Corporation was subsequently purchased by WMWI. City Disposal was also the transporter of much of the waste that was deposited at the Site. It is known

Figure 2
Site Diagram
Hagen Farm Site
Dunkirk Township, Wisconsin

(Not To Scale)



Prepared by Jacobs Engineering Group Inc. Chicago
for the U.S. Environmental Protection Agency, 7/22/90

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that Uniroyal, Incorporated (Uniroyal) generated industrial waste, some of which was deposited at the Site beginning sometime in 1962 and continuing through August 1966.

Waste solvents and other various organic materials, in addition to the municipal wastes, were disposed of at the Site, including acetone, butyl acetate, 1-2-dichloroethylene, tetrahydrofuran, solid vinyl, sludge material containing methyl ethyl ketone and xylenes, and toluene. In a 103(c) Notification submitted to the United States Environmental Protection Agency (U.S. EPA) by Uniroyal, in June 1981, Uniroyal indicated that F003 and F005 wastes (spent non-halogenated solvents), which are hazardous wastes within the meaning of the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6901, also were disposed of at the Site. This site stopped accepting waste in 1966, prior to regulation of hazardous waste disposal by RCRA Subtitle C.

Beginning in November 1980, in response to complaints received from local residents, the Wisconsin Department of Natural Resources (WDNR) began conducting groundwater sampling at nearby private water supply wells. Sampling of the on-Site monitoring wells during the period 1980-1986 indicated certain organic compounds were present in the groundwater, including benzene, ethylbenzene, tetrahydrofuran (THF), xylenes, and toluene.

In addition, nearby private water supplies on adjacent properties also contained detectable levels of volatile organic compounds (VOCs). The private wells located on adjacent properties had been impacted by acetone, THF, vinyl chloride, xylene, trans-1,2-dichlorethene, and trichloroethylene.

In 1983, the State of Wisconsin brought an enforcement action for abatement of a public nuisance against WMWI and Uniroyal. At the same time, nearby residents to the Site brought a civil action against WMWI and Uniroyal, seeking civil damages for reduced property values and potential health hazards resulting from groundwater and well contamination. The State of Wisconsin obtained a dismissal of its 1983 enforcement action against WMWI and Uniroyal after the Site was listed on the National Priorities List (NPL). In 1986, the parties to civil litigation brought by the nearby residents to the Site against WMWI and Uniroyal reached a settlement. The exact terms of the settlement are confidential. It is known, however, that one of the terms of the settlement required WMWI to purchase the Site property from Orrin Hagen, as well as other property located adjacent to the Site. Upon acquiring these properties, WMWI razed the structures constructed thereon.

The Site was proposed for inclusion on the NPL on September 18, 1985. The Site was placed on the NPL in July 1987. Subsequently, WMWI and Uniroyal, the two potentially responsible parties (PRPs) named by U.S. EPA in connection with the Site to

date, entered into an Administrative Order by Consent (U.S. EPA Docket No. VW 87-C-016, dated September 14, 1987) (the Consent Order) with U.S. EPA and WDNR. In the Consent Order, WMWI and Uniroyal agreed to conduct a Remedial Investigation and Feasibility Study (RI/FS) at the Site. Accordingly, in July 1988, upon U.S. EPA approval, in consultation with the WDNR, of the required Work Plans, fieldwork at the Site commenced.

Two operable units (OUs) have been defined for the Site. OU I, which is the Source Control Operable Unit (SCOU), is intended to address waste refuse and sub-surface soils (Waste/sub-Soils) at disposal area A and the two smaller disposal areas B and C. OU II, which is the Groundwater Control Operable Unit (GCOU), is intended to address the contaminated on- and off-property groundwater at the Site. For purposes of this ROD, "on-property groundwater" is defined as contaminated groundwater on and in the immediate vicinity of the main waste disposal area and "off-property groundwater" is defined as contaminated groundwater at any location within the plume other than in the area defined as on-property groundwater. The OU approach was agreed upon after discussions among U.S. EPA, WDNR, and the PRPs during the early phase of the implementation of the Work Plan for the RI. This ROD is developed for the GCOU, which is OU II.

The RI for the SCOU was completed in early 1989, and the ROD was signed on September 17, 1990. An Explanation of Significant Differences was issued in April of 1991. Subareas B and C were consolidated into the disposal area A and the construction of the Landfill Cover over the main disposal area A, which is one of the components of the selected remedy for the SCOU, was completed in May 1992. Prior to the implementation of the Landfill Cover, wastes from areas B and C were consolidated into the main disposal area A. The implementation of In-Situ Vapor Extraction, which is also part of the selected remedy for the SCOU, was initiated in May 1992. The RI for the GCOU was initiated in July 1989 and the final RI report was submitted in November 1991. An Alternative Array was prepared in July 1991, which provided a preliminary description of the technical methods under consideration for cleaning up the groundwater. Based on the evaluation and screening of technical methods available for addressing the groundwater contamination in the Alternative Array, a draft Feasibility Study (FS) report was submitted in October 1991. The draft FS was revised in order to include off-property contaminated groundwater in January 1992, and finalized in April 1992. The FS Report for the GCOU outlines the final alternatives under consideration for correcting contamination problems found in the groundwater, and provides a thorough evaluation of each alternative.

III. COMMUNITY RELATIONS ACTIVITIES

Upon the signing of the Consent Order in July 1987, U.S. EPA held a 30-day public comment period. A press release was sent to all local media and advertisements were placed.

A Community Relations Plan for the Site was finalized in July 1988. This document lists contacts in the government and interested parties throughout the local communities. It also establishes communication pathways to ensure timely dissemination of pertinent information.

An RI "Kickoff" meeting was held on July 14, 1988 to explain the RI process. A fact sheet was developed in conjunction with this meeting. Advertisements were placed in the Madison Capital Times and Stoughton Courier-Hub and a press release was sent to all local media.

A press release was sent to local media on March 27, 1989 to update the community on the progress of Dane County, Wisconsin Superfund sites, including Hagen Farm.

A public meeting was held on July 27, 1989 to explain the findings of the RI and the operable unit approach. A fact sheet was developed in conjunction with this meeting. Advertisements were placed to announce the meeting and a press release was sent to all local media. Prior to the public meeting, U.S. EPA representatives held a separate briefing for Town officials.

A public meeting was held on August 2, 1990, to present the recommended remedy for the SCOU. Advertisements were placed to announce the meeting and a press release was sent to all local media. A public comment period was held from July 11, 1990, to August 10, 1990. All comments received by U.S. EPA during the public comment period and at the public meeting were addressed in the Responsiveness Summary of the SCOU ROD.

A public meeting was held on August 29, 1991, to provide the public with an update on the progress for the SCOU and the GCOU at the Site. A fact sheet was developed in conjunction with this meeting. Advertisements were placed to announce the meeting and a press release was sent to all local media.

The RI/FS and the Proposed Plan for the GCOU were released to the public in May 1992. All of these documents were made available in the information repositories maintained at the Stoughton Public Library and Klongland Realty. An administrative record file containing these documents and other site-related documents was placed at the Stoughton Public Library. The notice of availability of these documents was published in the Stoughton Courier-Hub, Wisconsin State Journal, and Madison Capital Times on May 27, 1992. Press releases were

also sent to all local media. A public comment period was held from June 1, 1992 to July 1, 1992. The request for an extension of the comment period was made and the public comment period was extended until July 31, 1992. In addition, a public meeting was held on June 11, 1992 to present the results of the RI/FS and the preferred alternative as presented in the Proposed Plan for the Site. All comments received by U.S. EPA during the public comment period are addressed in the Responsiveness Summary which is the third section of this ROD.

As sampling results from private wells became available, U.S. EPA wrote letters to the property owners to inform them of these results. These letters were mailed in September 1989 and December 1990.

IV. SCOPE AND ROLE OF RESPONSE ACTION

As discussed in Section II above, U.S. EPA has divided the Site into two operable units. The SCOU addresses waste refuse and sub-surface soils at disposal area A and the two smaller disposal areas B and C. The GCOU, which is the subject of this ROD, is intended to address the contaminated on-and off-property groundwater at the Site.

U.S. EPA identified contaminated on- and off-property groundwater as posing potential risks to human health and the environment. To address these risks, U.S. EPA developed the following remedial objectives for the GCOU based on the data obtained during the RI:

1) Restore groundwater so that contamination levels meet appropriate Federal and State groundwater quality standards;

2) Stop the flow of contaminated groundwater downgradient of the Site and to the Yahara River; and

3) Prevent the flow of contaminated groundwater to residential wells.

This ROD was developed to meet these objectives and it addresses the contamination problems identified in the GCOU, namely the on- and off-property groundwater contamination at the Site. This response action is being implemented to protect human health and the environment from risks posed by the contamination problems.

This present response action, by addressing contaminated on- and off-property groundwater, is fully consistent with all future site work, including the on-going Remedial Design and Remedial Action (RD/RA) for the SCOU at the Site.

V. SUMMARY OF SITE CHARACTERISTICS

In November 1991, an RI Report for the GCOU was completed under the guidance and oversight of U.S. EPA and WDNR. The RI for the GCOU was to determine the nature and extent of contamination in the groundwater, and evaluate possible exposure pathways. The report summarized all soil-boring, surface water, on- and off-property groundwater, private well, pump test, and treatability study analytical data that had been collected. The RI report should be consulted for a more thorough description of the Site characteristics.

The following are the results of the RI at the Site:

- The uppermost aquifer at the Site is the glacial sand and gravel aquifer. This aquifer is unconfined with groundwater present approximately 10 to 40 feet below ground surface near the Site. The sandstone bedrock aquifer is located below the glacial sand and gravel aquifer. The saturated thickness of the unconsolidated sand and gravel aquifer generally ranges from 30 to 40 feet on site and 50 to 100 feet off site. The thickness of the bedrock aquifer is unknown. Based on the contact of the sand and gravel aquifer with the bedrock aquifer and the insignificant difference between water levels in the sand and gravel and bedrock wells, it appears that the two aquifers are hydraulically connected.

- Groundwater flow immediately beneath the main disposal area (Area A) is predominantly toward the southeast, but then rotates to a southerly and southwesterly direction immediately downgradient of disposal area A. Groundwater flow south of County Highway A appears to be generally southerly to southwesterly, with fairly uniform horizontal gradients. Groundwater velocities ranged from 1.2 to 145 feet per year.

- It does not appear that Sundby's pond functions as a local groundwater discharge area; groundwater flow appears to be horizontal or slightly downward beneath the pond. Data also indicate that the nearby drainage ditch is probably not a potential groundwater discharge point.

- The constant rate pumping test was run for 33 hours. During this test, 119,000 gallons were pumped from the aquifer resulting in a cone of depression extending out approximately 400 feet. This test indicates that the aquifer behaves as an unconfined aquifer with some degree of connection to the sandstone bedrock. Results showed an average transmissivity of 24,000 gallons per day per foot.

- The contaminants causing the most concern are VOCs. The elevated levels of VOCs detected in groundwater were THF (630,000 parts per billion (ppb)), ethylbenzene (4,400 ppb), toluene (2,700 ppb), and xylenes (37,000 ppb). Benzene (8 ppb), 1,1-dichloroethene (1 ppb), and vinyl chloride (77 ppb) were also detected in the groundwater. Inorganic compounds such as arsenic (25.2 ppb), barium (1,570 ppb), iron (17,000 ppb), lead (6 ppb), manganese (3,300 ppb), and mercury (6.5 ppb) were also found in the groundwater. Aroclor-1242 (0.25 ppb), arsenic (31.9 ppb), lead (997 ppb), cadmium (35.6 ppb), chromium (109 ppb), and mercury (1.0 ppb) were detected in the leachate from the landfill.

- The occurrence, concentration, and distribution of THF suggest there is a THF plume originating in the south-central section of disposal area A which extends downgradient (south) approximately 3,600 feet to between test boring #1 and well nest #34 (See figure 3).

- Private wells determined to be potential receptors were sampled in September 1989, August 1990 and September 1991. VOCs were not detected in private well samples collected during this investigation.

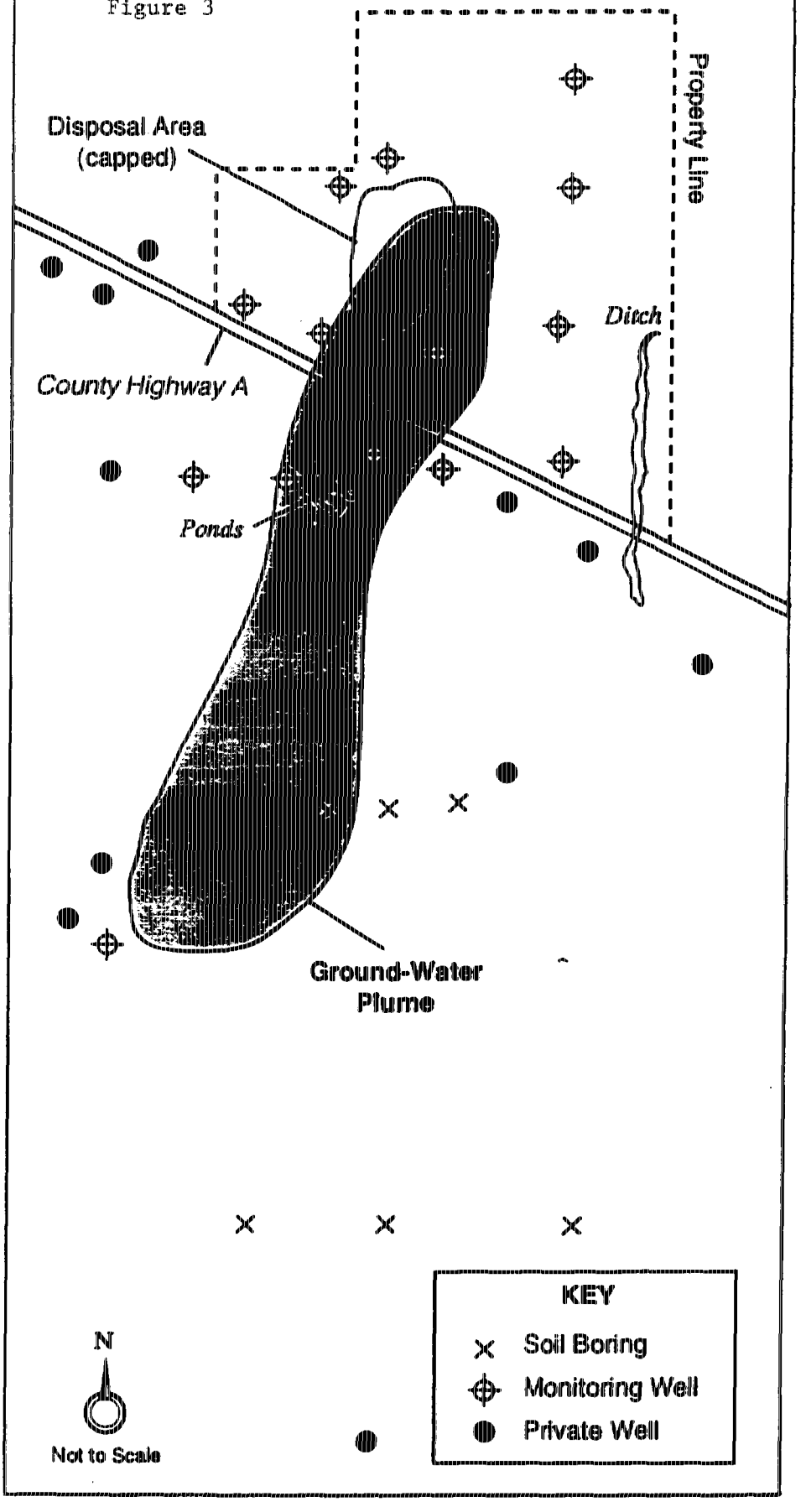
- A treatability study was conducted during the on-property pump test. The results of the treatability study indicate that air stripping can attain removal levels as high as 40 percent of the THF concentration in the sample tested. It is estimated that a cascade aeration system will remove up to 30 percent of the THF, with higher removal efficiencies for other VOC contaminants. Granular activated carbon (GAC) is an effective technology to remove VOCs by itself and also in combination with biological treatment. However, two of the contaminants, THF and 2-butanone, are not readily adsorbable. An activated sludge system can remove up to 99 percent of the THF and other organic compounds in the groundwater. UV-chemical oxidation should remove up to 99 percent of the contaminants.

VI. SUMMARY OF SITE RISKS

The baseline risk assessment was conducted to characterize the current and potential future threat to public health and the environment posed by chemicals in the groundwater originating at, or migrating from the Site. Both current and potential future-use conditions were examined in the baseline risk assessment. Under current conditions, the Site was assessed in the absence of remedial action for groundwater.

Plume Diagram

Figure 3



A risk assessment consists of four primary parts: identifying chemicals and other contaminants of concern; assessing pathways through which humans, plants, and animals could be exposed to contamination; assessing the toxicity of the contaminants; and characterizing cancerous and non-cancerous health effects on humans.

a. Human Health Risks

1. Contaminant Identification

The first step of the risk assessment was to select chemicals and other contaminants of potential concern for detailed evaluation. This was conducted by summarizing and evaluating RI data, including a consideration of naturally occurring background levels and the presence of chemicals in blank samples. Based on this evaluation, 56 chemicals of potential concern were selected for detailed assessment. These chemicals were considered most likely to be of concern to human health and the environment. The following compounds were selected as the chemicals and other contaminants of potential concern:

Organic Compounds		**Metals**
Acetone	Benzene	Arsenic
Benzoic acid	Benzyl alcohol	Barium
2-Butanone	Chlorobenzene	Copper
Chloromethane	1,1-Dichloroethene	Manganese
1,4-Dichlorobenzene	1,2-Dichloroethene	Mercury
4,4'-DDE	Dieldrin	Nickel
Diethylphthlalate	2,4-Dimethylphenol	Vanadium
Ethylbenzene	4-Methylphenol	Zinc
Naphthlalene	Di-n-octylphthalate	
Phenol	Tetrahydrofuran	
Toluene	Vinyl acetate	
Vinyl chloride	Xylenes (total)	

These contaminants were detected in both on- and off-property groundwater. Table 1 identifies the maximum concentration of contaminants in groundwater.

2. Exposure Assessment

An exposure assessment was conducted to identify potential pathways of exposure under current and future Site and surrounding land-use conditions. The following pathways were selected for detailed evaluation under current use conditions (Although no current private wells located around and downgradient of the Site are impacted by the contaminated groundwater, the assumptions were made that the private wells located in the near and far downgradient of the Site might be impacted due to the potential for groundwater flow changes.):

TABLE 1
Hagen Farm Site
Groundwater Contamination
Maximum Levels Detected/Groundwater Cleanup Standards

Compounds	Maximum Concentration (ug/l)		Standards (ug/L)			BD
	On-Property	Off-Property	ES	PAL	MCL	
Organic						
Benzene	8	ND	5	0.067	5	ND
1,1-Dichloroethene	1	ND	7	0.024	7	ND
Ethylbenzene	4,400	ND	1,360	272	700	ND
Tetrahydrofuran	630,000	1,200	50	10	NA	ND
Toluene	2,700	ND	343	68.6	1,000	ND
Xylenes	37,000	ND	620	124	10,000	ND
Vinyl Chloride	77	5	0.2	0.0015	2	ND
Inorganic						
Arsenic	25.2	ND	50	5	50	ND
Barium	1,570	ND	1,000	200	2,000	37
Iron	17,000	ND	300	150	300[1]	ND
Lead	6	5.6	50	5	15[2]	ND
Manganese	3,330	ND	50	25	NA	ND
Mercury	6.5	ND	2	0.2	2	ND

ES: Enforcement Standard, NR 140, WAC
PAL: Preventive Action Limit, NR 140, WAC
MCL: Maximum Contaminant Level, Safe Drinking Water Act
BD: Background Level
ND: Not-Detected
NA: Not Available

[1] Secondary MCL
[2] Action Level value

- Ingestion of groundwater ; and

- Inhalation of VOCs by residents located near and far downgrdient of the Site while showering.

Under future-use conditions, the following pathways were selected for evaluation:

- Ingestion of groundwater by a future resident on the Site; and

- Inhalation of VOCs while showering by a future residents on the Site.

For the ingestion of groundwater by current and future residents, adult residents were assumed to weigh 70 kg and ingest two liters of water per day, 350 days per year and to live in the same location for 30 years of their 70-year expected lifetime. For the inhalation of VOCs while showering, an exposure time of 17 minutes, a frequency of exposure of 350 days per year, and a duration of exposure of 30 years were assumed.

The maximum concentration of contaminants of concern was used for groundwater to calculate the risk. For the inhalation exposures while showering, the exposure point concentrations were calculated using a shower model.

3. Toxicity Assessment

The harmful effects, or toxicity, of a chemical in terms of its potential cancerous and non-cancerous health effects were evaluated. Research was conducted to determine the toxicity of chemicals, and the results and conclusions of this research were used in the evaluation of the toxicity of Site-related contamination. In the research of a chemical's toxicity, the effects of low levels of chemical exposure on people in the workplace are studied over long periods of time, and test animals are studied in laboratories, where animals are exposed to varying levels of chemicals over different lengths of time.

Cancer slope factors have been developed by U.S. EPA's Carcinogen Assessment Group for estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. Slope factors, which are expressed in units of $(mg/kg\text{-}day)^{-1}$, are multiplied by the estimated intake of a potential carcinogen, in mg/kg-day, to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper bound" reflects the conservative estimate of the risks calculated from the cancer slope factor. Use of this approach makes underestimation of the actual cancer risk highly unlikely. Cancer slope factors

are derived from the results of human epidemiological studies or chronic animal bioassays to which animal-to-human extrapolation and uncertainty factors have been applied. Table 2 contains the cancer slope factors for carcinogenic contaminants of concern at the Site.

Reference doses (RfDs) have been developed by U.S. EPA for indicating the potential for adverse health effects from exposure to chemicals exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/kg-day, are estimates of the daily exposure to the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of deleterious effects during a lifetime. RfDs are derived from human epidemiological studies or animal studies to which uncertainty factors help ensure that the RfDs will not underestimate the potential for adverse noncarcinogenic effects to occur. The reference doses for contaminants of concern at the Site are specified in Table 2.

4. Risk Characterization

Using the maximum levels of each contaminant detected in the groundwater for each respective calculation, the excess cancer risk and non-cancerous effects were calculated for current and future scenarios. Under current-use conditions, the groundwater data used was from monitoring wells located near and far downgradient from the Site. The cancer risk due to the ingestion of groundwater near downgradient is 2×10^{-4}.

The cancer risk due to the inhalation of VOCs from showering is 2×10^{-5}. The hazard index for ingestion of near downgradient groundwater is 3, and far downgradient groundwater is 10. The higher hazard index for far downgradient groundwater (10) is the result of higher contaminant concentrations detected in far downgradient wells. Higher contaminant concentrations in far downgradient wells may possibly be due to downward vertical gradients of the plume. The hazard index numbers indicate that exposure to contaminants may produce harmful, non-cancerous effects.

Accordingly, under future-use conditions, it is assumed that residential housing would be developed around the Site. The groundwater data collected from on-property wells were used to calculate the risk for the future-use scenario. The cancer risk through the ingestion of groundwater in shallow wells is 2×10^{-3}. The hazard index from shallow wells located on site is 6,000. U. S. EPA considers these risks unacceptable. Table 3 contains the cancer risk and hazard index for current and future cases.

TABLE 2
Hagen Farm Landfill Site
ORAL TOXICITY CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN

Chemical	Chronic Reference Dose $(mg/kg \cdot day)^{-1}$	Slope Factor $(mg/kg \cdot day)^{-1}$
Organic Chemicals		
Acetone	---	1.00E-01
Benzene	2.90E-02	---
Benzoic Acid	---	4.00E+00
Benzyl alcohol	---	3.00E-01
2-Butanone (methyl ethyl ketone)	---	5.00E-02
Chlorobenzene	---	2.00E-02
Chloromethane	1.30E-02	---
4,4'-DDE	3.40E-01	---
Di-n-octylphthalate	---	2.00E-02
1,4-Dichlorobenzene	2.40E-02	1.00E-01
1,1-Dichloroethene	6.00E-01	9.00E-03
1,2-Dichloroethene	---	2.00E-02
Dieldrin	1.60E+01	5.00E-05
Diethylphthalate	---	8.00E-01
2,4-Dimethylphenol	---	2.00E-02
Ethylbenzene	---	1.00E-01
4-Methylphenol (p-cresol)	---	5.00E-02
Naphthalene	---	4.00E-03
Phenol	---	6.00E-01
Tetrahydrofuran	---	2.00E-03
Toluene	---	2.00E-01
Vinyl Acetate	---	1.00E+00
Vinyl Chloride	1.90E+00	---
Xylenes (total)	---	2.00E+00
Inorganic Chemicals		
Arsenic	1.80E+00	1.00E-03
Barium	---	7.00E-02
Copper	---	3.70E-02
Manganese	---	1.00E-01
Mercury	---	3.00E-04
Nickel	---	2.00E-02
Vanadium	---	7.00E-03
Zinc and compounds	---	2.00E-01

TABLE 3

Hagen Farm Landfill Site

SUMMARY OF POTENTIAL HEALTH RISKS ASSOCIATED WITH CURRENT AND FUTURE LAND USE CONDITIONS

Exposure Pathway	Upper Bound Excess Lifetime Cancer Risk[a]	Hazard Index for Noncarcinogenic Effects [b]
Current Residents		
Ingestion of Groundwater (Off-property Shallow Wells)		
Downgradient - Near	2E-04	>1 (3)
Downgradient - Far	--	>1 (10)
Inhalation of Volatiles from Sowering with Groundwater (Off-Property Shallow Wells)		
Downgradient - Near	2E-05	<1
Downgradient - Far	8E-07	<1
Future Residents		
Ingestion of Groundwater		
Hypothetical Resident on Property		
(Shallow wells)	2E-03	>1 (6,000)
(Shallow wells - On Property Data)	--	>1 (30)
(Deep wells)	2E-05	>1 (300)
Inhalation of Volatiles from Showering with On-Site Groundwater		
Hyptothetical Resident		
(Shallow wells)	2E-04	>1 (300)
(Shallow wells - On Property Data)	--	=1[c]
(Deep wells)	5E-06	>1 (9)

[a] The upper bound individual excess lifetime cancer risk represents the additional probability that an individual may develop cancer over a 70-year lifetime as a result of exposure conditions evaluated.

[b] The hazard index indicates whether or not exposure to mixtures of noncarcinogenic chemicals may result in adverse health effects. A hazard index less than one indicates that adverse human health effects are unlikely to occur.

[c] When recalculated by target organ or effect, all hazard index values were less than one.

b. Environmental Risks

An ecological risk assessment was conducted to evaluate potential impacts on nonhuman receptors associated with the site. An evaluation of selected terrestrial plants and soil organisms (earthworms) to chemicals of potential concern indicated that neither plant nor earthworm populations would be adversely affected.

VII. DOCUMENTATION OF SIGNIFICANT CHANGES

No significant changes have been made since the May 1992 publication of the FS and Proposed Plan.

VIII. DESCRIPTION OF ALTERNATIVES

Based on the results of the RI and risk assessment, an FS was conducted to identify and evaluate a variety of alternatives for protecting human health and the environment from the contamination associated with the groundwater contamination at the Site. After identifying and screening potential remedial technologies for the Site, two alternatives were selected for further evaluation. The selection of these two alternatives from various remedial technologies was based on the screening process considering the remediation goal, the results of the treatability study, volume of groundwater to be treated, contaminant levels, and the merit of the technology. Each of the alternatives is evaluated using a set of nine criteria. These criteria reflect the goals of the Superfund program. They are used by U.S. EPA to compare the merits of each alternative. These criteria are explained in Section IX.

Descriptions of the two alternatives considered by U.S. EPA are provided below, including costs, estimated in terms of capital cost and annual operation and maintenance cost. Together, these dollar amounts are converted to net present worth. U.S. EPA's evaluation of each remedial alternative using the evaluation criteria is summarized in Section IX.

Due to the relatively low concentration levels of contaminants detected off-property and lack of information collected for the off-property aquifer, the groundwater contamination at the Site was separated into on- and off-property groundwater contamination. The terms "on-property" and "off-property" are defined in Section II. More studies will be conducted off-property as part of the RD/RA Phase to characterize the off-property aquifer and to gather other necessary information.

The alternatives considered for the GCOU are:

Alternative 1: No Action.

Alternative 2: Groundwater extraction and treatment; Discharge of treated groundwater to the wetlands or Yahara River.

A description of each of these alternatives follows:

Alternative 1: No Action

Under this alternative, the Site would be left in its present condition and no action would be taken to reduce the risk of exposure to contamination. U.S. EPA requires consideration of a no-action alternative to serve as a basis against which other remedial alternatives can be compared. Under this alternative, groundwater-quality monitoring of selected on-property, off-property, and all private wells located on and around the Site will be continued.

The capital cost of this alternative is approximately $179,000, and annual Operation and Maintenance (O&M) is $50,000. The 30-year present net worth (PNW) cost is $1,025,000.

Alternative 2: Groundwater extraction and treatment; Discharge of treated groundwater to the wetlands or Yahara River.

(a) Groundwater Extraction and Treatment

Under this alternative, on-property groundwater will be extracted and treated using an activated sludge biological system. The off-property groundwater will be extracted and treated using the treatment technology which will be selected during the Remedial Design (RD) stage. The off-property treatment technology will selected during the RD stage because additional information is needed concerning the off-property aquifer. The treated groundwater will be discharged into the wetlands or Yahara River. The treated on-property groundwater may also be reinjected to the on-property aquifer with nutrients and/or oxygen to enhance biodegradation. The private wells located around the Site will be monitored. It is anticipated that aquifer restoration under this alternative may require a 30 year period.

Groundwater extraction will be performed by a series of groundwater extraction wells placed at strategic locations downgradient of the source of contamination. The precise location, number, and depth of these wells will be established in the RD phase. Preliminary aquifer flow analysis indicates

that wells extracting 100 to 180 gallons per minute (GPM) should contain and significantly reduce the contamination within the plume.

The extracted groundwater from on-property will be treated using an activated sludge biological system. In a biological treatment process, the contaminants act as an energy source for biological microorganisms. If, over time, the contaminant concentrations become too low to support biological growth, additional materials (e.g., milk whey) may be added to maintain optimum biological activity for contaminant degradation. When influent contaminant concentrations in the biological process decrease to a level insufficient to support biological activity without large additions of substrate, a more cost-effective option may be to switch to a physical or chemical treatment process, such as Granular Activated Carbon (GAC). The biological system should remove up to 99 percent of the contaminants in the groundwater. Prior to the biological treatment, the extracted on-property groundwater would be passed through the pretreatment facility to remove metals and inorganic solids.

In addition, the treated on-property groundwater may be enhanced with nutrients and/or oxygen and reinjected into the aquifer to promote in-situ contaminant biodegradation in groundwater and saturated soils, potentially decreasing the time necessary for extraction and treatment. The reinjected water may also help flush additional contaminants from the aquifer. Preliminary groundwater flow analysis indicated that approximately 30 percent of the total on-property extraction volume will be treated to NR 140 Preventive Action Limits (PALs) by biological treatment and reinjected into the aquifer. Because the effectiveness of this enhancement is uncertain, full implementation should be preceded by a testing and evaluation phase to determine the feasibility of performing long-term in-situ bioremediation treatment. A bench scale study would be implemented first to determine the effect of nutrients and oxygen on contaminated groundwater. If the bench scale study shows positive results, a pilot study would be conducted with the ultimate goal of enhancing the selected remedy with an in-situ groundwater bioremediation system.

For the treatment of extracted off-property groundwater, the following five technologies will be evaluated:

Option 2A: Cascade Aeration
Option 2B: Biological Treatment
Option 2C: Air Stripping
Option 2D: Granular Activated Carbon (GAC)
Option 2E: Ultraviolet (UV)-Chemical Oxidation

Option 2A: Cascade Aeration

The cascade aeration system utilizes a modified pipeline with an open channel gravity flow section in order to strip the VOCs in the groundwater. This flow section would create turbulence in the water and enhance air-water contact prior to discharge to the Yahara River. This open channel segment would promote the transfer of volatile contaminants to the air. It is expected that the cascade aeration system is not as efficient as the air stripping process evaluated in the treatability study, and would remove less than 40 percent of the THF in the off-property groundwater. Pretreatment for metals and inorganic solids would be necessary prior to cascade aeration. Since cascade aeration has a low removal rate for THF, the treated groundwater using cascade aeration will not be discharged into the wetlands.

Option 2B: Biological Treatment

Off-property groundwater would be combined with more highly contaminated groundwater from on site, pretreated to remove metals and inorganic solids, and then biologically treated to remove the organic compounds. If combined groundwater contamination concentrations from both on- and off-property become too low to support biological growth, additional substrate material may be added to maintain optimum biological activity for contaminant degradation.

Option 2C: Air Stripping

Off-property groundwater would first be pretreated to remove metals and inorganic solids, and then conveyed to a packed-tower air stripper which uses countercurrent aeration, in which influent water flows into the top of the tower and cascades through a packing media, while air is forced upward through the tower. This allows a transfer of contaminants in the liquid phase to the gas phase by providing a larger contact surface and void volume for phase transfer of the contaminants and a sufficient residence time for the transfer to occur. The air stripping could reduce THF contamination by up to 40 percent and remove other less soluble VOCs by greater amounts. The treated groundwater using air stripping will not be discharged to wetlands due to the low removal rate.

Option 2D: Granular Activated Carbon (GAC)

Off-property groundwater would first be pretreated to remove metals and inorganic solids, and then conveyed to the GAC bed, where contaminants are adsorbed on the carbon. When the capacity of the carbon is exhausted, the bed is taken out of service and the spent carbon either regenerated or disposed of in an off-site landfill to meet the Land Disposal Restriction requirements. Based on the treatability study, the GAC would

remove up to 99 percent of the contaminants in the groundwater. However, the main contaminant in the off-property groundwater, THF, is not readily adsorbable, and will require large quantities of GAC for complete adsorption.

Option 2E: Ultraviolet (UV)-Chemical Oxidation

Chemical oxidation and UV light would be used to destroy VOCs in the contaminated off-property groundwater. Chemical oxidation uses strong oxidizing agents to react and destroy organics in groundwater. UV light would be used in conjunction with the oxidizing agents (such as hydrogen peroxide and ozone) to improve the oxidation process efficiency. The treatability study for on-property groundwater indicated that data from vendors show that UV/peroxide oxidation with pre-filtration was able to remove THF concentrations as high as 57,000 ug/l. This technology should remove up to 99 percent of the contaminants from the extracted off-property groundwater. Consequently, this process will need to be preceded by an inorganics removal pretreatment process such as air oxidation/precipitation or pH adjustment to remove metals which could cause scaling on ultraviolet lamps.

(b) Selection of Off-Property Groundwater Treatment Technology

U.S. EPA, in consultation with WDNR, will select the off-property groundwater treatment technology from the five technologies described above. The selection of the technology will be based on design information including, but not limited to, an off-property pump test, off-property treatability study, and bio-assay test. U.S. EPA will consider the off-property aquifer characteristics, the surface water discharge limits for the contaminants of concern for discharge to the Yahara River, groundwater discharge limits for the contaminants of concern for discharge to wetlands, and the ability of these technologies to meet ARARs. After selection of the off-property groundwater treatment technology, the U.S. EPA will issue an explanation of significant differences (ESD) to inform the public of U.S. EPA's decision.

(c) Discharge of Treated Groundwater

The treated on- and off-property groundwater could be discharged to the Yahara River through an 11,000-foot force main water line which must, at some point, tunnel beneath the Chicago, Milwaukee, St. Paul, and Pacific Railroad line which lies between the Site and the Yahara River. The cascade aeration treatment system would replace a segment of the force main if that treatment system is selected for off-property groundwater. The treated groundwater could also be discharged into wetlands.

The discharge location will be determined after a Site specific evaluation including an evaluation of the impact of ARARs on the design of the groundwater extraction and treatment system and effluent discharge limits.

(d) Groundwater Cleanup and Discharge Standards

Groundwater will be extracted until the groundwater no longer attains or exceeds Wisconsin NR 140 PAL standards at the point of compliance and beyond. Consistent with the exemption criteria of NR 140.28, WAC, an alternative concentration limit (WACL) may be established if it is determined that it is not technically or economically feasible to achieve the PAL for a specific substance. The point of compliance shall be the waste management boundary.

Discharge of treated groundwater to the Yahara River will be required to comply with the requirements set forth in a WPDES permit, since discharge to the Yahara River would be considered an off-site discharge.

Discharge of treated groundwater into the wetlands via the drainage ditch near the southeast corner of the Site or directly to the wetlands will be required to meet the substantive requirements of a WPDES permit and shall comply with NR 140, PAL standards. In addition, the State of Wisconsin also has policies on protection of wetlands which shall be complied with for actions affecting wetlands including NR 1.95 and 103 Wis. Adm. Code. Impacts to the wetlands will be considered and minimized to the extent possible during the design phase of this remedial action as directed in Executive Order 11990.

(e) Air Emission Treatment

The emitted gases produced by waste water treatment system will be treated to meet State air-quality standards in accordance with the Clean Air Act (CAA) and NR 400 through 499, WAC.

(f) Sludge Management

All residue, sludge, and/or spent coagulants/agents from the treatment of groundwater shall be treated to meet the Land Disposal Restriction (LDR) standards for F003-F005 wastes prior to disposal in a Resource Conservation and Recovery Act (RCRA) landfill in accordance with the requirements of 40 CFR 268.41. Spent carbon will be regenerated or treated to meet the LDR requirements.

(g) Cost

Depending on the selection of off-property groundwater treatment options and the location of discharge of treated groundwater, the cost of this alternative will vary. The detailed cost information is contained in Table 4. The capital costs range from $4,396,000 to $6,288,000, annual O&M costs range from $550,000 to $1,027,000, and 30-year total PNW cost ranges from $13,612,000 to $24,163,000.

IX. SUMMARY OF THE COMPARATIVE ANALYSIS OF ALTERNATIVES

A detailed analysis was performed on the two alternatives using the nine evaluation criteria in order to select a groundwater control remedy. The following is a summary of the comparison of each alternative's strength and weakness with respect to the nine evaluation criteria. These nine criteria are:

1) **Overall Protection of Human Health and the Environment**
2) **Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)**
3) **Long-Term Effectiveness and Permanence**
4) **Reduction of Toxicity, Mobility, or Volume through Treatment**
5) **Short-Term Effectiveness**
6) **Implementability**
7) **Cost**
8) **State Acceptance**
9) **Community Acceptance**

1. Overall Protection of Human Health and the Environment

Alternative 1, No Action, will not provide adequate protection from risks associated with contaminated groundwater. The private wells located downgradient of the Site might be exposed in the future. Therefore, it will not be discussed any further, since it is not protective and, thus, not an acceptable alternative. Additional contaminant loading into the aquifer will, however, be reduced by implementation of the cap and ISVE system determined in the ROD of the SCOU.

Alternative 2 provides protection of human health and the environment because it includes an extraction and treatment system to remove and treat the contaminated groundwater from the aquifer.

2. Compliance with ARARs

Alternative 2 would comply with all applicable or relevant and appropriate federal and state environmental laws.

TABLE 4
Summary of Cost Estimates for
Hagen Farm GCOU Feasibility Study Alternatives

Alternatve 1: No Action

Capital Costs	$ 179,000
Annual Operating Costs	$ 50,000
Total Present Net Worth	$ 1,025,000

Alternative 2: Extraction, Treatment, and Discharge

Alternative		Discharge to Yahara River	Discharge to Wetlands
Option 2A:	Capital Costs	$ 4,396,000	
Activated Sludge	Annual Operating Costs	$ 550,000	
Cascade Aeration	Total Present Net Worth	$13,612,000	N/A
Option 2B:	Capital Costs	5,217,000	4,413,000
Activated Sludge	Annual Operating Costs	699,000	665,000
	Total Present Net Worth	16,943,000	15,589,000
Option 2C:	Capital Costs	5,816,000	
Activated Sludge	Annual Operating Costs	765,000	
Air-Stripping	Total Present Net Worth	18,645,000	N/A
Option 2D:	Capital Costs	5.986,000	5,181,000
Activated Sludge	Annual Operating Costs	805,000	770,000
GAC	Total Present Net Worth	19,491,000	18,119,000
Option 2E:	Capital Costs	6,288,000	5,482,000
Activated Sludge	Annual Operating Costs	1,062,000	1,027,000
UV-Chem Ox	Total Present Net Worth	24,163,000	22,790,000

Note:

1. Present net worth assumes 30 years of operation, 9% discount rate, and a 5% inflation rate.
2. N/A indicates not applicable for the alternative or option.
3. The Alternative 2 costs include in-situ bioremediation.

The major groundwater ARARs include the Federal Safe Drinking Water Act (SDWA) and State Groundwater Quality Standards, NR 140, WAC.

The major surface water discharge ARARs include Chapter 147 Wisconsin Statutes, NR 102 , 104, 105, 106, 108, 200, 207 , 219, and 220 of WAC.

The major wetland discharge ARARs include NR 1.95, 103, and 140 (PAL Standards) of WAC, and the substantive requirements of a WPDES permit (Chapter 147 Wisconsin Statutes, NR 102, 104, 105, 106, 108, 200, 207, 219, and 220 of WAC).

The groundwater wells for the alternatives will be constructed according to the standards listed in NR 112 and 141, WAC. Wastewater treatment facility standards will be followed according to NR 108, WAC.

Water used for in-situ bioremediation will be treated to achieve NR 140, PALs prior to re-injection into the aquifer. Any proposal to re-inject treated groundwater enhanced with nutrients and/or oxygen must comply with the substantive requirements of Ch. NR 112, WAC. Feasibility and evaluation testing of in-situ bioremediation should be evaluated during implementation of the remedial action.

NR 445, Control of Hazardous Pollutants, is an ARAR for Alternative 2. Off-gases generated from the treatment process should be treated in order to meet NR 445 emission limit requirements. In general, NR 400 to 499, WAC (Air Quality Management) is an ARAR for the emission of off-gas.

A more complete list of ARARs is included in Section XI.

3. <u>Long-term Effectiveness and Permanence</u>

Cascade aeration and air stripping may require consideration of the residual risks due to potential exposure to the community. This exposure may occur through inhalation of volatilized contaminants from the aeration channel and air stripper, respectively, if they exceed NR 445 standards. Alternative 2 also has a risk component due to the residual contamination in the water being discharged to the Yahara River. The risk due to the implementation of air stripping may be slightly less than from cascade aeration because the air stripper is expected to remove more contaminants than the cascade aeration system.

Potential risks exist for all treatment options due to the transport, storage, and disposal of pretreatment and treatment process residuals which may be hazardous waste. The level of risk is approximately proportional to the quantities of waste generated. The GAC has greater potential risk because it

generates residuals from activated carbon treatment process. Biological treatment, air stripping, and UV-chemical oxidation generate slightly less treatment process residuals. Cascade aeration generates the smallest volume of potentially hazardous waste because there might be no pretreatment process for the water, and the cascade aeration treatment process generates no residuals.

There is no difference between the effectiveness of the institutional controls or the proposed groundwater monitoring for any of the treatment options in Alternative 2.

The surface water discharge limits, which will be established by U.S. EPA in consultation with WDNR, will determine whether the contaminant removal levels for off-property groundwater treatment options, cascade aeration and air stripping, are adequate. Treatment options such as biological treatment, GAC, and UV-chemical oxidation should be adequate for treatment to the required discharge limits.

4. Reduction in Toxicity, Mobility, or Volume

Alternative 2 uses a groundwater well extraction network to remove contaminated groundwater from the ground and a biological treatment process to remove organics from the extracted on-property groundwater. Pretreatment would be included and would likely consist of a precipitation process to remove inert solids and metals.

The amount of hazardous materials extracted from the groundwater aquifer is the same, regardless of which treatment option in Alternative 2 is selected.

The biological treatment system proposed to treat extracted groundwater from on-property is expected to remove up to 99 percent of the contaminants in the groundwater. Based upon the treatability study, the cascade aeration system proposed for off-property groundwater is expected to be less efficient than air stripping. Cascade aeration is expected to remove less than 40 percent of the THF in the off-property groundwater. It is also expected to remove the less-soluble VOCs (e.g., vinyl chloride) in the contaminated off-property groundwater. The biological treatment is expected to remove up to 99 percent of the contaminants in the off-property groundwater. The air stripper system is expected to remove up to 40 percent of the THF and provide even greater reduction of other less-soluble VOCs in the contaminated groundwater. The GAC treatment system and the UV-chemical oxidation system is expected to remove up to 99 percent of the contaminants from the extracted off-property groundwater. Removal efficiencies are based upon the treatability study, which was conducted using on-property contaminant concentrations. Actual removal efficiencies are

dependent upon field conditions, and would need to be further evaluated in the RD phase.

Reduction of hazardous materials through in-situ bioremediation cannot be estimated at this time. Evaluations of the effectiveness of in-situ bioremediation will be made in the in-situ bioremediation pilot testing phase conducted when the GCOU extraction system has equilibrated. Prior to conducting the in-situ bioremedial pilot testing phase, groundwater injection should be performed and the system allowed to reach equilibrium. An evaluation to assess the incremental benefit attributable to reinjection without the addition of nutrients and/or oxygen can then be made.

Alternative 2 will reduce the toxicity and volume of the contamination in the aquifer, and limit additional contaminant migration.

In-situ bioremediation may increase the rate of in-situ biodegradation. This potential for increased biodegradation will be evaluated by feasibility testing in the RA implementation phase.

The extraction of contaminated groundwater and subsequent treatment for all treatment options is irreversible. In-situ biodegradation reactions for the treatment of organic compounds is also irreversible.

In-situ bioremediation has the potential to reduce groundwater concentrations below those achievable by extraction alone. However, some residual contaminants are expected to remain under any extraction or in-situ treatment method.

The pretreatment system and biological treatment system for on-property groundwater treatment will produce an estimated 550 pounds per day of metal and inorganic residuals, which may be hazardous. The biological treatment system is expected to produce an estimated 170 pounds per day of potentially hazardous sludges due to inclusion of the off-property groundwater in the treatment process. The air stripping system, GAC, and UV-chemical oxidation are each expected to produce an additional estimated 200 pounds per day of potentially hazardous sludges. Sludge generation rates are based on sludge generation data gathered in the treatability study. GAC is also estimated to produce 75 pounds per day of spent carbon from the GAC process.

All Alternative 2 options will reduce the inherent hazards posed by the groundwater contamination at the Site to risk levels considered protective of human health and the environment through groundwater extraction and treatment.

Activated sludge biological treatment would utilize the ability of certain bacteria to break down organic compounds into carbon dioxide and water. Cascade aeration and air stripping involve the transfer of volatile contaminants to the air. The contaminants in the off-gas could be adsorbed in the carbon and treated if spent carbon is regenerated. Regeneration usually involves heating the carbon to very high temperature in a kiln to desorb the contaminants. The desorbed contaminants can then be incinerated. GAC utilizes the adsorption process in which molecules in an aqueous solution adhere to the surface of a solid. The contaminants which adhered in the surface of a carbon bed can be treated through a regeneration process. UV oxidation involves the use of UV radiation in conjunction with one or more oxidizing agents, usually ozone or hydrogen peroxide, to chemically destroy organic contaminants. Ozone and hydrogen peroxide are both strong oxidizing agents that can chemically break down organic compounds. In the presence of UV radiation, the effectiveness of these oxidizing agents is dramatically increased.

5. Short-term Effectiveness

Risks to the community from Alternative 2 are due to the off-site transport of sludges and treatment residues generated by the pretreatment and/or treatment processes for each treatment option. The level of risk is approximately proportional to the quantities of wastes generated.

Alternative 2 should cause no additional risks to workers beyond normal risks associated with construction, provided that a Health and Safety Plan is developed and followed.

The disturbance of the wetlands due to monitoring and extraction well construction could occur during the construction of Alternative 2, depending upon well locations. Wetlands may also be damaged during winter months by ice buildup from continual water discharges to wetlands from the treatment of the biological system, GAC, or UV-chemical oxidation. Such damage should not occur if preventative measures such as intermittent pumping or engineered control systems (e.g., stilling basins) are employed. Such damage could be avoided entirely if treated wastewater is discharged to the Yahara River instead of the wetlands. These potential impacts to the wetlands will be evaluated during the RD phase and will be minimized.

For Alternative 2, the time required to achieve the RA objectives is limited by the extraction technology, as described in Alternative 2. Remediation times are described in terms of advective flushing times. The effects of retardation and dispersion are not accounted for in the groundwater remediation time estimates. Advection flushing time is between 10 and 15 years for Alternative 2. The addition of in-situ bioremediation

may decrease the remediation time to between 5 and 10 years. Actual cleanup time will likely be substantially longer due to the effects of retardation and dispersion, although these effects may be offset by the degradation stimulated by in-situ bioremediation.

6. Implementability

The extraction well network for Alternative 2 is readily implementable.

The technologies required to implement the treatment system for Alternative 2 and its off-site treatment option are readily available, although the biological treatment system requires a start-up period before it reaches the optimum operating efficiency. If intermittent pumping is required to reduce impacts to the wetlands, operation of a biological treatment system will be difficult to control. However, intermittent pumping of individual wells should be possible without causing operational problems.

A testing and evaluation period is needed to determine if in-situ bioremediation is technically feasible before full-scale implementation. The biological treatment system which reduces contaminant levels to required discharge levels may require modifications as groundwater contaminant levels decrease over time. All off-property treatment options may require a pilot scale test to establish operation parameters of treatment technology.

Discharge standards to the Yahara River need to be determined before it will be known whether treatment options, such as cascade aeration or air stripping, meet surface water discharge standards.

Alternative 2 requires additional materials and services. However, these materials are expected to be readily available. If shown to be feasible, in-situ bioremediation utilizes materials and services available from the consulting and environmental services communities.

7. Cost

The cost of each alternative is summarized in Table 4.

8. State Acceptance

The WDNR concurs with the selection of Alternative 2 on the condition that the WDNR determines, at the time the proposed treatment design is finalized, that the effluent discharge limits and discharge location (including any reinjection of enhanced groundwater which is proposed) are acceptable to the

WDNR and are in compliance with the effluent discharge limit requirements of Chapters NR 102, 104, 105, 106, 108, 200, 207, 219 and 220, WAC, Ch NR 140, WAC, PAL Standards, the wetlands protection in Ch NR 103 WAC, and the applicable air quality standards in Chs NR 400 to 499, WAC.

9. Community Acceptance

The specific comments received and U.S. EPA's responses are outlined in the attached Responsiveness Summary.

X THE SELECTED REMEDY

As provided in CERCLA and the NCP, and based upon the evaluation of the RI/FS and the nine criteria, U.S. EPA, in consultation with the WDNR, has selected Alternative 2 as the groundwater control remedial action at the Hagen Farm Site.

- Institutional controls would include on-property land and on- and off-property groundwater use restrictions in the form of existing deed restrictions to the extent necessary to implement and protect the remedy, and to safeguard human health and the environment during implementation of the remedy. The cooperation of local agencies would be required to limit future off-property use of groundwater if the Respondents are unable to obtain deed restrictions from affected property owners. A fence shall be installed around the treatment facility system in order to prevent public access.

- Additional monitoring will be conducted in the selected on- and off-property monitoring wells and all of the private wells located around the Site, including but not limited to, the wells located on the properties of Fosdohl, Lee, Van Deusen, Sundby, Sundby Sand and Gravel, K-Way Insulation, Gullickson, Quam, Stoughton Conservation Club, Sagmoen, and Gjertson.

- Extracted groundwater from on- and off-property would be pretreated for the removal of metals and inorganic solids.

- On-property groundwater will be extracted until the groundwater at the waste management boundary and beyond (area of attainment) no longer attains or exceeds Wisconsin NR 140 PAL standards, and treated using an activated sludge biological system. All residue and/or sludge shall be treated as appropriate to meet the LDR standards for F003-F005 wastes and shall be placed in a RCRA landfill in accordance with the requirement of 40 CFR 268.41.

- Off-property groundwater will be extracted until the groundwater within the area of attainment no longer attains or exceeds Wisconsin NR 140 PAL standards and treated using an appropriate treatment technology. Treatment technologies such as cascade aeration, activated sludge, air stripping, GAC, or UV-oxidation shall be evaluated during the RD stage. Based on the off-property pump test, bioassay test, BAT requirements, surface water discharge limits, and other related factors, the technology will be selected for off-property groundwater treatment. The emitted gases will be treated to meet State air-quality standards of NR 445, WAC. All residue, sludge, and/or spent coagulants shall be treated as appropriate to meet the LDR standards for F003-F005 wastes and shall be placed in a RCRA landfill in accordance with the requirement of 40 CFR 268.41. The spent carbon could be regenerated or treated to meet LDR requirements prior to land disposal.

- A bench scale study will be conducted to examine the feasibility of injecting the treated on-property groundwater into the on-property aquifer in order to enhance in-situ bioremediation. Nutrients and/or oxygen would be added in order to promote the natural microbial degradation of organic compounds. The study will be designed to determine the optimum amounts of nutrients to be added to the aquifer, and the amount of groundwater to be injected. If determined to be feasible, a pilot study would be implemented with the ultimate goal of enhancing the selected remedy with a full scale in-situ groundwater bioremediation system. The discharge limit of NR 140, PAL standards shall be met in order to inject treated groundwater into the on-property aquifer.

- The treated groundwater will be discharged to the Yahara River or nearby wetlands. Discharge of treated groundwater into the wetlands via the drainage ditch near the southeast corner of the Site or directly to the wetlands should meet the substantive requirements of a WPDES permit and shall comply with NR 140, PAL standards. In addition, the State of Wisconsin also has policies on protection of wetlands which shall be complied with for actions affecting wetlands including NR 1.95 and 103, Wis. Adm. Code. Impacts to the wetlands will be considered and minimized to the extent possible during the design phase of this remedial action as directed in Executive Order 11990. Discharge of treated groundwater to the Yahara River will be required to comply with the requirements set forth in a WPDES permit, since discharge to the Yahara River would be considered an off-site discharge.

XI. STATUTORY DETERMINATIONS

The selected remedy must satisfy the requirements of Section 121 of CERCLA to:

a. protect human health and environment;
b. comply with ARARs;
c. be cost effective;
d. utilize permanent solutions and alternate treatment technologies to the maximum extent practicable; and,
e. satisfy the preference for treatment as a principal element of the remedy or document in the ROD why the preference for treatment was not satisfied.

The implementation of Alternative 2 at the Site satisfies the requirements of CERCLA as detailed below:

a. Protection of Human Health and the Environment

This selected remedy will provide adequate protection of human health and the environment through treatment.

Risk posed by groundwater contamination will be reduced and controlled by the operation of a groundwater extraction and treatment system. Access restrictions will prevent direct contact with contaminated groundwater until groundwater cleanup standards are met.

No unacceptable short-term risks will be caused by implementation of the remedy. Standard safety programs, such as fencing, use of protective equipment, monitoring, and off-gas treatment, should mitigate any short-term risks. Short-term risks include exposure of site workers and the community to VOCs, and to noise nuisance during implementation of the groundwater remedy. Ambient air monitoring would be conducted and appropriate safety measures would be taken if contaminants were emitted.

b. Compliance with ARARs

The selected remedy complies with all Federal and State environmental requirements that are legally applicable or relevant and appropriate. The major Federal and State ARARs for the selected remedial alternative for the GCOU are listed below.

A) Federal ARARs

i. Groundwater

Relevant and appropriate requirements for groundwater include primary drinking water standards established by the federal SDWA.

Several contaminants of concern identified at the Site have Maximum Contaminants Level (MCLs), proposed MCLs and/or Maximum Contaminant Level Goals (MCLGs). MCLs are relevant and appropriate to circumstances at the Site, since the aquifers are current and potential sources of drinking water. MCLGs are relevant and appropriate when the standard is set at a level greater than zero (for non-carcinogen).

The NCP 40 C.F.R. 300 et seq. provides that groundwater cleanup standards should generally be attained throughout the contaminant plume or at and beyond the edge of the waste management area when waste is left in place. At the Hagen Farm Site, groundwater quality Standards shall be attained at and beyond the edge of the waste management area (i.e., at the edge of the landfill cap) since waste has been left in place. This is considered the area of attainment.

ii. Surface Water Discharge

Surface water quality standards for the protection of human health and aquatic life were developed under Section 304 of the Clean Water Act (CWA). The Federal Ambient Water Quality Criteria (AWQC) are nonenforceable guidelines that set pollutant concentration limits to protect surface waters that are applicable to point source discharges, such as from industrial or municipal wastewater streams.

