ORIGINAL

RECEIVED
CLERK'S OFFICE
AUG 19 1997
STATE OF ILLINOIS
POLLUTION CONTROL BOARD

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

| | | |
|---|---|---|
| PETITION OF | ) | |
| CARUS CHEMICAL COMPANY, for | ) | AS 98-1 |
| ADJUSTED STANDARD from | ) | |
| Ill. Adm. Code Part 814, Subpart D. | ) | (Adjusted Standard-Land) |

## NOTICE OF FILING AND CERTIFICATE OF SERVICE

TO:

Dorothy Gunn, Clerk
Pollution Control Board
James R. Thompson Center
100 West Randolph Street
Suite 11-500
Chicago, IL 60601

Paul R. Jagiello
Division of Legal Counsel
Illinois Environmental
Protection Agency
1701 S. First Ave.
Maywood, IL 60153

Phillip A. Montalvo
Chief Legal Counsel
Illinois Department of
Natural Resources
524 S. Second Street
Springfield, IL 62701-1787

PLEASE TAKE NOTICE THAT on the 19th day of August, 1997, on behalf of Petitioner Carus Chemical Company and Respondent Illinois Environmental Protection Agency, we filed with the Clerk of the Pollution Control Board one original and nine copies of the attached **Joint Motion for Proposed Adjusted Standard and for Expedited Decision** in the above-entitled cause.

The undersigned hereby certifies that a true and correct copy of the above-described pleading was filed with the Clerk of the Pollution Control Board via hand delivery and served upon the other above-identified parties at their above-listed addresses via first class U.S. Mail, by enclosing same in an envelope, properly addressed, with postage fully prepaid, and by depositing said envelope in a U.S. Post Office mail box on the 19th day of August, 1997.

Mark Sargis

Mark Robert Sargis

Mark Robert Sargis
MAUCK, BELLANDE & CHEELY
19 South LaSalle Street
Suite 1203
Chicago, Illinois 60603
(312) 853-8713

THIS FILING IS SUBMITTED ON RECYCLED PAPER

M:Carus\Landfill\Not-Fil3

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD



| | | |
|---|---|---|
| IN THE MATTER OF: | ) | |
| | ) | |
| PETITION OF | ) | |
| CARUS CHEMICAL COMPANY, | ) | AS - 98- 1 |
| for ADJUSTED STANDARD from | ) | |
| Ill. Adm. Code Part 814, Subpart D | ) | (Adjusted Standard-Land) |

**JOINT MOTION FOR**
**PROPOSED ADJUSTED STANDARD**
**AND FOR EXPEDITED DECISION**

NOW COMES Petitioner, CARUS CHEMICAL COMPANY, a division of CARUS CORPORATION (collectively "Carus"), by its attorneys Mauck, Bellande & Cheely, and, Respondent, ILLINOIS ENVIRONMENTAL PROTECTION AGENCY ("the Agency"), and, pursuant to 35 Ill. Adm. Code 106.709, jointly propose language for an adjusted standard to be issued by the Illinois Pollution Control Board ("Board"), based on certain agreements reached between Carus and the Agency, and, in support thereof, state as follows:

1. Since Carus filed its Petition for Adjusted Standard in this matter on July 3, 1997, counsel for Carus and counsel for the Agency have conferred on numerous occasions, along with Carus's consultants and Agency staff, in an effort to clarify statements made in the Petition and to resolve as many technical issues and questions as possible concerning the Petition.

2. Pursuant to a jointly requested extension, the Agency filed its Response on August 11, 1997. In its Response, the Agency identified issues of agreement with Carus's Petition, and there were no technical bases for the Agency's recommendation of denial except one, the groundwater impact assessment. (See Agency Response, p. 13, attaching summary letter from Carus's counsel dated August 8, 1997).

3. The parties' one issue of disagreement is whether or not the adjusted standard should require that Carus submit a groundwater impact assessment ("GIA") to the Agency as a condition of the adjusted standard. The Agency indicated that it could recommend issuance of an

adjusted standard if Carus met this condition. Carus, however, disagrees that it should be required to satisfy this condition under the circumstances related to its facility. For the Significant Modification Permit, Carus performed and the Agency approved the GIA for adjacent Parcel 2. Furthermore, the groundwater quality standards established at the compliance boundary for Parcel 1 are more stringent than the standards established for Parcel 2 based on the approved zone of attenuation. While the Agency acknowledges these facts, the Agency nevertheless believes that a GIA for Parcel 1 should be performed to demonstrate projected compliance with groundwater standards at least for the design period of Parcel 1. The Agency further believes that the GIA should account for waste disposed of prior to issuance of the Significant Modification Permit because all sections of Parcel 1 are considered part of one contiguous "unit."