National Pollutant Discharge Elimination (40 CFR Part 125); includes best available technology.

iii Wetlands Discharge

Executive Order 11990, 40 CFR 6.302 (a) - Protection of Wetlands - is applicable for this site if the discharge of treated groundwater is to the wetlands.

iv. Sludges

All sludges, residues, spent carbon, and/or spent coagulants produced from groundwater and off-gas treatment will be treated to LDR standards for F003-F005 waste prior to disposal at a RCRA landfill in accordance with the requirement of 40 CFR 268.41. If testing determines that waste sludge generated from the activated sludge

biological system is not hazardous, the waste sludge could be disposed of by on-Site landspreading or off-Site landfilling. Residues such as spent carbon from the treatment of groundwater which are regenerated must be treated in a unit in compliance with 40 CFR Part 264 Subpart X. Federal ARAR 40 CFR Part 261 - Land Disposal Restrictions shall also be complied with.

The sludge is not expected to contain metals at concentrations above characteristic levels. If, after testing by the Toxicity Characteristic Leaching Procedure (TCLP), it is determined that the sludge is characteristic for metals, it will be treated to render it non hazardous.

v. Air Emissions

National Primary and Secondary Ambient Air Quality Standards (40 CFR Part 50)

National Emissions Standards for Hazardous Air Pollutants (40 CFR Part 61)

B) State ARARs

i. Groundwater

The State of Wisconsin is authorized to administer the implementation of the Federal SDWA. The State has also promulgated groundwater quality standards in NR 140 Wis. Adm. Code, which, according to WDNR, is being consistently applied to all facilities, practices, and activities which are regulated by WDNR and which may affect groundwater quality in the State. Chapter 160, Wis. Stats., directs WDNR to take action to prevent the continuing release of contaminants at levels exceeding standards at the point of standards application (point of compliance). PALs and Enforcement Standards (ESs), have been promulgated in NR 140, Wis. Adm. Code. PALs are the groundwater cleanup standards under NR 140. PALs are generally more stringent than corresponding Federal standards and, therefore, are ARARs for the Hagen Farm Site.

Consistent with the exemption criteria of NR 140.28, Wis. Adm. Code, U.S. EPA may establish a Wisconsin Alternative Concentration Limit (WACL), if, based on Site-specific monitoring data

gathered before and after implementation of the selected groundwater remedy, U.S. EPA determines that it is not technically and economically feasible to achieve the PALs for a specific substance. Except where the background concentration of a compound exceeds the ES, and consistent with the criteria in NR 140. 28(4)(B), the WACL that is established may not exceed the ES for that compound.

The implementation of the selected remedy at the Site will be in compliance with NR 140, Wis. Adm. Code, in that PALs will be met unless WACLs are established pursuant to the criteria in NR 140.28, Wis. Adm. Code, in which case the WACLs will be met. These standards will be met in accordance with the NCP at and beyond the edge of the waste management area.

Groundwater Monitoring and Recovery Well requirements include NR 112, NR 141, NR 508, Wis. Adm. Code. Groundwater monitoring wells will be installed in accordance with NR 141, Wis. Adm. Code. Extraction and injection wells will be installed and operated in accordance with Ch. NR 112, Wis. Adm. Code.

Wastewater treatment facility will followed according to NR 108, WAC.

In order to reinject the treated groundwater into the on-property aquifer PALs under NR 140, WAC shall be achieved.

ii. Surface Water Discharge

A WPDES permit must be obtained before treated groundwater can be discharged to the Yahara River. Discharge to the Yahara River would be considered an off-site discharge.

The substantive requirements of WPDES for discharge of wastewater (treated groundwater) to the land and/or surface waters; effluent limits; discharge permits; sampling/testing methods is regulated by Ch. 147, Statutes - Wastewater Management Programs and Chs. NR 102, 104, 105, 106, 108, 200, 207, 219, and 220, WAC Surface Water Discharge Regulations (WPDES). These requirements are all applicable to the discharge of treated groundwater to the Yahara River. Ch. NR 220, WAC, requires that the effluent limits be

based on the application of best available technology (BAT) prior to discharge. The State has promulgated Wisconsin Water Quality Standards and Criteria (WWQC) under Chapters NR 102 and 105, WAC, and the procedures for calculating the toxic effluent limits under Ch. NR 106, WAC, based on the Federal AWQC developed by U.S. EPA. NR 102, 104 and 207 WAC also apply in determining water quality based limits.

iii Wetlands Discharge

Discharge of treated groundwater to the on-site ditch or adjacent to the wetlands should meet the substantive requirements of a WPDES permit and shall comply with Ch. NR 140, PAL standards. In addition, Ch. NR 1.95, WAC - Wetlands Preservation, Protection, and Management and Ch. NR. 103 - Water Quality Standards for Wetlands are applicable for this site if treated groundwater is discharged to the wetlands.

vi. Air Emissions

The emitted gases produced by waste water treatment system(s) will be treated to meet State air-quality standards in accordance with the Clean Air Act (CAA) and NR 400 through 499, WAC.

v. Miscellaneous State ARARs

- Discharge structures or other structures in a navigable water (Chapter 30, Wis. Adm. Code)

- Ch. NR 27, WAC, the State Endangered and Threatened Species Act and Ch. NR 29, WAC, the State Fish and Game Act are State endangered resource laws which protect against the "taking" or harming of endangered or threatened wildlife resources in the area. These would be applicable to the remedial action in that the poisoning of endangered or threatened species by site contaminants could be considered by the WDNR to be a "taking".

C) "To be Considered" Requirements

CERCLA Off-site Policy. (May 12, 1986), Revised November 13, 1987, OSWER DIR. 9834.11.

"Interim Policy for Promoting the In-State and On-Site Management of Hazardous Wastes in the State of Wisconsin"

provides a prioritization outline for the treatment and disposal of hazardous wastes and is "to-be-considered" for the site. If out-of-state treatment and/or disposal for the generated sludges is determined, the written documentation of how the waste management strategy and the eight evaluation criteria were applied shall be submitted to the WDNR for review and approval.

C. Cost Effectiveness

Cost effectiveness compares the effectiveness of an alternative in proportion to its cost of providing environmental benefits. Table 4 lists the costs associated with the implementation of the remedies.

The selected remedy is cost effective because it provides a high degree of overall effectiveness proportional to its costs. The estimated cost of the selected remedy is comparable with the other alternatives and assures a high degree of certainty that the remedy will be effective in the long-term due to the significant reduction of the toxicity of the contaminants in groundwater.

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

U.S. EPA believes that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner for the RA at the Site. Treatment of contaminated groundwater will significantly reduce the hazards posed by the contaminated groundwater at the Site. The groundwater will be restored to the acceptable level to protect public health and the environment. U.S. EPA has determined that the selected remedy provides the best balance of tradeoffs in terms of long-term effectiveness and permanence, reduction of toxicity, mobility or volume through treatment, short-term effectiveness, implementability, cost, and State and community acceptance.

E. Preference for Treatment as a Principal Element

The selected remedy for the Site satisfies the statutory preference for treatment as a principal element through treatment of the contaminants in the groundwater. Treatment of the on-property groundwater contaminants using an activated biological sludge system will result in a significant reduction of contaminants in the groundwater. Treatment of the off-property contaminants using the technology selected during the RD stage will result in a significant reduction of contaminant toxicity in the off-property groundwater.

RESPONSIVENESS SUMMARY
FOR THE RECORD OF DECISION
FOR THE HAGEN FARM
GROUNDWATER CONTROL OPERABLE UNIT

The United States Environmental Protection Agency (U.S. EPA) held a public comment period from June 1 through July 31, 1992, for interested parties to comment on the Proposed Plan for remediating contamination problems in the Groundwater Control Operable Unit ("GCOU") at the Hagen Farm Site (the "Site") in Dunkirk Township, Wisconsin. Comments were also taken on the documents in the administrative record, including the Remedial Investigation/ Feasibility Study (RI/FS) for the GCOU. The required public meeting on June 11, 1992, focused on the results of the GCOU FS and the U.S. EPA recommended alternative as presented in the Proposed Plan fact sheet. The public comment period was held in accordance with Section 117 of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) as amended.

The purpose of the Responsiveness Summary is to document U.S. EPA's responses, in consultation with Wisconsin Department of Natural Resources (WDNR), to comments received during the public comment period and public meeting. These comments were considered prior to selection of the final remedy for the GCOU at the Site, which is detailed in the Record of Decision (ROD).

BACKGROUND ON COMMUNITY INVOLVEMENT

U.S. EPA is responsible for conducting community relations program for this Site. A Community Relations Plan (CRP) was established by U.S. EPA for the Site in July 1988. It established a process to develop two-way flow of project information between local officials, concerned citizens, the media, WDNR and U.S. EPA. Two information repositories were established in the community -- Stoughton City Library, and Klongland Realty. Several different press releases and fact sheets were issued to announce field activities and findings of the RI and FS activities. A public meeting was held on July 14, 1988, at the start of the RI/FS to explain the investigation that was about to begin. Another public meeting to present the findings of the RI/FS and the Proposed Plan for the GCOU was held on June 11, 1992. Community relations activities are summarized in the ROD.

PUBLIC MEETING

The public meeting on the Proposed Plan for the Hagen Farm GCOU was held at 7:00 p.m. on June 11, 1992, at the Dunkirk Town Hall, County Trunk Highway N near Stoughton, Wisconsin. Approximately 15 persons attended, including local residents and representatives of the PRPs. Representatives of U.S. EPA and the WDNR presented information concerning the RI, the FS, and the Proposed Plan and responded to questions from individuals attending the meeting. Oral public comments were accepted during the meeting. A transcript of that meeting including the oral public comments, was prepared by a court reporter in attendance. Copies of the transcript are available at the two Site information repositories. No oral comments were received from the public during the public meeting.

PUBLIC COMMENT AND AGENCY RESPONSE

The following presents comments received from Waste Management of Wisconsin (WMWI) during the public comment period, and U.S. EPA's responses to those comments. WMWI is one of two Potentially Responsible Parties (PRPs). No other comments were received from the general public.

The comments from WMWI were in the form of correspondence submitted to U.S. EPA during the public comment period. U.S. EPA summarized each issue raised by WMWI and, where appropriate, information and statements presented by WMWI with the comments to support the issue. The original unsummarized correspondence submitted by WMWI can be found in the Administrative Record.

COMMENTS:

WMWI comments that the requirement for immediate implementation of a groundwater pump and treat system is not being applied consistently throughout the State of Wisconsin as well as throughout Region V. WMWI asserts that they should not be subjected to a higher standard of remediation than municipally owned or operated NPL sites, such as the Stoughton City Landfill. The ROD and subsequent Scope of Work (SOW) for the RD/RA phase should parallel the Stoughton City ROD's approach. Specifically, technical decisions should be put on hold for source area groundwater until the questions on the downgradient contaminant plume can be fully characterized.

In addition, WMWI comments that the timing of the implementation of pump and treat systems are being applied on an **ad hoc** basis. WMWI feels this is arbitrary and capricious and is inconsistent with the NCP. WMWI asserts that the EPA and WDNR should reevaluate the requirement for immediate groundwater extraction and treatment system at the Hagen Farm Site.

SUPPORTING STATEMENTS:

Stoughton City Landfill has similar contaminants to Hagen Farm and has significantly more potential receptors, but the Stoughton City Landfill ROD allows a grace period of 12 months after effective date of ROD to establish if pump and treat (P&T) is necessary. P&T will be necessary at Stoughton City Landfill if any monitoring well indicates the attainment or exceedance of an Enforcement Standard (ES). WMWI feels that U.S. EPA and WDNR have based their decision to implement a "contingency" ROD based on economical analysis of incremental risk reduction. WMWI states that the approach applied at Stoughton City Landfill is similar to that proposed by WMWI in the submittal of the Hagen Farm Draft Feasibility Study. WMWI feels that approving an approach similar to the Stoughton City Landfill, such as that proposed in the Draft FS, U.S. EPA could maintain consistency in their approach to the requirement for implementation of groundwater extraction and treatment systems. In addition, deferral of implementation of an immediate groundwater extraction and treatment system would allow an interim period to assess the effectiveness of the source control remedy and its impact on groundwater. During the interim period WMWI could also collect groundwater monitoring data that would allow for a more accurate model to predict contaminant levels and migration.

RESPONSE:

U.S. EPA does not believe it appropriate to postpone the implementation of a groundwater pump and treat system at the Hagen Farm Site. Although the commenter believes that by postponing the active remediation of the groundwater the U.S. EPA could study the impact of the source control remedy on the groundwater, and conduct studies and modeling on contaminant movement, U.S. EPA does not believe this to be an appropriate action. Although it is expected there will be a reduction in the future release of contaminants to the groundwater as the result of the implementation of source control measures, these measures are not adequate to clean up groundwater contamination to its beneficial use within a time frame that is reasonable. The groundwater contamination has migrated a significant distance from the site (approximately 3600 feet downgradient from the Site) and requires active implementation of a groundwater pump and treat system. The decision made by the U.S. EPA to require immediate implementation of a groundwater pump and treat system is fully consistent with CERCLA Section 104(a)(1) and as described in the NCP. First and foremost, Congress tasked U.S. EPA to respond to releases of hazardous contaminants in order to protect human health and the environment. U.S. EPA is not holding WMWI to a "higher standard of remediation than municipally owned or operated NPL sites." Rather, U.S. EPA is carrying out the requirements of the law to protect human health and the environment. The baseline risk assessment provides the basis for determining whether remedial action is necessary and the justification for performing remedial actions to protect human

health and the environment. If contaminants of concern are listed in the baseline risk assessment as contributing to excess cancer risk outside an acceptable range of 1×10^{-4} to 1×10^{-6} or have a hazard index ratio greater than one, then remedial action is warranted. These criteria are provided in Section 300.430(e)(2) of the NCP. The Hagen Farm baseline risk assessment listed excess cancer risk as high as 2×10^{-3} and a hazard index ratio as high as 6,000. These values are outside the acceptable NCP values. Therefore, remedial action and compliance with pertinent ARARs under federal environmental laws or more stringent State environmental laws is necessary.

Based on information obtained during the RI, and on careful analysis of all remedial alternatives, U.S. EPA has concluded that the groundwater extraction and treatment component of the selected remedy has a high probability of success in terms of effectively withdrawing and removing contamination from the groundwater at the Hagen Farm Site. Therefore, U.S. EPA concludes that there is enough data to decide that groundwater extraction is necessary and appropriate for on- and off-property groundwater and that the information which is presented in the Final FS is appropriate.

Additional data collected from off-property groundwater during the RD Phase will be sufficient for a decision on a treatment technology for that contaminated groundwater. U.S. EPA believes that a delay in making a decision at the Hagen Farm Site would not be a prudent or responsible decision. A delay in the Agency's decision may result in further degradation of the aquifer's quality and may increase overall costs of a remedy. Seldom is the contamination problem less than what is discovered during the RI/FS. In fact, in most cases, based on Agency experience, the contamination problems become more complex and severe over time. The groundwater contamination at the Hagen Farm Site is very high, exceeding MCLs and/or State Enforcement Standards for organic compounds such as benzene, ethylbenzene, tetrahydrofuran, toluene, xylenes, and vinyl chloride. The highest exceedance was tetrahydrofuran, which was detected at a maximum concentration of 630,000 ug/l. Tetrahydrofuran alone exceeded the State Enforcement Standard of 50 ug/l by 12,600 times.

U.S. EPA does not believe that it is appropriate to apply the rationale used for selection of a groundwater remedy at the Stoughton Landfill in selecting the remedy for the Hagen Farm Site. The Stoughton City Landfill Site needs further characterization of the nature and extent of contaminated groundwater, both vertically and horizontally; hence the 12 month decision postponement. As stated above, enough information on the nature and extent of contamination at the Hagen Farm Site exists to support an Agency decision that groundwater extraction is an appropriate remedial technology. In addition, the two sites are not comparable.

Indeed, as WMWI admitted in trying to establish a similarity between the sites, the strongest statement that could be made was that the "...Hagen Farm Site, has contaminants similar to Stoughton City Landfill...". Although many sites may appear similar to the Hagen Farm Site, without a thorough examination of all of the site specific factors (i.e., geology, hydrogeology, and contaminants) it is difficult to determine an inconsistency in the application of environmental requirements.

Overall, WMWI's argument for a postponement of 12 months at the Hagen Farm Site is not based on the technical comparisons such as the type or concentration of contaminant present, but on consistency with another site. The only two technical arguments presented are: 1) the treatment option compatibility between off- and on-site (property) groundwater, and 2) the choice of a compliance point. Again, neither of these arguments are based technically on the type and concentration of contamination at the Hagen Farm Site, but are based on a question of consistency with the Stoughton City Landfill or other sites.

WMWI has charged that U.S. EPA based its decision at the Stoughton Landfill to implement a "contingency" ROD on an economical analysis of incremental risk reduction. This allegation is not true. On the contrary, U.S. EPA based its decision, in significant part, on the fact that the extent of groundwater contamination was not fully characterized. It was expected that the additional groundwater characterization activities would be completed within one year of ROD signature, thus the 12 month postponement of the extraction component of the remedy. In addition, WMWI stated that in the Stoughton ROD the U.S. EPA determined "treatment of the principle threat was not found to be practicable." However, this statement found in the Stoughton ROD refers to treatment of the actual waste material in the Stoughton Landfill, not the groundwater.

<u>COMMENTS:</u>

WMWI asserts that it is highly unlikely that the aquifer at the Hagen Farm Site can be restored to PALs or ESs, as established in NR 140.10, in a reasonable or even practicable time frame using groundwater extraction, even though groundwater extraction is the Best Available Technology (BAT) to mitigate the effects of groundwater contamination. WMWI states that at this time there exists no factual or credible evidence to support the belief or claim that the groundwater at the point of compliance selected by WDNR (the waste boundary) can be returned to its beneficial use as drinking water via the groundwater extraction remedial technology. Further, to require remediation of the aquifer to unachievable levels will only increase the length and cost of the cleanup, well beyond the point of diminishing returns. Therefore, WMWI asserts that U.S. EPA should issue an ARAR waiver for the applicability of the NR 140.10 and the Point of Compliance Applicability at the limits of the waste, based on the grounds of technical

impractibility pursuant to 40 CFR 330.430(f)(1)(ii)(c)(3), as authorized by 40 CFR 300.120. WMWI states that ACLs consistent with NR 140.28 and the protocol for establishing those levels should be developed during the preparation of the RD/RA SOW and subsequent Work Plans. WMWI wishes EPA to, at a minimum and in accordance with its own internal Memorandum on Groundwater treatment dated October 18, 1989, indicate in the ROD for the Hagen Farm Site that information gained during the implementation of the groundwater remedy may reveal that it is technically impractical to achieve health based concentration standards throughout the area of attainment.

SUPPORTING STATEMENTS:

WMWI cited a memorandum dated February 10, 1992 to William Reilly, U.S. EPA Administrator from Don Clay, Assistant Administrator, U.S. EPA, acknowledging the shortcomings of current groundwater remediation technology.

WMWI also cited recent studies which conclude that the effectiveness of extracting groundwater for the purposes of aquifer restoration is effective in containing contaminant migration and reducing contaminant mass, but is ineffective for restoring aquifer water quality within predictable time frames for highly contaminated sites.

WMWI listed site specific factors which could generally limit the effectiveness of groundwater extraction including:

* Moderate adsorption of contaminants (e.g., 1,2-dichloroethene) which would take several times longer to purge than low adsorption constituents.

* Numerous hydrogeologic heterogeneities that will tend to isolate some of the adsorbed contaminants from the extraction zone.

* Ineffectiveness of pumping wells to capture immobilized contaminants in the vadose and capillary zones immediately beneath the landfill. The contaminants in the vadose and capillary zones can become a secondary source.

* There has been no evidence of the presence of DNAPLs revealed during the course of the RI. However, it must be recognized that such evidence may not become readily apparent until the extraction system has been operating for an extended period of time.

RESPONSE:

Based on information obtained during the RI, and on careful analysis of all remedial alternatives, U.S. EPA concludes that the groundwater extraction and treatment component of the selected remedy has a high probability of success in terms of effectively

withdrawing and removing contamination from the groundwater at the Hagen Farm Site, especially THF. THF is completely miscible in water and is able to travel throughout the aquifer with negligible retardation effects. In addition, there is no evidence to demonstrate that a groundwater pump and treat system cannot restore the aquifer at the Hagen Farm Site to Wisconsin health based standards, even at the point of compliance. For these reasons, extraction and restoration of the plume in the aquifer is expected to be technically feasible. It follows then that an ARAR waiver for technical impractibility would not be appropriate. The technical impractibility waiver may be invoked when either of the following specific criteria are met:

- Engineering Feasibility. The current engineering methods necessary to construct and maintain an alternative that will meet the ARAR cannot reasonably be implemented.

- Reliability. The potential for the alternative to continue to be protective into the future is low, either because the continued reliability of technical and institutional controls is doubtful, or because of inordinate maintenance costs.

U.S. EPA does recognize the recent studies cited by WMWI concerning the effectiveness of groundwater extraction and a possible trend in the ineffectiveness of groundwater pump and treat technologies to restore aquifer water quality within predictable time frames. U.S. EPA also recognizes a guidance memorandum , "Considerations in Ground Water Remediation at Superfund Sites" OSWER Directive 9355.4-03, dated October 18, 1989, assessing the effectiveness of nineteen operating groundwater extraction systems in achieving specified goals. The memorandum explained that ground water extraction was effective in containing plumes and achieving significant mass removal of contaminants. However, in many cases (not all), contaminant concentrations did not decrease linearly over time to reach desired remediation goals. After significant initial decreases, concentrations typically leveled off, often at concentrations higher than the cleanup levels. In addition, WMWI cites other studies which came to a similar conclusion. These cases are site-specific and may involve many variables quite different from the Hagen Farm Site. Not all cases demonstrated the inability to achieve specified goals. Again, there is no evidence to demonstrate that a groundwater pump and treat system cannot restore the aquifer at the Hagen Farm Site to health based standards. The ability to achieve cleanup goals at all points throughout the area of attainment, or plume, cannot be determined until the extraction system has been implemented, modified as necessary, and plume response monitored over time. This includes the area in the immediate vicinity of the contaminants' source, where concentrations are relatively high. Therefore, U.S. EPA continues to believe that clean-up standards are achievable until

the system, during operation, demonstrates otherwise. U.S. EPA has considered language in the internal Memorandum on Groundwater dated October 18, 1989, for the ROD. Therefore, as allowed for under NR 140, the U.S. EPA shall provide text in the ROD as follows:

> Consistent with the exemption criteria of NR 140.28, Wis. Adm. Code, U.S. EPA may establish a Wisconsin Alternative Concentration Limit (WACL), if, based on site-specific monitoring data gathered before and after implementation of the selected groundwater remedy, U.S. EPA determines that it is not technically and economically feasible to achieve the PALs for a specific substance. Except where the background concentration of a compound exceeds the ES, and consistent with the criteria in NR 140. 28 (4) (B), the ACL that is established may not exceed the ES for that compound.

U.S. EPA disagrees that the protocol should be established during the SOW preparation.

WMWI is concerned that moderate adsorption of contaminants and numerous hydrogeologic heterogeneities could limit the effectiveness of groundwater extraction. The site specific factors presented by WMWI do not provide strong enough rationale to support a decision to not implement a groundwater pump and treat system or for an ARAR waiver based on technical impracticability. To begin with, U.S. EPA disagrees with WMWI's interpretation of the moderate adsorption of contaminants at the Hagen Farm Site. The RI describes the aquifer material as a sand and gravel matrix. The potential for attenuation/adsorption of organic contaminants within a sand and gravel deposit is low. Sand and gravels typically have low organic matter content which is not conducive to organic compound adsorption within the soil/water matrix. In addition, the the on-property groundwater organic and inorganic compounds of potential concern are ranked as relatively soluble in water and mobile, with the exception of BETX compounds. The primary off-property contaminant of potential concern is THF. THF is completely miscible in water and is able to travel throughout the aquifer with negligible retardation effects. Due to the high mobility of the contaminants at the Hagen Farm Site, the potential for contaminant migration in groundwater appears to be relatively high. Therefore, groundwater contamination is expected to be extracted relatively efficiently. BTEX compounds are expected to be less mobile than other compounds at the Site, but the effects of attenuation will remain uncertain until the groundwater pump and treat system is in operation. The specific example WMWI cited as a moderately adsorbed constituent was 1,2-dichloroethene. U.S. EPA disagrees with this characterization. 1,2-dichloroethene has organic carbon (K_{oc}) and octanol water (K_{ow}) distribution coefficients of 59 and 3.02 respectively, and a solubility of 6300 mg/l at 25°C. Compounds with K_{oc} values ranging from 50 to 150 and

K_{ow} values less than 5 are considered mobile to very mobile and have a low degree of adsorption (Dragun,1988). A compound with a solubility of 6300 mg/l in general is considered very soluble. Effects from any heterogeneities at the site have yet to be determined. If heterogeneities factors do limit the effectiveness of groundwater extraction, their significance can only be determined during the actual operation of the pump and treat system.

WMWI is concerned that pumping wells may be ineffective in capturing immobilized contaminants in the vadose and capillary zones immediately beneath the landfill. U.S. EPA notes WMWI's concern. However, the first phase of the cleanup plan at the Hagen Farm Site, referred to as the Source Control Operable Unit (SCOU), addressed remediation of contamination in the landfill and in the sub-waste soils (vadose zone) immediately beneath the landfill. The cleanup plan for the SCOU involved capping the landfill and operating an in-situ vapor extraction (ISVE) unit. The landfill cap is expected to be effective in preventing the leaching of contaminants from the waste mass and the vadose zone to the groundwater via infiltration of precipitation. The ISVE is a system designed to remove contaminants from the sub-waste soils (vadose zone) and from the groundwater near the water table which would include the capillary fringe (zone). Therefore, this concern appears to lack relevance at the Hagen Farm Site.

U.S. EPA notes WMWI's concern over the DNAPL issue. However, based on the results of the RI, U.S. EPA does not believe DNAPL's exist at the Site. However, ROD text which was presented earlier in this response can be used to address the limitations of an extraction system due to the presence of a DNAPL.

COMMENTS:

WMWI comments that U.S. EPA and WDNR appear to have arbitrarily assigned the limits of waste as the point of compliance for the Hagen Farm Site with little regard to recent precedent within Region V and the State of Wisconsin which dictates the property boundary and/or design management zone (DMZ) as the correct point of compliance. WMWI requests that U.S. EPA and WDNR establish a point of compliance application consistent with NR 140.22 for the Hagen Farm Site.

SUPPORTING STATEMENTS:

WMWI cites numerous RODs throughout the country that have selected varying locations as points of compliance. Some points include the boundary of the landfill property, the landfill property boundary with performance monitoring to be located downgradient but beyond

the zone of influence of the extraction wells, slightly downgradient of the landfill itself, facility property line, and the DMZ or the property boundary whichever is closer to the waste boundary.

RESPONSE:

The U.S. EPA has been consistent in applying NCP Section 300.430(f)(5)(iii)(A). The U.S EPA, through the NCP, established the waste management boundary as the point where remediation levels generally shall be achieved at Superfund Sites. Once standards are met at the waste management boundary, the U.S. EPA believes protectiveness has been achieved for the pathway of concern. The NCP allows that the specific location of the point of compliance could vary from site to site based on site-specific conditions. U.S. EPA believes it to be appropriate and necessary to apply the point of compliance at the waste management boundary for the following reasons. First, at the Hagen Farm Site, the surficial aquifer and bedrock are hydraulically connected and potential exists for contaminants to be drawn from the upper aquifer into the lower aquifer. Given this scenario, U.S. EPA believes that the most conservative point of compliance (the waste management boundary) is necessary to limit the impact of the upper aquifer on the lower aquifer. Secondly, for Superfund response actions in Wisconsin being conducted in accordance with the NCP, the goal is to reduce groundwater concentrations throughout the aquifer(s), so that PALs are not attained or exceeded. If waste is to be left in-place at the conclusion of a response action, NR 140 standards (i.e., PALs) should not be attained or exceeded at the waste management boundary and beyond.

COMMENTS:

WMWI comments that the technology selection for on-property groundwater treatment should be made after an analysis of the off-property groundwater. Use of biological treatment for the on-property groundwater may be practical only if the off-property groundwater is treated separately from the on-property groundwater. If the off-property groundwater can best be treated in a combined stream with the on-property groundwater, biological treatment may not be a compatible technology. The dilution caused by the addition of the off-property groundwater may disrupt and potentially inhibit the effectiveness of the bacteria critical to the successful application of the activated sludge technology specified for the on-property groundwater.

RESPONSE:

U.S. EPA believes that a delay in making a decision at the Hagen Farm Site to determine if off-property groundwater can best be treated in a combined stream with the on-property groundwater would not be a prudent or responsible decision. A delay in the Agency's

decision may result in further degradation of the aquifer's quality and may increase overall costs of a remedy. Use of biological treatment for the on-property groundwater has been proven to be technically implementable and cost effective. In addition, U.S. EPA does not believe that selection of the on-property treatment technology is dependent on selection of the off-property treatment technology.

U.S. EPA would consider "other comparable technology" only if additional information and proposals developed in investigation of the off-property plume clearly documents that effluent quality and percent pollutant removal would be equal to or better than current WMWI projections for biological treatment (with pretreatment for metals). U.S. EPA has selected the biological treatment option based on WMWI projections of effluent quality based on treatability studies. Please note that "other comparable technology" does not include air stripping as discussed in WMWI's comments on a cost/benefit analysis.

COMMENTS:

WMWI requests that WDNR, when developing final surface water discharge limits for the Hagen Farm Site, give careful consideration to developing realistic, consistent, economically achievable standards with full understanding that the protocols used to develop the Hagen discharge limits must be consistently applied to other industrial and municipal discharges throughout the State.

RESPONSE:

U.S. EPA recognizes that at CERCLA sites where technology-based controls are not adequate to achieve water quality standards in the receiving water body or no water quality standards have been established (i.e., THF), numerical and/or narrative standards must be developed which are site specific. However, U.S. EPA must emphasize that the goal of the discharge standard is to ensure that substantive requirements for discharge to surface waters are met in order to maintain the chemical, physical, and biological integrity of the receiving water body. U.S. EPA also recognizes that technology based limits must be developed carefully. Therefore, U.S. EPA shall take the most conservative approach to achieve that goal.

Additional comments on specific WMWI concerns are presented below:

- The example cost benefit analysis presented in Waste Management's comments is not accepted as valid since air stripping technology is not an acceptable treatment technology based on projected low pollutant removals (up to 40% THF in the example) and projected high effluent concentrations.

- WDNR notes that the "general" permit for discharge of treated contaminated groundwater does not apply to all groundwater remedial action projects. A more restrictive specific WPDES permit is required if water quality based limits and requirements are more restrictive than limits in the "general" permit or at the discretion of the Department. Therefore, the use of the general permit for appropriate LUST discharges does not preclude implication of more restrictive discharge limits. Generally, many LUST cases involve relatively minor remediations and low discharge volumes in comparison to more complex superfund remediations. Reference to the Model EPA permit for discharges from the cleanup of gasoline released from underground storage tanks will verify that the Department selected the least restrictive of the BTEX limits in EPA's model permit which were recommended for the smaller remediations (ie., gas stations, etc.) for the "general" permit. It is notable that EPA's Model NPDES permit recommended more restrictive limits of 5 ug/L for Benzene and 100 ug/L for total BTEX as well as biomonitoring for more significant gasoline cleanups.

- Background surface water quality must be accounted for in the development of water quality based limits in accordance with Wis. Stats. and Administrative codes referenced above.

- Chapter NR 140. Wis. Admin. code (WAC), groundwater standards PALs are not specified as limits for discharges to surface water. However, effluent limits for discharges to surface water developed in accordance with Chapter 147 Wis. Stats. and NR 102, 103, 104, 105, and 207, WAC, may be more or less restrictive than NR 140 PALs depending on site specific consideration and pollutants being evaluated. Technology based discharge limits and requirements specified in accordance with NR 220, WAC, may also be more restrictive than NR 140 PALs. If there is any component of a surface water discharge to groundwater, the more restrictive of NR 140 PALs, surface water quality based limits or technology based requirements are applicable, as is the case for discharge to the drainage ditch adjacent to the Site. Reference to example discharge limits in Table 1 of Waste Management's comments illustrates this for several pollutants.

COMMENTS:

WMWI asserts that the risk estimates presented in the Baseline RA, which were prepared in accordance with U.S. EPA methodologies and specifications, do not reflect the true or reasonable estimates of site risks. WMWI maintains that risk estimates prepared under

current U.S. EPA risk assessment guidance are inflated, thus unnecessarily alarming the public and diverting attention from other more important environmental problems. Furthermore, WMWI suggests that U.S. EPA should consider using the results of a report entitled "Alternative Methodology Risk Assessment of the Groundwater Ingestion Pathway at the Hagen Farm Landfill" in selecting an appropriate remedy for the Site. This report was submitted with WMWI comments. WMWI feels that the methodologies in that report more accurately depict and quantify the risks at the Hagen Farm Site as compared to U.S. EPA's approach. WMWI suggests that the report supports the conclusion that more than likely no adverse health effects would be expected from the Site if the groundwater were to be consumed as a drinking water supply.

SUPPORTING STATEMENTS:

* WMWI asserts that the Region V policy has not been authorized by U.S. EPA Headquarters, and, in fact, is inconsistent with current U.S. EPA national Superfund risk assessment guidance, and U.S. EPA's proposed exposure-related measurement and final exposure assessment guidelines. WMWI quotes U.S. EPA "Risk Assessment Guidance for Superfund, Volume I, Human Evaluation Manual (EPA/540/1-89/002, December 1989)" (p. G19) ...assuming long-term contact with the maximum concentration is not responsible. WMWI asserts that this is precisely the effect of following the Region V policy, which WMWI asserts uses an implausible worst-case analysis as the only level of analysis.

* WMWI presented quotes from U.S. EPA "Proposed Guidelines for Exposure-related Measurements" (53 Federal Register 48830, December 2, 1988) as follows:

- A legitimate use of worst case scenarios is to determine if the exposure or risk is low enough even at this extreme so as to dismiss concern for this scenario. It is not legitimate to use a worst-case scenario to prove that there in fact exists a concern in a real population.

- If the exposure or risk value estimated by a worst-case scenario is high enough to cause concern, the assessor must reevaluate the parameters used and perform reality checks before deciding a problem really exists.

* WMWI presented a quote from U.S. EPA "Guidelines for Exposure Assessment" (57 Federal Register 22888, May 29,1992) as follows:

- ...the only thing the bounding estimate can establish is a level to eliminate pathways from further consideration. It cannot be used to make a determination that a pathway is significant... and it certainly cannot be used for an estimate of actual exposure...

RESPONSE:

The methods used in the U.S. EPA "Risk Assessment Guidance for Superfund, Volume I, Human Evaluation Manual" to calculate risks at the Site have been developed by the U.S. EPA. U.S. EPA acknowledges that the assumptions used in our risk assessments are conservative. The assumptions are designed to be reasonable and not worst case. The assumptions are conservative because the Superfund program has always designed its remedies to be protective of all individuals and environmental receptors that may be exposed at a site; consequently, U.S. EPA believes it is important to include all reasonably expected exposures in its risk assessment. Again, U.S. EPA believes the assumptions used in the guidance referenced above to calculate risks are reasonable and necessary to determine whether action to be taken needs to be taken at a site in order to adequately protect human health and the environment. The risk assessment guidance referenced above is designed to focus the assessment on more realistic exposures. U.S. EPA has adopted these positions and policies and has not revised the regulation. In addition, the U.S. EPA guidance states that if good data identifying the center of the plume do not exist, modeling is not performed, and the collection of additional samples is precluded, generally the well with the overall highest concentration of contaminants of concern should be used as the exposure point concentration. At the Hagen Farm Site, the well with the overall highest concentration of contaminants of concern was used as the exposure point concentration. This is reasonable and does not constitute a worst case or "inflated" risk because it is not likely that under these conditions the true highest contaminant concentration has been detected in sampling.

The Human Health Evaluation Manual fully supports the Regional guidance as shown on page 6-27, "Selection of the location(s) used to evaluate future groundwater exposures should be made in consultation with the RPM." Also, Headquarters expects the Regions to determine the appropriate exposure area for use in calculating the exposure point concentration. Other Regions have adopted similar guidance.

U.S. EPA acknowledges the results from the report entitled "Alternative Methodology Risk Assessment of the Groundwater Ingestion Pathway at the Hagen Farm Landfill" submitted to U.S. EPA. However, U.S. EPA believes that using the results of the report, as suggested by WMWI, would not be appropriate for determining whether remedial action is warranted at this Superfund Site. With respect to risk assessments, U.S. EPA is obligated to follow Agency policy as opposed to recommendations or suggestions from PRPs or outside sources in order to consistently carry out the requirements of CERCLA. Therefore, U.S. EPA will continue to use the results of the Risk Assessment developed for Hagen Farm under U.S. EPA guidance to justify the need to take remedial action at the Site.

COMMENT:

Second bullet under paragraph "Remedial Action Goals" (page 6, RGCP) states that the goal of the remedy selection process is "to restore groundwater on and off-property so that contaminant levels meet state groundwater standards." WMWI comments that the affected groundwater on the property is not a source of drinking water and, according to NR 112.08, installation of private wells is restricted within 1,200 feet of the landfill. Additionally, property deed restrictions which are currently recorded will prohibit construction of on-property drinking water wells. The FS cited as a remedial action objective goal to "reduce the groundwater contamination beneath the Site to a technically feasible level producing acceptable health risk levels, and to attain compliance, where possible, with identified Federal and State ARARS". WMWI asserts that the restoration goal as described by U.S. EPA in the RGCP may be misleading to the public. WMWI requests that U.S. EPA acknowledge the low likelihood of complete groundwater restoration to WDNR groundwater standards as described by the RGCP.

RESPONSE:

U.S. EPA reaffirms its goal as stated in the RGCP (i.e., restoration of the aquifer on-property) for the following reasons:

- **Although WMWI is correct in stating that NR 112.08 allows for restriction on installation of private wells within 1,200 feet of a landfill, it should be noted that zoning cannot guarantee that no wells will be allowed in the area in the future. Because the State has the ability to grant variances under Section NR 112.43 from supply well restrictions, future prohibition of the use of the groundwater for drinking water purposes by the State cannot be guaranteed.**

- **According to the NCP Section 300.430(e)(3)(ii), institutional controls may be used as a supplement to engineering controls over time, but should not be substituted for active response measures as the sole remedy unless active response measures are not practicable. If it could be demonstrated that the aquifer will cleanse itself within a reasonable period of time, U.S. EPA could possibly consider that as a viable option. However, natural cleansing is not expected to occur within a reasonable period of time at the Hagen Farm Site.**

U.S. EPA acknowledges WMWI's concern over the likelihood of complete groundwater restoration to WDNR groundwater standards and that the restoration goal as described in the RGCP may be

misleading to the public. As stated earlier, U.S. EPA is confident that the groundwater extraction and treatment component of the selected remedy would have a high probability of success in terms of effectively withdrawing and removing contamination from the groundwater at the Hagen Farm Site to WDNR groundwater standards. However, U.S. EPA will inform the public if, after operation, it is determined that it is not technically feasible to meet ARARs.

COMMENT:

WMWI feels that further clarification of Section 4 "Reduction in Toxicity, Mobility, or Volume Through Treatment" (page 7, RGCP) is required. The paragraph states "Alternative 2 would increase the rate of cleanup by using micro-organisms injected into the groundwater to help treat the contaminants into chemicals that are not harmful." It should be noted that Alternative 2, since it will accelerate cleanup, will not necessarily operate for 30 years as it is traditionally assumed.

RESPONSE:

U.S. EPA interprets the comment regarding the necessity for clarification as involving the cleanup time frame. Therefore, U.S. EPA acknowledges WMWI's comment and notes that by using micro-organisms injected into the groundwater to accelerate cleanup, Alternative 2 may not necessarily operate for 30 years as it is assumed for costing purposes.

COMMENT:

WMWI states that the section "Compliance with ARARS" (page 7, RGCP) is misleading as written. WMWI asserts that U.S. EPA's representation that the remedy will meet all ARARs is misleading. The Draft Final Feasibility Study contained text discussing the potential future need for development of ACLs and/or a NR 140 ARAR waiver based upon technical impractability from an engineering perspective. This text was included in the draft final Feasibility Study as required by the National Contingency Plan (NCP) for sites where it is recognized that the remedy may not meet ARARS. WMWI states that the NCP requires that the potential for an ARAR waiver be identified in the Feasibility Study and be summarized in the Proposed Plan when it is released by the U.S. EPA.

RESPONSE:

Based on information obtained during the RI, and on careful analysis of all remedial alternatives, U.S. EPA is confident that the groundwater extraction and treatment component of the selected remedy would have a high probability of success in terms of effectively withdrawing and removing contamination from the groundwater at the Hagen Farm Site. In addition, there is no evidence to demonstrate that a groundwater pump and treat system

cannot restore the aquifer at the Hagen Farm Site to Wisconsin NR 140 standards, even at the point of compliance. For these reasons, extraction and restoration of the plume in the aquifer is expected to be technically feasible.

The ability to achieve cleanup goals at all points throughout the area of attainment, or plume, cannot be determined until the extraction system has been implemented, modified as necessary, and plume response monitored over time. This includes the area in the immediate vicinity of the contaminants' source, where concentrations are relatively high. Therefore, U.S. EPA will continue to believe that clean-up standards are achievable until the system, during operation, demonstrates otherwise. If during operation it is determined that it is not technically and economically feasible to achieve the PALs for a specific substance an Alternative Concentration Limit (ACL), may be established by U.S. EPA. Language reflecting this option shall be provided in the text of the ROD.

COMMENT:

WMWI feels that the in-situ vapor extraction system (ISVE) discussed on page 4 of the RGCP is inaccurate with respect to the proposed installation at Hagen Farm. Air injection is not appropriate for the Hagen Farm Site and as such, is not being considered. Therefore, WMWI requests that U.S. EPA correct this statement on the RGCP.

RESPONSE:

U.S. EPA recognizes the inaccuracy in the RGCP concerning the statement about air injection. Air injection was not considered. The statement should read, "The ISVE system works by removing volatile chemicals in the unsaturated waste/sub-soils without excavation. The process moves air through the Waste/sub-soils near hydrocarbon contamination using a vacuum pump."

COMMENT:

In reference to the discussion on page 5 of the RGCP concerning drinking groundwater from the immediate vicinity of the site, WMWI states that it should be noted that all private wells on-property have been abandoned according to state regulations and are no longer available as drinking water supplies.

RESPONSE:

U.S. EPA recognizes WMWI's statement and hereby notes that all private wells on-property have been abandoned according to state regulations and are no longer available as drinking water supplies.

U.S. EPA ADMINISTRATIVE RECORD INDEX

UPDATE #3

HAGEN FARM SITE

STOUGHTON, WISCONSIN

05/14/92

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1	00/00/00			Explanation of Significant Differences: Change to the Remedy in the 1990 ROD with Supporting Documents	53
2	00/00/90	Antens, I., USEPA	Dowden, J., Waste Management	Notice of Deliquency	2
3	01/25/90	Antens, I., USEPA	Dowden, J., Waste Management	Invoice for Recovery of Costs	21
4	04/25/90	Harrity, D., PRC	Lee, J., USEPA	Preliminary Risk Assessment Review	4
5	05/08/90	Antens, I., USEPA	Brncich, D., Waste Management	Letter Providing Revised Invoice for FY 1989 Oversight Costs	2
6	06/06/90	Jacobs, P., Warzyn	Lee, J., USEPA	Groundwater Sampling while Drilling at Boring B-32B	2
7	06/14/90	Jacobs, P., Warzyn	Brncich, D., Waste Management	Well Installation Procedures	2
8	07/00/90	USEPA		Fact Sheet--US EPA Issues Proposed Plan for - Landfill Cleanup	12
9	07/20/90	Lovejoy, M. & Asbury, G., Warzyn	Lee, J., USEPA	Letter re: Degree of Expected Reductions of VOCs (per FS)	2
10	08/00/90	Wisconsin Dept. of Health & Social Services		Health Information Newsletter	4
11	08/16/90	Brncich, D., Waste Management	Lee, J., USEPA & Evanson, T., WDNR	Issues for 8/23/90 Meeting with Attachments	10
12	08/17/90	Antens, I., USEPA	Brncich, D., Waste Management	Letter Providing Documentation for Jacobs Contract for Billing Period 10/1/88-9/30/89	1
13	08/28/90			Meeting Notes for Hagen Farm RI/FS	6
14	10/01/90	Asbury, G., Warzyn	Lee, J., USEPA	Cover Letter to Work Plan Addendum, Hagen Farm RI/FS	1

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15	10/16/90	Evanson, T., WDNR	Lee, J., USEPA	Comments on the 10/2/90 Work Plan Addendum, Hagen Farm RI/FS	4
16	10/19/90	Lovejoy, M., Warzyn	Lee, J., USEPA	Revision to Work Plan Addendum, Hagen Farm RI/FS	4
17	10/12/90	Straw, A., Counsel, Waste Management of Wisconsin	Sullickson, R., Property Owner	Consent for Access and Entry	4
18	10/16/90	Evanson, T., WDNR	Asbury, G., Warzyn	Variance to NR 141.19, Borehole Diameter for Pump Test Monitoring Wells	2
19	10/22/90	Asbury, G., Wayzyn	Lee, J., USEPA	Cover Letter to Work Plan Addendum and Attachments	1
20	10/23/90	Evanson, T., WDNR	Asbury, G., Wayzyn	Logging of Soil Boreholes During Phase II Drilling Activities	2
21	11/26/90	Burge, D., Versar, Inc.	Lee, J., USEPA	Report of Drilling Incident	2
22	11/30/90	Brncich, D., Waste Management	Everett, D., Stoughton Conservation Club	Request to Prohibit Use of Target Practice Range During Testing	5
23	12/03/90	Brncich, D., Waste Management	Lee, J., USEPA	Report of Drilling Incident	4
24	12/04/90	Lee, J., USEPA	Brncich, D., Waste Management	Approval of Work Plan Addendum	1
25	12/06/90	Brncich, D., Waste Management	Lee, J., USEPA	Monthly Progress Report: November 1990	63
26	12/11/90	Evanson, T. WDNR	Brncich, D., Waste Management	Aquifer Pump Test and Carbon Treatment of Effluent Requirements	5
27	12/17/90	Brncich, D., Waste Management	Lee, J., USEPA	Report of Aquifer Pump Test	2
28	12/19/90	Jordan-Izaguirre, D., ATSDR	Lee, J., USEPA	Private Wells Results	86
29	01/07/91	Brncich, D., Waste Management	Lee, J., USEPA	Hagen Farm Aquifer Pump Test Preliminary Report	46
30	01/07/91	Brncich, D., Waste Management	Lee, J., USEPA	Monthly Progress Report: December 1990	84

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34	02/15/91	Brncich, D., Waste Management	Lee, J., USEPA	Response to Comments by Versar, Inc. on Treatability Study Work Plan	2
35	02/20/91	Vanderpool, L., USEPA	Lee, J., USEPA	Geological Review Comments of Treatability Study Work Plan	1
36	02/28/91	Evanson, T., WDNR	Lee, J., USEPA	Comments on Treatability Study Work Plan	2
37	02/28/91	Harrity, J., PRC	Lee, J., USEPA	Cover and Review of Treatability Study Work Plan	8
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39	03/05/91	Lee, J., USEPA	Brncich, D., Waste Management	Approval of Work Plan	2
40	03/07/91	Holoska, T., U.S.EPA	Lee, J., USEPA	Comments on Treatability Study Work Plan	2
41	03/15/91	Brncich, D., Waste Management	Lee, J., USEPA	Request for Letter Granting Approval for Sample Collection	1
42	03/21/91	Brncich, D., Waste Management	Lee, J., USEPA	Response to Comments on Treatability Study Work Plan	30
43	03/26/91	Evanson, T., WDNR	Lee, J., USEPA	Waste Management's Compliance with WDNR Hazardous Waste Rules for Collection/Transportation of Hazardous Waste Samples	1
44	03/29/91	Vanderpool, L. U.S. EPA	Lee, J., USEPA	Review of Waste Managements Response to Comments on Work Plan	1
45	04/15/91	Evanson, T., WDNR	Urek, J., Waste Management	Collection/Transportation of Groundwater for Treatability Studies	2
46	04/15/91	Urek, J. Waste Management	Evanson, T., WDNR	Request for Variance of WDNR Hazardous Waste Rules for Collection/Transportation of Hazardous Waste Samples for Treatability Studies	6

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50	05/30/91	Termont-Schenk, S., Wayzyn	Lee, J., USEPA	Cover Letter to Full-Size Design Drawings	1
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52	06/04/91	Baumann, A., USEPA	Lee, J., USEPA	Review Comments on Health & Safety Plan	1
53	06/06/91	Thomas, C. USEPA	Lee, J., USEPA	Review Comments on Prefinal Landfill Cover Design Report	4
54	06/13/91	Dunn, J. WDNR	Lee, J., USEPA	FAX-Comments on RD/RA Prefinal Design Report	1
55	06/25/91	Gandhi, B., PRC	Lee, J., USEPA	Review Comments on Prefinal Landfill Cover Design Report	1
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57	07/02/91	Lee, J., USEPA	Brncich, D., Waste Management	Review Comments on Prefinal Landfill Cover Design Report	5
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60	08/00/91	USEPA		Fact Sheet--Progress Report	6
61	08/01/91	Termont-Schenk, S., Wayzyn	Lee, J., USEPA	Cover to Final Landfill Cover Design Report	1
62	08/05/91	Termont-Shenk, S., Wayzyn	Lee, J., USEPA	Responses by Wayzyn and Waste Management to Agency Comments on Prefinal Landfill Cover Design Report	18

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65	08/27/91	Straw, A., Waste Management Counsel	Gullickson, F.	Consent for Access and Entry	3
66	08/27/91	Straw, A., Waste Management Counsel	Sagmoen, C.	Consent for Access and Entry	3
67	08/27/91	Straw, A., Waste Management Counsel	Gjertson, M.	Consent for Access and Entry	3
68	08/27/91	Straw, A., Waste Management Counsel	K May Insulation, Inc.	Consent for Access and Entry	3
69	08/27/91	Straw, A., Waste Management Counsel	Sundby Sand & Gravel	Consent for Access and Entry	3
70	08/27/91	Straw, A., Waste Management Counsel	Sundby, G.	Consent for Access and Entry	3
71	08/29/91	U.S.EPA		Public Meeting Agenda	1
72	08/30/91	Moser, J., Wayzyn	Lee, J., USEPA	Cover Letter to Draft RI Report	1
73	09/05/91	Lee, J., USEPA	Addresses	Copies of Draft Remedial Investigation Report	1
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80	10/08/91	Schnoes, K., PRC	Lee, J., USEPA	Fax-Versar s Review Comments on Draft RI Report	8

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85	11/00/91	Wayzyn Inc.	Waste Management of Wisconsin, Inc. & Lee, J., USEPA	Final Remedial Investigation Report: Vol. 2 of 4 - Appendices A-C	580
86	11/00/91	Wayzyn Inc.	Waste Management of Wisconsin, Inc. & Lee, J., USEPA	Final Remedial Investigation Report: Vol. 3 of 4 - Appendices D-I	412
87	11/00/91	Wayzyn Inc.	Waste Management of Wisconsin, Inc. & Lee, J., USEPA	Final Remedial Investigation Report: Vol. 4 of 4 - Appendices J-M	350
88	11/04/91	Moser, J., Wayzyn	Lee, J., USEPA	Conference Call Report of Draft RI	2
89	11/22/91	Moser, J. & Termont-Schenk, S., Wayzyn Inc.	Lee, J., USEPA	Responses to Agency Review Comments on Draft RI Report	22
90	01/00/92	Warzyn Inc.	Waste Management of Wisconsin, Inc. & Lee, J., U.S. EPA	In-Situ Vapor Extraction Pilot Study Work Plan; Remedial Design/Remedial Action: Source Control Operable Unit	32
91	01/20/92	PRC Environmental Management, Inc.	Lee, J., USEPA	RD/RA Oversight Trip Report 2	92
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93	01/31/92	Termont-Schenk, S., Wayzyn Inc.	Lee, J., USEPA	Responses to U.S. EPA Comments on Draft FS	95
94	02/10/92	Warzyn Inc.	Lee, J., USEPA	Responses to Comments on the Draft In Situ Vapor Extraction Pilot-Study Work Plan	48
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96	03/02/92	Heinrich, B., Waste Management	Lee, J., USEPA	Meeting Notification re: Draft Feasibility Study	1

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98	03/06/92	Niemann, C., Waste Management	Lee, J., USEPA	Format for Revised GCOU Feasibility Study	2
99	03/06/92	Lee, J., USEPA	Niemann, C., Waste Management	Review Comments for GCOU Revised Feasibility Study	30
100	03/09/92	Niemann, C., Waste Management	Lee, J., USEPA	Revisions to Draft Final GCOU Feasibility Study	1
101	03/16/92	Niemann, C., Waste Management	Lee, J., USEPA	Comments on ROD with Sample ROD	80
102	03/16/92	Niemann, C., Waste Management	Lee, J., USEPA	Progress Letter on In-Situ Vapor Extraction	2
103	03/17/92	Gandhi, B., PRC	Lee, J., USEPA	RD/RA Oversight Trip Report 3	22
104	03/20/92	Niemann, C., Waste Management	Distribution	March 11, 1992 Meeting Issues	3
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106	03/31/92	Gandhi, B., PRC	Lee, J., USEPA	Acknowledgement of PRP Remedial Action Implementation Report	1
107	04/06/92	Warzyn, Inc.	Waste Management & Lee, J., USEPA	Final Feasibility Study for Groundwater Control Operable Unit	402
108	04/08/92	Lee, J., USEPA	Niemann, C., Waste Management	Review Comments on 3 Chapters of Draft FS	13
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UPDATE #4

HAGEN FARM SITE

STOUGHTON, WISCONSIN

09/08/92

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State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

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Carroll D. Besadny
Secretary

September 28, 1992

Mr. Valdas V. Adamkus, Administrator
U.S. EPA Region V
77 W. Jackson
Chicago, Ill 60604

SUBJECT: Concurrence on The Selected Groundwater Control Remedy, Hagen Farm Site, Town of Dunkirk, Dane Co., WI

Dear Mr. Adamkus:

The Department is providing you with this letter to document our concurrence with the remedy selected for the groundwater control operable unit at the Hagen Farm Superfund site. The proposed groundwater remedy, as outlined in the June, 1992 Proposed Plan, will address the contaminated groundwater both on and off site, and is considered the final remedy for the groundwater at the site. The selected remedy is alternative 2, which includes:

* Groundwater use restrictions in the form of deed restrictions to the extent necessary to implement and protect the remedy;

* Installation of a fence around the treatment system;

* Additional monitoring to determine the depth and extent of off-site contamination;

* A series of groundwater extraction wells both on and off-site designed to actively restore the groundwater in both areas;

* Pretreatment of all extracted groundwater for the removal of metals and inorganic solids;

* Treatment of the on-site extracted groundwater in an activated sludge biological treatment facility constructed at the Hagen Farms site;

* A bench scale study examining the feasibility of injecting the treated on-site groundwater into the aquifer below the site in order to enhance in-situ bioremediation;

* Treatment of off-site extracted groundwater using an appropriate treatment technology. This technology has not yet been determined but options include cascade aeration, activated sludge, air stripping, granular activated carbon (GAC) or UV-oxidation;

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* Treatment of residue, sludge, and/or spent coagulates to meet land disposal requirements, followed by disposal in a RCRA landfill; and

* Discharge of all treated groundwater to the Yahara River or nearby wetlands.

The range of costs for the selected remedy are estimated to be as follows:

Capital Cost	$ 4,396,000 - $6,288,000
Annual O&M 1st year	$ 550,000 - $ 1,062,000
Total Present Worth	$ 13,612,000 - $ 24,163,000
Estimated time to implement	30+ Years

Though the Department concurs with the selection of this remedy, WDNR concurrence is based upon the understanding that at the time the proposed treatment design is finalized, the effluent discharge limits and discharge location (including any reinjection of enhanced groundwater which is proposed) are acceptable to the WDNR and are in compliance with the effluent discharge limit requirements of Chapters NR 102, 105, 106, 207 and 220, the wetlands protection in Ch NR 103, and the applicable air quality standards in Chs NR 400 to 499, WAC. Our concurrence is also conditioned on EPA's supplementation of that portion of the administrative record that pertains to off-site groundwater extraction and treatment with all documents submitted by the WDNR in the future dealing with off-site groundwater extraction and treatment, in accordance with 40 CFR 300.825(a)(1). In addition, the Department recommends that the potential to discharge to a municipal sewerage system be further investigated during the remedial design.

We understand that if the potentially responsible parties (PRPs) do not agree to fund the remedy, it will be necessary for the State of Wisconsin to contribute 10% of the remedial action costs associated with the actions and 10% of the O&M costs for the first 10 years of groundwater extraction and treatment. In addition, if the PRPs do not agree to fund the O&M, the State of Wisconsin will need to contribute 10% of all other O&M costs for the first year and provide for all O&M after that, provided that no changes to the National Contingency Plan are made that would require an alternative cost allocation. We provide assurance of the State's willingness to provide this required state cost share on the assumption that U. S. EPA will pursue all feasible enforcement actions against the PRPs prior to expending the Fund at the site.

We understand that if the Fund is expended to conduct the remedy and if hazardous waste needing disposal is required to be managed off-site as part of the remedy, that the State of Wisconsin will be required to provide the assurances for hazardous waste management in §40 CFR 300.510(d) and (e) of the National Contingency Plan. The assurances are that a compliant hazardous waste facility is available, and that facility's use is consistent with our approved Capacity Assurance Plan. In addition, the Department recommends that an analysis and a finding be made during remedial design on whether hazardous wastes can be managed in-state and on-site, to the extent practicable. Hazardous waste residuals may be generated by the pretreatment of extracted

groundwater prior to treatment, and sludge generated during the treatment of groundwater may constitute hazardous waste.
We also understand that our staff will continue to work in close consultation with your staff during the pre-design, design and construction phases of the remedy.

Thank you for your support and cooperation in addressing the contamination problem at the Hagen Farm site. Should you have any questions regarding this matter, please contact Jane Lemcke, Superfund Remedial Unit Leader, at (608) 267-0554.

Sincerely,

C. D. Besadny
Secretary

cc: Lyman Wyble - AD/5
Linda Meyer - LC/5
Paul Didier - SW/3
Mike Schmoller - SD
Mary Pat Tyson - U. S. EPA Region V, 5HS/11
Mark Giesfeldt - SW/3
Jane Lemcke - SW/3
Paul Kozol - SW/3

ATTACHMENT 2

Scope of Work for
The Remedial Design and Remedial Action Work Plan
at the Hagen Farm Site, Groundwater Control Operable Unit
Stoughton, Wisconsin

I. PURPOSE

The purpose of the Scope of Work (SOW) is to fully implement the Hagen Farm Site (the Site) Groundwater Control Operable Unit Record of Decision (ROD) which the United States Environmental Protection Agency (U.S. EPA) issued on September 30, 1992 to select a remedial action for the Groundwater Control Operable Unit. In designing, implementing and submitting deliverables for the remedial action at the Hagen Farm Site, the Respondent shall follow this SOW, the U.S. EPA Superfund Remedial Design and Remedial Action Guidance, the ROD, the approved Remedial Design (RD) Work Plan, Remedial Action (RA) Work Plan, any additional guidance provided by U.S. EPA, and the provisions of the Administrative Order.

II. DESCRIPTION OF THE REMEDIAL ACTION

A. Overview of Site

Two operable units have been defined for the Site. The Site is defined as the area within the Hagen Farm property boundary and the contaminant plume. Operable Unit I, which is the Source Control Operable Unit (SCOU), is intended to address waste refuse and sub-surface soils at the disposal areas. The ROD for Operable Unit II, which is the Groundwater Control Operable Unit (GCOU), is intended to address the contaminated groundwater at the Site. This SOW details the work that is required in connection with the GCOU.

The major components of the remedial action for the GCOU that shall be designed and implemented by the Respondent are the following: Groundwater extraction; on-property groundwater treatment with an Activated Biological Sludge System; off-property groundwater treatment with a technology consistent with the results of work conducted during design as selected by U.S. EPA; and discharge of treated groundwater to either the wetland or Yahara River as determined by U.S. EPA. On-property groundwater is defined as contaminated groundwater on and in the immediate vicinity of the main waste disposal area. Off-property groundwater is defined as contaminated groundwater at any location within the plume other than in the area defined as on-property groundwater. The Respondent is required to initiate and/or accomplish these remedial actions within the time periods specified herein and are required to submit reports as identified in Section III below.

B. Standards and Specifications

The performance standards and specifications of the major components of the remedial action for the GCOU, which shall be designed and implemented by the Respondent are:

1. Fence Installation

The Respondent shall install and maintain fencing surrounding the on-property area from the edge of the disposal area to Trunk Highway A (CTH A), as well as the off-property areas where treatment facilities are located in order to reduce risks which may be posed to public health due to construction activities or exposure to hazardous chemicals during the cleanup process and also to protect treatment equipment from vandalism. The fence shall consist of a six-foot high chain link perimeter fence topped with three-strand barbed wire. The fence shall enclose all extraction wells and treatment facilities, and shall be equipped with a double locking swing gate at the entrance to the access road. Standard Superfund warning signs shall be posted at 200-foot intervals along the fence, or at least one warning sign on each side of a fenced in area with intervals less than 200 feet, and on the gate within fifteen (15) days after the completion of the fence. The warning signs shall advise that the area is hazardous due to chemicals in the groundwater which pose a risk to public health. The signs shall also provide a telephone number to callers for further information. The Respondent shall promptly take necessary steps to protect against vandalism at the Site and to minimize and repair any vandalism to the fence or other security measures. The Respondent shall inspect and maintain the fence to assure that the fence is intact and unbreached. The Respondent shall describe fence inspection and maintenance in the Operation and Maintenance Plan. After the Respondent receive notice of Certification of Completion under paragraph 93 of the Administrative Order, the Respondent may petition U.S. EPA for modification of the requirements of this paragraph.

2. Groundwater Monitoring and Treatment

a. Installation and Operation of Groundwater Monitoring Program

The Respondent shall design and implement a groundwater monitoring program. The design of the groundwater monitoring program shall be subject to U.S. EPA approval. The program shall be designed to detect changes in the chemical concentration of all contaminants in the groundwater, and to demonstrate the effectiveness of the Groundwater Extraction, Collection, Treatment, and Discharge System (Groundwater Extraction System) described in Section II.B.2.b., including, but not limited to, the effectiveness of the system to protect the private wells located around the Site and in achieving the cleanup standards set forth in Section II.B.2.b.(16), below. The groundwater

monitoring program shall include collection and field and laboratory analysis of samples from the monitoring wells and private wells, as set forth in more detail in Section II.B.2.a, below.

(1) Groundwater Monitoring Plan

The Respondent shall submit to U.S. EPA, for approval by U.S. EPA, a Groundwater Monitoring Plan (GMP) which complies with the requirements of paragraphs II.B.2.a.(2) through II.B.2.a.(6) below and a Quality Assurance Project Plan (QAPP). The GMP shall at a minimum include a schedule for the duration and frequency of sampling activity, the location of wells to be sampled, the method of sampling and analysis, the frequency and methodology for obtaining static water elevations, and the compounds to be analyzed. The Respondent shall implement the sampling and testing required under the GMP after U.S. EPA approval of the GMP and QAPP. The GMP and QAPP shall be submitted with the RD Work Plan.

(2) Additional Wells/Monitoring Locations

The Respondent shall obtain static water elevation measurements, and shall collect and analyze groundwater samples from wells specified in the approved GMP. The monitoring wells to be sampled pursuant to the GMP shall include, at a minimum, the wells located at the Site and installed at the properties surrounding the Site during the Remedial Investigation (RI) of the SCOU, the wells installed to determine background levels, wells installed during the RI/FS for the GCOU, any additional wells installed during the RD/RA, and the private wells located around the Site. The private wells to be sampled include, but are not limited to, the wells located on the following properties: Sundby, K-Way Insulation, Sundby Sand and Gravel, Gullickson, Fosdohl, Lee, Van Deusen, Quam, Stoughton Conservation Club, Sagmoen, and Gjertson assuming access to these wells is provided by the owners.

If U.S. EPA determines that the groundwater monitoring program is inadequate to detect changes in the chemical concentration in groundwater, or to determine the effectiveness of the Groundwater Extraction System, U.S. EPA may require, by written notification to the Respondent, additional groundwater monitoring wells. If U.S. EPA determines that the groundwater monitoring program is inadequate to detect changes in the chemical concentrations in private wells located around the Site, the U.S. EPA may require, by written notification to the Respondent, additional private wells to be sampled.

If, during the sampling activities of private wells, unusual phenomena or data are encountered, including, but not limited to, high or low pH or conductivity, or strange smell, the Respondent shall inform U.S. EPA immediately.

(3) Sampling Frequency

After approval of the GMP, groundwater monitoring wells designated in the GMP in accordance with paragraphs II.B.2.a.(1) and (2) above, shall be measured for static water level elevations and sampled by the Respondent. The Respondent shall perform the field and laboratory analysis as set forth in the GMP approved by U.S. EPA.

Monitoring wells shall be sampled and static water levels obtained during the operation of the Groundwater Extraction System. The frequency of sampling shall be set forth in the GMP. At a minimum, however, monitoring wells shall be sampled on a quarterly basis for the first three years of operation. Thereafter, each monitoring well shall be sampled on a quarterly basis until U.S. EPA allows semi-annual sampling of each such well based on a determination that such frequency is sufficient to demonstrate the effectiveness of the Groundwater Extraction System. The private wells located around the Site shall be sampled on an annual basis during the operation of the Groundwater Extraction System. Physical monitoring (static water elevation) shall be performed at a frequency sufficient to demonstrate the effectiveness of the Groundwater Extraction System. The Respondent at a minimum shall measure the water level on a monthly basis for the first year, every other month for the second year, and quarterly thereafter. The Respondent shall perform the field and laboratory analyses approved by U.S. EPA pursuant to the approved GMP. At the end of the operation of the Groundwater Extraction System, U.S. EPA shall determine the need for additional monitoring.

If U.S. EPA determines that the groundwater monitoring program is inadequate to detect changes or the rate of change in the chemical concentrations in groundwater, or to determine the effectiveness of the Groundwater Extraction System, U.S. EPA may modify the sampling frequency upon written notification to the Respondent.

(4) Analyses

The Respondent shall perform the static groundwater elevation measurements and field and laboratory analysis according to the GMP and QAPP approved by U.S. EPA pursuant to paragraph II.B.2.a.(1) above. At a minimum, field analyses shall include pH, temperature, and specific conductivity. At a minimum, laboratory analyses shall include the compounds presented in Table 1 of this SOW. In addition, the Respondent shall analyze

TABLE 1
Hagen Farm Site
Groundwater Contamination
Maximum Levels Detected/Groundwater Cleanup Standards

Compounds	Maximum Concentration (ug/l)		Standards (ug/L)			BD
	On-Property	Off-Property	ES	PAL	MCL	
Organic						
Benzene	8	ND	5	0.067	5	ND
1,1-Dichloroethene	1	ND	7	0.024	7	ND
Ethylbenzene	4,400	ND	1,360	272	700	ND
Tetrahydrofuran	630,000	1,200	50	10	NA	ND
Toluene	2,700	ND	343	68.6	1,000	ND
Xylenes	37,000	ND	620	124	10,000	ND
Vinyl Chloride	77	5	0.2	0.0015	2	ND
Inorganic						
Arsenic	25.2	ND	50	5	50	ND
Barium	1,570	ND	1,000	200	2,000	37
Iron	17,000	ND	300	150	300[1]	ND
Lead	6	5.6	50	5	15[2]	ND
Manganese	3,330	ND	50	25	NA	ND
Mercury	6.5	ND	2	0.2	2	ND

ES: Enforcement Standard, NR 140, WAC
PAL: Preventive Action Limit, NR 140, WAC
MCL: Maximum Contaminant Level, Safe Drinking Water Act
BD: Background Level
ND: Not-Detected
NA: Not Available

[1] Secondary MCL
[2] Action Level value

for the Target Compound List and Target Analyte List (TCL/TAL) once a year during the first five (5) years after the effective date of the Administrative Order and once every three (3) years thereafter.

If U.S. EPA determines that the groundwater monitoring program is inadequate to detect changes in the chemical concentrations in the groundwater at or adjacent to the Site or to determine the effectiveness of the Groundwater Extraction System, U.S. EPA may require laboratory analysis of additional parameters not identified in Table 1 upon written notification to the Respondent.

(5) Post-Shutdown Monitoring

After discontinuing operation of the on- and/or off-property Groundwater Extraction System required pursuant to the ROD, the Respondent shall thereafter perform monitoring of groundwater, in accordance with provisions of the approved Operations and Maintenance Plan as referenced in Part III, Task II B., and document the concentrations of hazardous substances, pollutants, and contaminants in such groundwater at and adjacent to the Site following shutdown of the Groundwater Extraction System. The frequency of monitoring after initial shut-off of the Groundwater Extraction System shall be monthly for the first six (6) months, and bi-monthly for the second six (6) months. If cleanup standards have been achieved for each compound in the aquifer at the point of compliance (identified in Section II.B.2.b.(15)) and beyond for one year, then monitoring can be conducted quarterly for the next two (2) years. Thereafter, the Respondent may petition for semi-annual monitoring. The Respondent shall conduct post-shutdown monitoring of all wells identified in Section II.B.2.a(2). Such monitoring shall continue until the Respondent demonstrates that the Cleanup Standards as referenced in Section II.B.2.b.(16) below have been continuously satisfied for thirty (30) years following final shutdown of the Groundwater Extraction System.

If U.S. EPA determines that the post-shutdown groundwater monitoring program is inadequate to detect changes or the rate of change in the chemical concentrations in groundwater at or adjacent to the Site, U.S. EPA may modify the sampling frequency and/or duration upon written notification to the Respondent.

(6) Groundwater Monitoring Report

The Respondent shall submit a Groundwater Monitoring Report (GMR) to U.S. EPA after completion of each monitoring well and private well monitoring event. The GMR shall at a minimum include all data generated by the monitoring event, and all relevant and related documents, such as QA/QC and chain of custody documentation. The GMR shall also demonstrate that the

Groundwater Extraction System is operating effectively to protect the private wells located around the Site. The report shall include physical/chemical data from the associated monitoring network and the physical/chemical data in private wells which prove with physical and chemical evidence that there are no contaminants in the private wells. The report shall be submitted with the GMR when the Groundwater Extraction System establishes stable groundwater level conditions.

The Respondent shall submit a Private Well Monitoring Report to U.S. EPA after completion of each private well monitoring event. The Report shall, at a minimum, include all data generated by the monitoring event, and all relevant and related documents, such as QA/QC and chain of custody documentation. The Respondent shall submit the raw data package from the private well analysis to U.S. EPA within three (3) days after proper QA/QC is completed for the private wells data.

If, based on the results of the private well monitoring, field information, and other groundwater data, U.S. EPA determines that private wells located around and downgradient of the Site are impacted by contaminated groundwater, then the Respondent shall implement appropriate response action as determined by U.S. EPA including, but not limited to, the supply of bottled water to the residences impacted.

b. <u>Design, Installation, and Operation of a Groundwater Extraction, Collection, Treatment, and Discharge System</u>

The Respondent shall design, construct, operate, monitor and maintain a groundwater extraction, collection, treatment, and discharge system (Groundwater Extraction/Treatment System) to capture and remove contaminated groundwater, to protect the private wells located around the Site, and restore the groundwater to cleanup standards. The Respondent shall operate the Groundwater Extraction/Treatment System until the groundwater cleanup standards established pursuant to paragraph II.B.2.b(16), below, are met for each compound in the aquifer at the compliance points identified in Section II.B.2.b.(15), below. The Groundwater Extraction/Treatment System shall assure that at the conclusion of the Work the groundwater will achieve each of the Groundwater Cleanup Standards established pursuant to paragraph II.B.2.b.(16) below. The Respondent shall demonstrate that the Groundwater Extraction System shall not introduce contaminants into the private wells located around and downgradient of the Site.

(1) Extraction Well Network

The on- and off-property Groundwater Extraction System shall be designed, constructed, operated, and maintained to capture and

extract the groundwater contaminant plume (Plume) to protect private wells located around and downgradient of the Site, to prevent the migration of contaminants from the Site further downgradient to the Yahara River, and to restore groundwater to cleanup standards in the aquifer. A Groundwater Extraction System utilizing a series of extraction wells shall be installed in the aquifer to capture the contaminant plume. A static water level monitoring well system shall be installed. The purpose of the static water level monitoring well system is to determine the effectiveness of the Groundwater Extraction System. The number of wells, well placement, and extraction rates for off-property groundwater will be established based on the results of information obtained from the Site during the design phase. The entire system's performance shall be evaluated through a network of static and chemical monitor wells which shall be measured on a regular basis, and U.S. EPA may require adjustments to the system as warranted by the performance data collected during operation.

(2) Off- Property Pump Test and Treatability Study

A Pump Test shall be performed in the off-property aquifer prior to the design of the Groundwater Extraction System network to assist in determining the off-property aquifer characteristics and optimum pumping rate to extract the plume from the off-property aquifer. Results from the Pump Test shall be used in the design of the Groundwater Extraction System. The Respondent shall submit the Pump Test Plan for the off-property groundwater along with the RD Work Plan to U.S. EPA for approval. The Pump Test Plan shall include, at a minimum, the locations of off-property extraction well(s) and observation wells, the rates of pumping, the treatment mechanism for extracted groundwater, the discharge location of treated groundwater, the method and frequency of well(s) monitoring, the sampling frequency and method, and compounds to be analyzed during the pump test, and the QA/QC to be conducted in connection with sampling and analysis. The Respondent shall implement this plan after U.S. EPA approval. Results of the Pump Test shall be submitted to U.S. EPA along with the Preliminary Design submittal for groundwater treatment. The collection and distribution system shall be used to transport extracted groundwater to the treatment system for chemical removal.

Concurrent with the Pump Test, the Respondent shall perform a Treatability Study (TS) to determine the effectiveness and design parameters of the off-property groundwater treatment technologies in order to comply with all applicable or relevant and appropriate federal and state environmental laws. The off-property groundwater treatment technologies that shall be tested under the TS include Cascade Aeration, Activated Biological Sludge, Air-Stripping, GAC, and UV-Chemical Oxidation. The Respondent shall submit the Treatability Test Plan for the off-property groundwater along with the RD Work Plan to U.S. EPA for

approval. The TS Plan shall include, but will not be limited to, the technologies to be performed, a detailed plan for on-property and/or laboratory scale test, the discharge location, the sampling frequency and method, and compounds to be analyzed during the TS, and QA/QC of sampling and analysis. The Respondent shall implement this plan after U.S. EPA approval. Results of the TS shall be submitted to U.S. EPA along with the Preliminary Design submittal for groundwater treatment. The collection and distribution system shall be used to transport extracted groundwater to the treatment system for chemical removal. If the effectiveness of any of these five (5) technologies listed above can be determined through extrapolating the results of the off-property TS or other means without conducting field and/or laboratory work, the Respondent shall specify in the TS Plan, in detail, how the effectiveness of the technology(ies) can be determined.

(3) Wetland Investigation

The Respondent shall conduct a wetlands investigation to determine the nature and extent of the wetlands located to the south of the Hagen Farm Site and the impact that potential discharge of treated groundwater will have on these wetlands. This investigation shall include identification of animal and plant species present and their hydrologic conditions that could reasonably be affected. The Investigation shall also include any impact of ice damage to wetland vegetation and/or biota. The Respondent shall submit the Wetland Investigation Plan to U.S. EPA for approval. The Plan shall include detailed investigation procedures to determine the nature and extent of the wetlands and the possible physical, biological, and hydrological impact from groundwater discharges. This Plan shall be submitted along with the RD Work Plan. The Respondent shall implement the Plan after the approval of the Plan by U.S. EPA. (Refer to January 1989 "Federal Manual for Identifying and Delineating Jurisdictional Wetlands".) Results of the wetlands investigation shall be included in the Preliminary Design submittals.

(4) Bio-Assay Test

The Respondent shall conduct a Bio-Assay test to determine the acute and chronic toxicity of on-property raw groundwater. The raw on-property groundwater to be used in the Bio-Assay test shall be representative of all groundwater that will potentially require treatment.

The Respondent shall submit the Bio-Assay Test Plan to the U.S. EPA for approval. The Bio-Assay Test Plan shall contain at a minimum the location of the potential discharge point to the Yahara River, the duration and frequency of the testing, the invertebrates and vertebrates to be used for the test, the location and estimated concentration ranges of effluent samples,

the location and amount of raw on-property groundwater collected, the detailed protocol of sample dilution in the laboratory, and the use of control samples. The plan shall also state the statistical data management procedures used to calculate 25 percent Inhibition Concentration (IC25), mortality rate, Hatchability, Teratagenicity, 50 percent Lethal Concentration (LC50), any other toxicity information, references, guidance, and the QA/QC used to develop this Plan. The Bio-Assay Test Plan shall be submitted along with the RD Work Plan. The Respondent shall implement the Bio-Assay Test Plan after U.S. EPA approval. The Respondent shall conduct this test in accordance with the requirements set forth in Wisconsin Pollutant Discharge Elimination System (WPDES) and shall be performed by laboratories certified or registered by the WDNR.

The Respondent shall submit a Bio-Assay Test Report to U.S. EPA after completion of Bio-Assay test. The Report shall at a minimum include all raw chemical, physical, and biological data generated by the test event, a summary of the test conditions, statistical data, and all relevant and related documents, including QA/QC and chain of custody procedures.

(5) Background Water Quality Study and Effluent Toxicity Test

The treated on- and off-property groundwater is anticipated to enter the Yahara River via direct discharge to the River or from surface runoff during discharge to the wetlands. Because effluent discharge is anticipated to enter the Yahara River, the Respondent shall design and construct the groundwater pump and treat system to produce an effluent discharge that prevents acute and chronic toxicity conditions to humans and wild and domestic animals and prevents human cancer exposure conditions. In order to determine the acute and chronic toxicity of the effluent from the groundwater pump and treat system, the Respondent shall conduct a background surface water quality study in the Yahara River and long term Effluent Toxicity Tests, as required by NR 102, 105, 106, and 207, Wis. Adm. Code. Preliminary water quality-based effluent limits for the Hagen Farm Site are presented in Attachment 1 (WDNR, January 1992). These preliminary numerical effluent limitations will be recalculated by U.S. EPA based on the off-property Pump Test, the off-property TS, and an assessment of the existing habitat conditions in the Yahara River. Complete priority pollutant scan information and pH and hardness information on representative Pump Test influent and effluent samples shall be provided to U.S. EPA by the Respondent.

(A) Background Water Quality Study

Results of background surface water quality testing shall be submitted to U.S. EPA and WDNR for review and approval. The

following background receiving water quality and aquatic life information shall be provided by the Respondent:

1) Background surface water quality sampling shall be conducted in accordance with NR 207.05, Wis. Adm. Code for the following seven indicator parameters having water quality criteria listed in NR 105, and which are contaminants of concern for the groundwater: arsenic, copper, lead, mercury, ethylbenzene, toluene, and vinyl chloride. In addition, background surface water sampling shall be conducted for tetrahydrofuran, xylenes, and manganese which are also contaminants of concern. A minimum of one sample round is required during average to low flow conditions. Three (3) additional sampling rounds of sampling are required for all substances detected in the first round. The additional rounds must be conducted two to three months apart. Background pH and hardness sampling are required to coincide with the indicator sampling. A minimum of four data sets shall be provided to U.S. EPA and WDNR.

2) An environmental assessment required in accordance with NR 150, WAC, for issuance of a WPDES permit requires identification of endangered and threatened species and impacts on any species identified. The Respondent shall contact the WDNR's Bureau of Endangered Resources for a current review of the Natural Heritage Inventory. Also available through the U.S. EPA and WDNR is a letter dated August 19, 1991 from WDNR's Bureau of Endangered Resources providing information on endangered and threatened species in the area. Based on this information, the Respondent shall submit to U.S. EPA their evaluation as to whether these habitat, which are identified for species listed on the Natural Heritage Inventory, are present for areas affected by the project. If determined by U.S. EPA to be present a comprehensive survey shall be completed. If any State threatened or endangered species are identified, an assessment of existing habitat conditions may be required, as determined by U.S. EPA, for the stretch of the Yahara River immediately down stream of the proposed discharge. If required, the assessment may include but not be limited to: suspended solids evaluation, stream bottom characteristics including the degree of sedimentation, and assessment of the macroinvertebrate community.

Appropriate treatment facility influent and effluent monitoring, and background water quality monitoring will be required to ensure that the water resources are being properly protected. The Respondent shall receive approval from U.S. EPA prior to initial discharge from the treatment system. The initial discharge from the treatment system shall meet the effluent limitations and monitoring requirements established for the proposed treatment facility and the discharge shall be discontinued if the requirements are no longer met.

The Respondent shall submit the Background Water Quality Study Plan (the BWQS Plan) to the U.S. EPA for approval. The BWQS Plan shall describe in detail how the study discussed in this section can be conducted. The Respondent shall submit the BWQS Plan along with RD Work Plan. The Respondent shall implement the BWQS Plan after approval of the Plan by U.S. EPA.

The Respondent shall submit a Background Water Quality Study Report (the BWQS Report) to U.S. EPA after completion of the study event in the Yahara River. The BWQS Report shall at a minimum include all data generated by the BWQS, and all relevant and related documents, such as QA/QC and chain of custody procedures.

If U.S. EPA determines that implementation of the BWQS Plan is inadequate, U.S. EPA may require, by written notification to the Respondent, additional studies.

(B) Effluent Toxicity Test

The Respondent shall conduct toxicity tests on effluent discharged to the Yahara River following the conditions specified below:

1) An acute toxicity test battery shall be initiated with three freshwater species (Ceriodaphnia dubia, Daphnia magna, and Fathead Minnows (Pimephales promelas)) during the first ten (10) days following commencement of discharge. Each acute toxicity test battery shall be completed with the following effluent treatments: 12.5%, 25%, 50%, and 100% (v:v). Upon completion of the first acute test battery, additional acute test batteries shall be performed once per three (3) months for a period of thirty-six (36) months, at which time the frequency of testing shall be reduced to once per year unless the U.S. EPA and WDNR determine that data warrant an alternative frequency.

2) A chronic toxicity test battery shall be initiated with two freshwater species (Ceriodaphnia dubia,

and Fathead Minnows (Pimpephales promelas)) during the first ten (10) days following commencement of discharge. Each chronic toxicity test battery shall be completed with the following effluent treatments: 12.5%, 25%, 50%, and 100% (v:v).Upon completion of the first chronic test battery, additional chronic test batteries shall be performed once per three months for a period of thirty-six (36) months, at which time the frequency of testing shall be reduced to once per year unless the U.S. EPA and WDNR determine that data warrant an alternative frequency.

3) An acute toxicity test battery shall be determined positive if lethality or immobilization is observed for more than 50% of the test organisms in an undiluted, 100% effluent test treatment for any test species. In the event of a positive acute toxicity test result, the U.S. EPA and WDNR must be notified of the results within five (5) business days following the completion of the test and two additional test batteries shall be completed within thirty (30) calendar days following the completion of the regularly scheduled test which yielded the positive result.

4) A chronic toxicity battery shall be determined positive for any test species if the IC_{25} associated with the effluent is less than the instream waste concentration (IWC) which is determined by the following formula:

$$IWC = \frac{Q_e}{(Q_e+Q_s)} \times 100$$

Where:

Q_e = Average daily effluent design flow (cfs) from outfall 001.

f = 0.0 for the Hagen Farm Site. Fraction of the effluent flow withdrawn from the receiving water (Yahara River).

Q_s = 3.5 cfs. Based on 25% of the estimated $7\text{-}Q_{10}$ flow of the Yahara River near Stoughton. ($7\text{-}Q_{10}$ = 14 cfs, 14 cfs X 25% = 3.5 cfs)

In the event of a positive chronic toxicity test result, the U.S. EPA and WDNR must be notified of the results within five (5) business days following the completion of the test and two (2) additional test batteries shall be completed within thirty (30) calendar days following the completion of the regularly scheduled test which yielded the positive result.

5) The U.S. EPA and WDNR shall review the data generated under this Statement of Work every five years to determine if modifications are necessary.

6) Within sixty (60) days after determination by the U.S. EPA, in consultation with WDNR, and based on data from previous toxicity test batteries, that the potential exists for persistent toxicity, a plan to do one of the following actions shall be developed and submitted to U.S. EPA and WDNR for approval:

   (a) Conduct a toxicity identification evaluation and complete all necessary steps to eliminate acute whole effluent toxicity;

   (b) Cease discharge to the Yahara River; or

   (c) Take other appropriate actions as determined necessary by the U.S. EPA in consultation with WDNR.

Any Best Available Control Technology Economically Achievable (BAT) limits and requirements determined in accordance with NR 220.2, Wis. Adm. Code must also be satisfied. The more stringent of either the water quality based limits or the BAT requirements must be met. The Respondent must submit, as part of the Preliminary Design Submittals, projections of effluent quality and pollutant removal efficiencies and additional treatment system design information based on the results of the Treatability Studies. In addition, projections of effluent quality and removal efficiency must be presented for the contaminants of concern listed in Table 1.

The Groundwater Extraction and Treatment System's performance will be monitored on a regular basis, and U.S. EPA may require adjustments to the system as warranted by the performance data collected during operation. Examples of adjustments which may be required by U.S. EPA are additional groundwater extraction wells and/or increased or decreased pumping rates.

The Respondent shall submit the Effluent Toxicity Test Plan (the ETT Plan) to the U.S. EPA for approval. The ETT Plan shall describe in detail how the test discussed in this section can be conducted. The Respondent shall submit the ETT Plan along with

Preliminary Design Submittals. The Respondent shall implement the Plan as approved by U.S. EPA.

The Respondent shall submit the ETT Report to U.S. EPA after completion of each test event. The Report shall at a minimum include all data generated by the study, and all relevant and related documents, such as QA/QC and chain of custody procedures.

If U.S. EPA determines that the Effluent Toxicity Test Plan is inadequate to determine the acute and chronic toxicity of effluent from the treatment facility, U.S. EPA may require, by written notification to the Respondent, additional test parameters, test frequency and duration.

(6) Determination of Off-property Groundwater Treatment Technology

After completion of the Pump Test and Bio-Assay Test and after receipt of the final Yahara River Discharge Limits from the U.S. EPA, the Respondent shall submit a proposal to the U.S. EPA for the technology for the treatment of the off-property groundwater. The technology proposed shall be selected from among the five technologies which were evaluated in the FS. The five potential off-property groundwater treatment technologies are the Cascade Aeration, Activated Sludge Biological, Air-Stripping, Granular Activated Carbon, and the Ultraviolet (UV) Chemical Oxidation. The proposal shall address, at a minimum, the Yahara River Discharge limits for the contaminants of concern, the ability of the technologies identified in the FS to meet these discharge limits, an evaluation of these technologies to meet BAT requirements, and any other information, criteria, data and references used to select the technology. The proposal shall demonstrate that the selected technology will treat the extracted off-property groundwater to the discharge limits for the contaminants of concern specified by U.S. EPA and will meet the requirements under BAT. The proposal shall be submitted to U.S. EPA for approval after the receipt of Yahara River discharge limits.

If U.S. EPA disapproves the proposal without selecting another technology, the Respondent shall submit a proposal with selection of another technology based on the comments provided by U.S. EPA. Such revised proposal shall be submitted after receipt of U.S. EPA's comments on the Proposal. If U.S. EPA disapproves the Proposal with selection of another technology, the Respondent shall accept and implement the technology selected by U.S. EPA as the groundwater treatment technology for off-property groundwater.

If the Respondent proposes the Activated Biological Sludge System as the off-property groundwater treatment technology, then the Proposal may include a detailed plan as to how the on-property

and off-property groundwater treatment can be combined, should the Respondent choose to propose to combine the two flows of groundwater.

(7) Treatment of On-Property Groundwater

Extracted on-property groundwater shall be pumped to the treatment system for removal of chemical contaminants prior to discharge.

The On-property groundwater treatment process shall be capable of treating the volume of contaminated groundwater necessary to meet the objectives of the Groundwater Extraction System in Section II.B.2.b, above. The treatment system shall, at a minimum, consist of an air oxidation/precipitation or pH adjustment to remove metals and inorganic solids in the groundwater. After metals pretreatment, the extracted on-property groundwater shall be treated using an Activated Sludge Biological System to remove organic compounds to the discharge levels.

If, during the course of biological treatment, the contaminant concentrations in the extracted on-property groundwater become too low to support biological activity, the Respondent shall add additional nutrients (i.e., milk whey) to maintain optimum biological activity for contaminant degradation. The Respondent shall inform the U.S. EPA, in writing, regarding all additions of nutrients in the system. The Respondent shall inform U.S. EPA thirty (30) before such addition of nutrients. When influent contaminant concentrations in the biological process decrease to a level insufficient to support biological activity without large additions of substrate, the Respondent shall replace the biological treatment system with a more cost-effective physical or chemical treatment process, such as Granular Activated Carbon (GAC), that shall be at least as efficient a system to remove organic compounds in the groundwater. The biological system is anticipated to remove up to 99 percent of the contaminants in the groundwater. The Respondent shall submit the plan to the U.S. EPA for approval within sixty (60) days before such replacement of new treatment technology is needed.

(8) Treatment of Off-Property Groundwater

Extracted off-property groundwater shall be pumped to the treatment system for removal of chemical contaminants prior to discharge.

The off-property groundwater treatment process shall be capable of treating the contaminated groundwater necessary to meet the objectives of Groundwater Extraction System identified in Section II.B.2.b, above. The treatment system shall, at a minimum, consist of an air oxidation/precipitation or pH adjustment to remove metals and inorganic solids in the groundwater. After

metals pretreatment, the extracted off-property groundwater shall be treated using the appropriate technology approved by U.S. EPA to remove organic compounds. The contaminated off-property groundwater produced during the Pump Test shall be treated in the Groundwater Treatment System, if necessary.

(9) Evaluation of In-Situ Bioremediation

After initiation of the operation of the Groundwater Extraction System and after stabilization of the groundwater flow pattern, the Respondent shall perform a study to examine the feasibility of re-injection of treated on-property groundwater to the aquifer to enhance in-situ bioremediation (the "Feasibility Test"). The Feasibility Test shall also be designed to determine the optimum amount of essential nutrients (e.g., moisture, nitrogen, methane, and phosphate) and/or oxygen to be added to the saturated soil zone and on-property aquifer in order to enhance the microbial degradation of organic compounds. The Feasibility Test should begin with a bench scale study to determine the effect of nutrients and/or oxygen on contaminated groundwater. If the bench scale study shows positive results, a pilot study would then be conducted. The Feasibility Test shall be subject to the supervision, review, and approval of the U.S. EPA. At the conclusion of the Feasibility Test period, the Respondent shall present the results of this study to the U.S. EPA in the form of a written report. The underlying data developed during the Feasibility Test shall be made available to the U.S. EPA at the request of the U.S. EPA. Based on the results of the Feasibility Test, U.S. EPA may require the Respondent to implement the re-injection of treated groundwater with the addition of essential nutrients and/or oxygen to the saturated soils and groundwater. Water used for in-situ bioremediation will be treated to achieve NR 140 PALs prior to re-injection into the aquifer. Any proposal to re-inject treated groundwater enhanced with nutrients and/or oxygen must comply with the substantive requirements of Ch. NR 112, WAC.

The Respondent shall describe the method of conducting the Feasibility Test in the Remedial Design for the Groundwater Extraction System. At a minimum, this description shall include the duration of the Feasibility Test, the location of re-injection, the method of re-injection, the amount and kinds of various nutrients, the vertical depth of re-injection, any sampling procedures used to determine the effectiveness of this Test, and QA/QC of sampling and analysis.

(10) Petition to Cease Operations

When the Respondent believes that the Groundwater Extraction System has achieved all of the groundwater cleanup standards, the Respondent shall submit to U.S. EPA a petition to cease operation of the system. The petition to cease operation shall include

documentation that all groundwater cleanup standards have been continuously achieved for at least three (3) years and a demonstration, based on Settling Defendant's best scientific judgement (as approved by U.S. EPA), that there is no likelihood that groundwater cleanup standards will be exceeded after the groundwater Extraction system is shut down. No individual extraction well shall be shut down. The Respondent shall perform any additional sampling and monitoring necessary to support the petition, as required by U.S. EPA. If U.S. EPA determines that additional sampling and monitoring is required, then respondents shall submit a groundwater sampling and monitoring plan related to the additional work at least six (6) months before sampling and monitoring begins. A final post groundwater clean-up report shall be submitted by the Respondent which demonstrates three (3) year clean-up objectives after the petition to cease operation has been approved by the U.S. EPA.

(11) Notification of Temporary Groundwater Extraction System Shutdown

If, for any reason during the period of operation of the Groundwater Extraction System, the operation of the Groundwater Extraction System is interrupted or stopped, whether due to mechanical failure, human error, or any other reason (except for routine maintenance), then the Respondent shall notify the U.S. EPA of such interruption or cessation of operation within twenty-four (24) hours after learning thereof. Such notification may initially be given orally, but must be confirmed in writing within five days after the date on which the oral notification is given. The Respondent shall notify U.S. EPA of the nature and cause of the interruption or cessation of operation, as well as the estimated length of time before the operation of the Groundwater Extraction System will be resumed.

If, for any reason during the period of operation of the Groundwater Extraction System, the Respondent determines that it is necessary to temporarily interrupt the operation of the Groundwater Extraction System in order to perform routine maintenance on the system, then the Respondent shall give U.S. EPA a minimum of forty-eight (48) hours notice, in writing, prior to such shutdown. The Respondent shall notify the U.S. EPA of the nature of the maintenance to be performed, as well as the estimated length of time before the operation of the Groundwater Extraction System will be resumed.

In all cases where there is an interruption or cessation in the operation of the Groundwater Extraction System, whether due to mechanical failure, human error, or to perform routine maintenance, as well as any other reason, the Respondent shall use their best efforts to repair, complete maintenance, or take any other steps necessary to timely resume the operation of the Groundwater Extraction System.

(12) Discharge of Treated Groundwater

The discharge criteria shall be determined by U.S. EPA. Such discharge criteria shall satisfy best available technology requirements and all more stringent limits necessary to satisfy water-quality based standards.

Discharge of treated groundwater to the Yahara River will be required to comply with the requirements set forth in a WPDES permit, since discharge to the Yahara River would be considered an off-Site discharge.

Discharge of treated groundwater into the wetlands via the drainage ditch near the southeast corner of the Site or directly to the wetlands will be required to meet the substantive requirements of a WPDES permit and shall comply with NR 140, PAL standards. In addition, the State of Wisconsin has policies on protection of wetlands including NR 1.95 and 103 Wis. Adm. Code. Impacts to the wetlands will be considered and minimized to the extent possible during the design phase of this remedial action as directed in Executive Order 11990.

Compliance with the WPDES discharge limits shall be determined by sampling and analysis of the treated groundwater at the point of discharge, as set forth in the WPDES requirements.

All discharges from treatment system(s) to the Yahara River or wetlands shall comply with all effluent limitations, monitoring requirements, reporting requirements, and other substantive requirements approved by U.S. EPA, and/or as required by law.

(13) Correction of Deficiencies.

If the groundwater monitoring program indicates that insufficient water is being withdrawn by the Groundwater Extraction System so that (a) groundwater contaminant concentrations in the leading edge of the plume are not decreasing, or (b) groundwater contaminant concentrations are not decreasing at the rate necessary to achieve the Cleanup Standards, or (c) the static monitoring well network indicates that contaminated groundwater is discharging to the Yahara River or otherwise escaping the influence of the Groundwater Extraction System, or (d) adverse hydrologic consequences (such as lowering the water table in the Wetlands or at drinking water wells) are occurring, the U.S. EPA may, by written notification to the Respondent, require modification of the operating parameters, including but not limited to additional groundwater extraction wells and/or an increased or decreased pump rate. Upon determination of a deficiency, corrections shall occur within sixty (60) days after notice from the U.S. EPA, unless a drinking water well is affected in which case corrective action shall occur as soon as possible but no later than 7 days after notice is received from

U.S. EPA. If monitoring of the static water elevations or equipment operation demonstrates a system malfunction, then the U.S. EPA shall be notified within 24 hours of knowledge of such malfunction and immediate steps shall be taken by the Respondent to determine the cause of the malfunction and the measures necessary to correct the malfunction. Such actions to correct the problem shall be taken immediately after approval by U.S. EPA of the proposed measures for correcting the malfunction.

(14) Restart.

If groundwater monitoring, as set forth under Section II.B.2.a(5), above, indicates that the concentration of any hazardous substance, pollutant, or contaminant increased above the Groundwater Cleanup Standards after operation of the Groundwater Extraction System has been terminated in accordance with the terms of the Administrative Order, ROD, and this SOW, then the Respondent shall reactivate the Groundwater Extraction System. The Respondent shall thereafter operate and maintain the Groundwater Extraction System until they again demonstrate compliance with the Groundwater Cleanup Standards as provided at Paragraph II.B.2.b(16) of this SOW.

(15) Point of Compliance.

The point of compliance shall be at the waste management boundary (i.e., at the edge of the landfill cap).

Groundwater cleanup standards will be met in accordance with the National Contingency Plan (NCP) at the point of compliance, and wherever groundwater is monitored beyond the point of compliance. The groundwater cleanup standards are presented in the attached Table 1. In order to monitor and evaluate the remedial actions, certain groundwater monitoring wells shall be selected by U.S. EPA in consultation with the State, to measure compliance with the performance standards and the cleanup standards. These wells shall be proposed by the Respondent for approval by the U.S. EPA in consultation with the WDNR in development of the RD/RA Workplan. If these wells are destroyed or in any way not able to be sampled, they shall be repaired or replaced by the Respondent within a time frame specified by U.S. EPA. Additional wells may be required by the U.S. EPA in consultation with the WDNR pursuant to Section VIII of the Administrative Order.

(16) Cleanup Standards

Groundwater will be extracted until the groundwater no longer attains or exceeds cleanup standards in the aquifer at the point of compliance and beyond. The clean-up standards for groundwater for the Site are Preventive Action Limits (PALs), as set forth in the Wisconsin Administrative Code, Chapter NR 140. Additionally, clean-up standards consistent with the National Contingency Plan

(NCP) and Record of Decision may be specified by the U.S. EPA for other contaminants that may be detected during monitoring that lack a Chapter NR 140 numeric standard. These clean-up standards apply to those chemicals found during the Remedial Investigation phases for the SCOU and the GCOU, which exceed PALs, as well as all chemicals found to exceed PALs during the Groundwater Monitoring Program. Table 1 lists the Wisconsin Administrative Code, Chapter NR 140, Preventive Action Limits and Enforcement Standards (ES).

Cleanup standards for the groundwater will be met according to the attached Table 1. However, consistent with the exemption criteria of NR 140.28, Wis. Adm. Code, U.S. EPA may establish a Wisconsin Alternative Concentration Limit (WACL) cleanup standard, if, based on Site-specific monitoring data gathered before and after implementation of the selected groundwater remedy, U.S. EPA determines that it is not technically and economically feasible to achieve the PALs for a specific substance. Except where the background concentration of a compound exceeds the ES, and consistent with the criteria in NR 140.28(4)(B), the WACL that is established may not exceed the ES for that compound.

The Respondent shall conduct five(5)-year reviews of groundwater conditions pursuant to U.S. EPA's review under paragraph 51 of the Administrative Order. The groundwater evaluations shall be submitted as part of the O&M Progress Reports.

Water used for in-situ bioremediation will be treated to achieve NR 140, PALs prior to re-injection into the aquifer. Any proposal to re-inject treated groundwater enhanced with nutrients and/or oxygen must comply with the substantive requirements of Ch. NR 112, WAC.

(17) Air Emissions

The Respondent shall submit an Air Monitoring Plan (AMP) and QAPP to U.S. EPA for approval to monitor air emissions during treatment of groundwater, if necessary. The AMP at a minimum shall include the duration and frequency of sampling activity, the locations of sampling, the methods of sampling and analysis, and the compounds to be analyzed. The AMP and QAPP shall be submitted along with the RD/RA design documents for groundwater. The AMP must comply with ARARs, including the Clean Air Act (CAA) and NR 400 through 499, Wis. Adm. Code.

The Respondent shall perform air emission monitoring of the Groundwater Extraction System to assure that air toxic criteria are met in accordance with the CAA, including 40 CFR Parts 50 and 61, and NR 445, Wis. Adm. Code. If air emissions from the Groundwater Extraction System exceed air emission discharge limits specified in the Clean Air Act (CAA) and/or NR 445, Wis.

Adm. Code, the Respondent shall treat the emissions using the air treatment system to meet such discharge limits.

If treatment of the air emissions is necessary, the Respondent shall design an Air treatment system for the Groundwater Extraction System that complies with NR 445, Wis. Adm. Code and shall submit the design to U.S. EPA for approval. The air treatment system shall be designed to treat air emissions produced from the Groundwater Extraction System, including but not limited to the air stripper and cascade aeration system, using a vapor phase carbon adsorption system. The Respondent shall implement the design upon U.S. EPA approval.

(18) Sludge/Residues Treatment and Disposal

All sludges, residues, spent carbon, and/or spent coagulants produced from groundwater and off-gas treatment will be analyzed for characteristic wastes and F003-F005 listed wastes and treated to LDR standards for F003-F005 waste prior to disposal at a RCRA landfill in accordance with the requirements of 40 CFR 268.41. If testing determines that waste sludge generated from the activated sludge biological system is not hazardous, the waste sludge could be disposed of by on-Site landspreading or off-Site landfilling. Spent carbon will be regenerated or treated to meet the LDR requirements.

The Respondent shall submit a Sludge Management Plan (SMP) and QAPP to U.S. EPA for approval to manage the sludges produced during the implementation of the Groundwater Extraction System. The SMP at a minimum shall include the duration and frequency of sampling activities, the amount and nature of sludges to be generated, the methods of sampling and analysis, the TCLP procedure, the compounds to be analyzed, and the detailed description of disposal. The SMP shall be submitted along with the RD/RA design documents for groundwater. The SMP must comply with ARARs, including 40 CFR 268.41 and Wisconsin "Interim Policy for promoting the In-State and On-Site Management of Hazardous wastes in the State of Wisconsin".

3. Institutional Controls

The Respondent shall comply with Section X of the ROD and all pertinent parts of Section II.B. of the SOW.

III. SCOPE

The RD and RA work shall consist of five tasks:

Task I: RD Work Plan

A. Groundwater Monitoring Plan and QAPP
B. Pump Test Plan
C. Treatability Study Plan
D. Wetlands Investigation Plan
E. Bio-Assay Test Plan
F. Background Water Quality Study Plan

Task II: Remedial Design

A. Design Plans and Specifications
B. Operation and Maintenance Plan and QAPP
C. Cost Estimate
D. Project Schedule
E. Construction Quality Assurance Objectives
F. Health and Safety Plan
G. Design Phases
H. Community Relations Support
I. Air Emission Monitoring Plan
J. Feasibility Test Plan
K. Effluent Toxicity Test Plan
L. Sludge Management Plan

Task III: RA Work Plan

Task IV: Remedial Action Construction

A. Responsibility and Authority
B. Construction Quality Assurance Personnel Qualifications
C. Inspection Activities
D. Sampling Requirements
E. Documentation

Task V: Reports

A. Progress
B. Annual Court Report
C. Notification of Completion of Construction Report
D. Operation and Maintenance Report
E. Remedial Action Implementation Report
F. Inspection Report
G. Remedial Action Report
H. Feasibility Test Report
I. Draft
J. Final

Task I: RD WORK PLAN

The Respondent shall prepare and submit to the U.S. EPA for approval in accordance with the schedule set forth in Part VI below, an RD Work Plan which describes the overall management strategy for performing the design, construction, operation, maintenance, and monitoring of remedial actions, including additional sampling, investigation and treatability study activities, groundwater pump and treatment, and Feasibility Study for the bioactivity. The plan shall document the responsibility and authority of all organizations and key personnel involved with the implementation and include a description of qualifications of key personnel directing the RD, including contractor personnel. A schedule for the selected remedy shall be included in the RD Work Plan. The Respondent shall submit a RD Work Plan sixty (60) days after the effective date of U.S. EPA's Administrative Order. The Respondent shall submit an amended RD Work Plan incorporating U.S. EPA's comments on the RD Work Plan according to the schedule identified in the Submission Summary below. The RD Work Plan shall include, but not be limited to, the following:

1. A Groundwater Monitoring Plan and QAPP;

2. A Pump Test Plan;

3. A Treatability Study Plan;

4. A Wetlands Investigation Plan;

5. A Bio-Assay Test Plan; and

6. A Background Water Quality Study Plan.

Each portion of the RD Work Plan shall also include the name(s) and a description of qualifications of key personnel directing the RD, including contractor personnel.

A. Groundwater Monitoring Plan and QAPP

See Section II.B.2.a.

B. Quality Assurance and Quality Control

The Respondent shall develop a Site specific Quality Assurance Project Plan (QAPP), covering all phases of future site work, based upon the Administrative Order and guidance provided by U.S. EPA. The QAPP shall at a minimum include:

- Project description
- Project organization
- Project responsibilities

- Sampling and custody procedures
- Calibration procedures
- Quality assurance objectives
- Analytical procedures
- Data analysis and reporting
- Internal QC checks
- Performance and system audits
- Preventative maintenance
- Method specific procedures for assessing data precision, accuracy and completeness
- Corrective actions
- QA reports

The Respondent shall attend a pre- QAPP meeting with U.S. EPA. The Respondent shall submit a draft QAPP to U.S. EPA for review with the Work Plan to cover pre-design sampling and analysis.

C. Pump Test Plan

See Section II.B.2.b.(2).

D. Treatability Study Plan

See Section II.B.2.b.(2).

E. Wetland Investigation Plan

See Section II.B.2.b.(3).

F. Bio-Assay Test Plan

See Section II.B.2.b.(4).

G. Background Water Quality Test Plan

See Section II.B.2.b.(5).

F. Site Safety Plan

The Respondent shall develop a site safety plan which is designed to protect on-Site personnel and area residents from physical, chemical and all other hazards posed by this remedial action. The safety plan shall develop the performance levels and criteria necessary to address the following areas.

- General requirements
- Personnel
- Levels of protection
- Safe work practices and safe guards
- Medical surveillance
- Personal and environmental air monitoring

- Personal protective equipment
- Personal hygiene
- Decontamination - personal and equipment
- Site work zones
- Contaminant control
- Contingency and emergency planning
- Logs, reports and record keeping

The safety plan shall follow U.S. EPA guidance and all OSHA requirements as outlined in 29 CFR 1910. The Respondent shall submit a draft safety plan for Agency review along with the prefinal design submittal. The Respondent shall incorporate all required corrections in the final safety plan submitted with the final design submittal. Document review shall be in accordance with the Administrative Order. A Site safety plan shall also be developed for pre-design activities.

H. Sampling Plan

The Respondent shall develop a sampling and analysis plan (as described in " Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA," October 1988) for the pre-design field activities).

I. Site Access

Site access agreements required to implement the remedial action shall be obtained by the Respondent as required under Paragraph 68 of the Administrative Order, prior to the initiation of remedial action or additional studies. Site access shall extend for the duration of the clean-up and include allowances for all operation and maintenance considerations in accordance with Paragraph 27 of the Administrative Order.

Task II: REMEDIAL DESIGN

The Respondent shall prepare and submit to U.S. EPA for approval final construction plans and specifications to implement the Remedial Actions at the Site as defined in the "Purpose" and the "Description of the Remedial Action" section of this SOW. Respondent shall include the items described in Section III below in the submittals.

A. Design Plans and Specifications

The Respondent shall develop and submit to U.S. EPA for approval clear and comprehensive design plans and specifications which include but are not limited to the following:

1. Discussion of the design strategy and the design basis, including:

   a. Compliance with all applicable and all relevant and appropriate environmental and public health laws, rules, regulations, and standards; and

   b. Minimization of environmental and public impacts.

2. Discussion of the technical factors of importance to the design and construction including:

   a. Use of currently accepted environmental control measures and technology;

   b. The constructability of the design; and

   c. Use of currently acceptable construction practices and techniques.

3. Description of assumptions made and detailed justification of these assumptions;

4. Discussion of the possible sources of error and references to possible operation and maintenance problems;

5. Detailed drawings of the proposed design including;

   a. Qualitative flow sheets; and

   b. Quantitative flow sheets.

6. Tables listing equipment and specifications;

7. Tables giving material and energy balances;

8. Appendices including;

   a. Sample calculations (one example presented and explained clearly for significant or unique design calculations);

   b. Derivation of equations essential to understanding the report;

   c. Results of Program;

   d. Well construction and installation details.

   e. Results of Laboratory or Field Tests.

B. Operation and Maintenance Plan

The Respondent shall prepare and submit to U.S. EPA for approval an Operation and Maintenance Plan to cover both implementation and long term maintenance of the Remedial Actions. The plan shall be composed of the following elements:

1. Description of normal operation and maintenance (O&M), including;

   a. Description of tasks for operation;

   b. Description of tasks for maintenance;

   c. Description of prescribed treatment or operation conditions; and

   d. Schedule showing frequency of each O&M task.

2. Description of potential operating problems, including;

   a. Description and analysis of potential operation problems;

   b. Sources of information regarding problems; and

   c. Common and/or anticipated remedies.

3. Description of routine monitoring and laboratory testing, including;

   a. Description of monitoring tasks;

   b. Description of required laboratory tests and their interpretation;

   c. Required Data Collection, Quality Assurance Project Plan (QAPP);

   d. Schedule of monitoring frequency and date, if appropriate, when monitoring may cease; and

   e. Description of triggering mechanisms for Waste/sub-Soils monitoring results.

4. Description of alternate O&M, including;

   a. Should system(s) fail, alternate procedures to prevent releases or threatened releases of hazardous substances, pollutants and contaminants

in order to protect public health and the environment and prevent exceedance of any applicable, relevant, and appropriate standard; and,

b. Analysis of vulnerability and additional resource requirement should a failure occur.

5. Corrective Action, including;

a. Description of corrective action to be implemented; and

b. Schedule for implementing these corrective actions.

6. Safety plan, including;

a. Description of precautions, of necessary equipment, etc., for safety of site personnel; and

b. Safety tasks required in event of systems failure.

7. Description of equipment, including;

a. Equipment identification;

b. Installation of monitoring components;

c. Maintenance of site equipment; and

d. Replacement schedule for equipment and installed components.

8. Records and reporting mechanisms, including;

a. Daily operating logs;

b. Laboratory records;

c. Records for operating costs;

d. Mechanism for reporting emergencies;

e. Personnel and maintenance records; and

f. Monthly/annual reports to State agencies.

An initial Draft Operation and Maintenance Plan shall be submitted by the Respondent to U.S. EPA simultaneously with the Prefinal Design Document submission and the Final Operation and Maintenance Plan with the Final Design Documents.

The Respondent shall submit to U.S. EPA for approval updates of the final Operation and Maintenance Plan after construction of each component of the remedial action in order to reflect any changes to the Operation and Maintenance Plan necessitated by the construction.

C. Cost Estimate

The Respondent shall develop and submit to U.S. EPA for approval cost estimates for the purpose of assuring that the Respondent has the financial resources necessary to construct and implement the Remedial Action. The cost estimate developed in the Feasibility Study shall be refined to reflect the more detailed/accurate design plans and specifications being developed. The cost estimate shall include both capital and operation and maintenance costs. An Initial Cost Estimate shall be submitted simultaneously with the Prefinal Design submission and the Final Cost Estimate shall be submitted along with the Final Design Document.

D. Project Schedule

The Respondent shall develop a Project Schedule for construction and implementation of the Remedial Actions. The Project schedule shall identify timing for initiation and completion of all critical path tasks. The Respondent shall specifically identify dates for completion of the Project and major interim milestones. An Initial Project Schedule shall be submitted simultaneously with the Prefinal Design Document submission and the Final Project Schedule shall be submitted along with the Final Design Document. The Final Project Schedule is subject to review and approval by the U.S. EPA.

E. Construction Quality Assurance Objectives

The Respondent shall identify and document the objectives and framework for the development of a construction quality assurance program including, but not limited to the following: responsibility and authority; personnel qualifications; inspection activities; sampling requirements; and documentation.

F. Health and Safety Plan

The Respondent shall modify and submit to U.S. EPA for approval the Health Safety Plan developed for the RI/FS to address the activities to be performed at the facility to implement the Remedial Action(s).

G. Design Phases

The design of the Remedial Action(s) shall include the phases outlined below.

1. Preliminary design

The Respondent shall submit the Preliminary Design when the design effort is approximately 30% complete. At this stage, the Respondent shall have field verified the existing conditions of the facility. The Preliminary Design shall reflect a level of effort such that the technical requirements of the project have been addressed and outlined so that they may be reviewed to determine if the final design will provide an operable and usable Remedial Action. The Respondent shall provide supporting data and documentation with the Design Documents defining the functional aspects of the program. The preliminary construction drawings by the Respondent shall reflect organization and clarity. The scope of the technical specifications shall be outlined in a manner reflecting the final specifications. The Respondent shall include with their preliminary design submission, calculations reflecting the same percentage of completion as the designs they support.