4. The Agency could not recommend approval of the adjusted standard because of the parties' disagreement on the issue concerning requirement of a groundwater impact assessment. Notwithstanding this disagreement, the parties identify this one issue as requiring consideration by the Board. Furthermore, the parties have proposed mutually agreeable language for an adjusted standard, to the extent of their agreement on all other issues.

5. Carus and the Agency therefore propose the following language as mutually acceptable for an adjusted standard:

> *Notwithstanding Sections 814.301 or 814.401, Carus Chemical Company may continue to accept waste for disposal in the remaining portions of Parcel 1 of Carus Disposal Area No. 2 in LaSalle County, Illinois, based on the remaining portions of Parcel 1 meeting the minimum design criteria of Subpart C of Part 814 and Section 814.302 for non-MSWLF units, for a period of up to 18 months after September 18, 1997, pursuant to the terms of its existing operating permit, subject to the following conditions:*
>
> *(1) after the adjusted period of operation, Carus must commence closure of the facility pursuant to the standards set forth in Part 811 of these regulations and its permit; and*

*(2) within 90 days after issuance of this adjusted standard, Carus shall submit as a permit modification to the Agency for review and approval a revised postclosure care plan and postclosure cost estimates, based on Sections 812.115, 812.116 and 814.402(b)(4), to account for the adjusted design period.*

6. In addition to the language proposed above, the Agency recommends addition of the following language as an additional condition of issuance of the adjusted standard, for the reasons stated in its Response:

*(3) within 90 days after issuance of this adjusted standard, Carus shall submit as a permit modification to the Agency for review and approval a groundwater impact assessment model for Parcel 1, pursuant to Sections 811.317 and 811.318(c), except that the model need only be performed for the adjusted design period.*

Carus, however, disagrees that it should be required to satisfy this condition under the circumstances related to its facility, for the reasons identified herein and in its Petition. Furthermore, Carus believes that the cost of performing a model, even as modified for the adjusted design period, will be substantially the same as performing a model that fully satisfies Sections 811.317 and 811.318(c), and is not necessary for the limited relief sought by Carus.

7. If an adjusted standard is issued, it is the Agency's position that Parcel 1 should not remain open for "an indefinite period" beyond September 18, 1997, and that the adjusted standard therefore should appear in Subpart D of the regulations, as new Section 814.403, rather than Subpart C. Along with its original proposal under Subpart D, Carus had proposed alternative language under Subpart C because the remaining sections of Parcel 1, though originally designated under Subpart D, were designed and constructed to the minimum design criteria of Subpart C of Part 814, which the Agency acknowledged in recent discussions. Despite meeting these design criteria, Carus does not need or want to operate Parcel 1 for more than the time necessary to achieve final contours and complete a transition to operation of Parcel 2, because operation of Parcel 1 for "an indefinite period" likely will increase Carus's overall operational and post-closure costs. Carus therefore acknowledges the Agency's preference that

the adjusted standard be made to Subpart D, but Carus still would not object to issuance of the adjusted standard under either Subpart C or D, depending on which subpart the Board finds more appropriate. For example, the Board may impose the same time limitation on continued operation in an adjusted standard whether under Subpart C or D, using language similar to that suggested above by the parties.

8. Because both Carus and the Agency desire a decision as soon as practicable in this matter because of the approaching regulatory dead line, the parties have agreed upon the language for a proposed adjusted standard, as set forth above, except that the parties disagree on whether the additional condition requiring a groundwater impact assessment model is necessary.

9. In addition to other information and documents submitted in this proceeding, the parties attach the following documents for the Board's reference: Significant Modification Permit dated October 4, 1993 (Exhibit A); and Groundwater Impact Assessment, included as Attachment 2 to Addendum 2 to the Application for Significant Modification attached to cover letter dated March 5, 1993 (Exhibit B), and modifications thereto attached to cover letter dated July 6, 1993 (Exhibit C).

10. No hearing has been requested in this matter, and the parties believe that all relevant information has been submitted to the Board for consideration and decision in this matter. Nevertheless, the parties acknowledge that the Board may schedule a hearing in this matter or request further information from the parties, if the Board deems necessary.