2. Correlating plans and specifications

General correlation between drawings and technical specifications is a basic requirement of any set of working construction plans and specifications. Before submitting the project specifications, the Respondent shall:

a. Coordinate and cross-check the specifications and drawings; and

b. Complete the proofing of the edited specifications and the cross-checking of all drawings and specifications.

These activities shall be completed prior to the 95% prefinal submittal to the U.S. EPA.

3. Equipment start-up and operator training

The Respondent shall prepare, and include in the technical specifications governing treatment systems, contractor requirements for providing

appropriate service visits by experienced personnel to supervise the installation, adjustment, start up and operation of the treatment systems, and training covering appropriate operational procedures once the start-up has been successfully accomplished.

4. Additional studies

The U.S. EPA may require the Respondent to conduct additional studies to supplement the available technical data. At the discretion and under the direction of the U.S. EPA for any such studies required, the Respondent shall furnish all services, including field work as required, materials, supplies, plant, labor, equipment, investigations, studies and superintendence. The Respondent shall perform sufficient sampling, testing and analysis to optimize the required treatment and/or disposal operations and systems. There shall be an initial meeting of all principal personnel with the Respondent involved in the development of the program. The purpose of the meeting will be to discuss objectives, resources, communication channel, role of personnel involved and orientation of the Site. The interim report shall present the results of the testing with the recommended treatment or disposal system (including options). A review conference shall be scheduled after the interim report has been reviewed by all interested parties. The Respondent's final report of the testing shall include all data taken during the testing and a summary of the results of the studies.

5. Prefinal and Final Design

The Respondent shall submit to the U.S. EPA for approval the Prefinal/Final design documents in two parts. The first submission shall be the "prefinal" submission which shall be submitted at 95% completion of design. After review and approval of the prefinal submission by the U.S. EPA, the Respondent shall execute any required revisions and submit the final documents to the U.S. EPA 100% complete with reproducible drawings and specifications.

The Prefinal Design submittal shall contain the Design Plans and Specifications, Operation and Maintenance Plan, Capital and Operating and Maintenance Cost Estimate, Project Schedule,

Quality Assurance Project Plan and the Health and Safety Plan.

The Final Design submittal contain the Final Design Plans and Specifications (100% complete), the Respondent's Final Construction Cost Estimate, the Final Operation and Maintenance Plan, Final Quality Assurance Project Plan, Final Project Schedule and Final Health and Safety Plan. The quality of the design documents should be such that the Respondent would be able to include them in a bid package and invite contractors to submit bids for the construction project.

H. Community Relations Support

A community relations program will be implemented by the U.S. EPA. The Respondent shall cooperate with the U.S. EPA by participating in the preparation of all appropriate information disseminated to the public, and in public meetings that may be held or sponsored by the U.S. EPA to explain activities at, or concerning, the Site, including, but not limited to the findings of the Pump Test, Treatability Study, Bio-Assay Test, Background Water Quality Study, Groundwater Monitoring Well sampling, Private Well sampling, Effluent Toxicity Test, and Wetlands Investigation.

The community relations support which the Respondent shall be required to undertake should be consistent with Superfund community relations policy as stated in the "Guidance for Implementing the Superfund Program" and "Community Relations in Superfund - A Handbook".

I. Air Monitoring Plan

The Respondent shall submit an Air Monitoring Plan consistent with Section II.B.2.b.(17) of this SOW.

J. Feasibility Test Plan

The Respondent shall submit a Feasibility Test Plan consistent with Section II.B.2.b.(7) of this SOW.

Task III: RA Work Plan

The Respondent shall submit to U.S. EPA for review an RA Work Plan (the RA Work Plan) which shall document the overall management strategy for performing the construction, operation, maintenance and monitoring of Remedial Actions. The RA Work Plan shall document the responsibility and authority of all organizations and key personnel involved with the implementation.

The RA Work Plan shall also include a description of qualifications of key personnel directing the Remedial Action, including contractor personnel. The Respondent shall submit an RA Work Plan according to the schedule identified in the Submission Summary. The Respondent shall submit an amended RA Work Plan incorporating U.S. EPA's comments on the Work Plan according to the schedule identified in the Submission Summary.

TASK IV: REMEDIAL ACTION CONSTRUCTION

Following U.S. EPA approval of the final design, the Respondent shall develop and implement a construction quality assurance (CQA) program to ensure that the completed Remedial Action meets or exceeds all design criteria, plans and specifications. The CQA Plan should be prepared specifically for the Hagen Farm Site. This plan shall be submitted to the U.S. EPA for approval prior to the start of the construction. At a minimum, the CQA Plan shall include the elements, which are summarized below as Section III Subpart, A through E. Upon U.S. EPA approval of the CQA Plan, the Respondent shall construct and implement the Remedial Actions in accordance with the approved design, schedule, and the CQA plan. The Respondent shall also implement the elements of the approved operation and maintenance plan.

A. Responsibility and Authority

For the CQA plan, the Respondent shall describe fully the responsibility and authority of all organizations (i.e., technical consultants, construction firms, etc.) and key personnel involved in the construction of the corrective measure shall be described fully in the CQA plan. The Respondent shall also identify a CQA officer and the necessary supporting inspection staff.

B. Construction Quality Assurance Personnel Qualifications

The qualifications of the CQA officer and supporting inspection personnel shall be presented in the CQA plan in order to demonstrate that they possess the training and experience necessary to fulfill their identified responsibilities.

C. Inspection Activities

The Respondent shall summarize in the CQA plan the observations and tests that will be used to monitor the construction and/or installation of the components of the Remedial Actions. The plan shall include the scope and frequency of each type of inspection. Inspections shall verify compliance with the environmental requirements and include, but not be limited to, air quality and emissions

monitoring records, waste disposal records (e.g., RCRA transportation manifests). The inspection shall also ensure compliance with all health and safety procedures. In addition to oversight inspections, the Respondent shall conduct the following activities.

1. Preconstruction inspection and meeting

Prior to initiating or commencing construction, the Respondent shall conduct a remedial action construction inspection and meeting with representative from the U.S. EPA and WDNR to:

a. Review methods for documenting and reporting inspection data;

b. Review methods for distributing and storing documents and reports;

c. Review work area security and safety protocol;

d. Discuss any appropriate modifications of the construction quality assurance plan to ensure that site-specific considerations are addressed; and

e. Conduct a site walk-around to verify that the design criteria, plans, and specifications are understood and to review material and equipment storage locations.

The preconstruction inspection and meeting shall be documented by a designated person and minutes shall be transmitted to U.S. EPA within fourteen (14) days after the meeting.

2. Prefinal inspection

Upon preliminary project completion, the Respondent shall notify U.S. EPA for the purposes of conducting a prefinal inspection. The prefinal inspection shall include representatives from the U.S. EPA and WDNR and consist of a walk-through inspection of the entire project site. The inspection is to determine whether the project is complete and consistent with the contract documents and the EPA approved Remedial Action. Any outstanding construction items discovered during the inspection shall be identified and noted. Additionally, treatment equipment shall be operationally tested by the Respondent. The Respondent shall certify that the equipment has performed to meet the purpose and intent of the specifications. Retesting will be completed where deficiencies are revealed. The prefinal inspection report shall outline the outstanding construction

items, actions required to resolve items, completion date for these items, and date for final inspection.

3. Final inspection

Upon completion of any outstanding construction items, the Respondent shall notify EPA for the purposes of conducting a final inspection. The final inspection shall include representatives from the U.S. EPA and WDNR and consist of a walk-through inspection of the project site. The prefinal inspection report will be used as a checklist with the Final inspection focusing on the outstanding construction items identified in the prefinal inspection. Confirmation shall be made that outstanding items have been resolved.

D. Sampling Requirements

The sampling activities, sample size, sample locations, frequency of testing, acceptance and rejection criteria, and plans for correcting problems as addressed in the project specifications shall be presented in the CQA plan.

E. Documentation

Reporting requirements for CQA activities shall be described in detail in the CQA plan. This shall include such items as daily summary reports, inspection data sheets, problem identification and corrective measures reports, design acceptance reports, and final documentation. Provisions for the final storage of all records shall be presented in the CQA plan.

TASK V: Reports and Submissions

The Respondent shall prepare and submit to U.S. EPA plans, specifications, and progress and other reports as set forth in Tasks I through Task IV to document the design, construction, operation, maintenance, and monitoring of the Remedial Action. The documentation shall include, but not be limited to the following:

A. Progress

The Respondent shall at a minimum provide the U.S. EPA with signed progress reports during the design and construction phases and semi-annual progress reports for operation and maintenance activities containing:

1. A description and estimate of the percentage of the RD/RA completed;

2. Summaries of all findings;

3. Summaries of all changes made in the RD/RA during the reporting period;

4. Summaries of all contacts with representative of the local community, public interest groups, and/or State government during the reporting period;

5. Summaries of all problems or potential problems encountered during the reporting period;

6. Actions being taken to rectify problems;

7. Changes in personnel during the reporting period;

8. Projected work for the next reporting period; and

9. Copies of daily reports, inspection reports, laboratory/monitoring data, etc.

B. Draft

1. The Respondent shall submit to U.S. EPA a draft RD Work Plan and a draft RA Work Plan as outlined in Task I;

2. The Respondent shall submit to U.S. EPA draft construction Plans and Specifications, Design Reports, Cost Estimates, Schedules, Operation and Maintenance plans, and Study Reports as outlined in Task II;

3. The Respondent shall submit to U.S. EPA a draft construction Quality Assurance Program Plan and documentation as outlined in Task III; and

4. At the completion of the construction of the project, the Respondent shall submit to U.S. EPA a Remedial Action Implementation Report. The Report shall certify that the project is consistent with the design specifications, and that Remedial Action is performing adequately. The Report shall provide or specifically reference all documents or material which support the statements contained in the Report. The Report shall include, but not be limited to the following elements:

   a. Synopsis of the Remedial Action and certification of the design and construction;

   b. Explanation of any modifications to the plans and why these were necessary for the project;

   c. Listing of the criteria, established before the Remedial Action was initiated, for judging the functioning of the Remedial

Action and also explaining any modification to these criteria;

d. Results of facility monitoring, indicating that the Remedial Action will meet or exceed the performance criteria;

e. Explanation of the operation and maintenance (including monitoring) to be undertaken at the facility; and

5. After achieving groundwater cleanup standards specified in paragraphs II.B.2.b.(15) and II.B.2.b.(16) respectively, the Respondent shall submit to U.S. EPA a Remedial Action Report for these cleanup standards. The Groundwater Remedial Action Report shall at a minimum contain groundwater cleanup standards and all groundwater monitoring data collected during implementation of the remedy.

C. Final

The Respondent shall finalize the RD and RA work plans, Design Reports, Construction Plans and Specifications, Cost Estimates, Project Schedule, Operation and Maintenance Plan, Study Reports, Construction Quality Assurance Program Plan/Documentation and the Remedial Action Implementation Report and Remedial Action Reports incorporating comments received from U.S. EPA on draft submissions.

VI SUBMISSION SUMMARY

The Respondent's RD and RA work plans shall comply with the following time table information reporting requirements:

Submission	Due Date
RD Work Plan (Task I) (including plans set forth in Part III, Task 1)	60 days after effective date of Administrative Order.
Amended RD Work Plan (Task I)	30 days after U.S. EPA comments on RD Work Plan.
Implementation of RD Work Plan	Within 30 days of U.S. EPA approval of amended RD Work Plan.
Bio-Assay Test Report	60 days after completion of Bio-Assay Test activity.
Background Water Quality Test Report	60 days after completion of Background Water Quality Test activity.
Initiation of Pump Test and Treatability Study for Groundwater	30 days after approval of Pump Test and Treatability Study Plans submitted with RD Work Plan.
Design Schedule for Groundwater Treatment Task II Activities	
Preliminary Design (30% completion) including, the results of Off-property Pump Test, Off-property Treatability Study, and Wetlands Investigation.	Within 45 days after completion of the Pump Test and Treatability Study for Groundwater Treatment.
Prefinal Design (95% completion) (including Drafts of all submittals set forth in Part III Task II)	60 days after U.S. EPA comments on the Preliminary Design for Groundwater Treatment.
Final Design (100% completion) (including all submittals set forth in Part III Task II)	30 days after U.S. EPA approval of the prefinal design for Groundwater Treatment.

RA Work Plan for Groundwater Treatment (Task III)	Concurrent with Prefinal Design for Groundwater Treatment.
Amended RA Work Plan for Groundwater Treatment (Task III)	30 days after EPA's comment on RA Work Plan Groundwater Treatment.
Draft Construction Quality Assurance Plan (Task IV)	Concurrent with Prefinal Design of Groundwater Treatment.
Final Construction Quality Assurance Plan (Task IV)	Concurrent with Final Design of Groundwater Treatment.
Construction of Remedial Action	As approved in Final Design.
Prefinal Inspection Report	30 days after Prefinal Inspection.
Final Inspection Report	30 days after Final Inspection.
Groundwater Monitoring Report	60 days after completion of each monitoring event.
Private Well Monitoring Report	30 days after completion of each private wells monitoring event.
Effluent Toxicity Test Report	60 days after completion of each toxicity test event.
Draft Remedial Action Implementation Report (Task V)	Upon completion of construction phase.
Completion of Construction	As approved by U.S. EPA in the RD and RA Work Plans.
Final Remedial Action Implementation Report (Task V)	30 days after U.S. EPA comment on Draft Remedial Action Implementation Report.

O & M Revisions	30 days after approval of Final Remedial Action Implementation Report.
Draft Groundwater Remedial Action Report	30 days after achieving the Groundwater Cleanup Standard.
Final Groundwater Remedial Action Report	30 days after approval of Draft Remedial Action Report.
Progress Reports for Tasks I through V	Monthly
Progress Reports during Operation and Maintenance	Quarterly

SCOPE OF WORK
ATTACHMENT 1

Evaluation

CORRESPONDENCE / MEMORANDUM STATE OF WISCONSIN

DATE: January 27, 1992

TO: Mark Giesfeldt - SW/3

FROM: Duane Schuettpelz - WR/2

SUBJECT: Projected Water Quality-Based Effluent Limits for the Hagen Farm Superfund Project - REVISION #2

The purpose of this memo is to summarize the water quality-based effluent limitations recommended for the proposed direct discharge from the Hagen Farm Superfund site to the Yahara River in Dane County. Effluent limitations were calculated for each of the substances detected in any of the groundwater samples from the Hagen Farm site. Those limitations were calculated using chapters NR 102, 105, 106 and 207 of the Wisconsin Administrative Code and are discussed below. Based on our review, the following recommendations are made on a water quality basis for a direct discharge to the Yahara River:

1) If the discharger is able to demonstrate, under s. NR 207.04 (1)(d), that the significant lowering of water quality in the receiving water that may result from the proposed discharge can be prevented in a cost-effective manner either by pollution control alternatives, alternative treatment technologies, or alternative discharge locations, the effluent limitations are as follows (based on 1/3 of the available assimilative capacity in the receiving water):

Substance	Daily Max. (ug/L)	Weekly Average (lb/d)	Weekly Average (ug/L)	Monthly Average (lb/d)
Arsenic	0.73 *	0.20 *		
Copper	0.096 *	@	0.032 *	
Iron		1.3		
Lead	1.4 *	0.052 *		
Mercury	3.1 *		0.002 (monthly ave.)	
Nickel	5.1 *	0.2 *		
Zinc	0.54 *	@	0.12 *	
Ethylbenzene	45			
Toluene	23			
2,4-Dimethylphenol	2.1			
4-Chloro-3-Methylphenol	0.03			
Phenol	7.0			
Bis(2-chloroisopropyl)ether				38
Bis(2-ethylhexyl)phthalate	11			
1,4-Dichlorobenzene				3.4
Diethyl Phthalate	52			
Naphthalene	6.6			

mg/l.

2) If the discharger is able to satisfactorily demonstrate, under s. NR 207.04 (1)(d), that the

significant lowering of water quality in the receiving water that may result from the proposed discharge can not be prevented in a cost-effective manner either by pollution control alternatives, alternative treatment technologies, or alternative discharge locations, the effluent limitations are as follows (based on the full available assimilative capacity in the receiving water):

Substance	Daily Max. (ug/L)	Weekly Average (lb/d)	Weekly Average (ug/L)	Monthly Average (lb/d)
Arsenic	0.73 *	0.60 *		
Copper	0.096 *	@	0.032 *	
Iron		3.9		
Lead	1.4 *	0.16 *		
Mercury	3.1 *		0.002 (monthly ave.)	
Nickel	5.1 *	0.61 *		
Zinc	0.54 *	@	0.12 *	
Ethylbenzene	45			
Toluene	23			
2,4-Dimethylphenol	2.1			
4-Chloro-3-Methylphenol	0.03			
Phenol	7.0			
Bis(2-chloroisopropyl)ether				113
Bis(2-ethylhexyl)phthalate	11			
1,4-Dichlorobenzene				10
Diethyl Phthalate	52			
Naphthalene	6.6			

* - The indicated limitations may be reported in the "total recoverable" form if such a test is available to the discharger.

@ - For copper, mercury and zinc, no assimilative capacity is available in the receiving water because that capacity has already been allocated to the existing discharge from the City of Stoughton municipal treatment plant. Any new discharges to the Yahara River will have effluent limitations equivalent to the appropriate water quality criteria in the form of a concentration limit that will be applicable at any discharge rate. For that reason, no mass limitations shall be recommended for these substances at this time. Any additional discharge of these substances is allowable only if a portion of the capacity allocated to the City of Stoughton outfall 001 is reassigned to Hagen Farm.

It is recommended that the set of the above limitations which is deemed appropriate based on the s. NR 207.04 (1)(d) evaluation should be accompanied by a requirement to perform, at a minimum, monthly testing for a period of up to six months following commencement of discharge. Following the conclusion of that sampling period, effluent limitations for individual substances may be removed from the recommended list if those substances are not detected at levels of detection equal to or less than 1/5 the calculated limits for those substances. If the level of detection exceeds 1/5 of the applicable limitation or if the substance is detected in the discharge to surface water, the need for limitations and/or monitoring should be re-evaluated by this Bureau using the procedures in NR 106.

The above limitations should be compared to Best Available Technology limitations, where available, prior to final recommendation to the discharger.

3) Whole Effluent Toxicity Testing Recommendations:

Language for Superfund Site discharges is currently undergoing discussion and revision between our Bureaus as well as the Bureau of Wastewater Management. The following recommendations are made pending the results of those discussions.

Based on the absence of biological data leading to the overall uncertainty regarding the potential for whole effluent toxicity and the proposed water quality-based chemical-specific effluent limitations derived for several toxicants identified in the contaminated groundwater, the following recommendation is provided:

Acute: Acute toxicity test batteries are recommended with three freshwater species at a frequency and duration of once each three months upon commencement of discharge for the duration of the permit. Due to the highly contaminated nature of the wastewater from the Hagen Farm Superfund Project, it is further recommended that the discharge be ceased immediately upon the failure of any one acute toxicity test battery.

Chronic: Monitoring for chronic whole effluent toxicity is not recommended at this time.

The chemical-specific recommendations are addressed in more detail in the following discussion.

Chemical Specific Evaluation:

Effluent limitations for a discharge to an unnamed tributary of the Yahara River from the Hagen Farm Superfund Site were calculated for each of the substances detected in any of the groundwater monitoring wells at the Hagen Farm site that have water quality criteria in ch. NR 105, Wis. Adm. Code. Those limitations were provided in my memo to you dated November 15, 1990. That memo is currently being updated to address several additional substances. The October 11, 1991 Feasibility Study for Hagen Farm also addressed potential discharge to any of three sites located along the Yahara River downstream of the Stoughton municipal treatment plant outfall. This memo shall address those new discharge sites. Since there are no major tributaries entering the Yahara River immediately downstream of Stoughton, each of the three proposed discharge sites shall have the same effluent limitations.

Background information used in calculating effluent limits for the Hagen Farm Superfund Site was calculated using instream data obtained above Stoughton's permitted outfall and effluent data from the City of Stoughton discharge. The background data issue is discussd in more detail below. The general information used in calculating effluent limitations at this location is summarized in the following table:

```
EFFLUENT LIMIT CALCULATIONS FOR:    Hagen Farm Superfund Site
RECEIVING WATER:            Yahara River

RECEIVING WATER INFORMATION:
CLASSIFICATION:  Warmwater Sport Fish, Non-Public Water Supply
RECEIVING WATER FLOWS (cfs):      7Q10     7Q2      Qave      Stoughton 001
                                  ----     ----     ----      -------------
                                   14       35       156     2.55 (1.65 MGD)

RECEIVING WATER HARDNESS =        300 PPM
EFFLUENT HARDNESS        =        310 PPM
```

The Yahara River, as shown in the preceding table, is currently classified as a warmwater sportfish community. That classification is consistent with that used in the evaluation of effluent limitations for Stoughton outfall 001 (see next paragraph).

Outfall 001 for the permitted discharge from the City of Stoughton (WPDES permit number WI-0020338-4, issued February 28, 1989) is located just upstream of one of the proposed outfalls for the Hagen Farm Site. Effluent limitations for toxic substances using NR 105 and 106 were calculated for Stoughton as presented in a November 11, 1991 memo from me to Roy Lembcke of Southern District. Since the City's outfall is located so close to the proposed outfall and has effluent limitations that were, in part, also based upon the above-mentioned Administrative Codes, the existing or allowable discharges through that outfall may influence the ambient concentrations of substances found downstream at the landfill site. Those ambient concentrations are used to calculate weekly and monthly average limitations, so as the ambient level of a substance increases, the allowable amount that can be added by an additional discharger in the vicinity decreases. To determine the ambient concentrations of the substances evaluated at Hagen Farm, it is necessary to perform a mass balance using the concentrations upstream of Stoughton outfall 001, the most stringent limitations for substances recommended for Stoughton's WPDES permit in the November 11, 1991 review, and the mean effluent concentrations of substances <u>not</u> recommended for WPDES permit limits in the November 11 Stoughton memo. Those concentrations, as well as the results of the mass balance, are summarized (in units of ug/L) in the following table.

				Instream Concentrations @ Hagen Farm:	
Substance	C_R	C_L	C_E	@ $Q_{10}/4$	@ Q_{mn}
Arsenic	0.91		ND	0.53	0.90
Copper	9.87	63.3		32.41	
Iron	(not evaluated at Stoughton)			0	0
Lead	1.65		ND	0.95	
Mercury	0	0.0253		(0.002 @ $_{30Q_5}$)	
Nickel	0		ND	0	0
Zinc	0	298.18		125.8	
Ethylbenzene	0		ND	0	0
Toluene	0		ND	0	0
2,4-Dimethylphenol	(not evaluated at Stoughton)			0	0
4-Chloro-3-Methylphenol	(not evaluated at Stoughton)			0	0
Phenol	0		20		0.32
Bis(2-chloroisopropyl)ether	0		ND	0	0
Bis(2-ethylhexyl)phthalate	0		ND	0	0
1,4-Dichlorobenzene	0		3.2		0.05
Diethyl Phthalate	0		ND	0	0
Naphthalene	(not evaluated at Stoughton)			0	0

C_R = Background concentration of a substance above Stoughton outfall 001.

C_L = Lowest concentration limit recommended for a substance in Stoughton's WPDES permit.

C_E = Mean effluent concentration of substances not limited at Stoughton outfall 001.

$_7Q_{10}/4$ = Seven-day, ten-year low flow = 14 cfs, so 1/4 of that is 3.5 cfs. Including Stoughton's 2.55 cfs results in a total of 6.05 cfs).

$_{30}Q_5$ = 85% of seven-day, two-year low flow = 0.85 X 35 cfs = 29.75 cfs (32.3 cfs including outfall 001 flow).

Q_{aa} = Mean annual flow = 156 cfs (158.55 cfs including outfall 001 flow)

ND = Substance was not detected at the indicated location. For mass balance purposes, a "no detect" will be treated as a zero.

Hagen Farm's daily maximum effluent limitations were calculated based on twice the NR 105 acute toxicity criteria (ATC) where available, pursuant to s. NR 106.06 (2). If, for a given substance, an NR 105 criterion is not available, the daily maximum effluent limitation equals the lowest species mean LC50 value for aquatic species considered among the warmwater sportfish community subcategory, which represents the classification of the Sheboygan River pursuant to s. NR 102.04 (3). Those limitations are summarized in the following table.

CALCULATION OF EFFLUENT LIMITATIONS BASED ON ATC

SUBSTANCE	REF. HARD. or pH	ATC (ug/L)	MAX. EFFL. LIMIT (ug/L)
Arsenic		363.80	727.60
Copper	310	48.13	96.26
Lead	310	713.77	1427.54
Mercury		1.53	3.06
Nickel	274	2528.06	5056.12
Zinc	310	269.29	538.58
EPA Criteria:			
Aluminum		748.00	1496.00
Limitations Based on LC_{50} Data (s. NR 102.04 (1)):			
Ethylbenzene			45315
Toluene			22800
2,4-Dimethylphenol			2120
P-Chloro-M-Cresol (or 4-Chloro-3-Methylphenol)			30
Phenol			7000
Bis(2-ethylhexyl)Phthalate			11100
1,4-Dichlorobenzene			4000
Diethyl Phthalate			52100
Naphthalene			6604

Since a specific effluent discharge rate was not proposed, the weekly and monthly average effluent limitations were calculated based on the available assimilative capacity in the Yahara River which, based on the definition in s. NR 207.02 (1), is the difference between the applicable water quality criterion for a substance and the existing concentration of that substance in a surface water. The antidegradation provisions in ch. NR 207 are applicable at Hagen Farm since this represents a new discharge. As a result, the assimilative capacity of the Yahara River is converted from a concentration into an allowable mass loading in pounds

per day using the appropriate streamflow pursuant to NR 106.

Weekly average limitations based on NR 105 chronic toxicity criteria (CTC) and monthly average limitations based on NR 105 wild and domestic animal criteria (WDAC), human threshold criteria (HTC) and human cancer criteria (HCC) are summarized in the following tables using the full assimilative capacity of the Yahara River and 1/3 of that capacity. The assimilative capacity is determined using the 7-day, 10-year low flow for the CTC, 85% of the seven-day, two-year low flow for the WDAC, and the mean annual flow for the HTC and HCC. 1/3 of the assimilative capacity using those flows represents the loading necessary to cause a significant lowering of water quality. For each of the various criteria, limitations are calculated to address two alternatives based on the implementation of NR 207. The discharger is required to make a series of demonstrations if the proposed discharge would result in a significant lowering of water quality as defined in s. NR 207.05. Those demonstrations are contained in s. NR 207.04 (1)(d) and are based on the availability of pollution control and treatment technology alternatives, including alternative discharge locations. If the discharger is able to demonstrate that there are no alternatives available that would satisfy the appropriate portions of s. NR 207.04 (1)(d), the recommended effluent limitations would be based on the full assimilative capacity of the receiving water. On the other hand, if the demonstrations in s. NR 207.04 (1)(d) show that alternatives are available, the recommended limitations would be based upon 1/3 of the available assimilative capacity in the Yahara River.

Since the discharger may be required to make the s. NR 207.04 (1)(d) demonstration, effluent limitations shall be recommended here based on both of the possible results of that demonstration. Therefore, two sets of weekly and monthly average limitations shall be recommended. Those alternative limitations are summarized below and on the following page.

CALCULATION OF EFFLUENT LIMITATIONS BASED ON CTC

RECEIVING WATER FLOW (cfs) = 6.05

SUBSTANCE	REF. HARD. or pH	CTC (ug/L)	BACK-GRD. (ug/L)	ASSIM. CAP. (ug/L)	1/3 OF CAP. (ug/L)	ASSIM. CAP. (lb/d)	1/3 OF CAP. (lb/d)
Arsenic		153.00	0.53	152.47	50.82	0.596	0.199
Copper	300	32.41	32.41	0.00	0.00	0.000	0.000
Lead	300	40.85	0.95	39.90	13.30	0.156	0.052
Nickel	274	155.14	0	155.14	51.71	0.607	0.202
Zinc	300	125.80	125.8	0.00	0.00	0.000	0.000
EPA Criteria:							
Iron		1000	0	1000.00	333.33	3.911	1.304

CALCULATION OF EFFLUENT LIMITATIONS BASED ON WDAC

RECEIVING WATER FLOW (cfs) = 32.30

SUBSTANCE	WDAC (ug/L)	BACK-GRD. (ug/L)	ASSIM. CAP. (ug/L)	1/3 OF CAP. (ug/L)	ASSIM. CAP. (lb/d)	1/3 OF CAP. (lb/d)
Mercury	0.002	0.002	0.000	0.000	0	0

CALCULATION OF EFFLUENT LIMITATIONS BASED ON HTC

RECEIVING WATER FLOW (cfs) = 158.55

SUBSTANCE	HTC (ug/L)	BACK-GRD. (ug/L)	ASSIM. CAP. (ug/L)	1/3 OF CAP. (ug/L)	ASSIM. CAP. (lb/d)	1/3 OF CAP. (lb/d)
Lead	50	0.027	50	17	5.1	1.7
Mercury	0.08	0.0003	0.080	0.027	0.008	0.003
Nickel	460	0	460	153	47	16
Ethylbenzene	10000	0	10000	3333	1024	341
Toluene	110000	0	110000	36667	11267	3756
Phenol	160000	0.32	160000	53333	16388	5463
Bis(2-chloroisopropyl)ether	1100	0	1100	367	113	38
Bis(2-ethylhexyl)phthalate	30000	0	30000	10000	3073	1024
Diethyl Phthalate	1100000	0	1100000	366667	112669	37556

CALCULATION OF EFFLUENT LIMITATIONS BASED ON HCC

RECEIVING WATER FLOW (cfs) = 158.55

SUBSTANCE	HCC (ug/L)	BACK-GRD. (ug/L)	ASSIM. CAP. (ug/L)	1/3 OF CAP. (ug/L)	ASSIM. CAP. (lb/d)	1/3 OF CAP. (lb/d)
Arsenic	50	0.9	49	16	5.0	1.7
1,4-Dichlorobenzene	100	0.05	100	33	10.2	3.4

In addition, following initial effluent sampling for the above substances, it may be necessary to revise the monthly average limitations based on human cancer criteria if it is determined that there is a concern over the cumulative cancer risk of the substances present in the Hagen Farm effluent.

Several substances are noted in the above tables with no mass limitations. Those substances (copper, mercury and zinc) are water quality limited at the City of Stoughton outfall 001 using the same criteria (chronic toxicity, wild and domestic animal, human threshold, or human cancer where appropriate) as those evaluated at Hagen Farm. In those situations, Stoughton has already been allocated the entire assimilative capacity of the Yahara River, meaning there is no extra capacity available in the river to handle new discharges such as that from the landfill. The effluent limitations for those substances are set equal to the appropriate water quality criteria since the Hagen Farm discharge is introducing additional flow to the river on a net basis. Additional discharge of those substances from the Hagen Farm beyond those concentrations is allowable <u>only</u> if a portion of Stoughton's allocated loading limit is reassigned to Hagen Farm. Such a distribution of limitations between the industrial outfall and the Superfund Site should be handled through Stoughton pursuant to s. NR 106.11. Any redistribution of the copper, mercury and zinc limitations may be acceptable to the Department as long as a total maximum load limit equivalent to Stoughton's current concentration limits at the permitted discharge rate of 1.65 MGD at outfall 001 plus the discharge rate from the Hagen Farm.

For each of the substances evaluated at Hagen Farm and detected in at least one of the

groundwater samples, the recommended effluent limitations (rounded) are summarized at the beginning of this memo. Where the calculated monthly average limitations exceed the weekly average limitations, only the weekly average limitations are recommended. Finally, where the acute toxicity criteria are lower than all of the remaining criteria, only a daily maximum limitation is recommended based on that acute toxicity criterion.

If there are any questions or comments, please contact Jim Schmidt (608) 267-7658 regarding chemical-specific determinations; Bob Masnado (608) 267-7662 regarding whole effluent toxicity testing; or either John Sullivan (608) 267-9753 or myself (608) 266-0156 regarding general issues.

jws/wp03/hagensf.re2/

PREPARED BY:

James W. Schmidt

James W. Schmidt, P.E.
Water Resources Engineer

APPROVED FOR SIGNATURE BY:

John R. Sullivan
Surface Water Standards Unit

cc: Tom Bainbridge - SD
Lee Liebenstein - WR/2
Mike Witt - WW/2

APPENDIX 1

ADMINISTRATIVE RECORD INDEX
HAGEN FARM SITE
STOUGHTON, WISCONSIN

FICHE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE	DOCNUMBER
	26	88/01/13	Letter re: Comments on Site Evaluation Report, Technical Workplan, and QAPP	D.Balloti,USEPA	R.DeBattista,WMMA of WI	Correspondence	1
	12	88/06/23	Letter forwarding responses to the Hagen Farm Site RI/FS QAPP, with the Chloride and Sulfate Analysis by Ion Chromatography	A.Medina,Roseco Inc.	J.Dadisman,Warzyn Engr.	Correspondence	2
	1	88/06/30	Letter re: Responses and Revisions to Comments from USEPA-Region V QA Office on the Hagen Farm RI/FS QAPP	J.Dowden,WMMA of WI,Inc.	S.Sylvester,USEPA	Correspondence	3
	5	88/08/11	Letter re: Linearity of Detector Response for Chloride and Sulfate Analyses	G.Asbury&R.Wendt, Warzyn Engineering,Inc.	Chang-Wen Tani,PhD,USEPA	Correspondence	4
	3	88/09/06	Letter re: Methodology Modifications for Sulfate and Chloride Analyses	G.Asbury,Warzyn Engineering,Inc.	J.Lee,USEPA	Correspondence	5
	7	88/10/25	Letter re: Work Plan Addendum for Source Characterization	J.Dowden,Waste Mgmt. of WI,Inc.	J.Lee,USEPA	Correspondence	6
	2	88/11/10	RI/FS QAPP Sign-off Sheet	J.Dowden,WMMA of WI, Inc.	J.Lee,USEPA	Correspondence	7
	20	89/07/20	Letter re: Work Plan Addendum for Phase 2 Site Investigation and Source Control Operable Unit FS	G.Asbury,Warzyn Engineering,Inc.	J.Lee,USEPA	Correspondence	8
	22	89/07/25	Letter re: Response to Comments - Tech Memo 1	G.Asbury,Warzyn Engineering,Inc.	J.Dowden,WMMA of WI,Inc.	Correspondence	9

ADMINISTRATIVE RECORD INDEX
HAGEN FARM SITE
STOUGHTON, WISCONSIN

FICHE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE	DOCNUMBER
	9	90/02/02	Letter re: Alternative Array Review Comments for the Source Control Operable Unit at the Hagen Farm Site	J.Lee,USEPA	D.Brucich,WMMA of WI,Inc.	Correspondence	10
	6	88/07/00	Superfund Fact Sheet Hagen Farm Site	USEPA		Fact Sheets	11
	15	88/09/29	Memo re: Approval of QAPP for the RI/FS Activity at Hagen Farm Superfund site	A.Jirka,USEPA	K.Niedergang,USEPA	Memorandum	12
	3	88/09/22	Addendum to Hagen Farm - Field GC Standard Operating Procedures	Warzyn Engineering,Inc.		Other	13
	63	87/09/14	Administrative Order by Consent Re: RI/FS for Hagen Farm Site	USEPA		Pleadings/Orders	14
	24	00/00/00	PRP Response Summary	Hagen Farm Site		Reports/Studies	15
	27	00/00/00.	Draft Statement of Work for Conducting a RI/FS at the Hagen Farm Site Dane County, WI	USEPA		Reports/Studies	16
	382	87/11/00	QAPP Hagen Farm Site Volume 3 of 3 November 1987	Warzyn Engineering,Inc.	Waste Mgmt. of WI,Inc.	Reports/Studies	17
	178	88/06/00	Work Plan Hagen Farm Site Volume 2 of 4	Warzyn Engineering,Inc.	Waste Mgmt. of WI,Inc.	Reports/Studies	18
	193	88/06/00	Site Evaluation Report Hagen Farm Site Volume 1 of 4	Warzyn Engineering,Inc.	Waste Mgmt. of WI,Inc.	Reports/Studies	19
	36	88/07/00	Final Community Relations Plan Hagen Farm	Jacobs Engineering Group Inc.	USEPA	Reports/Studies	20
	60	88/07/21	Quality Assurance Plan	Radian Corporation,		Reports/Studies	21

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			for the Analysis for Hazardous Substances List Volatile Organic Compounds in Air Samples by GC/MS	revised by USEPA			
	218	88/09/01	Report on the Electro-magnetic and Magnetic Survey Conducted at the Hagen Farm Site	Fromm Applied Technology	Warzyn Engineering,Inc.	Reports/Studies	22
	9	88/09/23	Preliminary Health Assessment for Hagen Farm Site Stoughton, WI	WDHS,Div. of Health, Bureau of Community Health and Prevention	ATSDR	Reports/Studies	23
	327	89/03/00	RI/FS Hagen Farm Site Technical Memorandum Number 1 - March 1989	Warzyn Engineering,Inc.	Waste Mgmt. of WI,Inc.	Reports/Studies	24
	87	89/03/00	RI/FS Hagen Farm Site Technical Memorandum Number 1	Warzyn Engineering,Inc.	Waste Mgmt. of WI,Inc.	Reports/Studies	25
	4	89/07/00	Progress Report Hagen Farm Superfund Site	USEPA		Reports/Studies	26
	45	89/10/00	Alternatives Array Document Source Control Operable Unit RI/FS Hagen Farm Site	Warzyn Engineering,Inc.		Reports/Studies	27
	229	90/02/00	RI/FS Hagen Farm Site Technical Memorandum Number 2	Warzyn Engineering,Inc.	Waste Mgmt. of WI,Inc.	Reports/Studies	28

ACRONYM GUIDE for the Administrative Record
Hagen Farm Site
Ashtabula County, Ohio

ACRONYM	DEFINITION
AR	Administrative Record
GC	Gas Chromatograph
GC/MS	Gas Chromatograph/ Mass Spectograph
QA	Quality Assurance
QA/QC	Quality Assurance/ Quality Control
QAPP	Quality Assurance Project Plan
RI/FS	Remedial Investigation/ Feasibility Study
RPM	Remedial Project Manager
USEPA	United States Environmental Protection Agency

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STOUGHTON, WISCONSIN

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	162	90/07/00	Feasibility Study Source Control Operable Unit RI/FS Hagen Farm Site	Warzyn Engineering Inc.	Waste Mgmt. of WI,Inc.	Reports/Studies	1

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STOUGHTON, WISCONSIN

COPY

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	2	90/08/13	Memo re: Remedy Delegation Report describing remedial actions delegated to the Regional Administrator for selection of remedy	D.Clay-USEPA	V.Adamkus-USEPA	Memorandum	1

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UPDATE #3

HAGEN FARM SITE

STOUGHTON, WISCONSIN

05/14/92

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1	00/00/00			Explanation of Significant Differences: Change to the Remedy in the 1990 ROD with Supporting Documents	53
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3	01/25/90	Antens, I., USEPA	Dowden, J., Waste Management	Invoice for Recovery of Costs	21
4	04/25/90	Harrity, D., PRC	Lee, J., USEPA	Preliminary Risk Assessment Review	4
5	05/08/90	Antens, I., USEPA	Brncich, D., Waste Management	Letter Providing Revised Invoice for FY 1989 Oversight Costs	2
6	06/06/90	Jacobs, P., Warzyn	Lee, J., USEPA	Groundwater Sampling while Drilling at Boring B-32D	2
7	06/14/90	Jacobs, P., Warzyn	Brncich, D., Waste Management	Well Installation Procedures	2
8	07/00/90	USEPA		Fact Sheet--US EPA Issues Proposed Plan for - Landfill Cleanup	12
9	07/20/90	Lovejoy, M. & Asbury, G., Wayzyn	Lee, J., USEPA	Letter re: Degree of Expected Reductions of VOCs (per FS)	2
10	08/00/90	Wisconsin Dept. of Health & Social Services		Health Information Newsletter	4
11	08/16/90	Brncich, D., Waste Management	Lee, J., USEPA & Evanson, T., WDNR	Issues for 8/23/90 Meeting with Attachments	10
12	08/17/90	Antens, I., USEPA	Brncich, D., Waste Management	Letter Providing Documentation for Jacobs Contract for Billing Period 10/1/88-9/30/89	1
13	08/28/90			Meeting Notes for Hagen Farm RI/FS	6
14	10/01/90	Asbury, G., Warzyn	Lee, J., USEPA	Cover Letter to Work Plan Addendum, Hagen Farm RI/FS	1

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16	10/10/90	Lovejoy, M., Warzyn	Lee, J., USEPA	Revision to Work Plan Addendum, Hagen Farm RI/FS	4
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18	10/15/90	Evanson, T., WDNR	Asbury, G., Warzyn	Variance to NR 141.19, Borehole Diameter for Pump Test Monitoring Wells	2
19	10/22/90	Asbury, G., Wayzyn	Lee, J., USEPA	Cover Letter to Work Plan Addendum and Attachments	1
20	10/23/90	Evanson, T., WDNR	Asbury, G., Wayzyn	Logging of Soil Boreholes During Phase II Drilling Activities	2
21	11/26/90	Burge, D., Versar, Inc.	Lee, J., USEPA	Report of Drilling Incident	2
22	11/30/90	Brncich, D., Waste Management	Everett, D., Stoughton Conservation Club	Request to Prohibit Use of Target Practice Range During Testing	5
23	12/03/90	Brncich, D., Waste Management	Lee, J., USEPA	Report of Drilling Incident	4
24	12/04/90	Lee, J., USEPA	Brncich, D., Waste Management	Approval of Work Plan Addendum	1
25	12/06/90	Brncich, D., Waste Management	Lee, J., USEPA	Monthly Progress Report: November 1990	63
26	12/11/90	Evanson, T. WDNR	Brncich, D., Waste Management	Aquifer Pump Test and Carbon Treatment of Effluent Requirements	5
27	12/17/90	Brncich, D., Waste Management	Lee, J., USEPA	Report of Aquifer Pump Test	2
28	12/19/90	Jordan-Izaguirre, D., ATSDR	Lee, J., USEPA	Private Wells Results	86
29	01/07/91	Brncich, D., Waste Management	Lee, J., USEPA	Hagen Farm Aquifer Pump Test Preliminary Report	46
30	01/07/91	Brncich, D., Waste Management	Lee, J., USEPA	Monthly Progress Report: December 1990	84

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33	02/11/91	Brncich, D., Waste Management	Lee, J., USEPA	Water Quality Results for Manganese and TCL Semi Volatiles	29
34	02/15/91	Brncich, D., Waste Management	Lee, J., USEPA	Response to Comments by Versar, Inc. on Treatability Study Work Plan	2
35	02/20/91	Vanderpool, L., USEPA	Lee, J., USEPA	Geological Review Comments of Treatability Study Work Plan	1
36	02/28/91	Evanson, T., WDNR	Lee, J., USEPA	Comments on Treatability Study Work Plan	2
37	02/28/91	Harrity, J., PRC	Lee, J., USEPA	Cover and Review of Treatability Study Work Plan	8
38	03/04/91	Brncich, D., Waste Management	Lee, J., USEPA	Clarification of Several Items in Treatability Study Work Plan	2
39	03/05/91	Lee, J., USEPA	Brncich, D., Waste Management	Approval of Work Plan	2
40	03/07/91	Holoska, T., U.S.EPA	Lee, J., USEPA	Comments on Treatability Study Work Plan	2
41	03/15/91	Brncich, D., Waste Management	Lee, J., USEPA	Request for Letter Granting Approval for Sample Collection	1
42	03/21/91	Brncich, D., Waste Management	Lee, J., USEPA	Response to Comments on Treatability Study Work Plan	30
43	03/26/91	Evanson, T., WDNR	Lee, J., USEPA	Waste Management's Compliance with WDNR Hazardous Waste Rules for Collection/Transportation of Hazardous Waste Samples	1
44	03/29/91	Vanderpool, L. U.S. EPA	Lee, J., USEPA	Review of Waste Managements Response to Comments on Work Plan	1
45	04/15/91	Evanson, T., WDNR	Urek, J., Waste Management	Collection/Transportation of Groundwater for Treatability Studies	2
46	04/15/91	Urek, J. Waste Management	Evanson, T., WDNR	Request for Variance of WDNR Hazardous Waste Rules for Collection/Transportation of Hazardous Waste Samples for Treatability Studies	6

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48	05/07/91	Brncich, D., Waste Management	Lee, J., USEPA	Monthly Progress Report: April 1991	84
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50	05/30/91	Termont-Schenk, S., Wayzyn	Lee, J., USEPA	Cover Letter to Full-Size Design Drawings	1
51	06/00/91	Warzyn Inc.	Waste Management of Wisconsin, Inc. & Lee, J., USEPA	RD/RA Work Plan; Remedial Design/Remedial Action: Source Control Operable Unit	56
52	06/04/91	Baumann, A., USEPA	Lee, J., USEPA	Review Comments on Health & Safety Plan	1
53	06/06/91	Thomas, C. USEPA	Lee, J., USEPA	Review Comments on Prefinal Landfill Cover Design Report	4
54	06/13/91	Dunn, J. WDNR	Lee, J., USEPA	FAX-Comments on RD/RA Prefinal Design Report	1
55	06/25/91	Gandhi, B., PRC	Lee, J., USEPA	Review Comments on Prefinal Landfill Cover Design Report	1
56	07/00/91	Wayzyn Inc.	Waste Management of Wisconsin, Inc. & Lee, J., USEPA	Landfill Cover Design: Remedial Design/Remedial Action: Source Control Operable Unit	335
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60	08/00/91	USEPA		Fact Sheet--Progress Report	6
61	08/01/91	Termont-Schenk, S., Wayzyn	Lee, J., USEPA	Cover to Final Landfill Cover Design Report	1
62	08/05/91	Termont-Shenk, S., Wayzyn	Lee, J., USEPA	Responses by Wayzyn and Waste Management to Agency Comments on Prefinal Landfill Cover Design Report	18

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64	08/27/91	Straw, A., Waste Management Counsel	Everett, D., Stoughton Conservation Club	Consent for Access and Entry	3
65	08/27/91	Straw, A., Waste Management Counsel	Gullickson, F.	Consent for Access and Entry	3
66	08/27/91	Straw, A., Waste Management Counsel	Sagmoen, C.	Consent for Access and Entry	3
67	08/27/91	Straw, A., Waste Management Counsel	Gjertson, M.	Consent for Access and Entry	3
68	08/27/91	Straw, A., Waste Management Counsel	K May Insulation, Inc.	Consent for Access and Entry	3
69	08/27/91	Straw, A., Waste Management Counsel	Sundby Sand & Gravel	Consent for Access and Entry	3
70	08/27/91	Straw, A., Waste Management Counsel	Sundby, G.	Consent for Access and Entry	3
71	08/29/91	U.S.EPA		Public Meeting Agenda	1
72	08/30/91	Moser, J., Wayzyn	Lee, J., USEPA	Cover Letter to Draft RI Report	1
73	09/05/91	Lee, J., USEPA	Addresses	Copies of Draft Remedial Investigation Report	1
74	09/10/91	Sundby, G., Property Owner	Waste Management	Fax-Signed Consent for Entry and Access	1
75	09/11/91	Termont-Schenk, S., Warzyn	Lee, J., USEPA	Responses to Agency Review Comments on Technical Memoranda Nos. 1-4	3
76	09/26/91	Jirik, A., Versar, Inc.	Lee, J., USEPA	Review Comments on Draft RI	2
77	09/26/91	Wisconsin State Laboratory of Hygiene	Evanson, T., WDNR	Sampling Results of Private Wells	28
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79	10/02/91	Matheson, T., USEPA	Figliulo, I., USEPA	Review Comments on Draft RI Report	1
80	10/08/91	Schnoes, K., PRC	Lee, J., USEPA	Fax-Versar's Review Comments on Draft RI Report	8

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85	11/00/91	Wayzyn Inc.	Waste Management of Wisconsin, Inc. & Lee, J., USEPA	Final Remedial Investigation Report: Vol. 2 of 4 - Appendices A-C	580
86	11/00/91	Wayzyn Inc.	Waste Management of Wisconsin, Inc. & Lee, J., USEPA	Final Remedial Investigation Report: Vol. 3 of 4 - Appendices D-I	412
87	11/00/91	Wayzyn Inc.	Waste Management of Wisconsin, Inc. & Lee, J., USEPA	Final Remedial Investigation Report: Vol. 4 of 4 - Appendices J-M	350
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91	01/20/92	PRC Environmental Management, Inc.	Lee, J., USEPA	RD/RA Oversight Trip Report 2	92
92	01/24/92	Antens, I., USEPA	Brncich, D., Waste Management	Invoice for the Recovery of Costs	37
93	01/31/92	Termont-Schenk, S., Wayzyn Inc.	Lee, J., USEPA	Responses to U.S. EPA Comments on Draft FS	95
94	02/10/92	Warzyn Inc.	Lee, J., USEPA	Responses to Comments on the Draft In Situ Vapor Extraction Pilot-Study Work Plan	48
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97	03/06/92	Heinrich, B., Waste Management	Simmons, V., USEPA	Documentation Deficiency on Oversight Cost Bill (1/24/92)	1
98	03/06/92	Niemann, C., Waste Management	Lee, J., USEPA	Format for Revised GCDU Feasibility Study	2
99	03/06/92	Lee, J., USEPA	Niemann, C., Waste Management	Review Comments for GCDU Revised Feasibility Study	30
100	03/09/92	Niemann, C., Waste Management	Lee, J., USEPA	Revisions to Draft Final GCDU Feasibility Study	1
101	03/16/92	Niemann, C., Waste Management	Lee, J., USEPA	Comments on ROD with Sample ROD	80
102	03/16/92	Niemann, C., Waste Management	Lee, J., USEPA	Progress Letter on In-Situ Vapor Extraction	2
103	03/17/92	Gandhi, B., PRC	Lee, J., USEPA	RD/RA Oversight Trip Report 3	22
104	03/20/92	Niemann, C., Waste Management	Distribution	March 11, 1992 Meeting Issues	3
105	03/30/92	Termont-Schent, S., Warzyn	Pfeiffle, D., US Army Corps of Engineers	Request for response re: Wetland Issues	1
106	03/31/92	Gandhi, B., PRC	Lee, J., USEPA	Acknowledgement of PRP Remedial Action Implementation Report	1
107	04/00/92	Warzyn, Inc.	Waste Management & Lee, J., USEPA	Final Feasibility Study for Groundwater Control Operable Unit	402
108	04/08/92	Lee, J., USEPA	Niemann, C., Waste Management	Review Comments on 3 Chapters of Draft FS	13
109	04/27/92	Termont-Schenk, S., Warzyn	Lee, J., USEPA	Responses to Comments on the Draft Final Feasibility Study	68

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UPDATE #4

HAGEN FARM SITE

STOUGHTON, WISCONSIN

09/08/92

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UPDATE #5

HAGEN FARM SITE

STOUGHTON, WISCONSIN

11/18/92

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1	07/05/90	Cahn, J., U.S. EPA	Straw, A., Waste Management of North America, Inc.	Transmittal Letter and 104(e) Requests for Information	15
2	07/19/90	Schubert, W., Waste Management of North America	Cahn, J., U.S. EPA	Response to 104(e)	160
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4	04/16/92	Cahn, J., U.S. EPA	Heinrich, B., Waste Management of North America, Inc. (sic)	Request for Supplemental Response to 104(e)	2
5	04/27/92	Heinrich, B., Waste Management of Wisconsin, Inc.	Cahn, J., U.S. EPA	Reply to Request for Supplemental Response to 104(e)	29
6	09/30/92	U.S. EPA		Record of Decision	71
7	11/11/92	Seglin, L., Waste Management Inc.	Cahn, J., U.S. EPA	Letter Providing Additional Information In Response to 104(e)	30

APPENDIX 2

HAGEN FARM SITE, WI
SOURCE CONTROL OPERABLE UNIT

DECLARATION FOR THE RECORD OF DECISION

Site Name and Location

Hagen Farm Site, Source Control Operable Unit
Dane County, Wisconsin

Statement of Basis and Purpose

This decision document represents the selected remedial action for the Hagen Farm site, in Dane County, Wisconsin, Source Control Operable Unit, which was chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and, to the extent practicable, the National Oil and Hazardous Substance Pollution Contingency Plan (NCP).

This decision is based on the Administrative Record file for the Hagen Farm site.

The State of Wisconsin concurs with the selected remedy.

Assessment of the Site

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this Record of Decision (ROD), may present an imminent and substantial endangerment to public health, welfare, or the environment.

Description of Remedy

This source control operable unit is the first of two operable units for the site. The selected remedial action for this operable unit addresses the source of contamination by remediation of on-site wastes and contaminated sub-surface soils.

The major components of the selected remedy include:

* Within the larger area of contamination (AOC), consolidation of non-native materials from disposal areas B and C into disposal area A with subsequent backfilling of disposal areas B and C with clean soil material;

* Installation of a WDNR NR 504 solid waste cap over disposal area A after consolidation;

- In-Situ Vapor Extraction of the waste refuse and sub-surface soils in disposal area A;
- Off-gas treatment through carbon adsorption;
- Regeneration of carbon from the off-gas treatment;
- Installation and maintenance of a fence around disposal areas A, B, and C during remedial activities; and
- Deed and access restrictions to prevent installation of drinking water wells within vicinity of the disposal areas and to protect the cap.

The following component of the selected remedy will be evaluated during the implementation of in-Situ Vapor Extraction:

- Determination of the optimum amount of essential nutrients (e.g., moisture, nitrogen, oxygen, and phosphate) to be added to the waste refuse and sub-surface soils in order to promote natural microbial activities, without decreasing the mass removal of the volatile organic compounds through in-Situ Vapor Extraction.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State environmental requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective. This remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable and satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element.

Because this remedy will result in hazardous substances remaining on-site, a review will be conducted within five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

Valdas V. Adamkus
Regional Administrator

September 17, 1990
Date

RECORD OF DECISION

DECISION SUMMARY

HAGEN FARM SITE

SOURCE CONTROL OPERABLE UNIT

DANE COUNTY, WISCONSIN

Prepared By:

U.S. Environmental Protection Agency

Region V

Chicago, Illinois

September, 1990

SUMMARY OF REMEDIAL ALTERNATIVE SELECTION
HAGEN FARM SITE, SOURCE CONTROL OPERABLE UNIT
DANE COUNTY, WISCONSIN

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ROD SUMMARY
HAGEN FARM SUPERFUND SITE, SOURCE CONTROL OPERABLE UNIT
DANE COUNTY, WISCONSIN

SITE LOCATION AND DESCRIPTION

The Hagen Farm Site (the "Site") is located at 2318 County Highway A, approximately one mile east of the City of Stoughton, Dane County, Wisconsin. The 10-acre Site is situated in a rural surrounding that is dominated largely by sand and gravel mining and agriculture. Soil and gravel mining operations are located northwest, northeast and south of the Site. The Stoughton Airfield is located adjacent to the northwest corner of the Site. County Highway "A" passes just south of the Site (See Figure 1).

The City of Stoughton's municipal wells are located approximately two miles to the west, and eight private wells are located within 1,200 feet of the Site. The private wells located at the Site are no longer in use. Approximately 350 people reside within one mile of the Site.

The Site is located in the Yahara River watershed, in an area of flat to gently rolling topography. The Yahara River is located approximately 1.5 miles to the West and flows in a southerly direction. The land surface generally slopes toward the Yahara River from topographically high areas located to the northeast and east. Surface water drainage in the area is generally poorly developed, apparently due to permeable surface soils. The only substantial surface water bodies in the area are a pond locate approximately 1/2 mile south of the Site and the Yahara River. There is no designated Wisconsin State significant habitat, or historic landmark site directly or potentially affected. There are no endangered species within close proximity of the Site.

The Site is located in an area dominated by glacial outwash deposits, which extend approximately one-half mile to the northeast. These deposits are dominated by sand and gravel. Beyond this, ground moraine and occasional drumlins are encountered. Lacustrine deposits associated with Glacial Lake Yahara are located approximately one-eighth mile south. Bedrock, primarily sandstones and dolomites, underlie the glacial deposits in this area. Bedrock generally slopes from the west to southwest, toward a preglacial valley associated with the Yahara River. The depth to bedrock ranges from 50 to 80 feet near the Site.

The current Site topography is the result of sand and gravel mining and waste disposal activities. Prior to these activities, the ground surface probably sloped from the existing topographically high area located west and northwest toward the southeast and east. The excavated area in the northwest corner of the property is flat. This flat area is separated by a ridge from the water-filled depression located to the northeast.

Within the Site's larger "Area of Contamination (AOC)", waste disposal took place within three subareas. These subareas are A (6 acres, located in the

southern portion of the Site), B and C (1.5 acres each, located in the northeastern portion) (See Figure 2). All three Areas reside within the Site's formally defined AOC. The Site has been covered with soil and is partially vegetated with grasses and tall trees.

SITE HISTORY AND ENFORCEMENT ACTIVITIES

The Site was operated as a sand and gravel pit prior to the late 1950's. Observations suggest gravel operations encompassed an area bounded by the current access road to the east, the former Schroeter property boundary to the west and the current property boundary to the north (See Figure 2). Mining operations reportedly terminated approximately 14 to 18 feet below ground surface. Excavation may have ceased at this depth due to the presence of groundwater, more fine grained materials, or a change in sand and gravel quality.

The gravel pit was then used for disposal of waste materials from the late 1950s to the mid-1960s. During the period that the Site was operated as a disposal facility, the property was owned by Nora Sundby. The Site was operated by City Disposal Corporation. City Disposal Corporation was subsequently purchased by Waste Management of Wisconsin, Incorporated ("WMWI"). City Disposal was also the transporter of much of the waste that was deposited at the Site. The Site is currently owned by WMWI. It is known that Uniroyal, Incorporated ("Uniroyal") generated industrial waste, some of which was deposited at the Site beginning sometime in 1962 and continuing through August 1966.

Waste solvents and other various organic materials, in addition to the municipal wastes, were disposed of at the Site, including acetone, butyl acetate, 1-2-dichloroethylene, tetrahydrofuran, solid vinyl, sludge material containing methylethyl ketone and xylenes, and toluene. In a 103(c) Notification submitted to the United States Environmental Protection Agency ("U.S. EPA") by Uniroyal, in June 1981, Uniroyal indicated that F003 and F005 wastes, which are hazardous wastes within the meaning of the Resource Conservation and Recovery Act ("RCRA"), 42 U.S.C. 6901, also were disposed of at the Site. This site stopped accepting waste in 1966, prior to regulation of hazardous waste disposal by RCRA Subtitle C.

Beginning in November 1980, in response to complaints received from local residents, the Wisconsin Department of Natural Resources ("WDNR") began conducting groundwater sampling at nearby private water supply wells. Sampling of the on-Site monitoring wells during the period 1980-1986 indicated certain organic compounds were present in the groundwater, including benzene, ethylbenzene, tetrahydrofuran, xylenes, and toluene.

In addition, nearby private water supplies on adjacent properties have also shown detectable levels of volatile organic compounds (VOCs). The private wells located on the Site had been impacted by acetone, tetrahydrofuran, vinyl chloride, xylene, trans 1,2-dichloroethene, and trichloroethylene.

In 1983, the State of Wisconsin brought an enforcement action for abatement of a public nuisance against WMWI and Uniroyal. At the same time, nearby

residents at the Site brought a civil action against WMWI and Uniroyal, seeking civil damages for reduced property values and potential health hazards resulting from groundwater and well contamination. The State of Wisconsin obtained a dismissal of its 1983 enforcement action against WMWI and Uniroyal after the Site was listed on the National Priorities List ("NPL"). In 1986, the parties to civil litigation brought by the nearby residents to the Site against WMWI and Uniroyal reached a settlement. The exact terms of the settlement were confidential. It is known, however, that one of the terms of the settlement required WMWI to purchase the Site property from Orrin Hagen, as well as other property located adjacent to the Site. Upon acquiring these properties, WMWI razed the structures constructed thereon.

The Site was proposed for inclusion on the NPL on September 18, 1985. The Site was placed on the NPL in July of 1987. Subsequently, WMWI and Uniroyal, the two potentially responsible parties ("PRPs") named by U.S. EPA in connection with the Site to date, entered into an Administrative Order by Consent (U.S. EPA Docket No. VW 87-C-016, dated September 14, 1987) (the "Consent Order") with the U.S. EPA and the WDNR. In the Consent Order, WMWI and Uniroyal agreed to conduct a Remedial Investigation and Feasibility Study ("RI/FS") at the Site. Accordingly, in July of 1988, upon U.S. EPA approval, in consultation with the WDNR, of the required Work Plans, fieldwork at the Site commenced.

Two operable units, which are being conducted concurrently, have been defined for the Site. Operable Unit ("OU") I, which is the Source Control Operable Unit ("SCOU"), is intended to address waste refuse and sub-surface soils ("Waste/sub-Soils") at disposal area A and the two smaller disposal areas B and C. OU II, which is the Groundwater Control Operable Unit ("GCOU"), is intended to address the contaminated groundwater at the Site. The OU approach was agreed upon after discussions among U.S. EPA, WDNR, and PRPs during the early phase of the implementation of the Work Plan for the RI.

The RI for the SCOU was completed in early 1989, and the Technical Memorandum for the SCOU was submitted in March 1989. The RI for the GCOU was initiated in July 1989 and the Technical Memorandum for GCOU was submitted in February 1990. Currently, additional field activities to define the extent of plume migration are ongoing. The RI report for the GCOU, including the Endangerment Assessment, is scheduled for completion in July 1991. The ROD for the GCOU is scheduled for early 1992.

COMMUNITY RELATIONS ACTIVITIES

A Community Relations Plan for the Site was finalized in July 1988. This document lists contacts and interested parties throughout the local and government community. It also establishes communication pathways to ensure timely dissemination of pertinent information. The RI/FS and the Proposed Plan for the SCOU were released to the public in July 1990. All of these documents were made available in the information repositories maintained at the Stoughton Public Library and Klongland Realty. An administrative record file containing these documents and other site-related documents was

placed at the Stoughton Public Library. The notice of availability of these documents was published in the Stoughton Courier-Hub and Madison Capital Times on July 5, 1990. Press releases were also sent to all local media. A public comment period was held from July 11, 1990 to August 10, 1990. In addition, a public meeting was held on August 2, 1990 to present the results of the RI/FS and the preferred alternative as presented in the Proposed Plan for the Site. All comments which were received by U.S. EPA during the public comment period, including those expressed verbally at the public meeting, are addressed in the Responsiveness Summary which is the third section of this ROD.

A public meeting was held on July 27, 1989 to explain the findings of the RI and the operable unit approach. A fact sheet was developed in conjunction with this meeting. Advertisements were placed to announce the meeting and a press release was sent to all local media. Prior to the public meeting, U.S. EPA representatives held a separate briefing for Town officials.

A press release was sent to local media on March 27, 1989 to update the community on the progress of Dane County, Wisconsin Superfund sites, including Hagen Farm.

An RI "Kickoff" meeting was held on July 14, 1988 to explain the RI process. A fact sheet was developed in conjunction with this meeting. Advertisements were placed in the Madison Capital Times and Stoughton Courier-Hub and a press release was sent to all local media.

Upon the signing of the Consent Order in July 1987, U.S. EPA held a 30-day public comment period. A press release was sent to all local media and advertisements were placed.

IV SCOPE AND ROLE OF RESPONSE ACTION

This response action is a final source control operable unit and is consistent to the maximum extent practicable with Section 300.430 (e)(3) of the National Contingency Plan ("NCP"). This final source control operable unit is being implemented to protect human health and the environment by controlling the migration and reducing the volume of contaminants from the Waste/sub-Soils to the groundwater. This ROD addresses the source of groundwater contamination, namely the waste mass in the AOC consisting of subareas A, B, and C and the underlying contaminated sub-soils.

This source control action, by reducing the toxicity and controlling the migration of contaminants, is fully consistent with all future site work, including the ongoing groundwater investigation at the Site. In addition, this action will positively affect the cost of the final groundwater remedy by limiting the amount of groundwater that is likely to become contaminated from this source.

The media that poses the greatest risk is considered to be the groundwater contaminant plume. The contaminated Waste/sub-Soils are considered to be a long-term threat to human health and environment, primarily as a principal

source of groundwater contamination. The VOCs in the Waste/sub-Soils are considered to be the principal threat for this SCOU.

The groundwater contamination problem will be addressed in a future GCOU, Record of Decision which is expected to be the final action for the Site.

The FS identified two remedial objectives for the SCOU based on the data obtained during the RI and the possible exposure routes identified. The objectives identified in the FS are:

1) To reduce or minimize direct contact with contaminated waste and soils; and,

2) To reduce or minimize release of contaminants to the groundwater.

V SUMMARY OF SITE CHARACTERISTICS

In March, 1989, a Technical Memorandum for the SCOU was completed under the guidance and oversight of U.S. EPA and WDNR. The Remedial Investigation (i.e., Technical Memorandum #1) for the SCOU was to determine the nature and extent of contamination at the source, and evaluate possible exposure pathways. The report summarized all soil-gas, test-pit, soil, air, and on-site groundwater analytical data that had been collected. This report should be consulted for a more through description of the site characteristics.

The following are the results of RI at the Site:

- Based on the geophysical survey, soil-gas, and test-pit survey, it appears that most of the waste disposal activity occurred in disposal area A. Disposal area A encompasses approximately six acres (100 feet long and 400 feet wide). The wastes within disposal area A are buried to a depth of two to three feet near the eastern edge, to a depth of 16 feet near the center. Eight feet is the average overall thickness of buried wastes. The volume of waste for disposal area A is estimated at 67,650 cubic yards. The test-pit survey and refuse borings indicate that the type of waste present in disposal area A includes plastic sheeting, paper-coated plastic, paint sludge, grease, rubber, and municipal waste, such as wood, glass, paper, and scrap metal. No drums were discovered during the test-pit excavation activity.

  Based upon refuse borings, test-pits, and groundwater table measurements, the bottom of the waste refuse material is estimated to be 10 to 15 feet above the seasonal high water table in disposal area A. The volume of unsaturated sub-waste soils for disposal area A is approximately 112,000 cubic yards.

  Disposal areas B and C seem to contain only scattered domestic wastes. A geophysical survey, test-pits and soil gas tests revealed a small quantity of municipal waste in disposal areas B and C. It appears that disposal areas B and C were not used for the disposal of industrial

wastes.

Surficial soils are thin or absent over most of the waste refuse areas. The waste is unsaturated. Contaminant movement through the waste occurs as surface water percolates into the waste mass and dissolved contaminants infiltrate through underlying unsaturated soils to the water table. Soil erosion could contribute to some movement of contaminants, but is not considered a primary pathway because the Site has a relatively flat, vegetated topography.

- During the soil-gas survey, VOCs detected include acetone, benzene, toluene, 2-hexanone, ethylbenzene, and xylenes. The distribution of VOCs in disposal area A appears to be fairly scattered, however, no detects occurred in the northwest section of disposal area A.

- To determine if the waste was "characteristic" according to RCRA Subtitle C, an Extraction Procedure ("EP") toxicity and Flammability test was conducted on a composite sample of refuse boring and soil boring spoils. Results of the EP toxicity characteristic test indicate that the waste refuse does not exhibit EP toxicity as defined by Wisconsin Administrative Code ("WAC") NR 181.

- Compounds detected in the source characterization wells (groundwater beneath disposal area A) include tetrahydrofuran, xylenes, ethylbenzene, toluene, and 2-butanone. The highest concentrations of these compounds, such as tetrahydrofuran (630 parts per million (ppm)), xylenes (35 ppm), and 2-butanone (4400 ppm) were observed in well SCW4, near the southern end of disposal area A. Semi-VOCs, such as benzoic acid (29 ppm), 4-methylphenol (6 ppm), and phenol (6 ppm) were also detected in the groundwater at the Site. Table 1 summarizes the VOC and semi-VOC groundwater concentration data.

- The results of the air analysis indicated low concentrations of a number of VOCs, generally below 10 parts per billion (ppb), in each of the samples collected. Two compounds, methylene chloride and trichlorofluoromethane, were detected at higher concentrations in the samples (approximately 100 ppb). However, these compounds were also identified in associated trip blanks. Air VOC concentrations measured from downwind location were not substantially different from those measured at the other locations. These data do not identify an atmospheric gradient of VOCs across the waste area, because the type and magnitude of VOCs identified from upwind samples were similar to downwind samples.

- The screened data for the waste refuse indicate that waste refuse material at the Site contains semi-VOCs, such as butylbenzylphthalate (18 ppm), and bis(2-ethylhexyl)phthalate (120 ppm). Low levels of poly chlorinated biphenyls ("PCBs"), in the range of 300 ppb were also detected in the waste refuse (See Table 2).

- Surface water does not appear to be a direct pathway for contaminant migration, due to a lack of an established surface water drainage

system. Furthermore, based on surface water quality results and inferred groundwater flow paths, it appears the drainage ditch east of the Site and Sunky's pond to the south are not groundwater discharge points.

The results of the RI at the Site indicate that the waste refuse materials in disposal area A have been and continue to be a source for sub-surface soil and groundwater contamination.

The investigation for the groundwater contamination at the Site is expected to be completed by the end of 1990. Initial results of the investigation indicate that the groundwater flows to the south and that the contaminant plume extends south of the pond located one-half mile from the Site. The exact boundary of the southern edge of the plume has not yet been determined. Seven residential wells located downgradient of the Site were sampled on August 1990 for any potential impact from the contaminant plume. More details of the nature and extent of the groundwater contaminant plume will be addressed in the subsequent GOOU.

VI SUMMARY OF SITE RISKS

This section qualitatively describes the risks posed by contaminants in Waste/sub-Soils to human health and the environment. Based on the historical findings and on-site groundwater data, which exceeded the drinking water and groundwater quality standards of the U.S. EPA and the WDNR, respectively, it is determined that remedial action is needed to address the source of the groundwater contamination. Because this remedy is a source control operable unit, a final baseline risk assessment for the Site is not available. No quantitative risk numbers have been calculated for exposure to site contaminants. However, qualitative risk information is organized and outlined below to demonstrate that action is necessary to stabilize the site and prevent the degradation of the groundwater. The baseline risk assessment for the Site will be conducted later during the GOOU phase.

The greatest risk present at the Site is from the groundwater contamination. However, the source of the groundwater contamination is the contamination found in the Waste/sub-Soils at the Site.

The following is a qualitative discussion of the site risks.

(A) Contaminants of Concern

The following chemicals have been detected in soil gas, leachate and on-site groundwater wells at concentrations above background, and screened waste refuse analyses and can be inferred to be present in source wastes.

VOCs	Semi-VOCs	
. Ethylbenzene	. Benzyl alcohol	. bis (2-chloroisppropyl)ether
. Toluene	. Phenol	. bis (2-ethylhexyl)phthalate

- Xylenes
- Tetrahydrofuran
- 2-Butanone
- Vinyl chloride
- Acetone
- Benzene
- 4-Methylphenol
- 2,4-Dimethylphenol
- Benzoic Acid
- Naphthalene
- Dieldrin
- PCBs
- 4-chloro-3-methylphenol
- diethylphthalate
- di-n-octyl phthalate
- 1,4-dichlorobenzene
- 4,4-DDE

In addition, inorganic compounds such as lead and barium were also detected at the Site at concentrations above background.

Table 3 compares the concentrations of these contaminants detected in groundwater at the Site with Federal and State Standards. As indicated in this table, the levels of contaminants found at the source characterization wells far exceed Federal and State standards. For the case of Tetrahydrofuran, the most frequently detected compound at the Site, the level (630,000 ppb) is 12,600 times higher than the State groundwater enforcement standard (50 ppb). This data clearly indicates that the Waste/sub-Soils are acting as a source of groundwater contamination. This source will continue to load contaminants to the groundwater unless addressed by a remedial action.

(B) Exposure Assessment

The exposure assessment identifies potential pathways and routes for contaminants of concern to reach the receptors. The potential exposure pathways are: exposure to air emissions from the landfill, direct contact exposure to contaminated waste and soils, and exposure to contaminated groundwater.

At present, the wastes do not appear to be a source of exposure via inhalation of volatilized chemicals. A preliminary evaluation of ambient air quality at the Site boundary did not identify an elevated level of VOC emissions. In addition, active generation of landfill gas, which can facilitate VOC emissions, is not occurring at the Site. Based on these preliminary air quality data, it appears that the air contaminants released from the Site to the downwind residents do not pose a risk to human health or the environment.

Wastes at the Site are covered with approximately 1 to 3 ft of soil, much of which supports thick vegetation. However, some areas of the Site are not vegetated and show exposed waste material. Therefore, a potential exists for direct human contact with waste. The most likely population group which may come in contact with the Site is anticipated to be periodic trespassers. This population group is small, because the Site is secured from incidental trespass by a fence and because the location is in a rural area which is not heavily populated. These individuals may incur contaminant exposure by skin contact with waste and by incidental ingestion of waste material adhering to hands.

Contaminants contained in the waste have affected groundwater in the vicinity of the Site. Data obtained from on-Site groundwater indicates that substantial amounts of contaminants have been released from the

Waste/sub-Soils to the groundwater. Present risks from the groundwater are unacceptable. As shown in Table 3, the contaminants in the on-Site groundwater exceed Federal and State Standards. Continued leaching of contaminants from the Waste/sub-Soils to the groundwater will result in continued unacceptable risks. Should the contaminants migrate to existing private wells, or in the unlikely event of future site development involving the installation of a water supply well, contaminant exposure via groundwater use and consumption may occur. More detailed evaluation of both current and future potential human health and environment risks associated with contaminated groundwater exposure will be addressed in subsequent steps of GCOU.

Implementation of the selected remedy as presented by this SCOU will reduce exposure to contaminated soils, control air emissions, and minimize or reduce contaminant migration to the groundwater.

(C) Environmental Assessment

The natural habitat existing prior to sand and gravel mining operations at the Site was destroyed. At present, the waste disposal area is covered with a layer of soil material which supports vegetation primarily consisting of grasses and other herbaceous plants, with some tall trees. This area is likely frequented by wildlife including birds, small mammals and deer. Although an inventory of plant and animal species has not been performed, the Site is not known to be inhabited by rare or endangered species. Land in the vicinity has been developed for agricultural, mining and commercial purposes. Sensitive ecological habitats (e.g., wetlands) are not in close proximity to the Site. The Site is not in a floodplain. The potential adverse impacts of Site wastes on the surrounding ecology are not considered appreciable in comparison to the loss of habitat which historically occurred during the active sand and gravel mining phase of the Site.

VII DOCUMENTATION OF SIGNIFICANT CHANGES

No significant changes have been made since the publication of the FS and Proposed Plan in July 1990.

VIII DESCRIPTION OF ALTERNATIVES

Alternatives for the remediation of contaminated Waste/sub-Soils, were developed to achieve the following goals:

- minimize the potential for direct contact with the contamination;
- minimize the potential for migration of waste/sub-Soils contaminants into the groundwater.

A comprehensive list of appropriate remedial technologies was identified for Source Control. These technologies were screened based on their cost,

implementability and effectiveness, characteristics of the Site and the characteristics of the contaminants. Technologies which satisfied the initial screening requirements were refined to form remedial action alternatives. The five alternatives developed are detailed below.

The source control alternatives are:

- Alternative 1: No Action;
- Alternative 2: Capping;
- Alternative 3: In-Situ Vapor Extraction and Capping;
- Alternative 4: Waste Consolidation with Biological Treatment, Vapor Extraction and Capping; and,
- Alternative 5: Waste Excavation with on-Site Incineration, Vapor Extraction and Capping.

A description of each of these options follows:

ALTERNATIVE 1: NO ACTION

This alternative is evaluated as required by the NCP to determine the public health, public welfare and environmental consequences of taking no further action.

ALTERNATIVE 2: CAPPING

Non-native materials (i.e., solid waste materials) as determined based on visual inspection, located within disposal areas B and C would be consolidated into disposal area A before cap construction begins, although additional fill material may be required to satisfy minimum slope requirements. Grading would be accomplished using conventional construction equipment. The final grade would be constructed so that precipitation would be directed away from the source waste. Drainage swales would be constructed to direct runoff to match existing surface flow patterns. After the desired slope is obtained, the necessary cap materials would be placed.

In the FS, three types of caps were considered: capping to upgrade the existing cover to meet the requirements for facilities without an operating license (i.e., an NR 181.44(12) cap); upgrading the existing cover to meet the requirements of a solid waste cap (i.e., an NR 504.07 or Subtitle D cap); and upgrading the existing cover to meet the closure requirements for facilities with an operating license (i.e., an NR 181.44(13) or Subtitle C cap). Figures 4 through 6 describe typical details of these caps.

Closure of the Site with a RCRA Subtitle C cap is a potentially relevant and appropriate requirement, because RCRA wastes (i.e., F003 and F005 listed waste) were disposed of at the Site. Because this alternative does

not involve any treatment to reduce the mobility, toxicity, or volume of waste, it was determined that the more impermeable capping option afforded by Subtitle C and NR 181 was both relevant and appropriate under this alternative. Therefore, only the Subtitle C cap will be evaluated for this alternative during the comparative analyses. No treatment of contaminants is involved in this alternative.

The cap would be designed to cover disposal area A. The area to be capped is approximately 240,000 sq ft (5.5 acres). The capital costs of this alternative is approximately $2,751,000, and annual Operation and Maintenance (O&M) cost is $8,899. The 30-year Present Worth (PW) cost is $2,888,000. The amount of time necessary to implement this alternative would be 7 months.

ALTERNATIVE 3: IN-SITU VAPOR EXTRACTION AND CAPPING

In this alternative, the Waste/sub-Soils in disposal area A would be treated using In-Situ Vapor Extraction (ISVE). Gas is extracted from the Waste/sub-Soils through extraction wells placed strategically at the Site. The gas travels from the wells through header pipes using a blower. The off-gases would be treated and discharged to the atmosphere.

Vapor extraction is used primarily for treating VOC contamination. A vapor extraction system is relatively inexpensive and allows for process flexibility during remediation activities. The major costs for this technology are the installation of extraction and injection wells. The number of wells used may vary during operation to improve system efficiency. By treating the Waste/sub-Soils in place without excavation, release of untreated contaminants to the atmosphere is avoided.

Prior to the implementation of in-Situ Vapor Extraction, non-native materials from disposal areas B and C will be consolidated to disposal area A. Approximately 37,000 cubic yards of fill is needed to bring area A up to required slopes before cap placement. Consolidation of solid waste materials from areas B and C will provide some of the required fill material and will ensure that all site waste materials are properly confined. Then a low permeability cap, which meets the requirements of NR 504.07, WAC, will be installed over disposal area A (see Figure 5). The NR 504.07 cap would reduce leachate production by reducing infiltration and would control moisture content in the Waste/sub-Soils to improve the Vapor Extraction system performance.

As stated for Alternative 2, a RCRA Subtitle C cap would be potentially relevant and appropriate. The U.S. EPA and WDNR have determined that for this particular Alternative, the Subtitle C cap, while relevant, is not appropriate because construction of the ISVE system would impair the integrity of a Subtitle C cap. An NR 504.07 cap will provide an adequate level of protection when combined with treatment and can easily be repaired after installation of the ISVE system.

For the discharge of off-gas emitted from the Vapor Extraction procedure,

Chapter NR 445, WAC, Control of Hazardous Pollutants, is an ARAR. The off-gases would be treated using a carbon adsorption system in order to meet NR 445, WAC. Spent carbon or other residues from the off-gases treatment process will be sent back to the manufacture to be regenerated.

During full-scale ISVE implementation, a treatability study will be performed to determine the feasibility of enhancing the natural biodegradation of organic compounds. The treatability study would be designed to determine the optimum amounts of nutrients (e.g., moisture, oxygen, nitrogen, and phosphate) to be added to the Waste/Sub-soils to promote biological activity without interfering with ISVE treatment.

The volume of waste to be treated is approximately 67,650 cubic yards, and the volume of sub-surface soils to be treated is approximately 112,000 cubic yards. The cap would be designed to cover disposal area A within the larger AOC. The area to be capped is approximately 240,000 sq ft (5.5 acres). The capital costs of this alternative is approximately $2,679,400, based upon a vapor extraction system of 25 Injection/Extraction wells. The average annual O&M cost is $29,530, and the 30-year PW cost is approximately $3,299,000. The amount of time necessary to implement this alternative, including ISVE, would be 5 years.

ALTERNATIVE 4: WASTE CONSOLIDATION WITH BIOLOGICAL TREATMENT, VAPOR EXTRACTION AND CAPPING

This alternative involves consolidating waste from disposal areas A, B and C into an upgraded facility within the AOC. The upgraded facility would be used as a treatment/disposal cell. Waste would be consolidated using conventional excavation equipment. Dewatering should not be necessary, because the water table is below the predicted depth of refuse. Once the treatment/disposal area has been upgraded, a high permeability soil cover will be placed over the waste to allow infiltration of precipitation, and to minimize direct contact risks during the implementation of this alternative. Leachate produced in the cell would be recirculated back through the waste to promote biological activity within the cell. Nutrients and microorganisms may be added to leachate to enhance biodegradation. The excess leachate produced during and at the end of the implementation will be treated and discharged to a surface water. The RCRA Subtitle C cap would be installed over the treatment cell after treatment is completed.

Under this alternative, a large depression would be created by waste excavation from disposal area A exposing contaminated subsurface soils. This depression would be filled with imported clean fill materials followed by a NR 504.07 solid waste cap. The remaining contaminated subsurface soils would be treated with in-Situ Vapor Extraction.

For the construction of the retrofitted unit within the AOC, the State and Federal hazardous waste landfill requirements, NR 181, WAC, and 40 CFR 264.301 were determined to be both relevant and appropriate. This determination was made because an entirely new treatment/disposal cell

would be constructed within a minimally contaminated area of the AOC. The double lined treatment/disposal cell would provide maximum protection for treatment of the contaminants. After completion of treatment, a RCRA Subtitle C (NR 181, WAC) cap would be placed over the treatment/disposal unit. The Subtitle C cap would be relevant and appropriate because the integrity of the cap could be maintained and it would provide maximum protection to the treatment/disposal unit. The LDR requirements are not ARARs for this alternative, because no "placement" of waste occurs. Upgrading an existing landfill facility to consolidate wastes within the AOC does not constitute placement, according to the NCP.

For the discharge of excess leachate produced from this alternative, the NR 105, WAC, Surface Water Quality for Toxic Substances, is an ARAR. The excess leachate would be treated in order to meet NR 105 standards. A toxicity characteristics leaching procedure ("TCLP") test will be conducted for the treatment sludge to determine whether further treatment is necessary for disposal in a RCRA compliant landfill in order to comply with Land Disposal Restrictions ("LDRs").

The volume of waste to be consolidated and treated is approximately 67,650 cubic yards from disposal area A and non-native materials from disposal areas B and C. The capital costs of this alternative is approximately $12,894,000. The average annual O&M cost is $82,300, and the 30-year PW cost is approximately $14,129,000. The amount of time necessary to implement this alternative would be 10 years.

ALTERNATIVE 5: WASTE EXCAVATION WITH ON-SITE INCINERATION, VAPOR EXTRACTION AND CAPPING

This alternative incorporates waste excavation with on-site incineration and disposal. The excavation activities are the same as described in Alternative 4. On-Site materials handling, staging, and storage may also be required. Waste would be characterized prior to incineration. Treatment residuals, such as ash and scrubber water, would be further treated, if necessary, and disposed of off-Site in accordance with the LDRs.

Under this alternative, a large depression would be created by waste excavation exposing contaminated sub-surface soils in disposal area A. This depression would be filled with imported clean fill materials and the non-native materials from disposal areas B and C, followed by a Solid Waste cap. The contaminated sub-surface soils would be treated with ISVE.

For this alternative, incineration would be done in an incinerator which meets the design requirements of 40 CFR Part 264 Subpart O. A TCLP test will be conducted for the treatment residuals, such as ash and scrubber water, to determine whether further treatment is necessary for disposal in a RCRA compliant landfill in order to comply with LDRs requirement.

The volume of waste to be incinerated is approximately 67,650 cubic yards from disposal area A. The capital costs of this alternative is

approximately $59,410,000. The average annual O&M cost is $22,800, and the 30-year PW cost is approximately $59,858,000. The amount of time necessary to implement this alternative would be 5 years.

IX. SUMMARY OF THE COMPARATIVE ANALYSIS OF ALTERNATIVES

A detailed analysis was performed on the five alternatives using the nine evaluation criteria in order to select a source control remedy. The following is a summary of the comparison of each alternative's strength and weakness with respect to the nine evaluation criteria. These nine criteria are:

1) Overall Protection of Human Health and the Environment
2) Compliance with Applicable or Relevant and Appropriate Requirements (ARAR's)
3) Long-Term Effectiveness and Permanence
4) Reduction of Toxicity, Mobility, or Volume through Treatment
5) Short-Term Effectiveness
6) Implementability
7) Cost
8) State Acceptance
9) Community Acceptance

1. Overall Protection of Human Health and the Environment

Alternative 1, No Action, will not provide protection from risks associated with site contaminants. Groundwater will continue to degrade due to release from the source. Therefore, it will not be discussed any further, since it is not protective and thus, not an acceptable alternative.

Alternatives 2 through 5 will reduce contaminant migration from the waste and minimize any future direct contact threats. Alternative 3 through 5 also provide treatment, thus reducing the amount of contaminants available to move into the groundwater. Continued groundwater impacts from Site contaminants will be reduced by varying degrees by Alternatives 2 through 5. Alternative 3, In-Situ Vapor Extraction, would provide protection from exposure to the waste during implementation because treatment would be in-situ and excavating the waste is minimized. Direct contact exposure to contaminated waste and soils may occur in Alternative 4 and 5 during excavation of disposal area A.

It is not the intent of the proposed alternatives to provide protection from risks which may be associated with contaminants currently existing in the groundwater. Existing groundwater contamination will be addressed in the GOOU.

2. Compliance with ARARs

The alternatives would comply with all applicable or relevant and appropriate federal and state environmental laws. No waiver would be

necessary to implement these alternatives.

For Alternative 2, a RCRA Subtitle C multi-layer cap would be installed in order to comply with RCRA cap design standards.

Alternatives 3 and 5 would meet the State landfill closure requirements (i.e., NR 504.07, WAC). Alternative 4 would meet State (NR 181, WAC) and Federal (40 CFR 264.301) hazardous waste landfill requirements. Alternative 4 also would meet the Federal RCRA Subtitle C cap requirement.

NR 445, Control of Hazardous Pollutants, is an ARAR for Alternatives 3, 4 and 5. The extracted off-gases should be treated in order to meet NR 445 emission limit requirements.

Toxic Substances Control Act ("TSCA") is not an ARAR for this site because PCBs detected at the Site, at a maximum level of 300 ppb, is less than 5 ppm.

The full listing of ARARs for the Site is contained in the FS.

3. Long-Term Effectiveness and Permanence

Residual risks associated with direct contact with wastes will be reduced by each alternative through capping, which will minimize direct exposure to wastes. Alternatives 3, 4 and 5 will reduce these risks further by removing and treating, biodegrading or incinerating contaminants. Risks associated with direct contact with waste materials in the future will be minimized through implementation of institutional controls.

Residual risks associated with migration of contaminants from the source to groundwater were considered greatest for Alternative 2, because the wastes are only contained and not treated or destroyed. Alternatives 3 through 5 provide the lowest residual risks to groundwater since the source of groundwater contamination is being treated.

Effectiveness is exclusively dependent on maintaining the integrity of the cap over the long term for Alternative 2. Alternative 2 will not remove contaminants within the waste which could ultimately migrate to the groundwater. Therefore, maintenance of the cap is key to the long-term effectiveness and permanence of this alternative.

Alternative 2 through 4 will be effective in achieving remedial objectives through installation of multi-layer cap, which will limit the infiltration of precipitation through the landfill and preclude the leaching of contaminants into the groundwater.

Alternative 3 will be effective in removing VOCs in the Waste/sub-Soils through vapor extraction. In addition, the installation of the solid waste cap will minimize the leaching of contaminants into the groundwater.

Alternative 4 is anticipated to be effective in achieving remedial objectives through biological degradation. Tests at other sites have

demonstrated that bioremediation is a promising technology. However, its application to this site would have to be verified. Alternative 5 is anticipated to be effective in removing contaminants in the landfill through contaminant destruction (incineration) permanently. Each of Alternatives 2 through 5 are anticipated to require system monitoring and maintenance of the integrity of the landfill cover materials.

4. Reduction of toxicity, mobility or volume (TMV) through Treatment

Alternative 2 does not provide treatment of contaminants to reduce the mobility, toxicity or volume of either the waste or the sub-waste soils.

Alternative 3 through 5 will reduce toxicity, mobility, or volume of the contaminants through treatment of Waste/sub-Soils. Alternative 3, in addition to the multi-layer cap, is estimated to remove as much as 90 percent of the VOCs from the Waste/sub-Soils through the implementation of ISVE, but will not address chemicals with low volatility (e.g., phenols and barium). Because semi-volatiles are not treated by ISVE, treatability tests for degradation of semi-volatiles by microbial methods will be explored during full-scale ISVE implementation. For alternatives 3, 4 and 5, the extracted VOCs in the air stream will eventually be destroyed through the regeneration of the carbon.

Alternative 4 uses leachate recirculation in the waste to promote biological degradation of the contamination. Leachate recirculation could potentially reduce 100 percent of the VOCs contamination, if the process is given enough time. During treatment, the waste will be within a RCRA-type cell where migration of contaminants into the groundwater will be minimized to the extent possible.

Alternative 5 will destroy the VOCs and semi-VOCs present in the Waste permanently through incinerating the waste mass.

5. Short-term Effectiveness

Alternative 2 and 3 can be implemented shortly after design approval because there are no substantive permit requirements. Alternatives 4 and 5 will require the longest time to implement due to the need to meet substantive permit requirements to site new disposal and treatment facilities. At least one, and as many as two to three years, may be required to comply with air and water quality discharge requirements, and perform the necessary treatability studies and test burns. These steps would likely require several years to complete before a full scale system would be operational.

A low risk would be posed to remediation workers and the community during the implementation of Alternative 5 related to potential exposure to incinerator off-gases. This risk is anticipated to be low because monitoring of air contaminants at the Site boundary will be conducted to ensure that acceptable levels are maintained. Alternatives which require excavation of site wastes (Alternatives 4 and 5) may pose a potential risk to remediation workers via direct exposure to wastes, dusts and VOCs.

Alternative 5, Waste Excavation with on-site Incineration, may pose added risks to the community and workers due to increased air emissions. However, the levels of potential contaminant exposure to remediation workers could be minimized by the use of personal protective equipment and standard dust control measures in each alternative. Alternatives 2 and 3 are anticipated to pose minimal risks to remediation workers and the community because they do not involve excavating the waste. Additional risks to the surrounding ecology were not considered appreciable for any of the alternatives.

6. Implementability

Alternatives 2 is the easiest to technically implement compared to the other three alternatives. Alternative 3 is somewhat easier to implement than Alternative 4 and 5 because it involves less construction at the Site. The most difficult alternative to implement would be Alternative 5. Difficulties associated with this alternative include accessing a supplementary fuel source on-site, disposing of the ash, supplying sufficient water needed for the scrubbers, and treating and disposing the contaminated scrubber water. Alternatives 3 and 4 would both be relatively straightforward to implement technically. Administratively, alternatives 2 and 3 are easier than alternatives 4 and 5 because they involve less coordination with relevant agencies.

Alternatives 2 through 4 require services and materials that should be available. It is assumed that appropriate material to perform cap construction could be obtained from a borrow source located within four miles of the Site. For Alternative 5, materials and services are available, but their availability is more restricted than the other alternatives.

7. Cost

Alternative 2 involves a capital costs of $2,751,000, annual Operation and Maintenance (O&M) costs of $8,899 and a 30-year Present Worth (PW) cost of $2,888,000.

Alternative 3 involves a capital costs of $2,679,400, average annual O&M cost of $29,530, and a 30-year PW cost of $3,299,000.

Alternative 4 involves a capital costs of $12,894,000, average annual O&M cost of $82,300, and a 30-year PW cost of $14,129,000.

Alternative 5 involves a capital costs of $59,410,000, average annual O&M cost of $22,800, and a 30-year PW cost of $59,858,000.

8. State Acceptance

The State of Wisconsin is in agreement with the U.S. EPA's analyses and recommendations presented in the RI/FS and the proposed plan. The State concurs with the selected alternative (presented in Section X, below).

9. Community Acceptance

The specific comments received and U.S. EPA's responses are outlined in the Attached Responsiveness Summary.

X. THE SELECTED REMEDY

As provided in CERCLA and the NCP, and based upon the evaluation of the RI/FS and the nine criteria, the U.S. EPA, in consultation with the WDNR, has selected Alternative 3 as the source control remedial action at the Hagen Farm Site.

The major components of Alternative 3 include the following:

* Within the larger AOC, the non-native material from the disposal areas B and C will be consolidated in disposal area A. All waste movement will be done within the AOC. No placement will occur. The excavated depression areas within disposal areas B and C will be filled with clean soil and landscaped with vegetation native to the area.

* The Cap will be placed on disposal area A in compliance with the current requirements of Ch. NR 504.07, WAC for closure of solid waste disposal facilities. The cap will consist of a grading layer, a minimum 2-foot clay layer (compacted to a permeability of 1×10^{-7} cm/s or less), a gravel drainage layer, a frost protective soil layer, and a minimum 6 inches top soil layer (see Figure 5). The cap will be constructed prior to the pilot-scale test and full-scale implementation of the in-Situ Vapor Extraction. The integrity of the cap will be maintained during the ISVE implementation and for many years afterwards.

* In-Situ Vapor Extraction will be implemented in the contaminated waste refuse and sub-surface soils of disposal area A. Prior to the full-scale implementation of the ISVE, a pilot-scale test will be conducted at the Site to determine the remedial design parameters (i.e., number of extraction and injection wells, the spacing between wells, pumping rate) to achieve maximum removal of the VOC's. The goal of the ISVE extraction will be 90 percent removal of VOCs in the Waste/sub-Soils.

  During the full-scale ISVE implementation, a treatability study will be performed to examine the feasibility of adding essential nutrients (e.g., moisture, oxygen, nitrogen, and phosphate) to the Waste/sub-Soils in order to enhance the natural microbial degradation of organic compounds. The study will be designed to determine the optimum amounts of nutrients to be added to the Waste/sub-Soils in order to promote the microactivities, without decreasing the mass removal of the VOCs by ISVE. If determined to be feasible, this treatment will be implemented as part of the remedy.

* Off-gas emitted from the extraction wells will be treated using a carbon adsorption system in order to meet the air quality standards of the State, NR 445, WAC. The spent carbon or any other residues from this off-gas treatment process will be sent back to the manufacturer to be

regenerated, thus they are not subject to LDRs.

* Institutional controls would be relied upon to provide additional effectiveness to the remedy. These include zoning restriction, deed notice, and construction of a fence.

XI STATUTORY DETERMINATIONS

The selected remedy must satisfy the requirements of Section 121 of CERCLA to:

a. protect human health and environment;
b. comply with ARARs;
c. Be cost-effective;
d. Utilize permanent solutions and alternate treatment technologies to the maximum extent practicable; and,
e. Satisfy the preference for treatment as a principle element of the remedy or document in the ROD why the preference for treatment was not satisfied.

The implementation of Alternative 3 at the Site satisfies the requirements of CERCLA as detailed below:

a. Protection of Human Health and the Environment

Implementation of the selected alternative will reduce and control potential risks to human health posed by exposure to contaminated waste and air emission by treating contaminated Waste/sub-Soils.

Capping the landfill, in addition to reducing any potential risks posed by direct exposure to contaminated waste, will reduce the infiltration of precipitation through the landfill. Groundwater contaminant loading will thus be reduced. In-Situ Vapor Extraction of the contaminated Waste/sub-Soils will also reduce the groundwater contaminant loading.

No unacceptable short-term risks will be caused by implementation of the remedy. The site workers may be exposed to noise and dust nuisances during construction of the cap. ISVE should not present short-term risks due to VOC emission if properly designed and monitored. A Standard Safety program will manage any short-term risks. Dust control measures and off-gas treatment would reduce those risks as well.

b. Compliance with ARARs

An NR 504.07 Solid Waste cap is an ARAR for Alternative 3. A RCRA Subtitle C cap, while relevant, is not appropriate, as described in Section VIII of this ROD. NR 445, WAC, Control of Hazardous Pollutants, is an ARAR for the discharge of off-gas from the vapor extraction procedure.

Compliance with Wisconsin Statute, Chapter 160 and NR 140, WAC, will be achieved through the selection of the final remedy for the GCOU for this

site.

The selected remedy will attain all Federal and State applicable or relevant and appropriate environmental requirements.

c. Cost-Effectiveness

Alternative 3 is a cost-effective alternative providing for protection of human health and the environment and long-term effectiveness. Alternative 2 is somewhat less expensive than the selected remedy, but provides a lesser degree of long-term effectiveness because no treatment of contaminants is involved. Because there is no treatment, there is a greater risk of contaminants entering the groundwater with Alternative 2 over the long term. Alternative 4 is four-times more expensive than Alternative 3 without providing proportional effectiveness. Alternative 5 (Incineration) is the most expensive remedy. Although Alternative 5 provides complete destruction of the contaminants at the Site, Alternative 3 provides similar effectiveness through a combination of treatment and containment of the residuals at far less cost.

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

U.S. EPA and the State of Wisconsin believe the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner for the SOOU remedy at the Hagen Farm site. Of the alternatives that are protective of human health and the environment and comply with ARARs, U.S. EPA and the State have determined that the selected remedy provides the best balance of tradeoffs in terms of long-term effectiveness and permanence, reduction in toxicity, mobility or volume achieved through treatment, short-term effectiveness, implementability, cost, also considering the statutory preference for treatment as a principal element and considering State and community acceptance.

Alternative 3 reduces the toxicity, mobility, and volume of the contaminants in the Waste/sub-Soils; complies with ARARs; provides long-term effectiveness; and protects human health and the environment equally as well as Alternatives 4 and 5. In terms of short-term effectiveness, Alternative 3 has the shortest time to implement because there are no substantive permit requirements, as needed for Alternatives 4 and 5. Alternative 3 also poses minimal risk to remediation workers and the community during the implementation period because it does not involve excavating the waste. Alternative 3 will be easier to implement technically because it requires less construction, and administratively because it will require less coordination with relevant agencies. Finally, Alternative 3 costs the least of the protective alternatives that utilize treatment. The major tradeoffs that provide the basis for this selection decision are short-term effectiveness, implementability, and cost. The selected remedy is more reliable and can be implemented more quickly, with less difficulty and at less cost than the other treatment alternatives and

is therefore determined to be the most appropriate solution for the contaminated Waste/sub-Soils at the Hagen Farm site.

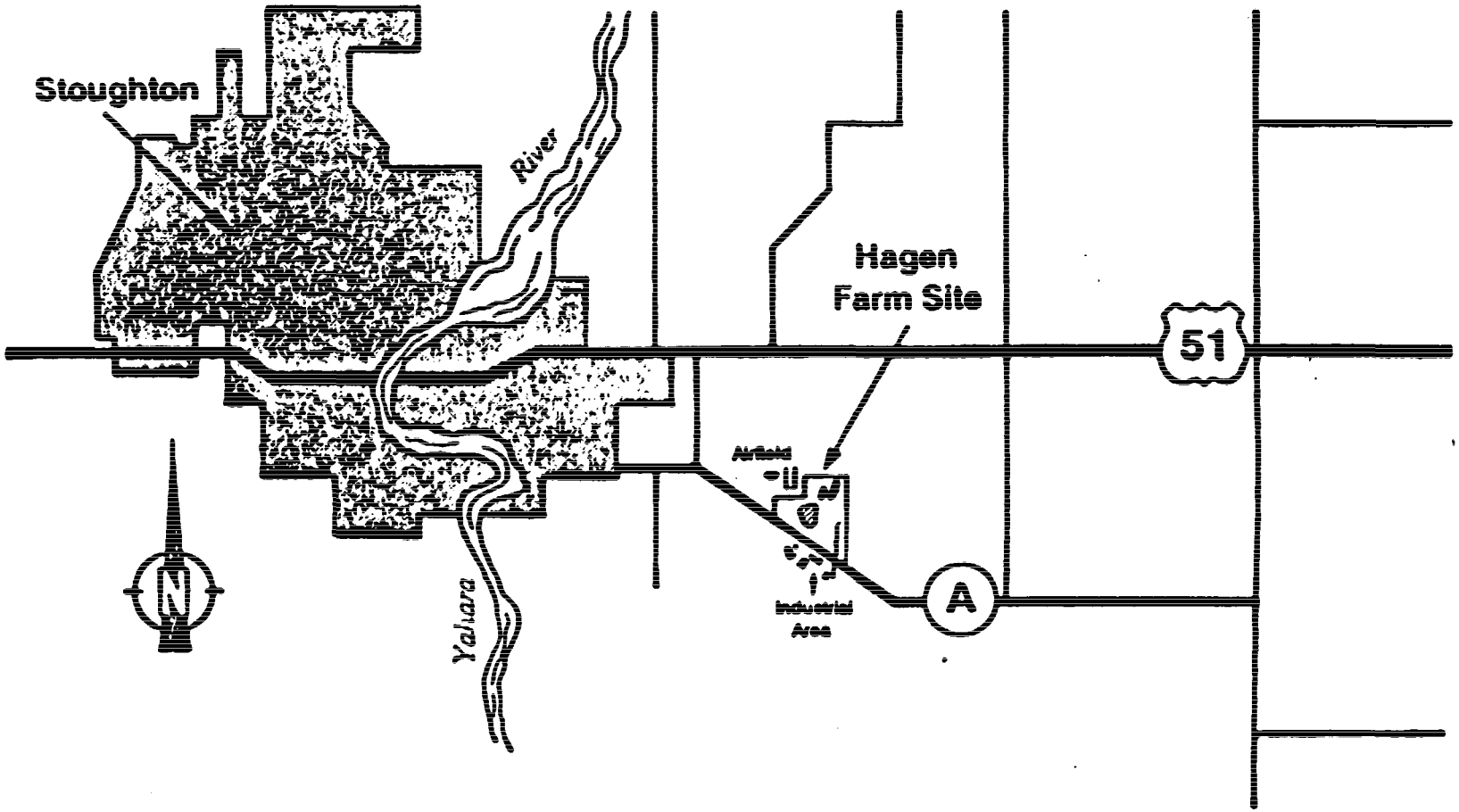
The State of Wisconsin is in concurrence with the selected remedy. A public comment was received concerning the cost of the remedy, and this comment is fully addressed in the Responsiveness Summary.

e. Preference for treatment as a principal element

The groundwater contaminant plume will be addressed in a second operable unit. Because the selected alternative treats the VOCs, which are the continuing source of groundwater contamination, it will address the principal threat for the SCOU at the Site through treatment and satisfies the preference for treatment as a principal element. In addition, during full-scale implementation of ISVE, enhanced biological treatment of semi-VOCs will be investigated and if feasible, implemented as part of this remedy.

Figure 1
Site Location Map
Hagen Farm Site
Dunkirk Township, Wisconsin

(Not To Scale)

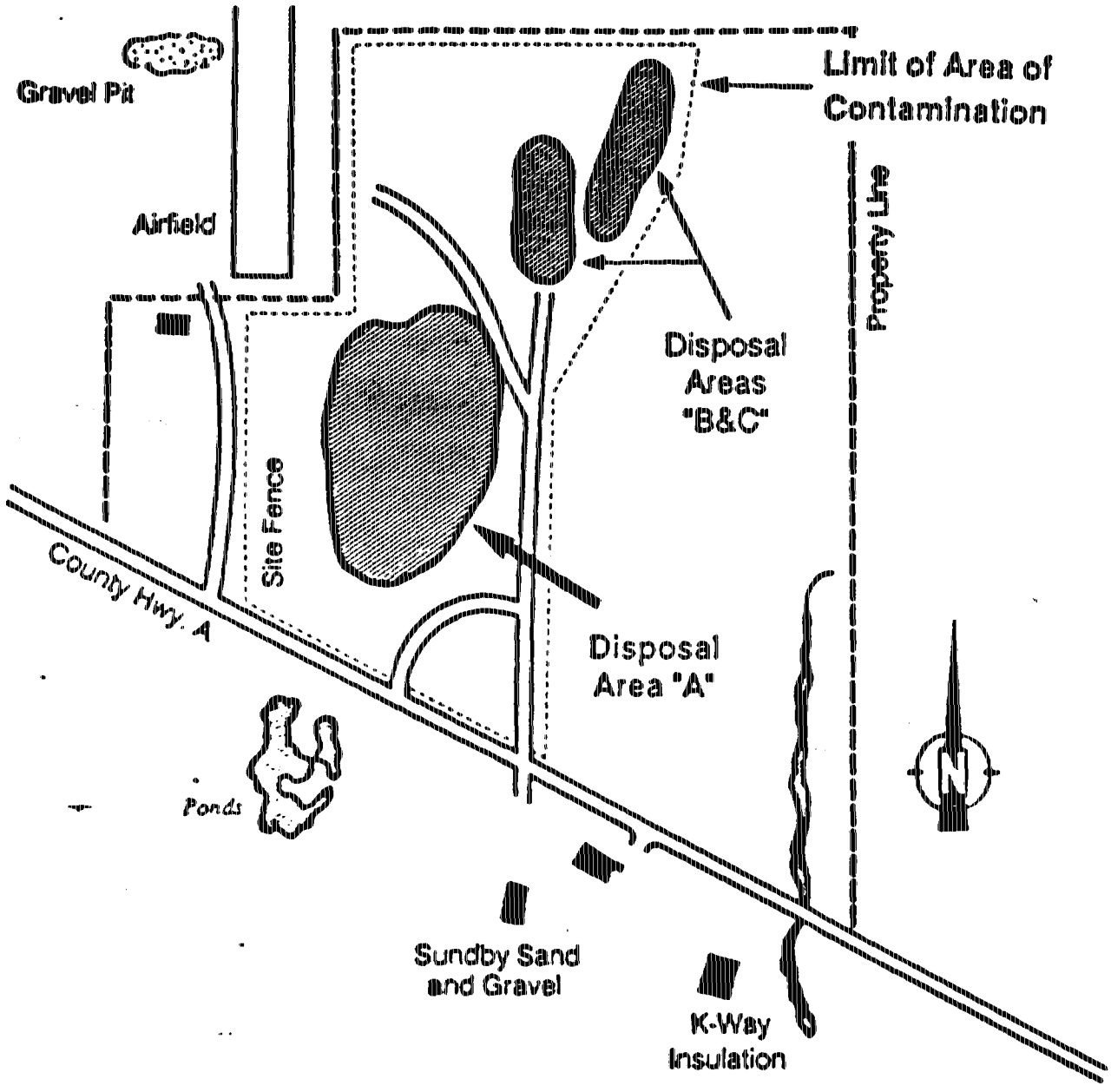


Prepared by Jacobs Engineering Group Inc. Chicago
for the U.S. Environmental Protection Agency, 7/22/90

Drawn AJH
Checked DS

Figure 2
Site Diagram
Hagen Farm Site
Dunkirk Township, Wisconsin

(Not To Scale)

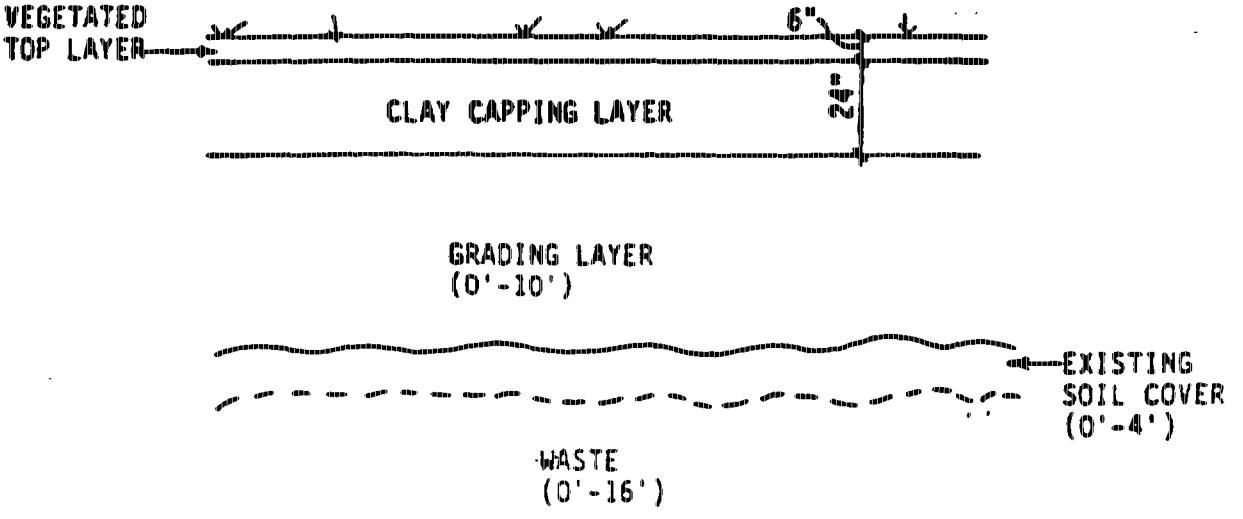


Prepared by Jacobs Engineering Group Inc. Chicago
for the U.S. Environmental Protection Agency, 7/22/90

Drawn AH
Checked DS

FIGURE 3

SPECIFICATION OF NR 181.44(12) CAP

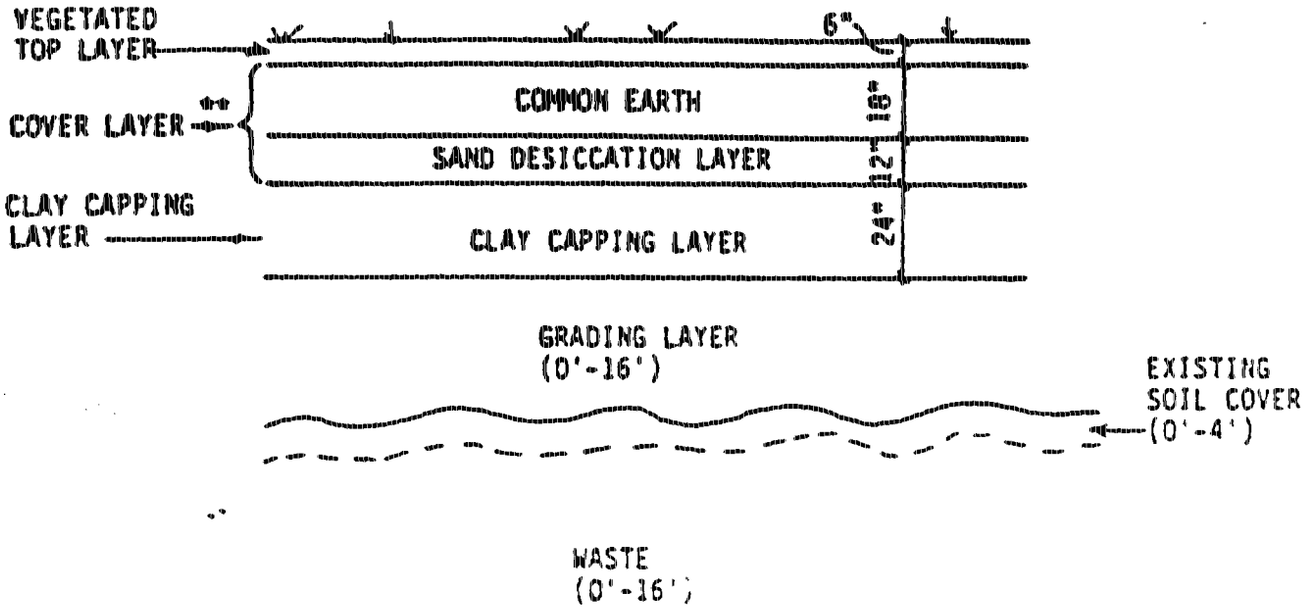


SCALE: 1" =

WARZYN	STRUCTURE OF CAP REPAIR PER NR 181.44 (12)	Drawn VEL	Checked MGJ.	App'd JEA
	REMEDIAL INVESTIGATION AND FEASIBILITY STUDY HAGEN FARM SITE	Revisions		Date 5-4-90
				13452 A

FIGURE 4

SPECIFICATION OF NR 504.07 SOLID WASTE CAP



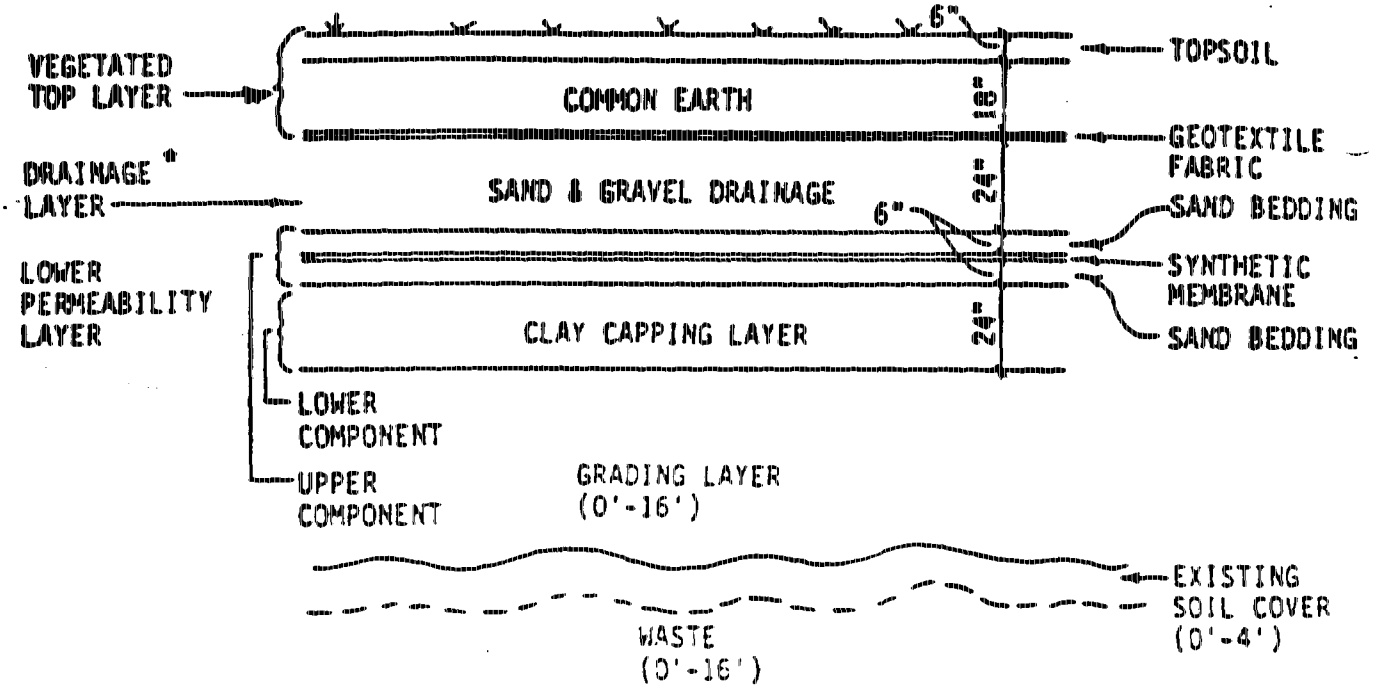
** THE COVER LAYER WAS SPECIFIED AT 30 IN. AS A WORST CASE SCENARIO TO ADDRESS THE CONCERNS OF NR 504.07 (5).