11. Because of the significant progress made by the parties in discussing the Petition and in resolving as many technical issues as possible, and because of Carus's need to know whether it may continue disposal operations at Parcel 1 pursuant to the relief requested, it is vital that a final decision in this proceeding be issued as soon as practicable prior to September 18, 1997.

WHEREFORE, Petitioner CARUS CHEMICAL COMPANY and Respondent ILLINOIS ENVIRONMENTAL PROTECTION AGENCY jointly request that the Board consider the proposed language for an adjusted standard submitted jointly by the parties, identifying one issue of disagreement for the Board's consideration, and request that the Board render an expedited final decision on Carus's Petition for Adjusted Standard.

Respectfully submitted,

CARUS CHEMICAL COMPANY,
a division of CARUS CORPORATION

By: Mark Sargis

Mark Robert Sargis
MAUCK, BELLANDE & CHEELY
19 South LaSalle Street
Suite 1203
Chicago, Illinois 60603
(312) 853-8713

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

By: Paul R. Jagiello

Paul R. Jagiello
Assistant Counsel
Illinois Environmental Protection Agency
1701 South First Avenue, Suite 600
Maywood, Illinois 60153
(708) 338-7900

M:Land6II\Mot-JNT1

State of Illinois
ENVIRONMENTAL PROTECTION AGENCY

Mary A. Gade, Director
2200 Churchill Road, Springfield, IL 62794-9276
217/524-3300

Orig → H. Adolf
cc: D. Covey

October 4, 1993

Carus Chemical Company
A Division of Carus Corporation
Attn: Mr. Paul Carus, Executive Vice President
1500 Eighth Street
LaSalle, Illinois 61301

Re: 0990800015 -- LaSalle County
Carus Chemical Company
Permit No. 1991-365-LFM
Log No. 1991-365
Permit File

Dear Mr. Carus:

Permit is hereby granted to Carus Chemical Company as owner and operator allowing a significant modification of the above-referenced non-hazardous special waste landfill all in accordance with the application and plans prepared by Andrews Environmental Engineering, Inc. Final plans, specifications, application and supporting documents as submitted and approved shall constitute part of this permit and are identified on the records of the Illinois Environmental Protection Agency, Bureau of Land by the permit number(s) and log number(s) designated in the heading above.

The application approved by Permit No. 1991-365-LFM consists of the following documents:

| DOCUMENT AND DATE | DATE RECEIVED |
|---|---|
| Original Application - November 15, 1991 | November 19, 1991 |
| Application Waiver - February 14, 1992 | February 18, 1992 |
| Application Waiver - April 16, 1992 | April 20, 1992 |
| Application Waiver - May 15, 1992 | May 19, 1992 |
| Application Waiver - June 12, 1992 | June 16, 1992 |

EXHIBIT
A

| | |
|---|---|
| Application Waiver - July 13, 1992 | July 15, 1992 |
| Application Waiver - August 31, 1992 | September 3, 1992 |
| Application Waiver - October 30, 1992 | October 30, 1992 |
| Application Addendum - November 30, 1992 | November 30, 1992 |
| Application Waiver - February 24, 1993 | February 26, 1993 |
| Application Addendum - March 5, 1993 | March 5, 1993 |
| Application Waiver - May 27, 1993 | June 1, 1993 |
| Application Addendum - July 6, 1993 | July 6, 1993 |
| Application Addendum - July 19, 1993 | July 20, 1993 |

Pursuant to Section 39(a) of Illinois Environmental Protection Act (hereinafter "the Act") and 35 IAC, 813.104(b), this permit is issued subject to the development, operating, and reporting requirements for non-hazardous waste landfills in 35 IAC Parts 810, 811, 812 and 813, as modified by 35 IAC Part 814, Subpart C, the standard conditions attached hereto, and the following special conditions. In case of conflict between the permit application and these conditions (both standard and special), the conditions of this permit shall govern.

I. CONSTRUCTION QUALITY ASSURANCE

1. All necessary surface drainage control facilities shall be constructed prior to other disturbance in any area.

2. Except for those areas permitted for operation pursuant to Item C of Permit No. 1991-365-LFM, no part of the unit subject to Permit No. 1991-365-LFM shall be placed into service (i.e. begin waste disposal) until a acceptance report for all the activities listed below has been submitted to and approved by this Agency as a significant modification pursuant to 35 IAC, 811.505(d) and 813.203.

a. Compaction of the subgrade and foundation to design parameters;

b. Installation of the compacted earth liner;

c. Installation of the leachate drainage and collection system; and

d. Construction of ponds, ditches, lagoons and berms.