SCALE: 1" =

WARZYN	STRUCTURE OF SUBTITLE D CAP (NR 500) PER NR 504.07	Drawn	Checked	Appd GEA
	REMEDIAL INVESTIGATION AND FEASIBILITY STUDY HAGEN FARM SITE	Revisions		Date 5-4-90
				13452 A 2

FIGURE 5

SPECIFICATION OF RCRA SUBTITLE C CAP



* THE DRAINAGE LAYER WAS SPECIFIED AT 24 IN. TO MEET THE REQUIREMENT THAT THE UPPER COMPONENT OF THE LOW PERMEABILITY LAYER BE LOCATED AT LEAST 12 IN. BELOW THE MAXIMUM RECORDED DEPTH OF FROST WHICH WAS ESTIMATED TO BE 36 IN.

SCALE: 1" = 4'

WARZYN	STRUCTURE OF SUBTITLE C CAP (NR 181) PER NR 181.44 (13)	Drawn JK, VKL	Checked MAZ	Appd GEA
	REMEDIAL INVESTIGATION AND FEASIBILITY STUDY HAGEN FARM SITE	Revisions		Date 5-4-90
				13452 A5

TABLE 1

Groundwater Quality Summary
VOCs and Semi-VOCs at Source Characterization Wells
Hagen Farm FS

Concentrations (ug/L)

	Maximum	Average(1)	No. Wells With Detection(2)
VOCs			
2-Butanone	4,400,000	2,620	3
Toluene	20	20	1
Ethylbenzene	2,400	99	3
Xylenes	35,000	1,066	5
Tetrahydrofuran	630,000	5,695	5
Semi-VOCs			
Benzoic Acid	29,000	780	2
2,4-Dimethylphenol	330	153	2
4-Methylphenol	6,100	243	2
Phenol	5,600	3,816	1
1,4-Dichlorobenzene	10	10	1
Benzyl Alcohol	26	26	1
Bis(2-Chloroisopropyl)Ether	19	19	1
Naphtalene	8	8	1
4-Chloro-3-Methylphenol	7	7	1
Diethylphthalate	5	4.5	1
Bis(2-Ethylhexyl)Phthalate	34	18	3
Di-n-Octyl Phthalate	5	5	1

Notes

(1) Geometric averages for positive detects at each well are calculated for duplicate analysis and multiple rounds, where applicable. Geometric average were then calculated using one single or, where more than one sample was obtained from a given well, average value for each well (5 wells).

(2) Out of five wells. Some wells had more than one sample analyzed as indicated in (1).

TABLE 2

Source Characterization Summary
Analytical Results of Refuse Samples
Hagen Farm FS

Compound	Concentration: Geometric Mean	Concentration: Maximum	Number of(1) Samples
Inorganic (mg/kg)			
Aluminum	7,690	13,000	10
Arsenic	3.1	4.6	10
Barium	96.8	2,550	10
Cadmium	1.3	1.8	8
Calcium	23,100	43,900	10
Chromium	10.7	16	10
Cobalt	296	296	1
Copper	15.6	160	10
Iron	11,100	15,900	10
Lead	24.4	107	10
Magnesium	14,800	26,500	10
Manganese	329	660	10
Mercury	0.12	0.42	6
Nickel	21.6	387	10
Pottasium	659	1,140	10
Sodium	1,550	4,920	2
Vanadium	18.4	29.8	10
Zinc	74.8	499	10
Semivolatiles (ug/kg)			
1,4-Dichlorobenzene	280	280*	2
Naphthalene	46	46*	1
Diethylphthalate	48	48*	1
Di-n-Butylphthalate	130	690	3
Fluoranthene	67	67*	1
Butylbenzylphthalate	220	18,000	8
bis(2-Ethylhexyl)Phthalate	3,410	120,000	9
Di-n-Octyl Phthalate	320	5,300	7
Phenanthrene	53	67*	2
Unknown Semivolatiles(2)	2,120	1,261,985	10

TABLE 2
(Continued)

Compound	Concentration		Number of(1) Samples
	Geometric Mean	Maximum	
Pesticide/PCB's (ug/kg)			
Dieldrin	11.6	11.6	1
4,4'-DDE	18.2	18.2	1
4,4'-DDD	11.9	128	4
4,4'-DDT	19.2	19.2	1
PCB-1242	104.8	284	4
PCB-1248	338	338	1
PCB-1254	222	222	1

Notes

(1) Out of 10 total sampling locations (Test Pits RS01 to RS10), excluding RS08 duplicate.

(2) Sum of tentatively identified compounds.

* Indicates concentration is below method quantitation limit. Value is estimated.

TABLE 3
COMPARISON OF SITE CONCENTRATION DATA
WITH FEDERAL AND STATE STANDARDS (UG/L)

Compounds	Maximum Concentration	Federal Standard (MCL)	State Standard (PAL)	State Standard (ES)	Source
2-butanone	4,400,000	N/A	90[1]	460[1]	SCW
Ethylbenzene	4,400	700[1]	272	1360	MW
Toluene	550	2,000[1]	68.6	343	MW
Xylene	35,000	10,000[1]	124	620	SCW
Tetrahydrofuran	630,000	N/A	10	50	SCW
Vinyl chloride[2]	77	2	0.0015	0.2	MW
Arsenic[2]	25.2	50	5	50	SCW
Barium	1,570	1,000	200	1000	SCW
Lead	6	50	5	50	SCW[3]
Mercury	6.5	2	0.2	2	SCW

1. Proposed standards
2. 10^{-6} cancer risk for vinyl chloride is 0.015 ug/l, and for arsenic is 0.03 ug/l.
3. Lead was detected at concentration of 997 ug/l in leachate well.

* MCL: Maximum Contaminant Level, Drinking Water Regulation
* PAL: Preventive Action Limit, Ch. NR 140
* ES : Enforcement Standard
* SCW: Source Characterization Well located at refuse disposal area
* MW : Monitoring well located at or around landfill
* N/A: Not Available

** All of above compounds were not detected above detection limit at background groundwater well.

RESPONSIVENESS SUMMARY
HAGEN FARM SITE
SOURCE CONTROL OPERABLE UNIT
DANE COUNTY, WISCONSIN

PURPOSE

This responsiveness summary, required by the Superfund Law, provides a summary of citizen's comments and concerns identified and received during the public comment period, and U.S. EPA's responses to those comments and concerns. All comments received by U.S. EPA during the public comment period will be considered in the selection of the remedial alternative for the Site. The responsiveness summary serves two purposes: It provides U.S. EPA with information about community preferences and concerns regarding the remedial alternatives, and it shows members of the community how their comments were incorporated into the decision-making process.

This document summarizes one written comment received during the public comment period of July 11 to August 10, 1990. The public meeting was held at 7:00 p.m. on August 2, 1990 at Dunkirk Town Hall, Stoughton, Wisconsin. No comments were submitted during the public meeting.

OVERVIEW

The preferred alternative for the Hagen Farm site was announced to the public just prior to the beginning of the public comment period. The preferred alternative includes:

* Installation of a WDNR required NR 504 solid waste cap over disposal area A after consolidation;

* In-Situ Vapor Extraction of the waste refuse and sub-surface soils in disposal area A;

* Off-gas treatment through carbon adsorption.

PUBLIC COMMENT AND AGENCY RESPONSE

COMMENT: It is unwise to spend more than $2 million of the taxpayers' money to remediate the Hagen Farm site which will not affect anyone. The money should be spent to control cigarette smoking which kills thousands of people each year. In addition, the commentor stated U.S. EPA should be active in alleviating "drunk drivers."

RESPONSE: It is believed that the wastes in the Hagen Farm landfill have been contaminating the groundwater at the site. If the Agency does not remediate this contaminated landfill now, the landfill would contaminate the groundwater continuously in the future, and people who use this groundwater as their drinking

water will be affected. Therefore, it is important and wise to remediate the contaminated landfill. We expect that the funds to remediate this site will come from the parties determined to be potentially responsible for the contamination, not from the taxpayers. The issue of a referendum concerning smoking in public places is not within the scope of the Superfund program. Instead, this is a local matter and should be addressed to the city council. U.S. EPA also cannot address the commentor's statement on "drunk drivers" because that subject is not within the scope of the Superfund program. Such concerns should be brought to the attention of State or Local lawmakers.

ADMINISTRATIVE RECORD INDEX
HAGEN FARM SITE
STOUGHTON, WISCONSIN

ARI PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE	DOCUMENTS
9	00/02/02	Letter re: Alternative Array Review Comments for the Source Control Operable Unit at the Hagen Farm Site	J.Lee,USEPA	D.Drautch,WDNR of WI,Inc.	Correspondence	10
6	00/03/00	Superfund Fact Sheet Hagen Farm Site	USEPA		Fact Sheets	11
15	00/09/29	Memo re: Approval of QAPP for the RI/FS Activity at Hagen Farm Superfund site	A.Sirko,USEPA	D.Niedergang,USEPA	Memorandum	12
3	00/09/23	Addendum to Hagen Farm - Field GC Standard Operating Procedures	Warzyn Engineering,Inc.		Other	13
63	07/09/14	Administrative Order by Consent Re: RI/FS for Hagen Farm Site	USEPA		Pleadings/Orders	14
24	00/00/00	PRP Response Summary	Hagen Farm Site		Reports/Studies	15
7	00/00/00	Draft Statement of Work for Conducting a RI/FS at the Hagen Farm Site Dane County, WI	USEPA		Reports/Studies	16
302	07/11/00	QAPP Hagen Farm Site Volume 3 of 3 November 1987	Warzyn Engineering,Inc.	Waste Mgmt. of WI,Inc.	Reports/Studies	17
170	00/06/00	Work Plan Hagen Farm Site Volume 2 of 4	Warzyn Engineering,Inc.	Waste Mgmt. of WI,Inc.	Reports/Studies	18
193	00/06/00	Site Evaluation Report Hagen Farm Site Volume 1 of 4	Warzyn Engineering,Inc.	Waste Mgmt. of WI,Inc.	Reports/Studies	19
36	00/07/00	Final Community Relations Plan Hagen Farm	Jacobs Engineering Group Inc.	USEPA	Reports/Studies	20
60	00/07/21	Quality Assurance Plan	Radian Corporation,		Reports/Studies	21

FINAL

ADMINISTRATIVE RECORD INDEX
OGDEN FARM SITE
STOUGHTON, WISCONSIN

FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE	DOCUMENT
36		08/01/13	Letter re: Comments on Site Evaluation Report, Technical Workplan, and QAPP	D.Ballori,USEPA	R.DeBattista,VHRA of WI	Correspondence	1
12		08/06/23	Letter forwarding responses to the Ogden Farm Site RI/FS QAPP, with the Chloride and Sulfate Analysis by Ion Chromatography	A.Medina,Envirco Inc.	J.Dodinson,Varsyn Engr.	Correspondence	2
3		08/06/30	Letter re: Responses and Revisions to Comments from USEPA-Region V QA Office on the Ogden Farm RI/FS QAPP	J.Dorden,VHRA of WI,Inc.	B.Sylvester,USEPA	Correspondence	3
5		08/08/11	Letter re: Linearity of Detector Response for Chloride and Sulfate Analyses	G.Asbury&L.Vendt, Varsyn Engineering,Inc.	Chung-Wen Paul,PhD,USEPA	Correspondence	4
3		08/09/06	Letter re: Methodology Modifications for Sulfate and Chloride Analyses	G.Asbury,Varsyn Engineering,Inc.	J.Lee,USEPA	Correspondence	5
7		08/10/25	Letter re: Work Plan Addendum for Source Characterization	J.Dorden,Waste Mgmt. of WI,Inc.	J.Lee,USEPA	Correspondence	6
2		08/11/10	RI/FS QAPP Sign-off Sheet	J.Dorden,VHRA of WI, Inc.	J.Lee,USEPA	Correspondence	7
39		09/07/20	Letter re: Work Plan Addendum for Phase 2 Site Investigation and Source Control Operable Unit FS	G.Asbury,Varsyn Engineering,Inc.	J.Lee,USEPA	Correspondence	8
23		09/07/25	Letter re: Response to Comments - Tech Memo 1	G.Asbury,Varsyn Engineering,Inc.	J.Dorden,VHRA of WI,Inc.	Correspondence	9

ADMINISTRATIVE RECORD INDEX - UPDATE 02
ROGER PARK SITE
STOUGHTON, WISCONSIN

FINAL

NUM	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE	DOCUMENTS
2		90/08/13	Memo re: Remedy Delegation Report describing remedial actions delegated to the Regional Administrator for selection of remedy	D.Clay-USEPA	V.Adamkus-USEPA	Memorandum	1

ADMINISTRATIVE RECORD INDEX
HAGEN FARM SITE
STOUGHTON, WISCONSIN

RANK	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE	DOCUMENT
		—	For the Analysis for Hazardous Substances List Volatile Organic Compounds in Air Samples by GC/MS	revised by WDNPA			
	218	03/09/01	Report on the Electro-magnetic and Magnetic Survey Conducted at the Hagen Farm Site	Prosa Applied Technology	Warzyn Engineering,Inc.	Reports/Studies	22
	9	08/09/33	Preliminary Health Assessment for Hagen Farm Site Stoughton, WI	WDNR,Div. of Health, Bureau of Community Health and Prevention	ATSDR	Reports/Studies	33
	337	03/03/00	RI/FS Hagen Farm Site Technical Memorandum Number 1 - March 1989	Warzyn Engineering,Inc.	Waste Mgmt. of WI,Inc.	Reports/Studies	20
	07	03/03/00	RI/FS Hagen Farm Site Technical Memorandum Number 1	Warzyn Engineering,Inc.	Waste Mgmt. of WI,Inc.	Reports/Studies	35
	4	03/07/00	Progress Report Hagen Farm Superfund Site	USEPA		Reports/Studies	26
	05	09/10/00	Alternatives Array Document Source Control Operable Unit RI/FS Hagen Farm Site	Warzyn Engineering,Inc.		Reports/Studies	27
	370	90/02/00	RI/FS Hagen Farm Site Technical Memorandum Number 2	Warzyn Engineering,Inc.	Waste Mgmt. of WI,Inc.	Reports/Studies	28

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Beaudry, Secretary
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Madison, Wisconsin 53707
608/ TELEFAX NO. 608-267-3579
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September 6, 1990

IN REPLY REFER TO: 4440

Mr. Valdas V. Adamkus, Regional Administrator
U.S. Environmental Protection Agency
230 S. Dearborn Street
Chicago, IL 60604

O: WMD
CC: RF
FREEMAN

SUBJECT: Selected Superfund Remedy
Hagen Farm Site
Dunkirk Township, Dane County, WI

Dear Mr. Adamkus:

The Department is providing you with this letter to document our position on the proposed source control operable unit for the Hagen Farm Site. The proposal, as identified in the draft Record of Decision, includes the following:

Alternative 3: In-Situ Vapor Extraction and Capping

Non-native waste materials from disposal areas B and C would be consolidated to disposal area A. The waste and contaminated sub-soil materials in disposal area A would be treated using In-Situ Vapor Extraction (ISVE). A low permeability cap meeting the Wisconsin requirements for capping municipal landfills will be placed over disposal area A.

Estimated Costs: Construction - $2,679,400
Operation and Maintenance - $29,530
30 Year Present Worth - $3,299,000

The total 30 year present net worth for the Hagen Farm Source Control Operable Unit is approximately $3,299,000. The Department concurs with Alternative 3, as described in the Record of Decision for this operable unit.

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U. S. EPA REGION 5
OFFICE OF REGIONAL ADMINISTRATOR

The State of Wisconsin will contribute 10% of the remedial action costs associated with this source control operable unit at the Hagen Farm Site if the potentially responsible parties (PRPs) do not agree to fund the remedy. This assurance assumes that EPA will pursue all legal action against the PRPs, including issuance of a unilateral order and litigation of such order, prior to expending the Fund.

We also understand that our staff will continue to work in close consultation with your staff during the remaining Remedial Investigation/Feasibility Study work associated with the groundwater control operable unit at the Hagen Farm Site, as well as during the design and construction of the source control operable unit remedy.

Thank you for your support and cooperation in addressing this contamination problem at the Hagen Farm Site in Dunkirk Township. If you have any questions regarding this matter, please contact Mr. Paul Didier, Director of the Bureau of Solid and Hazardous Waste Management, at (608) 266-1327.

Sincerely,

C. D. Besadny
Secretary

CDB:SB

cc. Lyman Wible - AD/5
Linda Meyer - LC/5
Paul Didier - SW/3
Joe Brusca - SOD
Pat McCutcheon/Mike Schmoller - SOD
Rae Lee - EPA Region V (5HS/11)
Mark Giesfeldt/Sue Bangert/Terry Evanson - SW/3

EXPLANATION OF SIGNIFICANT DIFFERENCES
HAGEN FARM SUPERFUND SITE
SOURCE CONTROL OPERABLE UNIT
STOUGHTON, WISCONSIN

Introduction

On September 17, 1990, the United States Environmental Protection Agency ("U.S. EPA"), issued a Source Control Operable Unit Record of Decision ("ROD"), in which U.S. EPA, with concurrence of the State of Wisconsin, determined the remedy to be implemented for the remediation of contaminated soils and waste materials found at the Hagen Farm Superfund site, located in Dane County, Wisconsin (the "Site"). Since the signing of the ROD, U.S. EPA has received information making it appropriate for U.S. EPA, with the concurrence of the State of Wisconsin (the "State"), to revise the methodology to be used in calculating the Clean-up Standard for the waste refuse and sub-surface soils ("Waste/sub-Soils") at the Site. In accordance with Section 117(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended ("CERCLA") and to the extent practicable, the National Contingency Plan, U.S. EPA has determined that the revised methodology for calculating the Clean-Up Standard for the Waste/sub-Soils, as discussed below, constitutes a significant change to a component of the remedy in the 1990 ROD. CERCLA Section 117(c) requires that U.S. EPA publish an Explanation of Significant Differences from the 1990 ROD. The purpose of this document is to provide a brief background of the Site, and to present this Explanation of Significant Differences, which explains how the revised methodology for calculating the Clean-Up Standard was arrived at, and how it differs from the Clean-Up Standard described in the ROD signed on September 17, 1990.

This Explanation of Significant Differences ("ESD") and the corresponding supporting documents are available for public review in the Hagen Farm Administrative Record, which is located at the following information repository:

Stoughton Public Library
304 S. 4th Street
Stoughton, Wisconsin 53589

SITE BACKGROUND

The Site is located at 2318 County Highway A, approximately one mile east of the City of Stoughton, Dane County, Wisconsin. The 10-acre Site is situated in a rural surrounding that is dominated largely by sand and gravel mining and agriculture.

The Site was operated as a sand and gravel pit prior to the late 1950s. The gravel pit was then used for disposal of waste material from the late 1950s to the mid-1960s. During the period that the Site was operated as a disposal facility the property was owned by Nora Sundby, who is now deceased. The Site was

operated by City Disposal Corporation ("City Disposal"), a predecessor corporation of the current Site owner, which is Waste Management of Wisconsin, Incorporated ("WMWI"). City Disposal accepted municipal wastes, waste solvents and other various organic materials including acetone, butyl acetate, 1-2-dichloroethylene, tetrahydrofuran, solid vinyl, sludge material containing methylethyl ketone and xylenes, and toluene for disposal at the Site. In a 103(c) notification submitted to the U.S. EPA by Uniroyal, Inc. ("Uniroyal"), in June 1981, Uniroyal indicated that F003 and F005 wastes, which are hazardous wastes within the meaning of the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6901, also were disposed of at the Site. WMWI and Uniroyal are the two Potentially Responsible Parties ("PRPs") that have been identified in connection with the Site.

Beginning in November 1980, in response to complaints received from local residents, the Wisconsin Department of Natural Resources ("WDNR") began conducting groundwater sampling at nearby private water supply wells. Sampling of the on-Site monitoring wells during the period 1980-1986 indicated certain organic compounds were present in the groundwater, including benzene, ethylbenzene, tetrahydrofuran, xylenes, and toluene. In addition, nearby private water supplies on adjacent properties have also shown detectable levels of volatile organic compounds ("VOCs"). The private wells located at the Site have been impacted by acetone, tetrahydrofuran, vinyl chloride, xylene, trans 1,2-dichlorethene, and trichloroethylene. These private wells are no longer in use.

The Site was proposed for inclusion on the National Priorities List ("NPL") on September 18, 1985. The Site was placed on the NPL in July of 1987. Subsequently, WMWI and Uniroyal, the two PRPs named by U.S. EPA in connection with the Site, entered into an Administrative Order by Consent (U.S. EPA Docket No. VW 87-C-016, dated September 14, 1987) ("Consent Order") with U.S. EPA and WDNR. In the Consent Order, WMWI and Uniroyal agreed to conduct a Remedial Investigation and Feasibility Study ("RI/FS") at the Site. Accordingly, in July of 1988, upon U.S. EPA approval, in consultation with the WDNR, of the required Work Plans, fieldwork at the Site commenced.

Two operable units, which are being conducted concurrently, have been defined for the Site. Operable Unit ("OU") I, which is the Source Control Operable Unit ("SCOU"), is intended to address Waste/sub-Soils at disposal area A and the two smaller disposal areas B and C. OU II, which is the Groundwater Control Operable Unit ("GCOU"), is intended to address the contaminated groundwater at the Site. This approach was agreed upon after discussions among U.S. EPA, WDNR, and the PRPs during the early phase of the implementation of the Work Plan for the RI for the SCOU.

The RI for the SCOU was completed in early 1989, and the Technical Memorandum for the SCOU was submitted in March 1989. The RI for the GCOU was initiated in July 1989 and the Technical Memorandum for GCOU was submitted in February 1990. Currently, additional field activities to define the extent of plume migration are ongoing. The RI report for the GCOU, including the Endangerment Assessment, is scheduled for completion in July 1991. The Record of Decision for the GCOU is scheduled for early 1992.

In June, 1990, U.S. EPA provided the FS and the Proposed Plan for the source control remedial action to the public. An opportunity for public comment was provided. Comments were to be submitted in writing to the U.S. EPA by August 10, 1990, or orally at the public meeting held in Stoughton, Wisconsin, on August 2, 1990.

The ROD for the SCOU was signed on September 17, 1990. Special Notice and a Consent Decree for Remedial Design and Remedial Action ("RD/RA") for the Site was issued to the PRPs on October 31, 1990. The PRPs did not submit a good faith offer within the statutorily mandated time period. Accordingly, on March 7, 1991, U.S. EPA issued to the PRPs a unilateral administrative order ("UAO") pursuant to Section 106 of CERCLA. The PRPs have agreed to comply with the terms and requirements of the UAO.

Remedial Investigation/Feasibility Study

Analyses of soils, waste, and fill materials performed during the RI revealed the presence of numerous hazardous substances including ethylbenzene, toluene, xylene, 2-butanone, tetrahydrofuran, vinyl chloride, arsenic, lead, and mercury. These contaminants are present in the subsurface soils at and above the water table and continue to be released into the groundwater.

Contaminants are being released to the environment through the following pathways: volatilization of contaminants through the soil to the air; direct contact; and release of contaminants from waste, and soils to the groundwater. These releases provide potential for exposure of VOCs to humans as well as terrestrial and aquatic life.

The level of contaminants found at the source characterization wells far exceed Federal and State standards. For the case of tetrahydrofuran, the most frequently detected compound at the Site, the level (630 parts per billion (ppb)) is 12,600 times higher than the State groundwater enforcement standard (50 ppb). This data clearly indicated that the Waste/sub-Soils are acting as a source of groundwater contamination. This source will continue to load contaminants to the groundwater unless addressed by remedial action.

Record of Decision

Considering the Proposed Plan for remedial action and the public comments received, U.S. EPA, with concurrence by the State, selected a source control remedy for remediation of on-site waste and sub-surface soils at the Site. U.S. EPA's decision is summarized in the ROD signed by the U.S. EPA Regional Administrator on September 17, 1990. The selected remedy includes the following: consolidation of non-native materials from disposal areas B and C into disposal area A with subsequent backfilling of disposal areas B and C with clean soil material; installation of a WDNR NR 504 solid waste cap over disposal area A after consolidation; In-situ vapor extraction of the waste refuse and sub-surface soils in disposal area A; off-gas treatment through carbon adsorption; installation and maintenance of a fence around disposal areas A, B, and C during remedial activities; and deed and access restrictions to prevent installation of drinking water wells within the vicinity of the disposal areas and to protect the cap.

U.S. EPA's ROD includes a discussion of U.S. EPA's reasons for the selection of the source control remedy. The remedial action ("RA") has been determined to be a cost-effective remedial action which provides adequate protection of public health, welfare, and the environment, and meets all Federal and more stringent State ARARs.

Description of Significant Differences and the Basis for those Differences

The description of the selected remedy in the ROD, Section X, Selected Remedy, states that "the goal of the ISVE extraction will be 90 percent removal of VOCs in the Waste/sub-Soils". Information became available to U.S. EPA and WDNR after the ROD was signed which allows U.S. EPA to further refine the Clean-Up standard. Because in this case there is no standard accepted method to collect and analyze the waste from this Site which would yield statistically reliable and representative results, U.S. EPA has determined that the Waste/sub-Soils Clean-Up standard be based upon a reduction of the soil-gas VOC concentrations. Based upon a literature survey (see Attachment A) and discussions with U.S. EPA's Environmental Research Laboratory, Ada, Oklahoma (see Attachment B), U.S. EPA, with State concurrence, has determined that it is more appropriate to use a state-of-the-art Groundwater/Soil-gas Model ("Model") for each VOC detected in the Waste/sub-Soils and/or the groundwater during the remedial investigation to determine the Clean-Up standard for the Waste/sub-Soils. Using this Model to determine the Clean-Up standard will ensure clean-up levels that are measurable and reliable, as well as consistent with the National Contingency Plan.

The Scope of Work that has been prepared for the implementation of the remedy selected in the ROD, as modified by this ESD, states that the PRPs shall submit a state-of-the-art Groundwater/Soil-gas Model to provide U.S. EPA with the data on which to base a soil-gas Clean-up Standard in the Waste/sub-Soils. It further states that the Groundwater/Soil-gas Model shall be used to determine the concentration of VOCs in the Waste/sub-Soils necessary to achieve the protective level of VOCs in the groundwater.

Wisconsin Department of Natural Resources Comments

WDNR has been given an opportunity to comment on this ESD. Their comments have been addressed and the State is in agreement with the revised Clean-up Standard under this ESD.

Affirmation of the Statutory Determination

Considering the new information that has been developed and the change that has been made to the methodology for calculating the Clean-Up standard component of the selected remedy, the U.S. EPA, with the concurrence of the State, believes that the remedy remains protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to this remedial action, and is cost-effective. In addition, the remedy and the revised methodology for calculating the Clean-Up standard utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable for this Site.

ATTACHMENT A

Modeling of Ground-Water Contamination Caused by Organic Solvent Vapors

by Carl A. Mendoza[a] and Todd A. McAlary[b]

Abstract

Mathematical models are used to evaluate the potential for ground-water contamination resulting from vapor transport of volatile organic solvents in the unsaturated zone. A two-dimensional numerical model for density-driven flow and transport of vapors shows that trichloroethylene (TCE) vapors can be expected to spread rapidly from a residual source above an unconfined aquifer in an unsaturated, sandy deposit. Sensitivity analyses show that the shape of the vapor plume is particularly sensitive to the ground surface boundary condition and the material permeability. The shape of the vapor plume is insensitive to the mass flux by diffusion through the capillary fringe, although the flux may be significant in terms of ground-water quality because the drinking-water standard is very low. The vapor plume simulations and a plug-flow infiltration model are used to calculate a source function for a ground-water transport model in order to estimate the potential for ground-water contamination. Ground-water simulations show that an impermeable surface cover could reduce the flux of contaminants to the aquifer by preventing infiltration through the vapor plume. However, for the conditions modeled, significant ground-water contamination can be expected to occur regardless of whether the ground surface is covered or not. Contaminants can reach the saturated zone from a residual source either by liquid-phase diffusion through the capillary fringe or by migrating as a vapor beyond the lateral limits of a cover and subsequently dissolving and being flushed to the saturated zone by infiltration.

Introduction

Vapor transport in the unsaturated zone has an important influence on the fate of volatile organic compounds released into the subsurface. Schwille (1988) suggested that vapors from solvents may spread laterally by diffusion and density-driven advection in the unsaturated zone and lead to ground-water contamination; however, there are few quantitative analyses of the problem presented in the literature. An understanding of the transport processes involved is important for the determination of the extent of contamination and for the design of remedial measures.

Discrete solvent releases in the subsurface move primarily downward through the unsaturated zone, leaving behind a trail of liquid solvent which occupies a small fraction of the pore space. Although this residual solvent is immobilized by capillary forces, the contaminant may reach the saturated zone by dissolving in the soil moisture and being transported by infiltration, liquid-phase diffusion, or a fluctuating water table. Since infiltration is generally the most important of these processes, it is common practice in remedial programs to place an impermeable cover on the ground surface over the residual solvent to minimize ground-water contamination. Many hydrophobic organic solvents, however, will vaporize readily and migrate through the gas phase in the unsaturated zone, which constitutes an alternative pathway to the saturated zone. Dissolution of the vapors in the soil moisture creates an effective source of ground-water contamination which can spread so quickly that the liquid residual itself is soon insignificant by comparison (Sleep and Sykes, 1989). In these cases, a surface cover over the residual solvent alone may not provide adequate protection from ground-water contamination.

The objective of this study was to simulate the ground-water contamination resulting from vapor transport, dissolution, and infiltration for a hypothetical case where a residual solvent source occurs above the water table in a sandy unconfined aquifer. A two-dimensional finite-element model was used to simulate vapor transport of trichloroethylene (TCE) from a residual source in the unsaturated zone and to conduct sensitivity analyses for the influence of the ground surface and water-table boundary conditions and the permeability of the geologic material. The results of the unsaturated zone model were used to define a source for a ground-water transport model to evaluate the potential for ground-water contamination from spreading solvent vapors. The models were used collectively to simulate the effect of placing a low-permeability cover over a solvent spill site in an attempt to diminish the severity of ground-water contamination.

The rationale for choosing TCE as the compound was that it is one of the most common organic contaminants found in ground water. Since many other chlorinated solvents have properties similar to those of TCE, the general results of the study apply to many cases where volatile chlorinated solvents are accidentally released into the unsaturated zone.

The approach of using decoupled models for the unsaturated and saturated zones was chosen to give an acceptable balance between the accurate representation of the physical processes and the appropriate level of mathematical complexity justified for the hypothetical scenario being considered. Decoupling results in more efficient models since the spatial and temporal scales of transport in

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Discussion open until September 1, 1990.

the two zones are different. One-dimensional transport models have been developed by Weeks *et al.* (1982) and Baehr and Corapcioglu (1987), however, two dimensions are required to represent the lateral spreading of the vapors. The two-dimensional models of Abriola and Pinder (1985) and Baehr (1987) do not consider advection in the gaseous phase and so were not suitable for this study since density-driven advection may be important for chlorinated solvents. The model developed by Sleep and Sykes (1989), which considers advection and dispersion in both the gaseous and aqueous phases, was not available at the time of this study. Thus, a new model, based partly on that of Allan (1986), was developed to simulate the transport of vapors in the unsaturated zone. Existing flow and transport models were used for the saturated zone.

Mass Transport Modeling in Porous Media

The mathematical simulation of subsurface contaminant plumes is obtained by solving the partial differential flow and transport equations, subject to boundary and initial conditions. The general mathematical equations describing fluid and mass transport in granular materials are applicable to both the gaseous and aqueous phases (Bear, 1972). In this study, transport in the saturated and unsaturated zones was simulated separately since gaseous phase transport is restricted to the unsaturated zone and we assumed that aqueous phase transport dominates only in the saturated zone.

Some general assumptions were made which apply to the governing equations for both fluid phases. Chemical and biological transformations were not considered, so the results are restricted to compounds that are not degraded over the time scales of the simulations. The gas, liquid, and solid phases were all assumed to be essentially incompressible and under isothermal conditions. The temperature was chosen to be 20°C. Additional assumptions are discussed later.

Flow and Transport in the Unsaturated Zone

In the unsaturated zone, gas flow may result from pressure gradients or density gradients within the vapor plume. Pressure gradients due to vacuum extraction were not considered in this study and the effects of barometric pressure fluctuations were assumed to be negligible. Density gradients were considered as a function of molecular weight and vapor concentration relative to natural soil gas. Density flow can be modeled using the same mathematical formulation as for the density-dependent ground-water flow model presented by Frind (1982). To maintain numerical efficiency, an equivalent head (h^*) and relative density (ρ_r) may be defined:

$$h^* = \frac{P}{\rho_a g} + z \qquad \rho_r = \frac{\rho}{\rho_a} - 1 \qquad (1a,b)$$

where ρ is the density of the gas mixture, ρ_a is the density of uncontaminated air, P is the fluid pressure, and g is the gravitational constant.

In the absence of large pressure gradients, the gas phase may be assumed incompressible, and density is then a function of concentration only (Sleep and Sykes, 1989). The two-dimensional flow equation for the vapor phase is then:

$$\frac{\partial}{\partial x}\{k_x^* \frac{\rho_a g}{\mu}\frac{\partial h^*}{\partial x}\} + \frac{\partial}{\partial z}\{k_z^* \frac{\rho_a g}{\mu}(\frac{\partial h^*}{\partial z} + \rho_r)\} = S_s \frac{\partial h^*}{\partial t} \qquad (2)$$

where k_x^* and k_z^* are the principal directions of effective permeability (assumed to be horizontal and vertical), and μ is the gas mixture viscosity. In this study, the effective gas permeability is taken as being 80% of the intrinsic permeability. The specific storage is defined by:

$$S_s = \theta_g \rho_a g \gamma \qquad (3)$$

where γ is the macroscopic compressibility of the gas phase, and θ_g is the gas-filled porosity.

The unsaturated zone transport equation developed here ignores transport in the aqueous phase by assuming that the soil moisture is held motionless by capillary tension. This is reasonable if infiltration, evapotranspiration, and water-table fluctuations are negligible over the period of time represented by the vapor transport simulation. The vapor transport equation for static moisture conditions may be written as:

$$\frac{\partial}{\partial x}\{\theta_g(D_{xx}\frac{\partial c}{\partial x} + D_{xz}\frac{\partial c}{\partial z})\} + \frac{\partial}{\partial z}\{\theta_g(D_{zx}\frac{\partial c}{\partial x} + D_{zz}\frac{\partial c}{\partial z})\}$$
$$- v_x\frac{\partial}{\partial x}(\theta_g c) - v_z\frac{\partial}{\partial z}(\theta_g c) = \frac{\partial}{\partial t}(\theta_g R_v c) \qquad (4)$$

where c is the concentration, and v_x and v_z are the velocities. The vapor dispersion tensor is:

$$D_{ij} = \alpha_T |v| \delta_{ij} + (\alpha_L - \alpha_T)\frac{v_i v_j}{|v|} + D_a^* \delta_{ij} \quad (i,j = x,z) \qquad (5)$$

with α_L and α_T being the longitudinal and transverse dispersivities, respectively, and δ_{ij} is the Kronecker delta.

For nonreactive vapors in moist granular soils, Millington and Quirk (1961) showed that the effective diffusion coefficient (D_a^*) can be calculated from the free-air diffusion coefficient (D_a) using the relationship:

$$D_a^* = \frac{\theta_g^{7/3}}{\theta_t^2} D_a \qquad (6)$$

where θ_t is the total porosity.

The effects of sorption and dissolution reactions can be accounted for by using a vapor retardation factor of the form suggested by Weeks *et al.* (1982). The retardation factor for the vapor phase is then:

$$R_v = 1 + \frac{\theta_w}{\theta_g} K_h + \frac{\rho_b}{\theta_g} K_h K_d \qquad (7)$$

where K_h is the inverse dimensionless Henry's Law constant (mg/l liquid per mg/l gas), K_d is the solid-liquid partitioning coefficient (mg/g solid per mg/ml liquid), ρ_b is the bulk density of the soil, and θ_w is the water-filled porosity. The first term in (7) accounts for mass removed by dissolution into the soil moisture assuming two-phase equilibrium described by Henry's Law, the second term accounts for sorption onto the solids from the aqueous phase assuming a linear sorption isotherm. These phase transfer reactions are

assumed to be essentially instantaneous. This formulation is not valid for very dry soils where sorption increases dramatically and becomes strongly nonlinear (Chiou and Shoup, 1985), nor for highly advection-dominated situations where reaction kinetics should be considered (Johnson *et al.*, 1987). The geologic setting used here is expected to satisfy the above constraints, but more research is needed to determine the range of conditions under which these assumptions are valid.

Flow and Transport in the Saturated Zone

Ground-water flow was simulated at steady-state by neglecting temporal flow variations and the effects of the solvent on the physical properties of the aqueous solution. The solubility of TCE in water is low enough for the second assumption to be valid. In terms of hydraulic head (h), the two-dimensional steady-state flow equation for water in the saturated zone is:

$$\frac{\partial}{\partial x}(K_x \frac{\partial h}{\partial x}) + \frac{\partial}{\partial z}(K_z \frac{\partial h}{\partial z}) = 0 \qquad (8)$$

where K_x and K_z represent the principal directions of hydraulic conductivity.

For saturated transport, the advection-dispersion equation is:

$$\frac{\partial}{\partial x}(D_{xx} \frac{\partial c}{\partial x} + D_{xz} \frac{\partial c}{\partial z}) + \frac{\partial}{\partial z}(D_{zx} \frac{\partial c}{\partial x} + D_{zz} \frac{\partial c}{\partial z})$$

$$- q_x \frac{\partial c}{\partial x} - q_z \frac{\partial c}{\partial z} = \theta_w R_d \frac{\partial c}{\partial t} \qquad (9)$$

where R_d is the retardation factor for dissolved solutes, and q_x and q_z are the Darcy fluxes. The aqueous dispersion term is defined as:

$$D_{ij} = \alpha_T |q| \delta_{ij} + (\alpha_L - \alpha_T) \frac{q_i q_j}{|q|} + D_w^* \delta_{ij} \quad (i,j = x,z) \qquad (10)$$

where D_w^* is the effective aqueous diffusion coefficient.

Boundary and Initial Conditions in the Unsaturated Zone

The upper and lower boundary conditions for the unsaturated domain were modeled using theoretical methods of estimation for the boundary mass transfer coefficients. Since these estimation methods have not been verified experimentally, a sensitivity analysis was conducted for each boundary condition. The ground surface boundary was simulated as: (1) an impermeable boundary intended to represent a building foundation, pavement, or frozen ground, or (2) a permeable boundary with vegetative cover. The impermeable boundary was simulated by specifying zero gradients of head and concentration normal to the boundary. The permeable boundary was simulated using the boundary layer theory of Thibodeaux (1981). If a stagnant layer of air of thickness h_{gs} exists above the ground surface, the steady-state diffusive flux across the layer can be described by:

$$\theta_g D_n \frac{\partial c}{\partial n} - \theta_g v_n c = \frac{D_a}{h_{gs}} c_{gs} \qquad (11)$$

where c_{gs} is the vapor concentration at the ground surface boundary, D_n is the normal dispersion coefficient within the domain, v_n is the normal velocity within the domain, and n is the unit normal to the boundary. The concentration in the atmosphere is assumed to be zero. The head along the permeable boundary was constrained to correspond to constant atmospheric pressure.

The top of the saturated zone has been assumed to be impermeable to transport in most previous vapor models; however, a diffusive flux must be considered if a concentration gradient exists between the unsaturated and saturated zones. Assuming that the rate limiting mass transfer process is aqueous phase diffusion through a horizontal flow layer of thickness h_{wt} near the capillary fringe, the steady-state boundary flux can be described by an equation similar to that used by Weeks *et al.* (1982):

$$D_n \frac{\partial c}{\partial n} = \frac{D_w^*}{h_{wt}} c_{wt} \qquad (12)$$

where c_{wt} is the aqueous phase concentration at the top of the boundary layer. The concentration at the bottom of this boundary layer is assumed to be zero. Since this boundary is impermeable to gas flow, the head gradient was specified to be zero.

The initial condition for flow was a static air phase everywhere. For transport, zero concentration was specified everywhere but the source.

Numerical Method of Solution

The Galerkin finite-element method was applied using triangular elements and linear basis functions. Details of the method were presented by Wang and Anderson (1982) and Huyakorn and Pinder (1983). The vapor flow equation was solved using implicit time-weighting, while the vapor and aqueous transport equations were solved using the Crank-Nicolson time-weighting scheme. Stability and accuracy problems were controlled by satisfying the Peclet and Courant criteria (Daus *et al.*, 1985).

In the vapor model, the flow and transport equations are not independent because the velocities from equation (2) are required for the solution of equation (4), yet the velocities depend on the concentrations calculated from (4). An iterative solution was used therefore to solve repeatedly the flow and transport equations until the concentrations converged to within 0.001% of the source concentration between iterations. With TCE as the solvent, only two iterations were generally necessary, except at early times where three to five iterations were required because of high-density gradients.

Output from the vapor model was compared to simple linear analytical solutions of the diffusion and advection-dispersion equations to verify that the basic equations were being solved correctly. The conservation of mass was shown to be acceptable by mass balance calculations, which compared the mass input to the domain, to the difference between the mass stored within the domain and the mass transported across the boundaries. Experimental data that definitively exhibit density-driven advection do not yet exist (Sleep and Sykes, 1989), so the model could not be

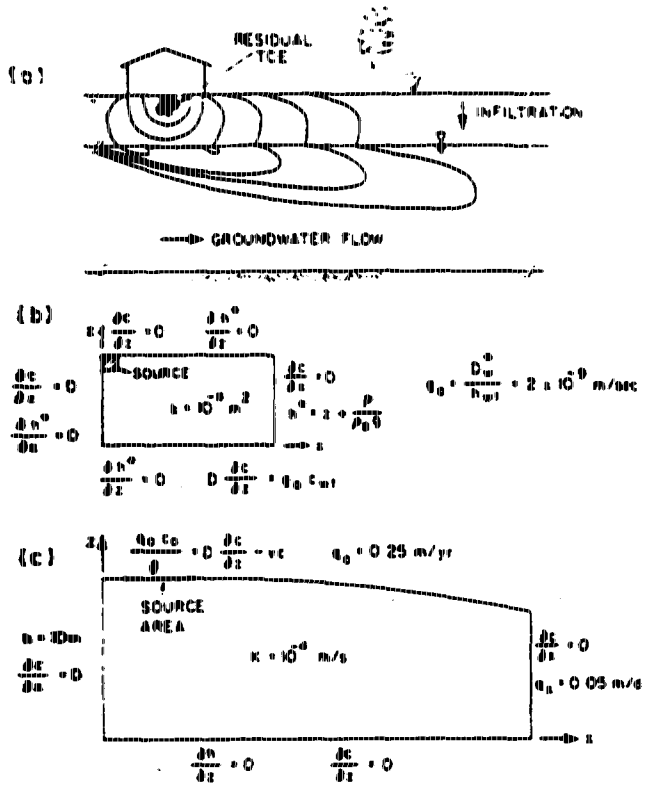

Fig. 1. (a) Schematic representation of hypothetical setting. Domain and boundary conditions for (b) the unsaturated zone base case, and (c) the saturated zone.

The ground-water flow equation was solved using a potential/stream function model (FLONETS) based on the dual formulation of flow (Frind and Matanga, 1985). Only a single solution of the flow equation was required for each simulation because the ground-water flow was assumed to be at steady-state. The transport equation was then solved using a general purpose solute transport model (FEMTRAN). These models, developed by E. O. Frind and E. A. Sudicky at the University of Waterloo, have been tested extensively and applied to a number of situations.

Physical Setting

The vapor and ground-water models were applied to a hypothetical geologic setting in a humid, temperate climatic region intended to be representative of south-central Canada or the northeastern United States. Although the models will accommodate heterogeneity and anisotropy, a simple setting of an unconfined aquifer in a homogeneous, isotropic, medium-grained, sandy deposit was considered sufficient to show the potential impact of vapor plumes on ground-water quality. A schematic representation of the setting, with postulated vapor and ground-water plumes, is shown in Figure 1 along with the domains and boundary conditions for the simulations. The physical properties for both domains are summarized in Table 1.

The soil moisture content throughout the unsaturated zone was assumed to be uniform at a field capacity of 6% of bulk volume. In reality, there is a transition zone of gradually increasing moisture contents above the saturated zone, but this was ignored here to avoid extremely small elements near the capillary fringe. Increased moisture contents near the bottom of the unsaturated zone would be expected to reduce vapor transport rates and increase mass partitioning to the aqueous phase.

The source of organic vapors was assumed to originate from a hypothetical surface spill of 200 l (approximately one barrel) of trichloroethylene (TCE) which spread out uniformly over a 1 m by 3 m area and infiltrated until it reached residual saturation. Assuming that the residual saturation was uniform at 15% of the pore volume, which is within the range reported by Schwille (1988) for medium sand, the residual liquid solvent would penetrate to a depth of 1.2 m. We assume that vaporization was fast enough so that the local soil gas was continually saturated with TCE vapors, and thus the vapor source would have a constant concentration of 7.9% (by volume) and a relative density (compared to air) of 1.3. The coexisting aqueous phase at equilibrium would be saturated with TCE at a concentration of about 1100 mg/l.

Results of Unsaturated Zone Modeling

The results of the vapor model are shown as plots of one-half of the unsaturated domain because of the symmetry about the residual solvent source. The fate of TCE was calculated for the half domain and is summarized in Table 2 for each of the vapor simulations. Mass balance errors were less than 0.01% of the vaporized mass.

The contours in Figures 2, 3, and 4 show the vapor concentration expressed as a fraction of the source vapor concentration (430 mg/l gas). From Henry's Law and the assumption of equilibrium between the gas and liquid phases, the vapor contours correspond to aqueous concen-

Table 1. Simulation Parameters

Unsaturated zone (base case)	
Effective permeability, k^*	8.0×10^{-12} m^2
Bulk-water content, θ_w	6%
Porosity, θ_t	30%
Bulk density, ρ_b	1.65 g/ml
Effective diffusion coefficient, D_a^*	3.2×10^{-6} m^2/s
Longitudinal dispersivity, α_L	1.0 m
Transverse dispersivity, α_T	0.1 m
Inverse Henry's constant, K_h	2.56
Partitioning coefficient, K_d	0.01 ml/g
Calculated retardation factor, R_v	1.8
Water-table diffusion thickness, h_{wt}	0.3 m
Domain dimensions	4 by 24 m
Domain discretization	11 by 31 nodes 600 elements
Saturated zone	
Hydraulic conductivity, K	1.0×10^{-4} m/s
Porosity, θ_t	30%
Effective diffusion coefficient, D_w^*	3.0×10^{-10} m^2/s
Longitudinal dispersivity, α_L	2.0 m
Transverse dispersivity, α_T	0.1 m
Assumed retardation factor, R_d	1.0
Domain dimensions	10 by 224 m
Domain discretization	21 by 71 nodes 2800 elements
Both zones	
Temperature, T	20°C

trations in the soil moisture as a fraction of the solubility. Although the drinking-water standard for TCE is about five orders of magnitude lower than the solubility, only the first three orders of magnitude are shown on the plots since numerical dispersion may cause significant errors at lower levels.

Base Case

The base case simulation shows the vapor plume development for the medium-grained sand deposit described in the previous section. It is intended to be used as a basis for comparing the results of the sensitivity analyses. It was also used to generate the source function for the ground-water zone modeling.

The base case vapor plume after 45, 90, and 135 days is shown in Figure 2. The shape of the base case plume is very similar to simulations conducted using a zero density gradient (see Figure 4) which indicates that diffusion is the dominant transport mechanism. The effect of density-driven advection is barely detectable, but it results in the contours extending slightly further from the source near the bottom of the domain. Again, it should be noted that vapor migration just above the water table would be expected to be slower than shown because of the increased retardation with increasing moisture content that was not accounted for in the simulations.

The base case simulations indicate that vapor transport can cause rapid spreading of contaminants from a residual solvent source in unsaturated sand. The source of potential ground-water contamination expands with the vapor plume since the vapors will dissolve into the local soil moisture and can be transported later to the saturated zone by aqueous-phase diffusion, infiltration, or a fluctuating water table.

Sensitivity Analysis

1. Ground Surface Boundary

The sensitivity analysis on the ground surface boundary condition shows the effect of natural venting to the atmosphere. The shape of the vapor plume after 135 days is shown in Figure 3 for the cases of an impermeable ground surface cover, a permeable ground surface with a thick boundary layer (h_{gs} = 1 m), and a permeable ground surface with a thinner boundary layer (h_{gs} = 25 cm). The thickness of the boundary layer of air above the ground surface corresponds to about two-thirds the height of the vegetative cover (Oke, 1978). For each of the permeable cases, the ground surface was modeled as being impermeable to a distance of 6 m from the source to show the effects of passive venting at the edge of a cover.

Both of the permeable ground surface simulations show that venting to the atmosphere can be an important attenuation mechanism for vapor plumes, although the effect diminishes with depth below the surface. An impermeable surface cover minimizes natural venting, thereby maximizing the areal extent of the effective source of ground-water contamination. Vapors will eventually spread beyond the limits of a surface cover where infiltration can transport dissolved contaminants to the water table, thereby counteracting the remedial effects of the surface cover.

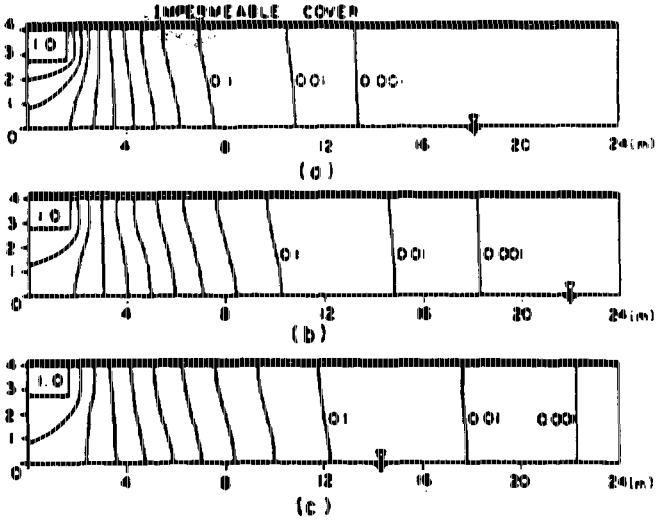

Fig. 2. Base case TCE vapor plume development: (a) 45, (b) 90, and (c) 135 days. Contours represent vapor concentrations relative to the source vapor concentration, or equivalently, soil moisture concentrations relative to saturation.

This study did not consider some factors which may affect the ground surface boundary flux. Barometric pressure fluctuations might increase vertical dispersion near the ground surface resulting in increased venting of TCE to the atmosphere. A rising water table would also increase venting to the atmosphere. Organic-rich soil layers near the ground surface would decrease venting through an increase in sorption. Similarly, sorption onto mineral surfaces has been shown to increase dramatically at very low moisture contents which can occur near the ground surface (Chiou and Shoup, 1985).

2. Water-Table Boundary

A sensitivity analysis on the water-table boundary condition was conducted to determine the effect of diffusion

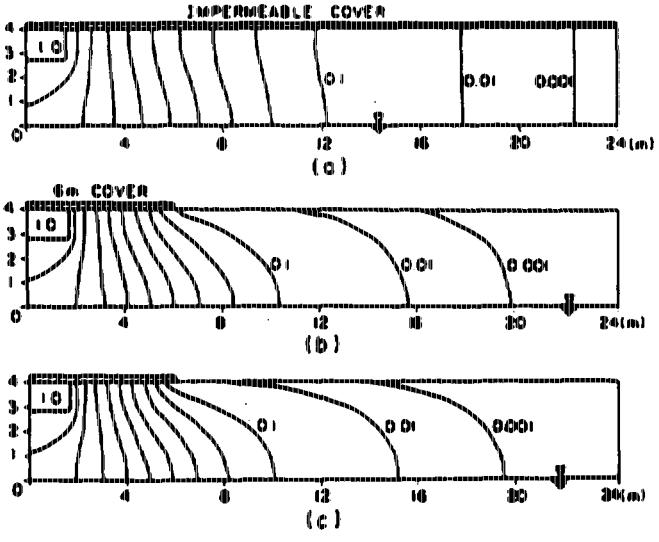

Fig. 3. Effect of the ground surface boundary condition on TCE vapor plumes after 135 days: (a) impermeable surface (base case), (b) a thick boundary layer (h_{gs} = 1.0 m), and (c) a thinner boundary layer (h_{gs} = 0.25 m).

Table 2. Mass Fate for Vapor Transport Simulations

Simulation	*Source vaporization (kg)*	*Vapor phase (kg)*	*Retarded phase (kg)*	*Atmospheric losses (kg)*	*Water-table losses (g)*
Base case:					
90 days	4.02	2.23	1.79	0.00	2.68
135 days	4.79	2.66	2.13	0.00	5.09
Ground surface sensitivity (135 days):					
h_{gs} = 1.0 m	5.05	2.12	1.70	1.24	4.76
h_{gs} = 0.25 m	5.15	2.03	1.62	1.50	4.68
Water-table sensitivity (135 days):					
h_{wt} = 3.0 m	4.79	2.66	2.13	0.00	0.509
h_{wt} = 0.03 m	4.81	2.56	2.12	0.00	50.5
Permeability sensitivity (90 days):					
Diffusion only	3.47	1.98	1.59	0.00	2.03
$k^o = 8 \times 10^{-11}$ m^2	7.55	4.19	3.35	0.00	7.34

Values are for the half domain, 1-m wide in the third dimension.

into the saturated zone. Vapor transport simulations were conducted with three different mass transfer coefficients which correspond to boundary layer thicknesses (h_{wt}) of 3, 30, and 300 cm. In all cases, the mass flux across the water table was small enough to have a negligible effect on the shape of the vapor plume; however, it might have a considerably more important effect on ground-water quality. The mass fate values in Table 2 confirm that there was little effect on the vapor plume, but the mass transported into the saturated zone by diffusion alone was between 0.5 and 50 g for the half domain after 135 days. This may be a considerable load since the U.S. EPA drinking-water standard for TCE is 5 μg/l. Ground-water contamination may therefore occur even in the absence of infiltration or water-table fluctuations. Thus, the water table should not be considered an impermeable boundary for contaminant transport from solvent vapors if ground-water contamination is the primary concern.

3. Material Permeability

The sensitivity analysis of material permeability shows the potential effects of density-driven vapor advection. The vapor plumes after 90 days are shown in Figure 4 for a pure diffusion case with density gradients removed, the base case, and a high-permeability case with an order of magnitude increase in permeability relative to the base case. The high-permeability material is equivalent to a clean coarse sand (aqueous hydraulic conductivity, $K = 10^{-3}$ m/s), whereas the material of the base case is equivalent to a clean medium sand ($K = 10^{-4}$ m/s).

Based on the similarity between the base case and the pure diffusion simulations, it is evident that molecular diffusion is the dominant vapor transport mechanism for TCE in a medium sand deposit. Advection becomes increasingly important as the permeability increases, although diffusion still dominates near the periphery of the vapor plume because the density gradient diminishes at lower concentrations. For chemicals whose vapor density is significantly different from air, subsurface vapor advection should be considered until it is shown to be negligible for the specific chemical and geological conditions. Models which neglect advection may underestimate the rate of vapor transport and fail to provide conservative estimates for the protection of ground-water resources.

Results of Saturated Zone Modeling

The saturated zone simulations show the effect of placing an impermeable cover on the ground surface over the residual solvent in an attempt to reduce ground-water contamination by controlling infiltration. In the first case, a 13-m long impermeable cover was placed over the center of the vapor plume, and infiltration was restricted to the uncovered areas. In the second case, the ground surface boundary was completely uncovered.

Ground-Water Flow

The steady-state ground-water flow model was used to calculate the velocities needed to solve the transport equation. The flow model solved iteratively for the position of the water table based on a prescribed head value of 10 m

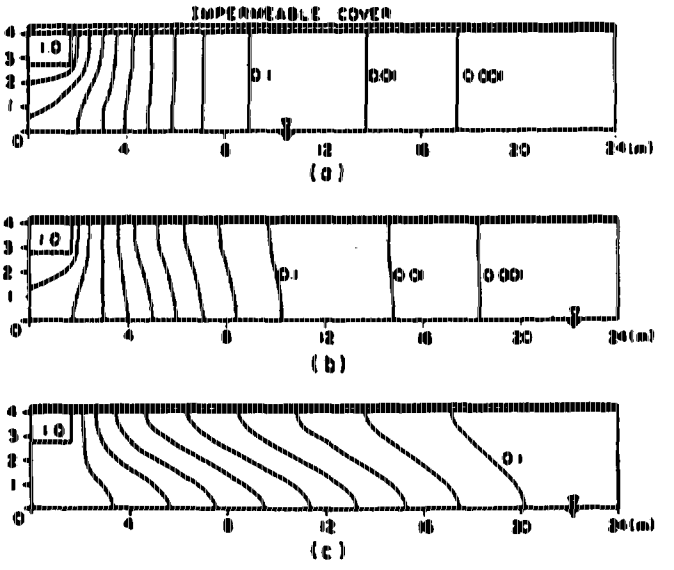

Fig. 4. Effect of density-driven advection on TCE vapor plumes after 90 days: (a) pure diffusion, (b) 8×10^{-12} m^2 permeability (base case), and (c) 8×10^{-11} m^2 permeability.

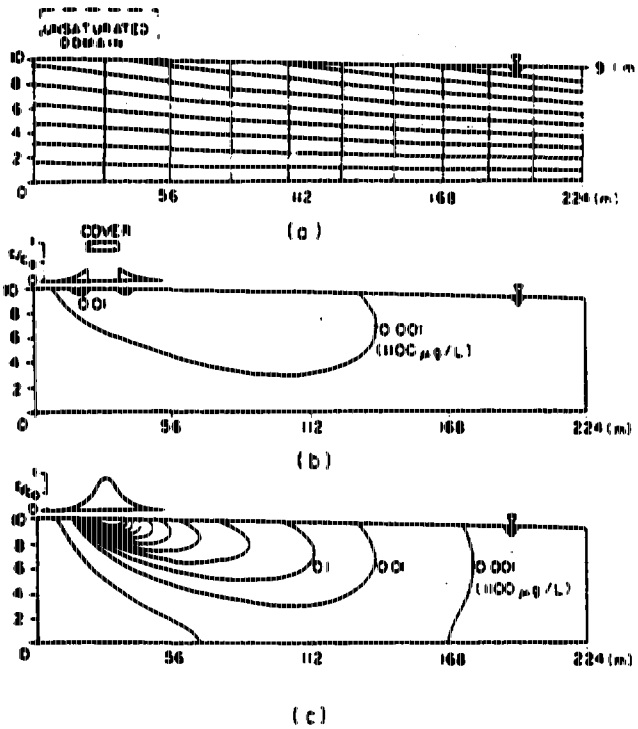

Fig. 5. (a) Saturated zone flownet for the uncovered case showing the location of the model domain for the vapor simulations. TCE ground-water plumes after three years and input concentration functions for (b) the covered case, and (c) the uncovered case. Contours represent aqueous concentrations relative to saturation (1100 mg/l).

on the left boundary and a prescribed Darcy flux of 0.05 m/d on the right boundary. The lower boundary was impermeable. Infiltration was considered constant at 25 cm/yr over the uncovered portions of the upper boundary. For both cases, the resulting horizontal velocities ranged from about 0.08 m/d (30 m/yr) near the left boundary to 0.14 m/d (50 m/yr) near the right boundary, and the elevation of the upper right corner of the domain was 9.12 m. Figure 5(a) shows the flownet for the uncovered case. The covered case flownet was very similar in appearance.

Ground-Water Transport

The input of TCE to the saturated zone was calculated using a simple plug-flow infiltration model. The mass flux was defined by multiplying the infiltration rate by the aqueous TCE concentration at the water table. The diffusive flux through the capillary fringe was considered to be negligible by comparison. For the covered case, the flux beneath the cover was specified to be zero. The aqueous concentration at the water table was selected from the base case vapor simulation at 135 days. The base case scenario was used since the concentration distribution at the water table was not particularly sensitive to the ground surface boundary condition. The time of 135 days was chosen so that the rate of net mass input by vaporization into the unsaturated zone was of the same order as the rate of mass removed by infiltration into the ground-water zone, a condition which would correspond to stabilization of the unsaturated zone plume. Although the actual concentration distribution at the water table changes over time, this snapshot was considered sufficient to show the effects of controlling infiltration through a vapor plume. The water-table concentration distributions used for each case are shown on Figures 5(b) and 5(c).

Figures 5(b) and 5(c) show the dissolved plumes after three years for the covered and uncovered cases, respectively. Since the contours represent aqueous concentrations relative to saturation, the outermost contour represents a concentration of 1.1 mg/l. This concentration is still several orders of magnitude greater than the U.S. EPA drinking-water standard of 5 μg/l, and thus, the zone of contamination actually extends for some distance beyond this outer contour. Limitations on the accuracy of numerical model simulations prevent a full description of the problem to concentrations as low as the drinking-water standard.

For these three-year simulations, the mass input to the ground-water zone for the uncovered case was 6.15 kg, whereas the input for the covered case was only 0.93 kg. While the extent of ground-water contamination is less severe in the covered case, infiltration beyond the limits of the cover still causes extensive ground-water contamination. Considering the low drinking-water standards for TCE, alternative remedial measures would be required if the aquifer was to be used for a drinking-water supply. Ground surface covers therefore should be considered only as a partial form of remediation for vadose zone solvent spills and should be supplemented with vapor control systems or alternative remedial strategies for maximum effectiveness.

Conclusions

Vapor transport and subsequent dissolution of volatile organics have been shown to be potentially important sources of ground-water contamination. For a spill of TCE in a permeable sandy material, a vapor plume will spread a few tens of meters through the unsaturated zone within a few months by molecular diffusion and possibly by density-driven advection. Phase transfer reactions will contaminate the soil moisture within the vapor plume and significantly increase the size of the potential source of ground-water contamination. The dissolved TCE may be transported to the saturated zone by infiltration, water-table fluctuations, or liquid-phase diffusion across the capillary fringe.

The ground surface boundary condition is a sensitive parameter for vapor transport. A permeable ground surface allows natural venting to the atmosphere which reduces the lateral extent of the unsaturated zone vapor plume; however, it also allows infiltration which can flush contaminated soil moisture into the saturated zone. An impermeable cover over the ground surface will reduce surface venting and increase the lateral migration of the vapor plume.

The water-table boundary should not be considered impermeable to mass transport when investigating the potential for ground-water contamination from solvent vapor plumes. Liquid-phase diffusion can cause a flux of volatile organics across the capillary fringe. The mass flux by diffusion alone is generally too small to affect the shape of the vapor plume; however, it may cause significant contamination in the ground-water zone.

Ground-water simulations demonstrate that a cover at the ground surface can greatly reduce the flux of solvent

mass to the saturated zone by preventing infiltration through the residual source and the concentrated regions of a vapor plume. However, because of infiltration beyond the limits of a surface cover and the low concentrations of concern, the reduction in mass flux does not lead to a comparable reduction in the size of the ground-water plume. Surface covers therefore are not considered to be effective remedial measures for the protection of ground-water quality.

Although the simulations presented here are for TCE, the results generally can be expected to apply to other volatile chlorinated solvents. Similar behavior is expected since many other solvents have high vapor pressures and Henry's constants, which favor vapor phase transport in the unsaturated zone. In addition, small amounts of solvent can contaminate large volumes of ground water to undesirable levels because drinking-water standards are generally very low. For example, 1,1,1-trichloroethane, which has a Henry's constant twice that of TCE, will migrate faster in the unsaturated zone. Dichloromethane has a Henry's constant that is one-quarter that of TCE, so migration will be slower; however, its high solubility will place large amounts of mass in the soil moisture that can then be transported to the ground-water zone.

More research is required in order to more fully understand the processes by which aquifers can become contaminated through vapor transport. In particular, experimental data are necessary to validate the theoretical basis for the density-driven advection of vapors, and additional chemicals and geological settings should be investigated.

Acknowledgments

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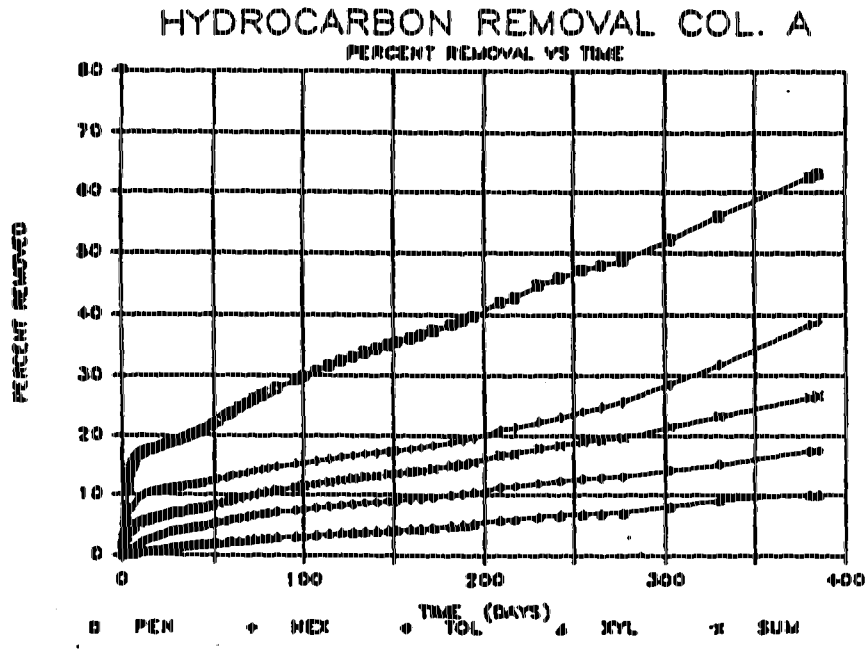

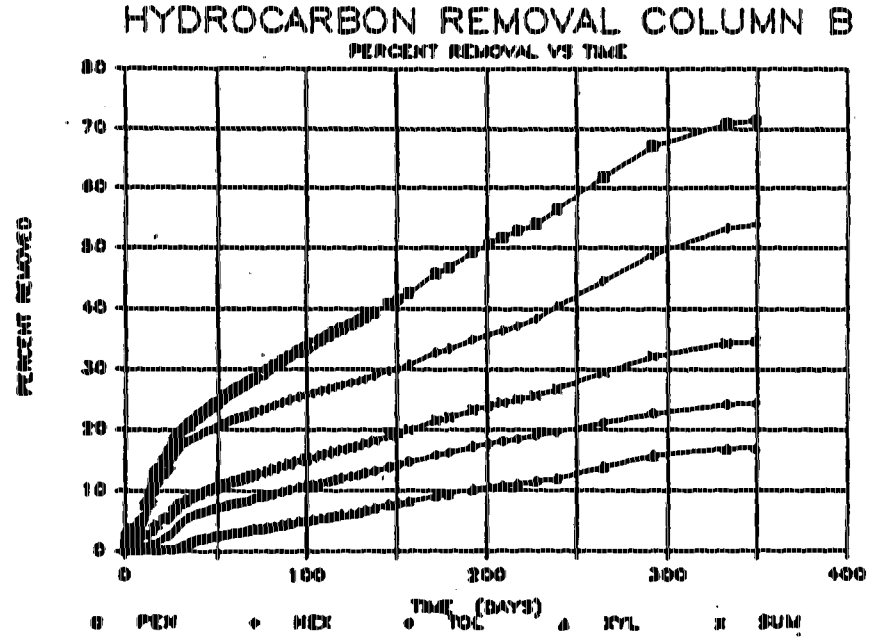

Figure 3. Hydrocarbon Removal Results through August 31, 1988

LARGE-SCALE LABORATORY EXPERIMENTS FOR FORCED AIR VOLATILIZATION OF HYDROCARBON LIQUIDS IN SOIL

Ken Rainwater, Billy J. Claborn, Harry W. Parker,
Douglas Wilkerson and Mohammad R. Zaman

Texas Tech University Water Resources Center
Lubbock, Texas

ABSTRACT: The process of in situ volatilization of liquid hydrocarbon pollutants has been and continues to be applied successfully at field sites around the country. The technique utilizes air vacuum wells which remove hydrocarbon vapors from the subsurface, and may also include air injection wells to complete the flow circuit. Current design practice for these systems consists of pilot-scale operation in a small portion of a polluted site to establish operational parameters, followed by scaling up the process to restore the entire site. Little work has yet been done to describe the volatilization mechanisms in porous media for development of an accurate model for design of these systems. Use of field data for this purpose is limited due to lack of control of initial and boundary conditions. This research project was formulated to answer this need. Two soil columns, 10 feet in height by 3 feet in diameter, were assembled and filled with a fine sand. The moisture content of the sand was set at field capacity. A mixture of pentane, hexane, toluene, and xylene was used to represent a petroleum fuel. The hydrocarbon mixture was introduced to set an initial condition in the unsaturated zone with residual water and hydrocarbons. Forced radial air flow was caused by a vacuum pump connected to a well in the center of each column. Bulk liquid movement was monitored with gamma density measurements, and hydrocarbon on concentrations in the removed air were analyzed by gas chromatography. This paper provides a report of the removal data and description of preliminary modeling efforts.

INTRODUCTION

Restoration of contaminated groundwater sites is a major current environmental concern. Infiltration of organic

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Evaluation of Sampling Method Effects on Volatile Organic Compound Measurements in Contaminated Soils

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An experiment was conducted to evaluate the effects of sample disturbance, container headspace volume and integrity, and sample preservation on volatile organic compound (VOC) measurements in contaminated soil. A sandy soil was contaminated under controlled conditions at 10 °C by an aqueous solution containing six target VOCs: methylene chloride (157.5 mg/L), 1,2-dichloroethane (130 mg/L), 1,1,1-trichloroethane (16 mg/L), trichloroethane (12.8 mg/L), toluene (4.5 mg/L), and chlorobenzene (2.85 mg/L). Replicate soil samples were then collected by different methods at an air temperature of 20 °C. For all VOCs, the highest concentrations were measured in undisturbed soil samples immediately immersed in methanol in Teflon-sealed glass bottles. With these measurements as a reference, the relative negative bias was highest for container integrity (up to 100%) and lack of methanol immersion (up to 81%) and considerably lower for container headspace volume (up to 17%) and soil disturbance (up to 15%). The potential for negative bias appeared to be correlated with the VOC soil sorption affinity (i.e., low K_h and high K_{oc}). For accurate measurements of the more volatile compounds, rigorous sampling procedures are necessary.

Introduction

Volatile organic compounds (VOCs) such as trichloroethylene and toluene are present in diverse products found throughout society and are commonly among the controlling contaminants in site remediation projects. Since decisions regarding the significance of contamination and the extent of cleanup have far-reaching effects, it is essential that they be based on accurate measurements of the VOC concentrations present. Unfortunately, this is difficult to achieve as the sampling process is subject to numerous sources of random and systematic errors. Sample collection and handling activities can contribute relatively large errors compared to the analysis itself (*1*). Of these, negative bias (i.e., measured value less than true value) is perhaps the most significant and most difficult to delineate and control. This error is principally caused by volatilization losses during soil sample collection, storage, and handling.

There are currently no standardized procedures for sampling soils for VOC analyses. In the United States, disturbed soil samples are often containerized in Teflon-sealed glass jars and refrigerated at 4 °C. However, practical experience and some recent field research has suggested that simple procedures such as these may lead to substantial error when sampling soils for VOCs and alternative procedures are now being promoted (*2*). Yet controlled research has so far been limited, due in part to a lack of a methodology for effective analysis of this problem. In the experiment described herein, a methodology was developed and used to determine the VOC measurement effects of several key sampling method attributes. This paper presents a synopsis of this research while details may be found elsewhere (*3*).

Experimental Methods

Experimental Approach. To enable the evaluation of sampling method effects, it was necessary to have a volume of soil uniformly contaminated with VOCs. Due to anticipated problems with uncontrolled field conditions, an experimental approach was conceived which include a laboratory soil column contaminated by VOCs during saturated upflow of an aqueous solution containing a number of target compounds. After desaturation and equilibration, sampling the column by methods with different attributes would enable determination of their relative effects on VOC measurements. The attributes chosen for evaluation were sample disturbance, sample container headspace volume and integrity, and sample preservation.

Column Apparatus. Soil for this experiment was collected from the upper 50 cm of a glaciofluvial deposit near Myren, Norway. The field moist soil was sieved (4-mm mesh) and then a composite sample was characterized as a sand (USDA texture) with 1% silt plus clay content, an ambient water content of 8.6% (dry weight basis), pH of 5.21, organic carbon content of 0.44% (dry weight basis), and cation exchange capacity of 4.0 meq/100 g (*4, 5*).

Each of two glass columns (one control and one test column) was packed with 3.6 kg of moist soil yielding moist bulk density of 1.64 g/cm^3, total porosity of 43.5%, and a water filled porosity of 32% of total porosity (Figure 1). Each column was scanned with a computer-assisted X-ray tomograph (Siemens Somatom 2) to determine spatial uniformity as measured by relative density (i.e., density relative to water) (*3, 6*). The tomography analyses (visual and quantitative) revealed no spatial heterogeneities that would confound the interpretation of the experimental results.

The target VOCs were methylene chloride (MC), 1,2-dichloroethane (DCA), 1,1,1-trichloroethane (TCA), trichloroethylene (TCE), toluene (TOL), and chlorobenzene (CB) (Table I). The VOC concentrations in the column feed solution were selected to saturate the VOC retention capacity of the soil column at a likely cleanup action level (e.g., 1–10 μg/g) with a workably small volume of feed solution (e.g., <20 L). The appropriate VOC concentrations were established by an iterative analysis involving consideration of the soil column characteristics and a series of empirical relationships for VOC distribution between the soil liquid, vapor, and solid phases (*3, 7–9*). Based on this analysis, the VOC concentrations chosen for the feed solution were as follows: [MC] = 200 mg/L, [DCA] = 125 mg/L, [TCA] = 25 mg/L, [TCE] = 20 mg/L, [TOL] = 7.5 mg/L, and [CB] = 5.0 mg/L. These concentrations were inversely proportional to the soil sorption potential and ca. 1–2% of the VOC water solubilities (Table I). The feed

* Oak Ridge National Laboratory (ORNL).

† Institute for Georesources and Pollution Research.

‡ Operated by Martin Marietta Energy Systems, Inc., under Contract DE-AC05-84OR21400 with the U.S. Department of Energy. Publication No. 3543, Environmental Sciences ORNL.

Table I. Characteristics of the Target VOCs[a]

characteristics	compound					
	MC	DCA	TCA	TCE	TOL	CB
MW	84.9	99.0	133.4	131.5	92.1	112.6
specific gravity, g/cm^3	2.32	1.25	1.35	1.46	0.87	1.11
water solubility (10 °C), g/L	11.09	10.55	1.40	1.50	0.58	0.41
water solubility S_w (10 °C), mol/L	0.131	0.107	0.0105	0.0114	0.0062	0.0036
molar vol V, L/mol	0.064	0.079	0.099	0.090	0.105	0.101
vp (20 °C), mmHg	349	61	100	60	22	8.8
K_{ow}, mL/g	17.8	30.2	148	195	490	692
K_h (10 °C)	0.060	0.050	0.415	0.232	0.164	0.105
K_{om}, mL/g	4.96	4.92	27.1	27.4	39.6	63.6
K_d, mL/g	0.036	0.036	0.197	0.199	0.288	0.463
RF	1.12	1.12	1.68	1.68	1.99	2.59

[a] Data and empirical relationships from refs 13–15: K_{ow}, octanol/water partition coefficient, mL/g; K_h, Henry's law constant, dimensionless; log K_{ow} = −0.813 log ($S_w V$) − 0.993; K_{om}, organic matter partition coefficient; soil distribution coefficient, $K_d = 1.72 f_{oc} K_{om}$, with fractional soil organic carbon content, f_{oc} = 0.00423; retardation factor, RF = 1 + $K_d(\rho_b/\theta)$ with dry bulk density, ρ_b = 1.5, and volumetric water content, θ = 0.436.

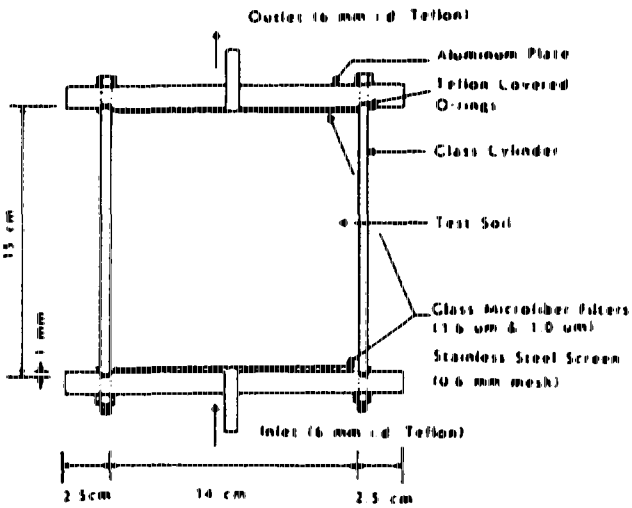

Figure 1. Characteristics of the soil column apparatus.

solution volume required to saturate the VOC retention capacity was, in every case, estimated to be less than 3 pore volume (PV) equivalents.

The feed solution was prepared by diluting stock solution containing the six target VOCs (1000×, ethanol matrix) in "reconstituted freshwater" (RFW) (*10*). The RFW, prepared by adding salts to distilled water (96 mg/L $NaHCO_3$, 60 mg/L $CaSO_4 \cdot 2H_2O$, 60 mg/L $MgSO_4$, 4.0 mg/L KCl), had a pH of 7.0 and specific conductance (EC) of 290 μS/cm.

The test soil column was connected to the rest of the experimental apparatus in a laboratory at 10 °C (Figure 2). Then ca. 25 mL of the VOC stock solution was added to the RFW in the feed reservoir and the two gas-washing reservoirs. After mixing for ca. 1 h, 1 L of solution from the feed reservoir was used to fill the two, 0.5-L gas washing bottles. Tritiated water (5 mL) was next added to the feed reservoir as a hydraulic tracer (feed concentration 170 Bq/mL). Following a few minutes of mixing, flow through the test column was initiated. After initial saturation, 15 PVs of feed solution was passed through the column at a hydraulic gradient of ca. 1.5. The column was then desaturated under a tension of approximately 50 cm with the pore replacement gas derived from the gas-washing system. After drainage ceased (<1 h), the colur was sealed and allowed to equilibrate at 10 °C overnig.. (ca. 17 h) prior to soil sampling. The control soil column was treated in a similar fashion, except the target VOCs and tritiated water were not added to the RFW feed solution and the control column run occurred the day preceding the test column run.

Sample Collection and Analyses. During contamination of the test column, samples of the feed and outflow solutions were collected periodically. Following contamination, desaturation, and equilibration, the test column was partially embedded (50% of length) in ca. 10 kg of 10 °C soil to provide support and maintain the soil temperature during sampling. The column was then moved from the laboratory at 10 °C to one at 20 °C to simulate field conditions where cool soil is removed into a warmer am-

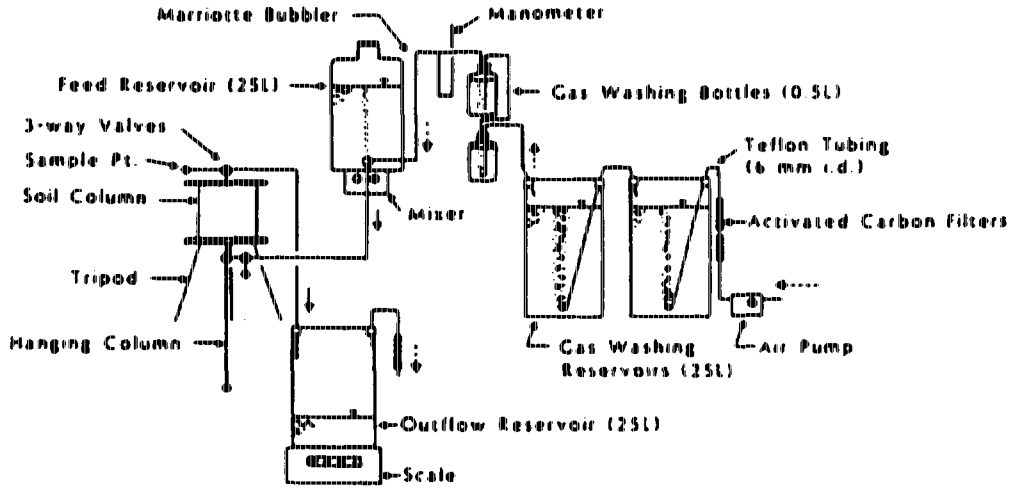

Figure 2. Soil column flow system apparatus.

Table II. Characteristics of the Soil Sample Collection Methods

A. undisturbed samples in glass bottles with high headspace (A, A′)
1.6 cm i.d., 10 cm long core (ca. 17 mL, 29 g) extruded directly into a Teflon-sealed glass bottle (128 mL) with headspace volume of ca. 85% of container volume

B. undisturbed samples in glass bottles with low headspace (B, B′)
3.0 cm i.d., 10 cm long core (ca. 75 mL, 125 g) extruded into a Teflon-sealed glass bottle (128 mL) with headspace volume of ca. 40% of container volume

C. undisturbed samples immersed in methanol in glass bottles (C, C′)
3.0 cm i.d., 10 cm long core (ca. 75 mL, 125 g) extruded into a Teflon-sealed glass bottle (250 mL nominal, 300 mL actual) with 100 mL of reagent grade methanol added and headspace volume of ca. 40% of container volume

D. disturbed samples in glass bottles with low headspace (D, D′)
3.0 cm i.d., 10 cm long core (ca. 75 mL, 125 g) emptied in 7–10 aliquots with a stainless steel spoon and deposited into a Teflon-sealed glass bottle (128 mL) with headspace volume of ca. 40% of container volume

E. disturbed samples in empty plastic bags with low headspace (E, E′)
soil sample (ca. 40 mL, 70 g) removed directly from the column in 7–10 aliquots with a stainless steel spoon and deposited into a laboratory-grade plastic bag (12 × 18 cm, 0.5 L nominal) with zip closure and headspace volume of ca. 40% of container volume

bient air temperature environment. The column top was removed and replaced with a sampling template to maintain the centerpoint of each sampling location at the same radius within the column. Duplicate soil samples were then collected at diametrically opposite positions within the column according to the methods described in Table II. All of the stainless steel sampling tubes were inserted simultaneously with the tops covered with aluminum foil. Then the samples were collected sequentially in a clockwise fashion (A to E, A′ to E′), with each sample containerized and refrigerated prior to collecting the next sample. Each sample was collected with separate, precleaned utensils and bottles (all at 20 °C). The first sample from the test column (A) was collected 6.2 min after removal of the column top plate, while the last sample (E′) was collected 10.3 min later. Samples for soil water content and organic carbon content were then collected from each column at 0–5 and 5–10 cm depth increments at two (test column) or three (control column) horizontally separate locations.

Solution samples were analyzed for pH, specific conductance, tritium, and the six target VOCs. Analyses for pH and specific conductance were made onsite electrometrically. Tritium was determined by liquid scintillation counting of a 1-mL subsample. Analyses for each of the target VOCs were made by extraction and gas chromatography (GC). A subsample (4.0 mL) of each solution sample was spiked with 40 μg of bromotrichloromethane as an internal standard and then extracted with 4 mL of pentane. The pentane extract was recovered and dried with sodium sulfate prior to GC analysis. Analyses of the four halocarbons were made using a GC apparatus (Hewlett-Packard Model 5730) equipped with a 60 m long, 0.25 mm i.d. J&W fused-silica capillary column and an electron capture detector (^{63}Ni). Analyses of the two aromatics were made on a GC apparatus (Hewlett-Packard Model 5890) equipped with a 30 m long, 0.32 mm i.d. J&W fused-silica capillary column and interfaced with a mass selective detector (5970 series) operated in the single-ion-monitoring mode. For all GC runs, the injection volume was 2 μL.

Soil samples were analyzed for soil water content, total organic carbon, and the target VOCs. Soil water content was determined gravimetrically and total organic carbon content was determined by dry combustion. VOC analyses of soil samples A, A′, B, B′, D, D′, E and E′ were made as follows. The refrigerated soil sample was homogenized in the sample container and a weighed amount (10 g) was transferred to a test tube. After addition of 40 μg of the internal standard, the soil was extracted with a mixture of 10 mL of 2-propanol and 4 mL of pentane. The solvent mixture was transferred to a small separatory funnel, and the extraction was repeated with 5 mL of 2-propanol and 4 mL of pentane. The extracts were combined, and the pentane phase was isolated by extraction with deionized water. The pentane extract was washed with 2 mL of water and dried with sodium sulfate prior to gas chromatographic analyses as described above. The water content of each sample was determined on a separate aliquot of soil and VOC concentrations were expressed on a dry soil basis. The analytical detection limits (μg/g) were as follows: [MC] = 0.4, [DCA] = 0.1, [TCA] = 0.01, [TC = 0.004, [TOL] = 0.05, and [CB] = 0.01.

VOC analyses of samples C and C′ (both immersed in methanol) were made differently. The methanol/soil sample was mechanically shaken for 20 min and settled for 30 min, after which an aliquot of the methanol was removed and centrifuged at 3000 rpm for 5 min. A 4.0-mL sample of the methanol phase was then spiked with 40 μg of the internal standard, 2.0 mL of water and 2.0 mL of pentane were added, and the mixture was shaken. The pentane phase was removed and the extraction repeated. The two pentane extracts were combined and washed with 2 mL of deionized water and then dried with sodium sulfate prior to GC analyses as above. The VOC results were converted to a dry soil basis. The analytical detection limits (μg/mL) were as follows: [MC] = 0.1, [DCA] = 0.05, [TCA] = 0.005, [TCE] = 0.002, [TOL] = 0.04, and [CB] = 0.03.

For quality control purposes, all reagents were glass-distilled or GC grade and the sodium sulfate was heated at 550 °C overnight. All reagents were stored at 4 °C. All glassware was precleaned by washing, rinsing with deionized water, and drying overnight at 550 °C. VOC analyses of the 2-propanol and pentane revealed trace concentrations of TCA, TCE, and TOL, but no MC, DCA, or CB. These trace concentrations were near the analytical detection limits and were subtracted from all sample analyses. Soil samples collected from the control soil column by methods A, B, and C revealed no detectable concentrations of the target VOCs. Analyses of clean soil and the methanol used for infield preservation similarly yielded no detectable target VOCs. A sample of the clean soil was spiked with the target VOCs and analyses revealed the following recoveries: [MC] = 77%, [DCA] = 73%, [TCA] = 100%, [TCE] = 112%, [TOL] = 115%, and [CB] = 95%. Replicate analyses were made on ca. 50% of the soil samples, revealing negligible differences in the concentrations measured for each respective sample.

During preanalytical holding, all samples were stored at 2–4 °C. During all analyses, the samples and extracts were kept in ice baths. All samples for VOC analyses were extracted within 14 days of sample collection. GC analyses were completed within 48 h of the extractions.

Results and Discussion

Column Dynamics. The test column was initially saturated by upward flow. Then saturated upflow oc-

Table III. VOC Concentrations As Measured by Different Sampling Methods[a]

	Sampling Method[b]						
	E	A	D	B	C		
disturbance	yes	no	yes	no	yes		
headspace	low	high	low	low	low		
container	bag	glass	glass	glass	glass		model
methanol	no	no	no	no	yes	LSD[c]	estimate (3)
MC, μg/g	<0.4	1.75	6.10	4.90	7.2	6.66	24.5
DCA, μg/g	<0.1	5.15	5.15	6.70	18.72	1.14	22.6
TCA, μg/g	<0.01	0.20	0.28	0.36	1.87	0.08	6.6
TCE, μg/g	0.01	0.32	0.42	0.55	2.27	0.136	4.7
TOL, μg/g	0.06	0.37	0.39	0.49	0.70	0.062	1.7
CB, μg/g	<0.01	0.56	0.58	0.69	0.76	0.072	1.5

[a] The values shown are averages of single analyses of duplicate samples. [b] Refer to Table II for a description of each sample method. [c] LSD (95%), least significant difference at 95% confidence level.

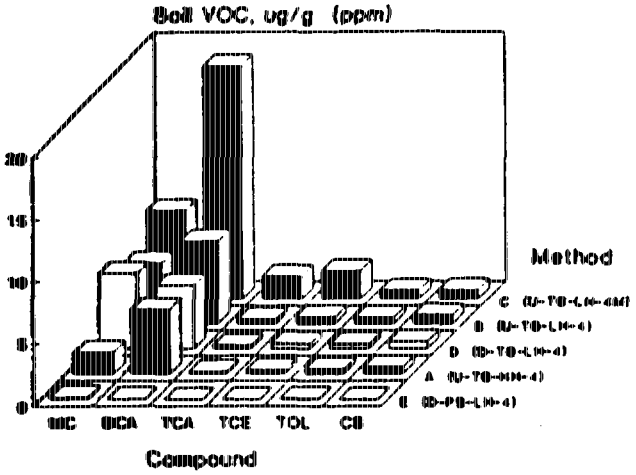

Figure 3. Average concentrations of soil VOCs as a function of sampling method. (See Table II for sampling method descriptions and Table III for numerical results.)

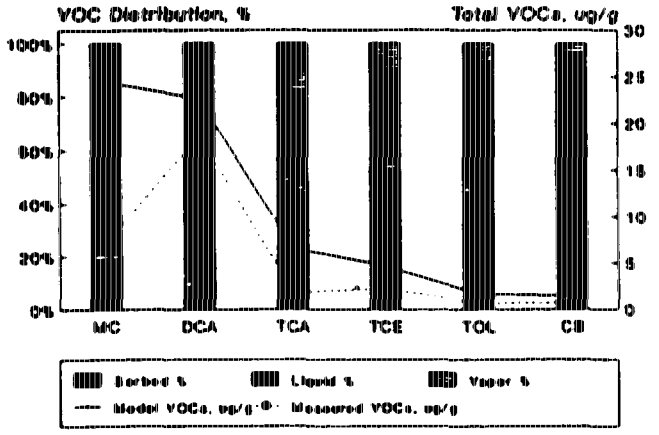

Figure 4. Model-estimated VOC concentration and phase distribution within the test column and the highest VOC concentration measure (i.e., by method C with methanol immersion).

curred over a 2.5-h period at a flux of 870 cm/day, yielding an average hydraulic retention time in the column of ca. 10.4 min. The results of the tritium tracer study indicated that the feed solution both bypassed and mixed with the soil pore water in the initially unsaturated column. For the test column, by 1.1 PVs of outflow (1.8 PVs of column feed) the outflow to inflow ratio (C_o/C_i) approached unity (0.96). The final concentrations of the target VOCs in the feed solution (mg/L) were as follows: [MC] = 157.5, [DCA] = 130, [TCA] = 16, [TCE] = 12.8, [TOL] = 4.5, and [CB] = 2.85. As predicted, there was little retardation of the target VOCs within the sandy soil under the conditions of this experiment. By three PVs of outflow, the VOC concentrations in the outflow solution were substantially similar to those in the feed solution (i.e., 84–106%).

Soil water content analyses indicated an increasing water content with depth in the test soil column, but similar results at horizontally separate spatial locations. The water content trend with depth (9.6% at 0–5 cm to 12.3% at 5–10 cm) is probably due to moisture drainage and redistribution following the contamination phase. The total organic carbon content was consistent regardless of depth or location [average 0.423% (dry weight basis); SD = 0.015%; n = 4].

Soil Sampling Method Effects. The soil samples collected by the different sampling methods yielded markedly different soil VOC concentrations (Figure 3, Table III). An analysis of variance revealed that sampling method had a significant effect on the determinations of all six VOCs. The effects were highly significant (p > 99.5%) for all VOCs but MC (p = 75%). The lack of a highly significant effect for MC may have been due in part to sample replicate variability as well as the analytical difficulties often associated with quantitation of this compound.

The undisturbed soil samples collected with infield immersion in methanol (method C) consistently yielded the highest VOC concentrations. However, even these concentrations were only 28–83% of the model-estimated soil-associated concentrations at the time of sampling (Figure 4). This discrepancy may be due to some undefined negative bias due to volatilization losses during soil column exposure and sample collection. Error due to sample storage and laboratory subsampling would presumably be limited due to the methanol immersion, as would measurement error associated with irreversible sorption. Alternatively, the estimates of VOC retention may have been too high due to inaccuracies in the empirical VOC distribution relationships used or due to the absence of equilibrium conditions due to the high flux of contaminant solution. The above discrepancies illustrate the difficulties in accurately predicting soil-associated VOC concentrations, even in a relatively simple soil system.

Given that the highest concentrations measured may have deviated from the "true" value by an appreciable but unknown negative bias, it was still possible to make comparisons of the relative negative bias associated with different sampling method attributes. This was done by using the highest measured concentration as a reference (i.e., method C) and comparing sampling methods with different attributes (methanol equals method B vs C; soil disturbance equals method D vs B; headspace volume

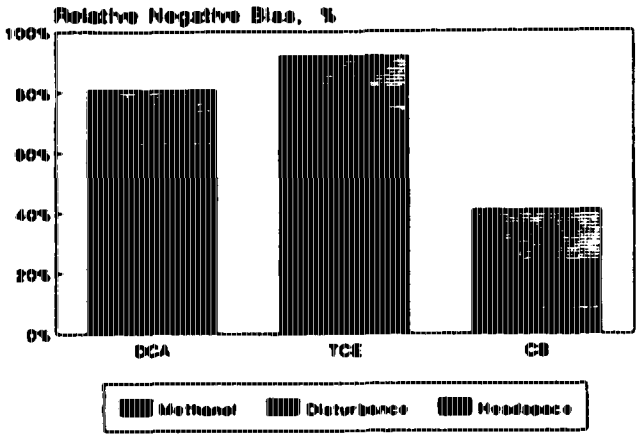

Figure 5. Relative negative bias associated with sampling method attributes. (Relative negative bias is computed with the VOC concentration in the sample immersed in methanol as a reference.)

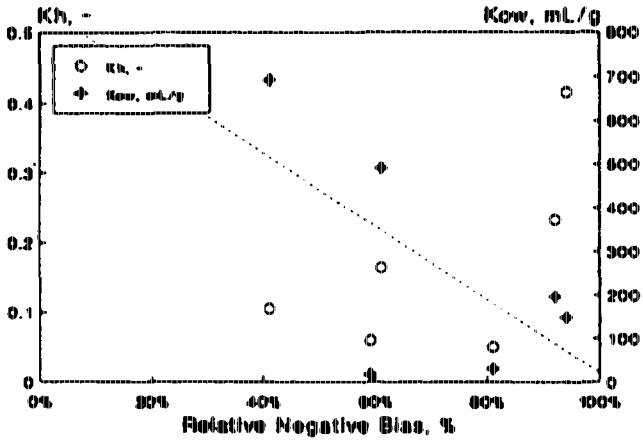

Figure 6. Relative negative bias as a function of VOC properties: Henry's law constant (K_h) and octanol/water partition coefficient (K_{ow}).

equals method A vs B; container integrity equals method E vs D). By this analysis, for soil samples containerized in Teflon-sealed glass jars, the relative bias contributions were highest for lack of infield immersion in methanol (up to 81%), followed by considerably lower contributions by headspace volume (up to 17%) and soil disturbance (up to 15%) (Figure 5). For soil samples containerized in plastic bags there was substantial relative negative bias (up to 100%). In general, sampling bias declined with increasing soil sorption affinity of the target VOC (i.e., lower Henry's constant, K_h, and higher distribution coefficient, K_d) (Figure 6). For example, the relative bias for TCA was considerably higher than that for CB.

The principal mechanism underlying the sampling method effects observed is believed to be volatilization. For all sample collection methods, there was likely some negative bias associated with column exposure and sample collection. Additional bias during storage and laboratory subsampling would be minimized in samples immediately immersed in methanol (i.e., method C). Additional negative bias in undisturbed samples containerized in Teflon-sealed glass jars without methanol (method B) was likely due to a combination of volatilization losses during storage and subsampling in the laboratory. Additional bias was caused by increasing soil disturbance and headspace volume (methods D and A), attributes that would enhance volatilization losses. The substantial negative bias associated with collection of a disturbed sample in the plastic bag (E) was probably exacerbated by sorption and vapor leakage through the polyethylene bag during preanalytical holding.

The research results indicating enhanced VOC recoveries with methanol preservation are consistent with those reportedly recently by Urban et al. based on field experience with TCE and 1,1-dichloroethene (*2*). These investigators found that VOC concentrations in soil samples collected from a standard split-spoon sampler and containerized in 40-mL VOC vials with Teflon-lined caps typically were only 20% or less of those measured in split samples immediately immersed in methanol in glass bottles with Teflon-lined caps. The research results suggesting VOC losses from samples stored in plastic bags are supported by data of Slater et al., which indicated substantial leakage of TCE through multiple polyethylene bags used to encase soil samples contained in Teflon-sealed glass vials (*11*). For all methods, transformation losses during preanalytical holding were probably low, based on recent research where good stability was observed for VOCs in water samples during holding at 4 °C for up to 28 days (*12*).

Practical Implications. It is clear that standardized procedures are needed that account for the special properties and behavior of VOCs in soils. However, procedures must also account for the difficult situations in which samples are often collected (e.g., wet/cold weather, dirty/dusty environments, high hazard locations) and the costs associated with sample collection. Ideally, standardized procedures should provide for an acceptable accuracy and precision by a sample collection process that is as workable and efficient as possible. There are a wide variety of sample collection procedures currently in routine use, others being promoted, and still others under development. These include procedures employing basic soil-sampling concepts as well as those based on more sophisticated materials and methods (e.g., specialized mini-core extractors, infield containerization in special purge and trap vessels, or infield solvent immersion). Adoption of standardized procedures, particularly if they involve complicated and costly apparatus and methods, should ideally be based on scientific evidence justifying the need. The research described conducted herein has provided the following practical information toward this goal.

Collection of soil samples with containerization in plastic bags is unacceptable where analyses for VOCs are intended. Containerization in a Teflon-sealed glass jar is workable and appropriate, but decisions regarding sample disturbance, headspace volume, and infield methanol preservation appear subject to considerations associated with target VOC properties and contamination levels. For analyses of VOCs with relatively high soil sorption affinities (e.g., CB), collection of a disturbed sample with containerization in a Teflon-sealed glass jar and refrigeration at 4 °C would usually provide an accuracy similar to that of more complex methods. For such samples, equally accurate results are produced by collecting a disturbed sample and completely filling a sample container as by collecting an undisturbed sample that yields a high headspace volume in the container. For analyses of VOCs with relatively low soil sorption affinities and particularly where concentrations are anticipated in the range of a cleanup action level (e.g., TCA at ca. 1 μg/g), enhanced accuracy may require the collection of an undisturbed sample with infield immersion in methanol in a Teflon-sealed glass jar and refrigeration at 4 °C.

Conclusions

The methodology developed in this experiment appears workable and appropriate although some refinements are under consideration. In an initial experiment, the effects on soil VOC measurements of several sampling method attributes (i.e., soil disturbance, container headspace

volume, container integrity, and sample preservation) were observed to be significant and to result in potentially serious systematic error or bias (up to 100%). The potential for negative bias appeared to be correlated with the soil sorption affinity of the target VOC (i.e., low K_h and high K_{ow}). Clearly, great care must be exercised when sampling soils for VOC measurements and more sophisticated sampling procedures may be required to control sampling errors, particularly with the more volatile VOCs. Further research is necessary to study other organic compounds, soil conditions, and sampling environments. This information is needed to facilitate the development and implementation of standardized sampling procedures for VOC measurements in soils.

Registry No. MC, 75-09-2; DCA, 107-06-2; TCA, 71-55-6; TCE, 79-01-6; TOL, 108-88-3; CB, 108-90-7.

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MEASUREMENT ERROR POTENTIAL AND CONTROL WHEN QUANTIFYING VOLATILE HYDROCARBON CONCENTRATIONS IN SOILS [1]

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INTRODUCTION

Due to their widespread use throughout commerce and industry, volatile hydrocarbons such as toluene, trichloroethene and 1,1,1-trichloroethane routinely appear as principal pollutants in contaminated sites throughout the U.S. and abroad. As a result, quantitative determination of soil system hydrocarbons is necessary to confirm the presence of contamination and its nature and extent; to assess site risks and the need for cleanup; to evaluate remedial technologies; and to verify the performance of a selected alternative. Decisions regarding these issues have far-reaching impacts and ideally should be based on accurate measurements of soil hydrocarbon concentrations. Unfortunately, quantification of volatile hydrocarbons in soils is extremely difficult and there is normally little understanding of the accuracy and precision of these measurements. Rather, the assumption is often implicitly made that the hydrocarbon data are sufficiently accurate for the intended purpose. This paper presents a discussion of measurement error potential when quantifying volatile hydrocarbons in soils and outlines some methods for understanding and managing these errors.

ENVIRONMENTAL MEASUREMENTS IN SOILS

Basic Concepts

Environmental measurements in soils must account for the extreme variability which characterizes a natural soil system [1-4]. Variations in natural soil properties which affect water movement and contaminant transport and fate can be substantial. Spatial variations predominate and include short-range (e.g. < 1m) and long-range effects. It is common for coefficients of variation for soil properties to vary from a few percent to several hundred percent, although 10 to 100 percent may predominate for many situations [2,3]. Temporal variations can also occur although these are less well characterized. It has long been recognized that these natural variations can lead to sampling errors which can be substantially greater than analytical errors. As early as 1944, it was acknowledged that "the limit of accuracy was determined by the sample, not by the analysis" and this remains true even today [1].

When making measurements in a contaminated soil, the process is even more complicated. Contamination incidents with unknown characteristics and transport and fate processes

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which are highly nonlinear and poorly understood, create problems and often leads to data deficiencies for normal measurement programs. In fact, it might be argued that a contaminated soil system may be so "chaotic" that accurate and precise characterization over space and time may be impossible.

It is important to explicitly define the objectives and scope of a environmental measurement program and specify the requisite type, quantity and quality of the data to be generated. According to the U.S. EPA, data quality objectives (DQOs) should be explicitly stated a priori and include the desired data accuracy, precision, representativeness, completeness and comparability [4]. Accuracy defines the bias in a measurement system while precision defines the reproducibility of measurements under set conditions. Representativeness expresses the degree to which sample data accurately and precisely define the true characteristic in question. Completeness is defined as the percentage of measurements made which are judged to be valid. Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Common to all of the DQOs is an understanding of the nature and magnitude of any measurement errors. It is essential to data analysis and hypothesis testing that the measurement errors on the average be sufficiently small that they may be ignored when analyzing and interpreting measurement data (e.g. measurement error variance = <10% of total variance between measurements) [4]. Moreover, since measurement error as bias is elusive if not impossible to determine, it is often necessary to presume that it is absent.

When sampling contaminated sites, soil samples are collected according to various statistical designs (e.g. random, systematic, judgemental) under a wide variety of soil conditions (e.g. soil texture, depth, water content, temperature). The collection process may often be hindered by adverse site conditions (e.g. health and safety hazards requiring personal protective apparel and equipment). Sampling involves a wide variety of classical methods to expose the soil volume to be sampled (e.g. shovel, power auger, backhoe) and to remove and containerize a sub-sample for analysis (e.g. utensils, hand implements, thin-walled tubes). Qualitative analyses of soil sub-samples have often been made in the field by test kits while quantitative analyses of separate sub-samples have been made in an onsite or remote laboratory. Determination of measurement error variance has normally focused on laboratory operations with analyses of a wide variety of quality assurance/quality control (QA/QC) samples (e.g. spiked sample analyses, blank samples, duplicate analyses). Field operations are less well addressed with field "duplicates" (separated in space by some distance) and decontamination rinses the only common field QA/QC samples.

Volatile Hydrocarbon Measurements

Beyond the problems associated with natural soil variability and site contamination, quantitative characterization of soil volatile hydrocarbons, or VOCs are they are often called (volatile organic compounds), is complicated by the complex and highly unpredictable behaviors of these hydrocarbons [5,6]. For example, there are ca. 35 hydrocarbons categorized as VOCs in the U.S. EPA hazardous substance list (HSL). These compounds have widely different physical and chemical properties (Table 1) and in soil systems, VOCs can be present in the liquid (dissolved or non-aqueous phase), solid (sorbed) and gas (vapor) phases. The biodegradability of these compounds varies from readily degradable (e.g. toluene) to recalcitrant (e.g. tetrachloroethylene).

Quantification of soil system VOCs requires conduct of a series of tasks as illustrated in Figure 1. In practice, quantification of soil VOCs has been achieved by various means often driven by laboratory convenience, regulatory requirements or personal preferences. Materials and methods for collecting and containerizing soil samples are often similar to those used for basic sampling of soil and geologic materials. Numerous methods have

been used to reach and expose the point of sampling (e.g. hand implements, backhoes, power augers, drilling rigs) as well as to remove a bulk volume to be sampled (e.g. hand utensils, push probes, thin-walled tubes, split-spoons). Methods to extract and containerize a soil sub-sample (e.g. 25 to 100 g) for later analysis have also been varied (e.g. spatulas and spoons, trowels, coring devices). Qualitative analyses of soil sub-samples have often been made in the field by hand-held detectors (e.g. photoionization or flame ionization units) while quantitative analyses of separate sub-samples been made in a remote laboratory. Analyses of the containerized soil samples are normally accomplished by removing 1 to 5 g from the field subsample and immersing this soil in water or methanol. The soil/liquid sample undergoes extraction, purge and trap concentration followed by gas chromatography or gas chromatography/mass spectrometry and up to 35 VOCs are identified and quantified. More recently, there has been increased use of field portable laboratory instruments for quantitative field analyses, often employing head-space techniques, principally to provide real-time data.

VOLATILE HYDROCARBON MEASUREMENT ERRORS

Measurement Error Potentials

Efforts to interpret and draw conclusions from soil VOC data are often frustrated by apparent data quality problems. For example, it is common for laboratory data to correlate poorly if at all with the field screening measurements made by photoionization or flame ionization detectors [8] Moreover, "duplicate" samples collected within 10 cm of each other from a given field sample (e.g. from a split-barrel sampler) can yield VOC results which vary by one or more orders of magnitude. These results are not totally surprising given the highly variable nature of contaminated soils and the multi-phase, dynamic behavior of soil VOCs. However, an alternative explanation for these types of data quality problems is that quantitative measurements of soil VOCs can be subject to serious *measurement error potential*. In the context of this discussion, measurement error potential means the tendency for a VOC measurement at a given location and time, to have a measurement error variance and/or bias which is statistically unacceptable for the purpose for which the data was collected. While practitioners have wondered about the measurement errors associated with sampling and analysis of VOCs in soils, only recently has research begun to elucidate the measurement error potential associated VOC quantification and provide guidance on improved methodologies. Highlights of some of this work are summarized in Tables 2 and 3. In addition to the work outlined in Tables 2 and 3, additional efforts are in progress by the ASTM and U.S. EPA to assess and develop new standardized procedures and/or modify existing ones.

The existing database (Tables 2 and 3), while limited, suggests that soil VOC measurements may be subject to substantial measurement error potentials when samples are collected and analyzed by classical methods. A measurement error variance (as coefficient of variation) of 10 to 100% can reasonably be expected. More important and of greater concern is the measurement error bias which can be in the range of -100% to +25%. Siegrist and Jenssen (1990) concluded that measurement error potential was strongly influenced by the phase distribution of a given VOC. Increasing error potential was correlated with increasing VOC Henry's Constant (K_h) and decreasing soil sorption affinity (K_d). These error potentials have significant implications given the vast numbers of soil VOC measurements that have been and are being made and the far-reaching decisions being reached based on an assumed acceptable data quality.

Despite the results of recent research, much uncertainty remains regarding the nature and magnitude of soil VOC measurement errors. There are a wide variety of soil and site conditions and volatile hydrocarbons yet to be studied. In addition, compilation and integration of sample collection and analytical errors is virtually impossible with the limited existing database. Research conducted to date has dealt with either the sample collection or the sample analyses components and has not integrated the error potential across the entire measurement process. Finally, potential short-range temporal and spatial variability has not been accurately characterized for soil VOCs.

Controlling Measurement Errors

Given the measurement error potential for volatile hydrocarbons in soils, effective procedures for error management and control are needed. With the current understanding of measurement errors, the greatest improvements in accuracy and precision can be made by using more rigorous materials and methods for sampling. Ideally, the measurement process should involve assessment of measurement error potential for a given sampling scenario to yield the required rigor for the measurement procedures. An example of this integration is illustrated in Table 4. It is emphasized that further work is necessary to better define the categories and factors in Table 4 and determine their significance to the measurement error management task.

At this time, two measurement approaches have been developed and shown to reduce measurement error potentials. These involve collection of undisturbed soil cores and either infield containerization in a purge and trap vessel or infield immersion in methanol. The purge and trap vessel method has the advantage of simplicity, maintaining low detection limits and not requiring field handling of chemicals. However, the sample volume analyzed is quite small (1 to 5 g) and compositing of soil samples is precluded. The methanol protocol has the advantage of increasing the sample size analyzed (thereby attenuating short-range spatial variability) and it also enables sample compositing. However, the methanol addition can increase the detection limits by a factor of 10 to 100 and requires field handling of chemicals.

In addition to more rigorous methods for sample collection and analysis, sampling designs should include more close-range sampling points (e.g. <10 cm separation) to help define short-range spatial variability and its contribution to measurement error variance identified through duplicate sample analyses. QA/QC procedures need to be developed which account for the measurement error potential of volatile hydrocarbons. In addition to field duplicate and laboratory split samples, it is recommended to include field blank and audit soil samples. The field blank samples would consist of a similar but clean soil matrix while the field audit samples would consist of the clean soil matrix spiked with a suite of compounds similar to those anticipated in the field. Both types of samples would be carried from/to the laboratory and handled similarly to the field collected soil samples. These samples would enable determination of measurement error bias.

Finally, minimizing the pre-analytical holding time and variability of holding conditions should be accomplished where measurement error potentials are high. Improved and expanded use of infield analytical instrumentation and procedures may provide great benefits here. However, the contribution of field quantitation to reducing measurement error potentials is yet to be determined.

Development and implementation of methods to control measurement error potential must recognize the limitations associated with sample collection and analysis. For example, samples are often collected under adverse field conditions where cumbersome collection

procedures might be impractical, if not impossible to implement. Also, since laboratory capacity is often limited, rapid sample analyses are impossible and samples are often held for many days prior to sub-sampling and analysis.

CONCLUSIONS

Despite the sophistication and cost of sample collection and analyses, there remains substantial and significant uncertainty associated with soil VOC measurement data. Interpretation of existing VOC data must include careful analysis of sample collection, handling and analysis procedures. Early VOC characterization data may be more suspect than recent data due to recently improved sampling practices. In general, measurement error can be assumed to be significant, comprised of both simple error variance and negative bias. The measurement error potential is particularly high for the more volatile compounds with low aqueous solubilities. When prescribing procedures for VOC measurements, consideration must be given to the measurement error potential of a given measurement scenario and available measurement methodologies as well as the application of the data and the seriousness of a data-quality related incorrect decision. More rigorous methods are available and/or under development which can reduce as well as delineate measurement error variance and bias when quantifying soil VOCs. Further research is necessary to elucidate the measurement errors involved in quantifying volatile hydrocarbons in soils and to facilitate continued development and refinement of sampling and analysis methods and QA/QC procedures.