3. The permittee shall designate and independent third party contractor as the Construction Quality Assurance (CQA) Officer(s). The CQA Officer(s) shall be an Illinois Certified Professional Engineer who is independent from and not under the control or influence of the operator, any employee of the operator, or any other corporation, company or legal entity that is a subsidiary, affiliate, parent corporation or holding corporation associated with the operator.

4. All standards for testing the characteristics and performance of materials, products, systems and services shall be those established by ASTM unless otherwise stated in the permit application.

## II. OPERATING CONDITIONS

1. Pursuant to 35 IAC, 811.107(a) and 811.107(b), throughout the operating life of this landfill, waste shall not be placed in a manner or at a rate which results in unstable internal or external slopes or interference with construction, operation or monitoring activities.

2. The operator of this solid waste facility shall not conduct the operation in a manner which results in any of the following:

a. refuse in standing or flowing waters;

b. leachate flows entering waters of the State;

c. leachate flows exiting the landfill confines (i.e., the facility boundaries established for the landfill in a permit or permits issued by the Agency);

d. open burning of refuse in violation of Section 9 of the Act;

e. uncovered refuse remaining from any previous operating day or at the conclusion of any operating day, unless authorized by permit;

f. failure to provide final cover within time limits established by Illinois Pollution Control Board (the Board) regulations;

g. acceptance of wastes without necessary permits;

h. scavenging as defined by Board regulations;

i. deposition of refuse in any unpermitted (i.e., without an Agency approved significant modification authorizing operation) portion of the landfill;

j. acceptance of a special waste without a required manifest;

k. failure to submit reports required by permits or Board regulations;

l. failure to collect and contain litter from the site by the end of each operating day.

3. Moveable, temporary fencing shall be used to prevent blowing litter when the refuse is above the natural ground line.

4. All waste which is not covered within 14 days of placement of another lift of waste, intermediate cover or final cover shall have daily cover consisting of compacted clean soil with a minimum thickness of six (6) inches applied to it.

5. No later than 60 days after placement of the final lift of waste in any area, the area shall receive a final cover system consisting of three (3) feet of low permeability material overlain by three (3) feet of final protective layer as detailed in 35 IAC, 811.314.

6. All waste, which is not covered within 60 days of placement of another lift of waste or final cover, shall have an intermediate cover of compacted clean soil with a minimum thickness of one (1) foot applied to it.

7. The operator shall implement a load checking program that meets the requirements of 35 IAC, 811.323. If regulated hazardous waste or other unacceptable wastes are discovered, the Agency shall be notified no later than 5:00 p.m. the day it is detected. The load checker shall prepare a report describing the results of each inspection. A summary of these reports shall be submitted to the Agency as part of this facility's annual report.

8. No special waste shall be received for disposal at this facility without a special waste stream permit granted by the Agency.

9. All of this facility's previously issued, "individual" special waste stream permits, which have not yet expired, shall also remain in effect. However, their respective expiration dates are not modified by the issuance this permit.

10. In managing special waste at this landfill, the operator shall comply with the requirements of 35 IAC, Part 811, Subpart D. These requirements include:

    a. A prominent sign at the entrance of the facility notifying waste generators and transporters of the documents by which loads of special wastes must be accompanied;

    b. Special waste manifesting;

    c. Special waste profile identification sheets and special waste recertifications;

    d. Recordkeeping requirements; and

    e. Procedures for excluding regulated hazardous wastes.

11. The permittee shall submit an annual report to this Agency for all non-hazardous special waste in accordance with 35 Ill. Adm. Code, Subtitle G, Part 809, Subpart E.

12. The operating hours for this facility shall be limited to between 7:00 a.m. - 3:00 p.m., Mondays through Fridays, excluding holidays and between 7:00 a.m. - 11:30 a.m. on Saturdays. Operating hours are those hours during which waste may be accepted at this facility.

13. The operation of this facility shall not cause a violation of the Noise Control Regulations in 35 IAC Subtitle H, Section 901.

## III. GENERAL CONDITIONS

1. This permit is issued with the expressed understanding that no process discharge to Waters of the State or to a sanitary sewer will occur from these facilities except as authorized by a permit issued by the Bureau of Water Pollution Control.

2. Site surface drainage, during development, during operation and after the site is closed, shall be managed in accordance with the approved drainage control plan.

3. If changes occur which modify any of the information the Permittee has used in obtaining a permit for this facility, the Permittee shall notify the Agency. Such changes would include but not be limited to any changes in the names or addresses of both beneficial and legal titleholders to the herein-permitted site. The notification shall be submitted to the Agency within fifteen (15) days of the change and shall include the name or names of any parties in interest and the address of their place of abode; or, if a corporation, the name and address of its registered agent.

4. The Agency reserves the right to require installation of additional monitoring devices, to require analyses for certain parameters, to alter the sample parameters list and to modify the method of evaluating the monitoring results as necessary to fulfill the intent and purpose of the Act or Board Regulations.

5. This permit is subject to review and modification by the Agency as deemed necessary to fulfill the intent and purpose of the Act, and all applicable environmental rules and regulations.

6. Pursuant to 35 IAC, 813.201(a), any modifications to this facility shall be proposed in the form of a permit application and submitted to the Agency.

7. Pursuant to 35 IAC, 813.301, an application for permit renewal shall be filed with the Agency at least 90 days prior to the expiration date of this permit.

8. All elements of this permit, which do not require a significant modification authorizing operation pursuant to 35 IAC, 811.505(d) and 813.203, shall be implemented immediately. Examples of such elements include, but are not limited to, groundwater and leachate monitoring of existing monitoring points and the load checking programs required by 35 IAC, 811.323 and 811.401 - 811.406.

## IV. LEACHATE MANAGEMENT/MONITORING

1. The following monitoring points are to be used in the Leachate Monitoring Program for this facility:

Leachate Collection Manholes

| Applicant Designation | Agency Designation |
|---|---|
| MH-1 (Parcel 1) | L301 |
| Undesignated Manhole In Parcel 2 | L302 |

2. Pursuant to 35 IAC 811.309(g), 811.319(a)(1)(C)(ii), 810.103, 811.202, 722.111 and 721, Subpart C, leachate monitoring (i.e., sampling, measurements and analysis) must be started at each manhole when that manhole accumulates a measurable quantity of leachate for the first time. The concentrations or values for the parameters contained in List L1 (below) shall be determined on a quarterly basis for each "producing" manhole and submitted with the

quarterly groundwater reports. Condition IV.3. presents the sampling, testing and reporting schedules in tabular form. Leachate monitoring at each manhole shall continue as long as groundwater monitoring at this landfill is necessary pursuant to 35 IAC, 811.319(a)(1)(C).

LIST L1

| Routine Leachate Monitoring Parameters | STORET |
|---|---|
| Temp. of Leachate Sample (°F) | 00011 |
| Specific Conductance | 00094 |
| pH | 00400 |
| Elevation Leachate Surface | 71993 |
| BTM of Well Elevation | 72020 |
| Leachate Level from Measuring Point (ft.) | 72109 |
| Arsenic (total) | 01002 |
| Barium (total) | 01007 |
| Cadmium (total) | 01027 |
| Chromium (hexavalent) | 01032 |
| Chromium (total) | 01034 |
| Iron (total) | 01045 |
| Manganese (total) | 01055 |
| Nickel (total) | 01067 |
| Chloride | 00940 |
| Potassium | 00937 |
| Sulfate | 00945 |
| Total Dissolved Solids | 70300 |

3. Leachate monitoring data shall be collected and reported to this Agency in accordance with the following schedule:

| SAMPLING PERIODS | MONITORING POINTS | PARAMETER LIST | REPORT DUE DATE |
|---|---|---|---|
| January or February | L301 and L302 | List L1 | April 15 |
| April or May | L301 and L302 | List L1 | July 15 |
| July or August | L301 and L302 | List L1 | October 15 |
| October or November | L301 and L302 | List L1 | January 15 |

4. Pursuant to 35 IAC 811.309(h)(1), leachate from this landfill shall be collected, treated, or disposed of beginning as soon as it is first produced and continued for at least five (5) years after closure. Collection, treatment and disposal of leachate may cease only when the conditions described in 35 IAC 811.309(h)(2) have been achieved. Leachate removed from this landfill shall be treated at an IEPA permitted facility or reused at the Carus Chemical plant in accordance with the leachate management plan proposed in the Permit Application, Log No. 1991-365.

5. Pursuant to 35 IAC 811.307(a) and (b), 811.308(a) and (h) and 811.309(a), throughout the period that the leachate collection/management system must be operated, the maximum leachate head above the liner shall be one (1) foot.