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Table 1. Volatile hydrocarbons included within the Hazardous Substance List (HSL) in the USA and their occurrence at U.S. EPA Superfund Sites.

Compound	Properties[1]				Hazardous Waste Site Rank and Prevalence[2]
	Molecular Weight	Boiling Point	Vapor Pressure	Aqueous Solubility	
	g/mol	°C	mm	mg/L	
Chloromethane	51	-24	3800	4000 *	
Bromomethane	95	4.6	-	900	
Vinyl Chloride	62	-13.9	2660 (25°C)	1100 (25°C)	23 [8%]
Chloroethane	64.5	12.4	1000	5740	
Methylene Chloride	85	40	349	20000	18 [10%]
Acetone	58	56.2	270 (30°C)	Miscible	
Carbon Disulfide	76.1	46.3	260	2300 (22°C)	
1,1-Dichloroethene	97.0	31.9	500		20 [9%]
1,1-Dichloroethane	99.0	57.3	180	5500	19 [10%]
trans-1,2-Dichloroethene	97.0	48	200 (14°C)	600	17 [12%]
Chloroform	119.4	62	160	8000	6 [20%]
1,2-Dichloroethane	99.0	83.5	61	8690	25 [7%]
2-Butanone	72.1	79.6	78	353000 (10°C)	
1,1,1-Trichloroethane	133.4	71/81	100	4400	8 [17%]
Carbon Tetrachloride	153.8	76.7	90	800	27 [7%]
Vinyl Acetate	86.1	73.0	83	25000	
Bromodichloromethane	163.8	90.0			
1,2-Dichloropropane	113.0	96.8	42	2700	
trans-1,3-Dichloropropene	111.0	112	34 (25°C)	2800	
Trichloroethene	131.5	86.7	60	1100 (25°C)	1 [35%]
Dibromochloromethane	208.3	116-122			
1,1,2-Trichloroethane	133.4	113.7	19	4500	
Benzene	78.1	80.1	76	1780	5 [23%]
cis-1,3-Dichloropropene	111.0	104.0	43 (25°C)	2700	
Bromoform	252.8	149	5.6 (25°C)	3190 (30°C)	
4-Methyl-2-Pentanone	100.2	116/119	6	17000	
2-Hexanone	100.2	128	2	35000	
Tetrachloroethene	165.8	121.4	14	150 (25°C)	9 [17%]
1,1,2,2-Tetrachloroethane	167.9	146.4	5	2900	
Toluene	92.1	110.8	22	515	3 [27%]
Chlorobenzene	112.6	132	8.8	500	26 [7%]
Ethylbenzene	106.2	136.2	7	152	15 [12%]
Styrene	104.1	145.2	5	300	
m-Xylene	106.2	139	6		14 [13%]
o-/p-Xylene	106.2	144.4	5	175	*

1 Properties are at 20°C unless another temperature is shown in ( ).

2 Rank (highest = 1) and prevalence (% of sites) based on a total of 466 different substances found at the 888 Superfund sites (as of October 1986).

Figure 1. Sampling process for volatile hydrocarbon measurements in contaminated soil and quantification error components.

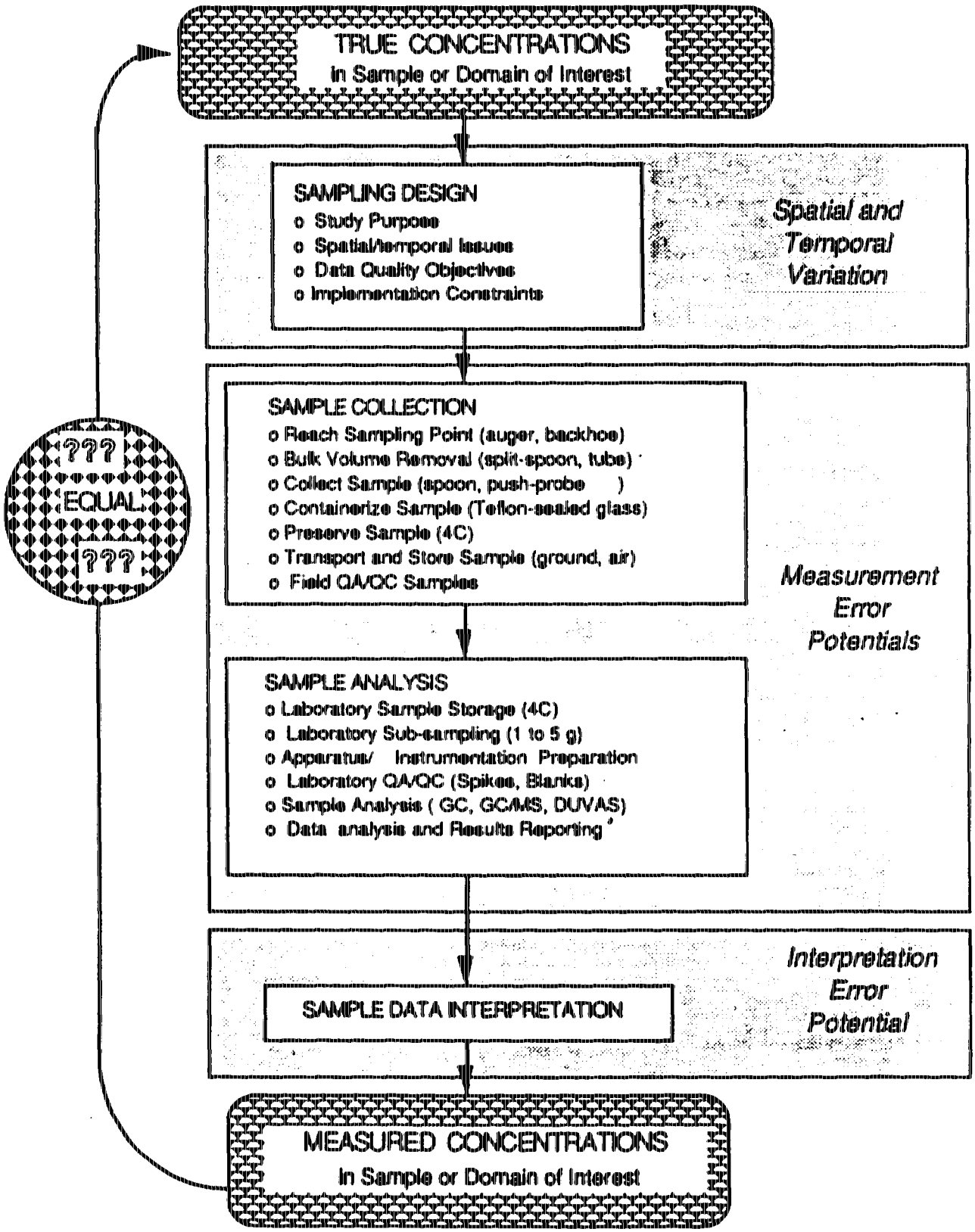

Table 2. Measurement error associated with sampling practices for soil VOCs.[1]

Study and Location	Conditions	VOCs Studied	Findings
Siegrist and Jenssen [8] Aas, Norway	Natural Sand from 0-50 cm depth Laboratory controlled contamination Samples collected with thin-walled tubes to evaluate: 1.Container 2.Disturbance 3.Headspace 4.Methanol preservation	Methylene Chloride 1,2-dichloroethane 1,1,1-trichloroethane Trichloroethene Toluene Chlorobenzene	VOCs measured = 0 to 83% of model estimate Highest VOCs in samples infield immersed in methanol Measurement coefficient variation always <66% and typically < 15% Relative negative bias of 15 to 100% (compared to highest measured value) Bias correlated with sampling method and VOC K_h and K_d VOC recoveries in matrix spikes = 57 to 125%
Urban et al. [9] Pennsylvania, USA	Silty clay- clayey silt Uncontrolled hazardous waste site Field collected samples from split-barrel samples to evaluate: 1.Conv. EPA process 2.Methanol preservation	Trichloroethene 1,1-dichloroethene	Highest VOCs in samples infield immersed in methanol Measurement coefficient variation <17% Relative negative bias compared to methanol was typically >80%. VOC recoveries in matrix spikes = 31 to 96%
Maskarinec et al. [10] Tennessee, USA	Soil spiked with mixture of VOCs Samples collected by two methods to evaluate sub-coring device and direct containerization in a purge and trap vessel	19 VOCs on U.S. EPA HSL	Negative bias varied with VOC Eliminating the laboratory sub-sampling and container transfer using direct containerization in purge and trap vessels can reduce negative bias from an average of 89% to 29%.

Table 3. Measurement error associated with sample analyses for soil VOCs (after 11).[1]

Hydrocarbon	Measurement Error Component			
	Intra-Laboratory Precision			
	Number of Duplicate Pairs	Mean Relative Standard Deviation	QC Recovery Limits	Contract Detection Limit
1,1-Dichloroethene	353	8.9 %	59 - 172 %	5 ug/kg
Trichloroethene	438	7.8 %	59 - 139 %	5 ug/kg
Chlorobenzene	432	6.7 %	60 - 133 %	5 ug/kg
Toluene	376	7.4 %	59 - 139 %	5 ug/kg
Benzene	411	7.4 %	66 - 142 %	5 ug/kg
	Inter-Laboratory Precision and Bias			
	Number	Mean Relative Standard Deviation	Bias	QC Recovery Limits
Toluene-d8	10399	13.2 %	+ 2.0 %	88 - 110 %
4-Bromofluorobenzene	10395	15.9 %	- 1.7 %	86 - 115 %
1,2-Dichloroethane-d4	10402	18.1 %	- 3.2 %	76 - 114 %
	Method Bias (Blind Sample Analyses)			
	Number	Mean Relative Standard Deviation	Bias	
Chloroform	9	8.0 %	- 0.1 %	
1,2-Dichloroethane	14	13.1 %	+ 11.1 %	
Dibromochloromethane	9	35.0 %	- 12.0 %	
Benzene	9	32.1 %	- 10.3 %	
Bromoform	10	16.6 %	- 12.1 %	
2-Hexanone	6	16.6 %	- 45.5 %	
Toluene	10	13.8 %	+ 13.7 %	
Chlorobenzene	10	21.2 %	+ 13.2 %	

[1] Data based on analyses conducted under U.S. EPA Contract Laboratory Program during Dec. 1984 and November 1985. All results based on analyses of spiked soil samples.

Table 4. Example integration of measurement error potential and measurement rigor for quantification of soil VOCs.[1]

	Relative Error Potential or Measurement Rigor [2]		
Element	Low	Moderate	High
Measurement Error Potential	VOCs of low K_h and high K_{ow} (e.g. chlorobenzene) Soils with high TOC (e.g. surface soils of various textures) Low ambient air temperatures (e.g. <10°C) Undisturbed samples can be collected easily (e.g. surface soils)	VOCs of moderate K_h and K_{ow} (e.g. toluene) Soils with low TOC but high clay content (e.g. clays) Moderate ambient air temperatures (e.g. 10-20°C) Undisturbed samples can usually be collected (e.g. shallow subsoils)	VOCs with high K_h and low K_{ow} (e.g. trichloroethene) Soils with low TOC and clay content (e.g. subsoils of clean sand) High ambient air temperatures (e.g. >20°C) Undisturbed samples are hard to collect (e.g. deep subsoils, saprolites and rock material)
Appropriate Measurement Rigor	Disturbed samples containerized in Teflon-sealed glass jars with low head-space and preserved at 4°C QA/QC requires only routine laboratory QA/QC samples and analyses	Undisturbed samples containerized in Teflon-sealed glass jars with low head-space and preserved at 4°C QA/QC requires field duplicate samples and a field audit sample is recommended along with other routine laboratory QA/QC samples and analyses	Undisturbed samples containerized infield in purge and trap devices or immersed in methanol and preserved at 4°C QA/QC requires field duplicate samples and field audit sample as well as other routine QA/QC samples and analyses

[1] Information provided in this table is for illustrative purposes only. Further research and development is needed to define the error and measurement rigor categories and the factors involved.

[2] K_h = Henry's Constant, K_{ow} = octanol/water partition coefficient, TOC = soil total organic carbon content.

MODELING POTENTIAL MIGRATION OF PETROLEUM HYDROCARBONS FROM A MIXED-WASTE DISPOSAL SITE IN THE VADOSE ZONE

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ABSTRACT

Environmental monitoring of a mixed-waste disposal site at the Idaho National Engineering Laboratory has confirmed release and migration into the vadose zone of: (1) chlorinated hydrocarbons in the vapor phase and (2) trace levels of certain transuranic elements. The finding has prompted an evaluation of the potential role of waste petroleum hydrocarbons in mediating or influencing contaminant migration from the disposal site. Disposal records indicate that a large volume of machine oil contaminated with transuranic isotopes was disposed at the site along with the chlorinated solvents and other radioactive wastes.

A multiphase flow model was used to assess the possible extent of oil and vapor movement through the 177 m thick vadose zone. One-dimensional simulations were performed to estimate the vertical distribution of the vapor phase, the aqueous phase, and immiscible free liquid as a function of time. The simulations indicate that the oil may migrate slowly through the vadose zone, to potentially significant depths. Calculated transport rates support the following ranking with regard to relative mobility: vapor phase > aqueous phase > free liquid.

INTRODUCTION

Subsurface contamination by mixtures of organic chemicals and radionuclides associated with energy-related activities has been identified as a major environmental problem (U. S. Department of Energy, 1984; 1988). Past disposal practices of mixed wastes associated with national defense programs were not subject to current environmental regulations, with the result that problems of migration of organic and radionuclide co-contaminants are arising at numerous mixed-waste disposal sites. In some cases, the remediation of mixed-waste sites is made more difficult by the synergistic effects of co-contaminant migration. A further difficulty is encountered when mixed-waste contamination occurs in variably saturated, interbedded porous and fractured media.

In the western United States, arid waste disposal sites were originally selected on the basis of climatic and hydrogeologic conditions considered best suited to the avoidance of contaminant migration. It is often more difficult to model any contaminant transport that occurs at disposal sites located in arid regions, because there is a smaller set of data for understanding co-contaminant flow and transport in areas with low recharge and thick vadose zones of variable permeabilities.

In order to effectively mitigate contamination at a mixed-waste disposal site located in an arid environment, it is necessary to develop a fundamental understanding of the hydrological and geochemical processes that affect organic co-contaminant migration, transport, and chemical reaction in the subsurface. Computer models of contaminant releases from mixed-waste sites can be used to provide insight to the processes controlling co-contaminant release and transport.

This paper presents the application of computer models to a case study of the movement of chlorinated hydrocarbon solvents, petroleum hydrocarbons, and transuranic (TRU) radionuclides from a mixed-waste disposal site located over a 177 meter thick vadose zone at the U. S. Department of Energy's Idaho National Engineering Laboratory (INEL) in southeastern Idaho. Ongoing site characterization has demonstrated that chlorinated solvents and transuranic radionuclides have migrated through the vadose zone (Laney *et al.*, 1988). The fate of the co-disposed petroleum hydrocarbons is less certain. Therefore, modeling was conducted to evaluate the relative mobility of the co-contaminants in the subsurface and to determine the possible contribution of the petroleum hydrocarbons to radionuclide migration.

The paper includes a brief description of the site hydrogeology and the nature and extent of the co-contaminant migration. The conceptual and mathematical basis for the modeling approach is presented. The paper presents results of computer simulations of petroleum hydrocarbon migration, and a discussion of the aspects of the model that warrant further evaluation.

SITE HYDROGEOLOGY

As part of past waste disposal practices at the INEL in southeastern Idaho, transuranic and low-level nuclear wastes mixed with hazardous constituents have been disposed in a shallow landfill, the Subsurface Disposal Area (SDA). The INEL is located in a shallow basin in the north-central part of the eastern Snake River Plain and the SDA is sited at the Radioactive Waste Management Complex in the southwestern corner of the INEL (Figure 1).

The INEL is underlain by Pleistocene basalt flows and intercalated sedimentary units that host the Snake River Plains aquifer. The unsaturated zone separating the SDA disposal site from the Snake River Plain aquifer is approximately 177 meters thick and basalts constitute approximately 95% of the stratigraphic section. Alluvial sediments of Holocene age occur in a band that extends across the site from northeast to southwest, and are associated with the flood plain of the Big Lost River.

The subsurface geology of the unsaturated zone at the INEL and the SDA is well-characterized as a result of data collected by the United States Geological Survey and site contractors from numerous monitoring wells on the INEL site. The SDA is located in several meters of surficial alluvium. Beneath the SDA, basalt flows range in thickness from 2 meters to 20 meters, with an average thickness of approximately eight meters (U. S. Department of Energy, 1983). The flows are interlayered with unconsolidated cinders and volcanic breccia, and fluvial, lacustrine, and aeolian sediments.

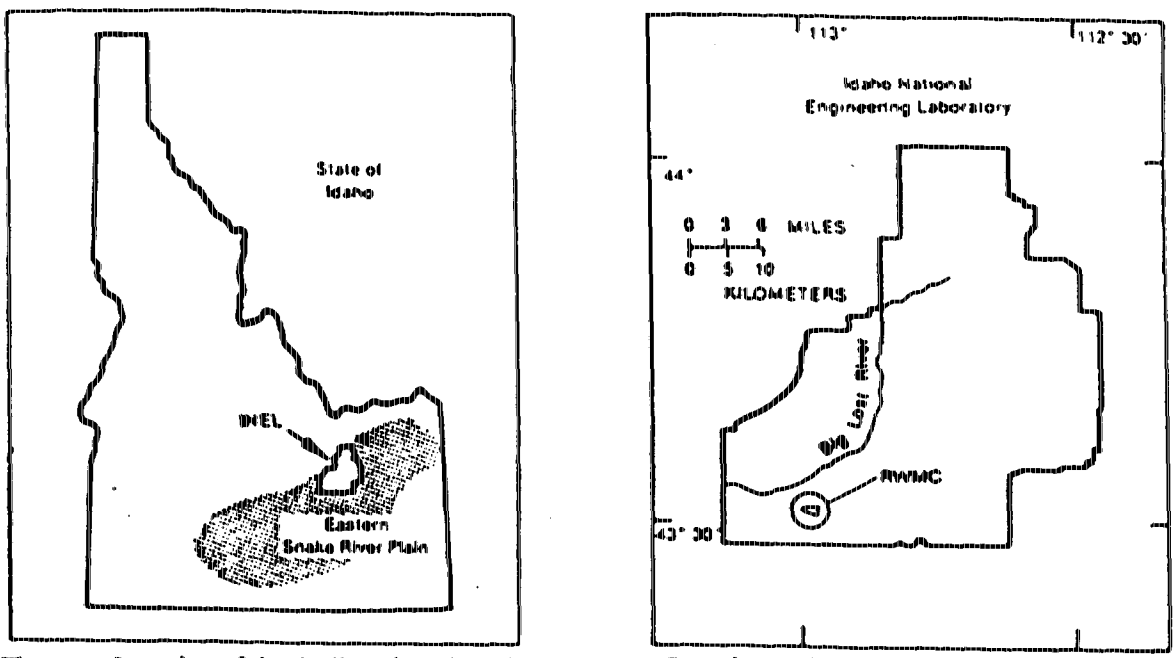

Figure 1. Location of the Radioactive Waste Management Complex at the INEL.

Two major interbeds occur beneath the SDA, at depths of 34 meters (110 ft) and 73 meters (240 ft) (U. S. Department of Energy, 1983). A discontinuous interbed at approximately 9-10 meters (30 ft) has also been identified. The clay minerals that are found in the alluvium and sediments are predominantly illite, mixed illite/smectite, and smectite, with minor kaolinite. Concentrations of organic carbon are less than 0.5 weight percent (Rightmire and Lewis, 1987). A summary of the lithology and mineralogy of the vadose zone units (alluvium, basalts, and sedimentary interbeds) is given in Rawson and Walton (1989).

Fractures in basalt are commonly filled with clay- and silt-sized phyllosilicates and caliche where the basalt was previously exposed to the surface. Several basalts are locally very highly fractured, with fracture fillings of loess that signify a long period of exposure at landsurface. Some of the fracture infilling material may have been transported into fractures by suspension in water and downward infiltration of the water through the fracture network (Rightmire and Lewis, 1987). As the water evaporates in the unsaturated zone, thin layers of clays are either deposited from suspension or precipitated from solution. Fractures and vesicles both exhibit some layering of the fracture fill material (Rightmire and Lewis, 1987).

Hydrology of the unsaturated zone at the INEL is controlled in part by the average precipitation. Precipitation on the INEL site is in the range of 13 to 36 centimeters per year, with an average of 20 cm per year (Barraclough *et al.*, 1976). Snowfall accounts for 30% of the annual precipitation. In areas of thick alluvial fill, evapotranspiration exceeds 95% of the precipitation. The average annual infiltration rate ranges from 5-10% of the precipitation.

NATURE AND EXTENT OF CONTAMINATION

The SDA consists of trenches and pits, some of which were originally excavated down to basalt. A soil buffer that ranged from 0.67 to 1 meter thick was left between the waste and the uppermost basalt flow. Between 1952 and 1970, approximately 96,300 cubic meters (3.4×10^6 ft^3) of transuranic and low-level radioactive wastes were

emplaced on the soil buffer and covered with a soil cap. Further burial of transuranic waste was prohibited by regulation in 1970, but disposal of low-level waste has continued until present.

Surface and subsurface environmental monitoring for radionuclides at the SDA has been conducted since the 1960s. Recently, monitoring for the migration of transuranic radionuclides established the presence of environmental concentrations of plutonium and americium (activities up to picocuries/gm) at a depth of 34 m below land surface (Laney *et al.*, 1988). The contaminant migration problem was exacerbated by the discovery of elevated levels of hazardous volatile organic compounds (VOCs) in the Snake River Plain aquifer beneath the SDA in 1987 (Mann and Knobel, 1987). Corrective action required by the Resource Conservation and Recovery Act (RCRA) has been implemented at the site (EG&G, 1988).

Although detectable quantities of carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, and chloroform were measured in monitoring wells in the aquifer in 1987, the concentrations of all but one of the contaminants were below the maximum EPA allowable concentration of 5 μg/l. Carbon tetrachloride concentrations in a single sample were above allowable levels (6.6 μg/l) during only one sampling period (Mann and Knobel, 1987).

Maximum concentrations of VOCs detected by aquifer sampling, and soil gas surveys of the surface alluvium and deep borehole gases are shown in Table 1. The most extensive contamination is related to vapor plumes of carbon tetrachloride, trichloroethylene, chloroform, 1,1,1-trichloroethane, and tetrachloroethylene in the vadose zone (EG&G, 1988). Partitioning of VOCs from a vapor into the perched water and the aquifer is assumed responsible for the indicated aqueous concentrations.

The RCRA corrective action prompted by release of hazardous VOCs into the vadose zone at the SDA included an effort to establish a complete inventory of the hazardous materials that were disposed at the site. Disposal records indicate that approximately 334,000 liters (88,400 gallons) of TRU- contaminated, mixed-waste sludges from a national defense plant were disposed in several pits and trenches at the SDA between 1966 and 1970 (EG&G, 1988). Prior to disposal, the wastes were absorbed on calcium silicate and emplaced in 208 liter (55 gallon) steel drums that were subsequently sealed. An additional 89,000 liters (23,400 gallons) of oil contaminated by unidentified radionuclides were also disposed at the SDA.

The defense plant sludges consisted of mixtures of a light machine oil and various chlorinated solvents contaminated with transuranic radionuclides. According to disposal records, carbon tetrachloride, trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane comprised the bulk of solvents disposed during 1966-1970(Laney *et al.*, 1988). The generator of the defense plant sludges provided information indicating that the lathe coolant used in foundry operations consisted of 60% machine oil and 40% carbon tetrachloride (EG&G, 1988). As much as 148,000 liters of machine oil were disposed, bringing the total volume of disposed petroleum hydrocarbons to approximately 237,000 liters.

Transuranic radioactivity, hazardous organic wastes, and petroleum hydrocarbons are assumed to be co-contaminants, because a significant volume of the organic sludges from the defense plant was used in plutonium foundry operations and component fabrication (EG&G, 1988). The chemical form of the plutonium used in foundry operations and component fabrication is assumed to be plutonium metal, based on the unclassified information discussed by Baldwin and Navratil (1983). The plutonium recovery operations at the defense plant involved purification of the metal and impure

TABLE 1. MAXIMUM CONCENTRATIONS FOR VOCs RELEASED FROM SDA[1]				
VOLATILE ORGANIC COMPOUNDS	VADOSE ZONE SOIL GAS (mg/M^3)	VADOSE ZONE BOREHOLE GAS (mg/M^3)	VADOSE ZONE PERCHED WATER (µg/L)	SNAKE RIVER PLAIN AQUIFER (µg/L)
Carbon tetrachloride	1400	1000	1200	6.6
Chloroform	ND[2]	230	650	1.0
Trichloroethylene	690	380	860	1.4
Tetrachloroethylene	40	62	110	<3.0
1,1,1-Trichloroethane	310	120	140	0.9
Dichloroethane	NA[2]	3	13	<3.0

[1]Data from EG&G, 1988.

[2]ND = not detected. Analytical interference with carbon tetrachloride. NA = not analyzed

plutonium oxides (Baldwin and Navratil, 1983). The plutonium associated with the organic sludges is assumed to have initially been physically entrained in the sludge as small particles from foundry operations. Contaminated acids and solvents from the plutonium recovery operations may also contain lesser amounts of particulate plutonium in the oxide form.

Of the radionuclides disposed at the SDA, detectable quantities of plutonium-238, plutonium-239+240, americium-241, strontium-90, cesium-137, cobalt-60, and europium-154 have been reported from surficial sediments (Laney *et al.*, 1988). Plutonium-238, plutonium-239+240, and americium-241 have also been detected in the 34m interbed (Laney *et al.*, 1988). The mode of radionuclide transport is currently being investigated as part of an ongoing study of the SDA subsurface (Rawson *et al.*, 1989).

A conceptual model for the release of VOCs was developed to describe the evolution of the soil gas plumes and the subsequent aquifer contamination (Baca *et al.*, 1988; Walton *et al.*, 1989b). Processes considered in the model of VOC migration include aqueous flow, vapor transport by gaseous diffusion, and nonaqueous fluid phase flow. The observed migration of VOCs was modeled previously using one and two dimensional flow and transport codes to describe vapor generation and transport (Walton *et al.*, 1989b; Baca *et al.*, 1988). The models of VOC migration indicate vapor transport is the predominant mode for chlorinated solvent transport.

Likewise a similar model for the migration of the radionuclides in the unsaturated zone was developed, and preliminary calculations on aqueous flow and solute transport were performed using a three-dimensional flow and transport code (Walton *et al.*, 1989a). The majority of transuranic radionuclides are assumed to migrate as colloids that undergo no retardation during transport (Rawson *et al.*, 1989).

To evaluate the possible role of the machine oil in the migration of both VOC contaminants and radionuclides from the SDA, the primary mechanism for petroleum hydrocarbon migration must be established. The remainder of the paper reports results of modeling oil flow in the unsaturated zone at the SDA.

MODELING PROCESS

The possible extent of migration of the machine oil relative to the other contaminants has been evaluated by the application of a model for multiphase flow

and transport, described below. A systematic approach was applied in all the modeling studies that were used to evaluate the relative mobility of the co-contaminants in the subsurface. The approach is summarized below:

1. Determine the key physical and chemical properties of the organic and radionuclide contaminants
2. Develop a conceptual framework to describe the controlling processes and driving forces
3. Formulate mathematical models for vapor generation and transport, aqueous flow and transport, and multiphase fluid flow and transport
4. Implement the mathematical models with general computer codes
5. Check the transport model predictions using available data for organic and radionuclide contaminants
6. Predict the fate of the co-disposed machine oil
7. Evaluate the relative rates of contaminant migration

Because models of VOC vapor transport and radionuclide aqueous transport have been previously presented (Baca *et al.*, 1988; Walton *et al.*, 1989b), the modeling process as applied to the petroleum hydrocarbon migration is the only facet of the modeling effort discussed here.

Physical and Chemical Properties of Machine Oil

The key physical and chemical properties of the machine oil were developed as part of the current study. Characterization of the oil disposed between 1966 and 1970 has involved certain assumptions due to the difficulty in obtaining detailed compositional information on any machine oil. Most lubricating oil fractions contain normal alkanes (n-alkanes) in the range of C_{22}-C_{40}, as well as a wide range of branched alkanes, cycloalkanes, and mono- and polynuclear aromatics (Kinghorn, 1983). The most common cycloalkanes or napthenes in lubricating oil consist of one to five rings of carbon. The aromatics are primarily of the fused-ring type, with phenanthrene derivatives more common than anthracene-based compounds (Kinghorn, 1983).

Heteroatomic compounds containing nitrogen, sulphur, and oxygen are more prevalent in lubricating oils, and are also more reactive. Usually it is the medium chain length alkanes that impart the lubricating properties while the cyclic compounds are detrimental to these properties. Only n-alkanes have been isolated as pure compounds from the lubricating oil fraction, although many compound types have been identified by mass spectrometry (Kinghorn, 1983).

The machine oil used at the defense plant was a mixture of several base oils that were either solvent-dewaxed, paraffinic oils or napthenic oils. Because 32- to 68-weight oils are used in current machining operations at the defense plant, the oil used between 1966-1970 was assumed to fall in this category. The manufacturer of the machine oil was unable to provide information on the proportion of paraffinic to napthenic oils used to generate the machine oil produced in the late 1960s, so general chemical characteristics were estimated from data on machine oil currently in use. The hydrocarbon compounds in machine oil are assumed to be approximately 64-70% paraffinic hydrocarbons (mostly branched), 21-29% napthenic hydrocarbons, and 8-9% aromatic hydrocarbons.

A 68-weight oil has a kinematic viscosity of 64.5 cSt at 40°C and one of 489 cSt at 10°C. The kinematic viscosity of 32-weight oil at 40°C is 30.5 and at 10°C is approximately 230 cSt. Data for the 32 weight oil were used in simulations to ensure the most conservative case was modeled.

Conceptual and Mathematical Models

The conceptual model of petroleum hydrocarbon migration in the unsaturated zone considered multiphase transport. The co-contaminants were modeled as coexisting immiscible liquids and a vapor phase. The process chosen for simulation was the simultaneous movement of water, machine oil, and air in the SDA unsaturated zone.

The computer code MOFAT developed by Parker and Kaluarachchi (1989) was used in the oil migration simulations. MOFAT is a two-dimensional, multiphase Galerkin finite element code. The code is implemented on the INEL Cray and on a SUN Workstation. The non-linear nature of the governing equations extracts a high cost in computer resources for the simulations.

The continuity equations for multiphase flow are:

$$\phi \frac{\partial \rho_w S_w}{\partial t} = \frac{\partial}{\partial x} \rho_w K_{wx} \left(\frac{\partial}{\partial x} h_w \right) + \frac{\partial}{\partial z} \rho_w K_{wz} \left(\frac{\partial}{\partial z} h_w + \rho_{rw} \right) \tag{1}$$

$$\phi \frac{\partial \rho_o S_o}{\partial t} = \frac{\partial}{\partial x} \rho_o K_{ox} \left(\frac{\partial}{\partial x} h_o \right) + \frac{\partial}{\partial z} \rho_o K_{oz} \left(\frac{\partial}{\partial z} h_o + \rho_{ro} \right) \tag{2}$$

$$\phi \frac{\partial \rho_a S_a}{\partial t} = \frac{\partial}{\partial x} \rho_a K_{ax} \left(\frac{\partial}{\partial x} h_a \right) + \frac{\partial}{\partial z} \rho_a K_{az} \left(\frac{\partial}{\partial z} h_a + \rho_{ra} \right) \tag{3}$$

where:

K = fluid conductivity

ρ = density

S = fluid saturation

ϕ = porosity

t = time

h = fluid pressure head = $P/\rho_w g$

subscripts

w, o, a = water, oil, air

r = reference

The gas phase has a much lower viscosity than the two immiscible liquid phases. For this reason pressure gradients in the gas phase will generally be low and can frequently be ignored when calculating migration of the liquid phases. Elimination of the gas flow equation is referred to as the Richards approximation.

When several fluids coexist in a porous medium, the fluids become arranged in the pores according to wettability for the solid phase. The fluid with preferential wettability will occupy the smallest pores and the fluid with least wettability will occupy the largest pores. In the water/oil/air system, the water occupies the smallest pores and the air occupies the largest pores. The oil phase occupies pores of intermediate dimension. The relationship between the three components is illustrated in Figure 2.

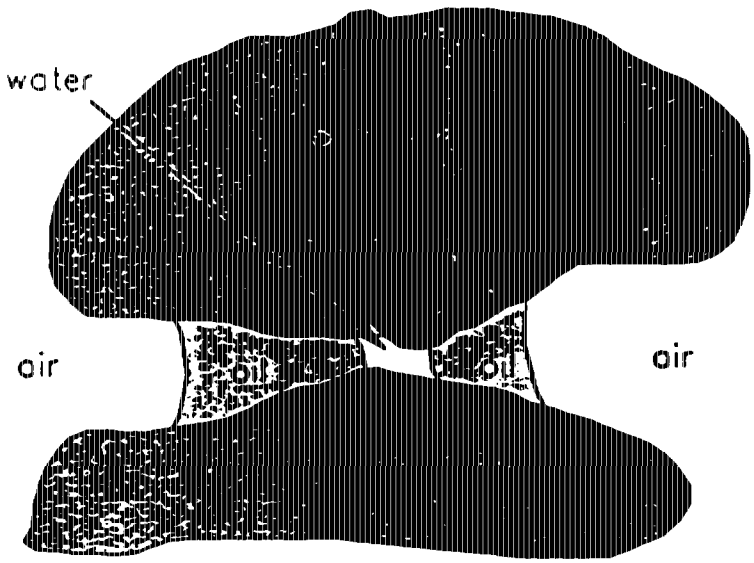

Figure 2. Arrangement of water, oil, and air phases in soil pores.

In the governing equations (Equations 1-3), the liquid saturation (S) and the fluid conductivity (K) are dependent upon the relative amounts of water, oil, and air in the pores. Constitutive relations for the multiphase system were derived using the van Genuchten (1980) model, where the saturation versus pressure head relation for an air-water system is:

$$\bar{S}_w = (1 + (\alpha h_{aw})^n)^{-m} \qquad m = 1 - \frac{1}{n} \qquad \text{for } h_{aw} > 0 \tag{4}$$

$$\bar{S}_w = 1 \qquad \text{for } h_{aw} \le 0$$

where:

$$\bar{S}_w = \frac{S_w - S_m}{1 - S_m}$$

S_m = residual water saturation

When modeling a multiphase system, it is assumed that the relation given in Equation 4 represents a pore size distribution of the medium which is fluid-independent. This assumption allows the relation to be generalized to a three-phase system.

$$\bar{S}_w(\beta_{aw} h_{aw}) = \bar{S}_w(h_{aw}) \qquad \bar{S}_o(\beta_{ao} h_{ao}) = \bar{S}_w(h_{aw}) \tag{5), (6}$$

$$\beta_{ao} = \sigma_{aw}/\sigma_{ao} \qquad \beta_{ow} = \sigma_{aw}/\sigma_{ow} \tag{7), (8}$$

$$h_{ao} = h_a - h_o \qquad h_{ow} = h_o - h_w \qquad h_{aw} = h_a - h_w \tag{9), (10), (11}$$

The relative permeability of each phase is also a function of the amounts of each phase present. Relative permeability is estimated using the Mualem (1976) integral. These integrals are evaluated analytically using the van Genuchten (1980) expressions giving explicit relations between saturation and relative fluid conductivity.

The source of contaminants must be characterized as input to the model. A total of 237 cubic meters of TRU-contaminated machine oil and unspecified oils in absorbents were estimated to have been disposed at the RWMC. The total area of the disposal pits is approximately 30,000 square meters. Assuming oils were disposed as free liquids, an average oil depth in the pits of 0.75 cm can be calculated from these data. For disposal, the oils were solidified by addition of calcium silicate; however, no credit is given in the modeling for this solidification.

Since the distribution of the oil is unlikely to be uniform, greater amounts are expected to be present in some areas. The simulations performed as part of this study assumed the availability of up to 15 cm of oil in the pits.

Information concerning the viscosity of machine oil was obtained from the manufacturer as described above. In the interest of conservatism, the behavior of 32 weight machine oil is simulated in the analysis. The ratio of oil/water viscosity is then approximately 150. Heavier oils will migrate more slowly than the oils modeled in this example. B_{ow} (Eq. 8) was assumed equal to 2.25.

TABLE 2. HYDROLOGIC PROPERTIES USED IN SIMULATIONS

LAYER	SATURATED HYDRAULIC CONDUCTIVITY	VAN GENUCHTEN α(Eq. 4)	VAN GENUCHTEN n (Eq. 4)	RESIDUAL SATURATION (Eq. 4)	POROSITY
Sedimentary interbeds	25 cm/hr	0.0108	1.38	0.06	0.476
Basalts	5 cm/hr	0.161	2.11	0.062	0.28

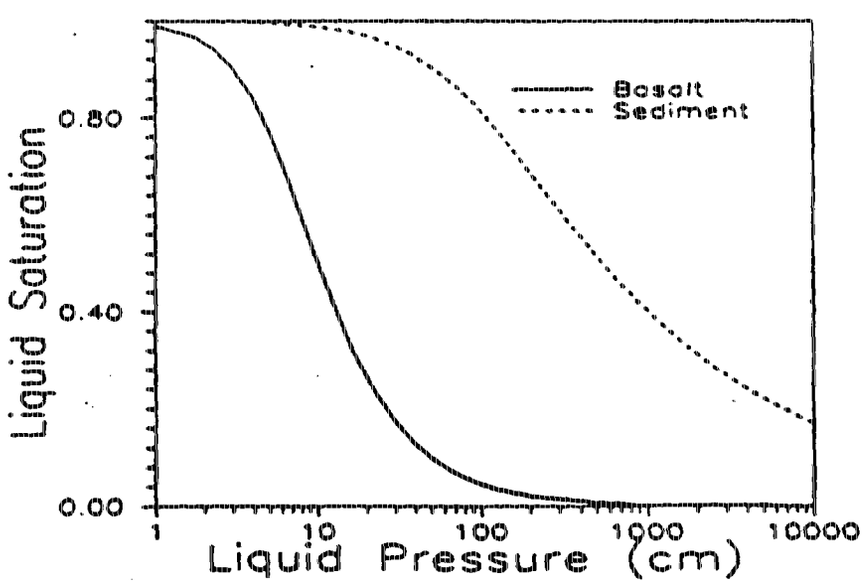

Figure 3. Relationship between liquid saturation and liquid pressure. Note the large differences between the basalt and sedimentary materials.

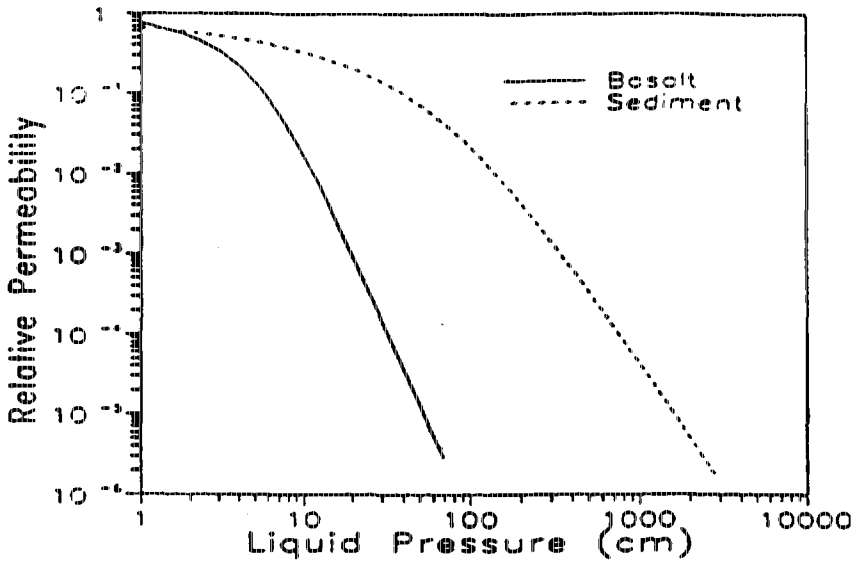

Figure 4. Relationship between relative permeability and liquid pressure.

Additional model inputs include the hydrologic properties of the sediments and basalts that control the amount of water and oil that will infiltrate the SDA unsaturated zone. The material properties assumed for the sedimentary materials and basalts from the SDA unsaturated zone are given in Table 2 and Figures 3-4. The properties for basalt are modeled as a combination of fractured and porous media. Fracture properties are derived from fracture properties for tuff (Wang and Narasimhan, 1985), and porous properties for basalt matrix were determined by TerraTek on basalt sample RWMC-1 collected from beneath the SDA. Fracture porosity was assumed to be 5% and matrix porosity was 23%. The final curve represents a summation of matrix and fracture properties. A linear interpolation was used to estimate matrix properties for low suctions. Note that the residual saturation for each lithology was calculated from Equation 4.

The model domain was broken into 158 finite elements with 318 nodes making a one-dimensional simulation. The medium was modelled as two discrete layers. The sediments were assumed to cover the basalt to a depth of 5 meters. The grid spacing was nonuniform with a greater concentration of elements near the sediment/basalt interface where numerical problems are greatest.

RESULTS OF SIMULATIONS

The simulation of oil migration was performed for a period of 10, 20, and 30 years. Net percolation of water through the pits was assumed to be 5 cm/yr, with 15 cm of total oil available for transport. The results of the simulations are shown in Figures 5 - 7.

In Figure 5, oil pressure head is plotted as a function of depth into the subsurface for times of 10, 20, and 30 years. Starting from initial conditions as a 15 cm layer within the pit, the oil moves downward as a front under a positive pressure head. The front advance appears to slow once the oil has entered the basalt, but the simulation suggests that the machine oil could penetrate 1-2 meters into the basalt in a 30 year time frame.

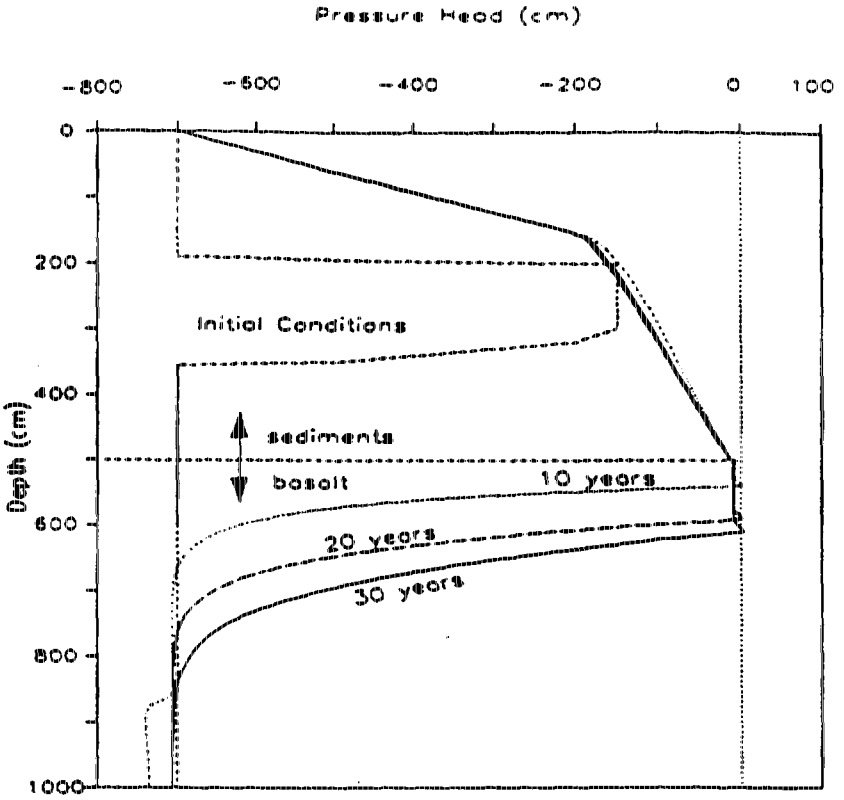

Figure 5. Simulated oil pressure head as a function of time and distance. The oil is predicted to move through the basalts as a front under positive pressure.

Figure 6 depicts the degree of oil saturation as a function of depth for times of 10, 20, and 30 years. Again, the oil phase moves downward as a front near total saturation. A residual saturation of up to 10% oil is left behind in the unsaturated sediments after 10 years, but is reduced below 6% after 30 years. This result is comparable to residual saturation values obtained experimentally for other organic liquids migrating in the unsaturated zone (Wilson *et al.*, 1988) The residual oil saturation in the basalt ranges from 20% at 10 years to approximately 10% after 30 years and is expected to further decrease over time. The oil front at near-saturated conditions penetrated over 1 meter into the basalt over 30 years.

Figure 7 shows the simulated degree of total saturation (machine oil plus water) as a function of depth for times of 10, 20, and 30 years. The oil front moves downward as a front, as was shown in Figure 6. An interesting effect is the development of capillary perching of water at the interface between the sediment and the basalt. Residual saturations of water plus oil in the unsaturated sediments were approximately 70% at the base of the pits after 10, 20, and 30 years, and increased to approximately 95% at the interface between the surface soil and the basalt. Total residual saturation left behind the oil fronts in the basalt varied from approximately 20-35%.

DISCUSSION

The results of the numerical simulations suggest that the potential for a significant amount of petroleum hydrocarbon migration exists at the SDA. The amount of machine oil that actually migrates in the system is currently unknown and

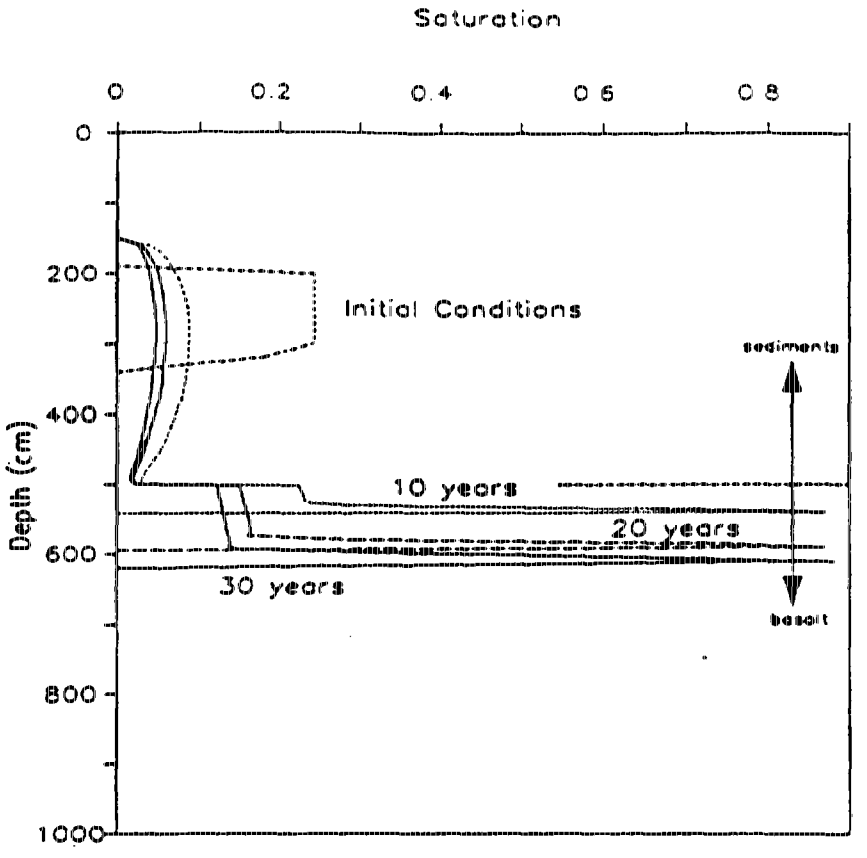

Figure 6. Simulated oil saturation as a function of time and distance. The oil moves through the basalts as a front near saturation. Lower amounts of oil, which drain more slowly, are left behind the advancing oil front.

simulations conducted to date do not account in any way for the chemical degradation of the oils. However, the simulations performed as part of this study indicate that oil could have moved from the pits within a 10 year time frame.

The machine oil is predicted to migrate as a front that will have moved approximately four meters from the base of the pits in 30 years after disposal. If the VOCs are associated with the oil by cosolvency, the migration distance is still too low to account for the observed extent of migration of the VOCs through the vadose zone to the aquifer. Likewise if the machine oil has moved as predicted, it is not responsible for the presence of transuranic radionuclides in the 34m interbed.

It is considered unlikely that movement of the petroleum hydrocarbons has had any significant impact on the extent of migration of the VOCs or the radionuclides. The presence of the oil affects the VOCs by increasing their residence time, by cosolvency, in the source area. However, the predicted migration of machine oil from the pits changes the residence time of VOCs in the source area only slightly from original predictions. The migration of VOCs is still best explained by diffusion in the vapor phase. The earlier modeling studies indicate that the VOCs reached the aquifer within 10 years of release from containment in the pits (Baca *et al.*, 1988; Walton *et al.*, 1989b).

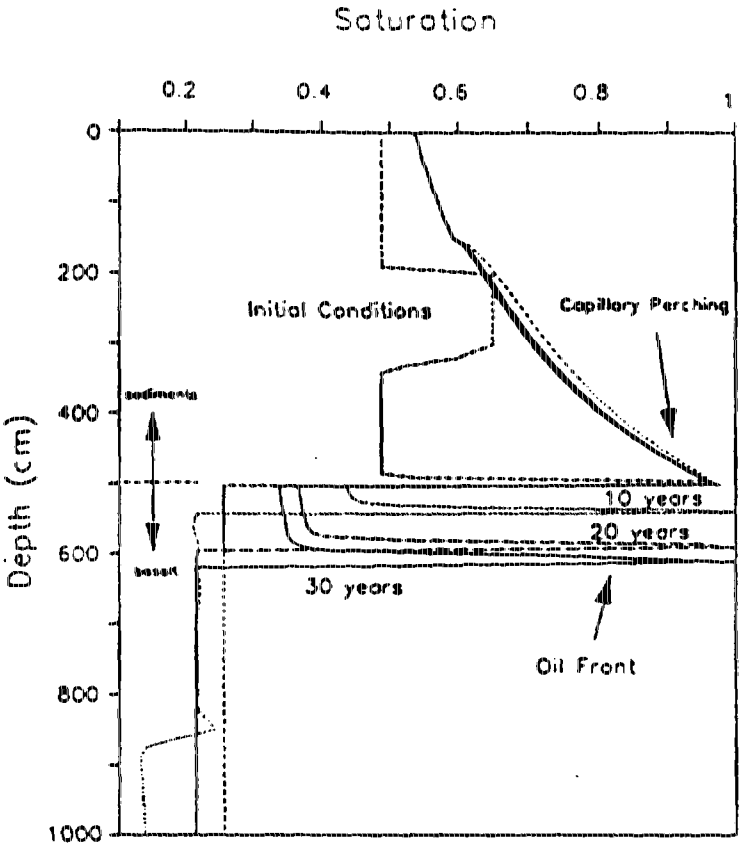

Figure 7. Simulated total saturation (oil + water) as a function of time and distance. Note the capillary perching of water in the sediments just above the basalt.

Entrained radionuclides will migrate with the machine oil. The issue of most concern regarding the interaction of radionuclides with the petroleum hydrocarbons is the possibility of radiolytical degradation of oil contributing to complexation of radionuclides in a form soluble in the aqueous phase (Rawson and Walton, 1989). Studies are ongoing to assure that solubilization of plutonium by organic degradation products of the machine oil is not occurring.

Because any oil that has migrated into the basalts will likely contain entrained radionuclides, the potential exists for introducing a significant residual radionuclide source term to the vadose zone. While the predicted migration distance of radionuclides associated with the oil is insignificant in relation to distance to the groundwater table, such a source term could prove difficult to remediate due to the difficulty of applying current technologies to basalt.

An ongoing field investigation is being conducted at the site, and it is planned to obtain samples from the soil buffer that exists beneath the base of the pits. Any samples taken beneath the waste pits will be analyzed for the presence of petroleum hydrocarbons to determine if the simulated migration of oil is actually occurring. Further study of the effect of microbial and radiolytic degradation of oil is underway to evaluate remedial actions should the predicted migration of petroleum hydrocarbons be confirmed.

ACKNOWLEDGEMENTS

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BIOGRAPHICAL SKETCHES:

Shirley A. Rawson is a Senior Scientist at the Idaho National Engineering Laboratory (INEL). Dr. Rawson has a Ph. D. in Geology, with specialization in geochemistry, from the University of Oregon. Her research includes geochemical aspects of nuclear and hazardous waste disposal and experimental and modeling studies of radionuclide and metal solubility and sorption as related to solute transport. She has published studies on chemical reaction and mass transfer in water-rock systems.

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Robert G. Baca is the Technical Leader for Fluid and Contaminant Transport modeling at the INEL. Mr. Baca holds an M.S. degree in Mechanical Engineering from Washington State University and an M.S. degree in Nuclear Engineering from the University of Washington. His expertise includes development and application of computer models to problems of hazardous and nuclear waste disposal. He has published numerous papers on hydrological and environmental modeling.

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January 9, 1991

SUBJECT: Review of SOW for Operation of Soil Venting at Hagen Farm

FROM: Dom DiGiulio,
Applications and Assistance Branch

TO: Jae Lee, RPM
U.S. EPA - Region V
Chicago, IL

THRU: Jerry Thornhill, Deputy Chief
Applications and Assistance Branch

As requested, I have reviewed the proposed Scope of Work for Remedial Design at the Hagen Farm Site and comments by the potentially responsible parties (PRPs). My comments are as follows:

1.0 Cleanup Standard

I agree with the PRPs that a cleanup standard based on mass removal is for all practical purposes infeasible. The PRPs expressed concern on the difficulty of sampling and analyzing landfill waste material. Another concern is the ability in general to accurately determine contaminant mass at a hazardous waste site. Subsurface conditions, especially contaminant concentration, is often so spatially variable that a very large number of samples would be required to determine contaminant mass with any degree of certainty.

The PRPs propose as an alternative to base remediation on a 90% reduction of initial offgas total volatile organic compound (VOC) concentration. I suggest that remediation be based on static (i.e., soil venting system not operating) vapor concentrations of individual constituents. Static vapor measurements are more indicative of the presence and location of contaminant mass in soils. Offgas measurements represent averaged gaseous concentration levels from extraction wells drawing air from large volumes of soil. Offgas levels represent integrated volumes rather than discrete areas of soil or waste contamination. Also, offgas measurements do not adequately account for air phase VOC re-equilibration observed under static conditions. Vapor phase re-equilibration is thought to be primarily caused by diffusion of VOCs from less permeable to more permeable areas. In regard to monitoring total VOC concentration

as an indication of remediation, I suggest monitoring individual constituents. Risk is based on the carcinogenicity or toxicity of individual compounds, thus performance should also be based on individual constituents. I recommend that remediation be based on static levels of individual constituents at concentrations indicative of acceptable soil-water levels. Published values for Henry's Constants and soil-water partition coefficients based on organic carbon content can be used to evaluate soil-gas levels indicative of acceptable soil-water concentrations. Acceptable soil-water concentrations can be determined using appropriate vadose zone modeling or if soils are excessively heterogeneous (waste) by using a simple water balance method.

2.0 Pilot Scale Test

Objective identified in the SOW for the pilot scale test include determining efficient design parameters for full-scale venting implementation and evaluation of soils cleanup standard. I agree that pilot testing should determine the initial number of extraction/injection wells, well spacing, and pumping rates. A pneumatic pump test could be conducted to determine air permeability under steady state conditions. The PRPs state that a short term field test will not predict the long-term effectiveness of a vacuum extraction system. I agree with this conclusion but add that, if properly designed, a long term (3 to 6 months) pilot test could determine the feasibility of meeting proposed cleanup standards. In conducting a field test to evaluate long term effectiveness, a small area of the site could be isolated through the use of passive inlet wells and air exchange maximized (i.e. high soil-gas velocity). Within a relatively short period of time (weeks to months) the system would be driven to diffusion limited transport which in effect determines remediation time.

3.0 Venting Enhancement

The SOW states that during the first 6 months of full-scale operation, the PRPs shall examine the feasibility of enhancing microbial degradation. The PRPs state that the effectiveness of bioenhancement can be determined by having the system operational long enough to evaluate the system's capability. I suggest evaluating the feasibility of bioventing during pilot testing. Pilot testing on bioventing have been completed at a number of sites by Battelle. Procedures used by Battelle can easily be adapted for the Hagen Farm site.

ATTACHMENT B