6. In the event that the leachate monitoring program identifies a constituent in the leachate that is not already in the parameter lists for the groundwater monitoring program, the operator shall, within 90 days of such discovery, submit a permit application to the Agency proposing to include that constituent in the groundwater monitoring program.

7. The Agency has determined that the leachate holding ponds are treatment facilities and are therefore subject to permits from the Bureau of Water, Permit Section to construct and operate a treatment works.

## V. GROUNDWATER MONITORING

1. The groundwater monitoring program must be capable of determining background groundwater quality hydraulically upgradient of and unaffected by the units and to detect, from all potential sources of discharge, any releases to groundwater within the facility. This Agency reserves the right to require installation of additional monitoring wells as may be necessary to satisfy the requirements of this permit.

2. The groundwater monitoring wells shall be constructed and maintained in accordance with the requirements of 35 IAC, 811.318(d) and designs approved by the Agency.

3. Groundwater monitoring wells shall be installed in the locations shown in Figure 2 of Addendum No. 2, dated March 5, 1993 of the Permit Application, Log No. 1991-365, and screened in the hydrogeologic unit(s) identified as potential contaminant pathway(s) within the uppermost aquifer. All of the groundwater monitoring wells shown in Figure 2, for Parcel 1 which have not yet been constructed, shall be installed within 90 days of Permit No. 1991-365-LFM's date of issuance. Monitoring of these new wells

shall begin during October or November of 1993 in accordance with Conditions V.14 and V.15. Groundwater monitoring wells shown in Figure 2 for Parcel 2 shall be installed prior to the operator's request for operating authorization for Parcel 2.

4. Within 60 days of installation of any groundwater monitoring well, boring logs compiled by a qualified geologist, well development data and as-built diagrams shall be submitted to the Agency utilizing the enclosed "Well Completion Report" form. For each well installed pursuant to this permit, one form must be completed.

5. Groundwater monitoring wells shall be easily visible, labelled with their Agency monitoring point designations and fitted with padlocked protective covers.

6. In the event that any well becomes consistently dry or unserviceable and therefore require replacement, a replacement well shall be installed within ten (10) feet of the existing well. The Agency shall be notified in writing at least 15 days prior to the installation of all replacement wells. A replacement well that is more than ten feet from the existing well or which does not monitor the same geologic zone is considered to be a new well and must be approved via a significant modification permit.

7. All borings/wells not used as monitoring points shall be backfilled in accordance with the enclosed IEPA monitoring well plugging procedures. The decommissioning and reporting procedures, contained in the Illinois Department of Public Health's Water Well Construction Code, 77 IAC, Part 920 (effective 1/1/92), shall also be followed.

8. Elevation of stick-up is to be surveyed and reported to the Agency when: a. The well is installed (with the as-built diagrams), b. every two years thereafter, or c. whenever there is reason to believe that the elevation has changed.

9. Groundwater sampling and analysis shall be performed in accordance with the requirements of 35 IAC 811.318(e) and the specific procedures and methods approved by the Agency.

10. The applicable groundwater quality standards (AGQS) for the facility are subject to the following conditions:

    a. Temperature and the field parameters requiring depth or elevation measurements are not considered groundwater constituents and do not require AGQS.

    b. For constituents which have not been detected in the groundwater, the approved method detection limit (MDL) or practical quantitation limit (PQL) shall be used as the AGQ.

## LIST G1 (Groundwater - Quarterly)

| FIELD PARAMETERS | STORETS |
|---|---|
| pH | 00400 |
| Specific Conductance | 00094 |
| Temperature of Water Sample (°F) | 00011 |
| Depth to Water (ft. below land surface) | 72019 |
| Depth to Water (ft. below measuring point) | 72109 |
| Elevation of Measuring Point (Top of casing ft. MSL) | 72110 |
| Elevation of Groundwater Surface (ft. MSL) | 71993 |
| Elevation of Bottom of Well (ft. MSL) | 72020 |

| LABORATORY PARAMETERS | STORETS |
|---|---|
| Sulfate (MG/L) | 00945 |
| Sulfate (Dissolved, MG/L) | 00946 |
| Chloride (MG/L) | 00940 |
| Chloride (Dissolved, MG/L) | 00941 |
| Chromium | 01034 |
| Chromium (Dissolved) | 01030 |
| Manganese | 01055 |
| Manganese (Dissolved) | 01056 |
| Potassium (MG/L) | 00937 |
| Potassium (Dissolved, MG/L) | 00935 |
| Total Dissolved Solids (TDS, Dried at 180°C) (Dissolved) | 70300 |
| Aluminum | 01105 |
| Aluminum (Dissolved) | 01106 |
| Calcium (MG/L) | 01027 |
| Calcium (Dissolved, MG/L) | 01025 |
| Cobalt | 01037 |
| Cobalt (Dissolved) | 01035 |
| Copper | 01042 |
| Copper (Dissolved) | 01040 |
| Lead | 01051 |
| Lead (Dissolved) | 01049 |
| Sodium (MG/L) | 00929 |
| Sodium (Dissolved, MG/L) | 00930 |

## LIST G2 (Groundwater - Biennial)

| ORGANIC PARAMETERS | STORETS |
|---|---|
| 1,1 Dichloroethane | 34496 |
| 1,1 Dichloroethene | 34501 |
| Trans-1,2 Dichloroethene | 34546 |
| Ethyl Benzene | 78113 |
| Napthalene | 34696 |
| Phenols | 32730 |
| Toluene | 34010 |
| Trichloroethene | 39180 |
| Trichlorofluoromethane | 34488 |
| Vinyl Chloride | 39175 |
| Xylenes (Total) | 81551 |

LIST G2 (Groundwater - Biennial)
(Con't)

| ORGANIC PARAMETERS | STORETS |
|---|---|
| Atrazine | 39033 |
| Bromomethane (Methyl Bromide) | 34413 |
| n-Butylbenzene | 77342 |
| sec-Butylbenzene | 77350 |
| Carbofuran | 81405 |
| Carbon Tetrachloride | 32102 |
| Chlordane | 39350 |
| Bis (Chloromethyl) Ether | 34268 |
| o-Chlorotoluene | 77970 |
| p-Chlorotoluene | 77970 |
| Chlorodibromomethane (Dibromochloromethane) | 32105 |
| DDT | 39370 |
| Dibromomethane (Methylene Bromide) | 77596 |
| m-Dichlorobenzene | 34566 |
| o-Dichlorobenzene | 34536 |
| Dichlorodifluoromethane | 34668 |
| Dieldrin | 38380 |
| Ethylene Dibromide (EDB) (1,2-Dibromomethane) | 77651 |
| Heptachlor | 39410 |
| Heptachlor Epoxide | 39420 |
| Hexachlorobutadiene | 39702 |
| Iodomethane | 77424 |
| Isopropylbenzene | 77223 |
| p-Isopropyltoluene | 34723 |
| Lindane | 39782 |
| Methoxychlor | 39480 |
| Oil (Hexane-Soluble or Equivalent) MG/L | 00550 |
| Parathion | 39540 |
| Pentachlorophenol | 39032 |
| Polychlorinated Biphenyls | 39516 |
| n-Propylbenzene | 77224 |
| Styrene | 77128 |
| Tert-Butylbenzene | 77353 |
| Tetrachloroethylene | 34475 |
| Toxaphene | 39400 |
| m-Xylene | 77134 |
| o-Xylene | 77135 |
| p-Xylene | 77133 |
| 1,1,1-2-Tetrachloroethane | 77562 |
| 1,1,2,2-Tetrachloroethane | 34516 |
| 1,1-Dichloropropene | 77168 |
| 1,2,3-Trichlorobenzene | 77613 |
| 1,2,3-Trichloropropane | 77443 |

LIST G2 (Groundwater - Biennial)
(Con't)

| ORGANIC PARAMETERS | STORETS |
|---|---|
| 1,2,4-Trichlorobenzene | 34551 |
| 1,2,4-Trimethylbenzene | 77222 |
| 1,2-Dibromo-3-Chloropropane | 38760 |
| Cis-1,2-Dichloroethylene | 77093 |
| 1,2-Dichloroethane | 34531 |
| 1,2-Dichloropropane | 34541 |
| 1,3,5-Trimethylbenzene | 77226 |
| 1,3-Dichloropropane | 77173 |
| 1,3-Dichloropropene | 34561 |
| 2,2-Dichloropropane | 77170 |
| 2,4,5-tp (Silvex) | 39760 |
| 2,4-Dichlorophenoxyacetic Acid (2,4-D) | 39730 |
| Acrylonitrile | 34215 |
| Alachlor | 77825 |
| Aldicarb | 39053 |
| Benzene | 34030 |
| Chlorobenzene | 34301 |
| Chloroethane | 34311 |
| Chloroform | 32106 |
| Chloromethane | 34709 |
| p-dichlorobenzene | 34571 |
| Dichloromethane | 34713 |
| Fluorotrichloromethane | 34722 |

Note: All parameters with the "(Dissolved)" label to the right shall be determined using groundwater samples which have been filtered through a 0.45 micron filter. All other parameters shall be determined from unfiltered samples.

ii. The applicable groundwater quality standards (AGQS) are given in ug/l except as otherwise noted. Also, the monitoring results should be reported in ug/l units unless otherwise indicated.

11. The following monitoring points are to be used in the groundwater monitoring program for this facility:

Background Groundwater Quality Wells

| Applicant Designation | Agency Designation |
|---|---|
| G110 | G110 |
| G15D | G130 |
| G16D | G131 |

Zone of Attenuation Wells

| Applicant Designation | Agency Designation |
|---|---|
| G132 | G132 |
| G133 | G133 |
| G134 | G134 |
| G135 | G135 |

Detection Monitoring Wells

| | |
|---|---|
| G104 | G104 |
| G12D | G12D |
| G13D | G13D |
| G111 | G111 |

Piezometer Wells

| | |
|---|---|
| P101 | P101 |
| P102 | P102 |
| P132 | P132 |
| P133 | P133 |
| P134 | P134 |
| P135 | P135 |

12. The approved monitoring program shall begin immediately, and continue for at least fifteen (15) years after closure and shall not cease until the conditions described in 35 IAC, 811.319(a)(1)(C) have been achieved. The operator shall collect samples from all of the monitoring points listed in Condition V.11 for the parameters listed in Condition V.10 (Lists G1 and G2) and the sample results reported to this Agency, all in accordance with the following schedule:

| Sampling Period | Parameter List | Report Due Date |
|---|---|---|
| January or February | List G1 | April 15 |
| April or May | List G1 | July 15 |
| July or August | List G1 | October 15 |
| October or November | Lists G1 and G2 | January 15 |

Note: List G2 shall be conducted biennially.

13. Elevation of groundwater surface (ft. MLS), Storet No. 71993, shall be measured at all groundwater monitoring points listed in Condition V.11. on a monthly basis. The measurements shall be submitted quarterly in accordance with schedule listed above.

14. The MAPCs proposed in Section 3, Table 5 of Addendum 2 dated March 5, 1993 are hereby approved. However, MAPCs for all inorganic constituents detected in the leachate were not developed. Therefore, unless modified by the permittee, the MAPC values listed below for the following constituents at each downgradient monitoring well have been set at background groundwater values. (In the event a statistical background value was not provided in Section 3, Appendix J of Addendum 2 to the application, the Class I groundwater quality standard was used):

| PARAMETER | MAPC |
|---|---|
| Boron | 1.107 |
| Fluoride | 4.0 + |
| Nitrogen (as Nitrate) | 10.0 + |
| Beryllium | 0.002 * |
| Iron | 46.516 |
| Magnesium | 133.42 |
| Mercury | .0014 |
| Silver | .084 |
| Zinc | 17.081 |

+ = Class I Standard
* = Detection Limit

Note: All values in mg/l.

15. The permittee shall use the method in Attachment 23, page 11 of Log No. 1991-365 or propose for Agency approval, a more appropriate method to statistically evaluate the groundwater monitoring data. The selected method must provide for statistical comparisons between upgradient and downgradient groundwater quality data and a reasonable balance between the probability of obtaining Type I (false positive) and type II (false negative) errors. The Type I error rate must be no less than 1% percent. The proposal must consider the gathering of a background data set (from upgradient wells), sufficient to provide an accurate representation of the variability in the quality of groundwater that is unaffected by operations at the facility, and to assure that the selected test has a reasonable chance of detecting releases should they occur.

16. Pursuant to 35 IAC, 811.319(a)(4)(A), any of the following events shall constitute an observed increase:

   a. The concentration of any constituent in List G1 of Condition V.10. shows a progressive increase over four (4) consecutive quarters.

b. The concentration of any constituent monitored in accordance with List G1 or List G2 of Condition V.10. exceeds the MAPC at an established monitoring point within the zone of attenuation.

c. The concentration of any <u>organic</u> constituent in List G2, monitored in accordance with Condition V.10.:

i. Exceeds the preceding measured concentration at any established point; <u>and</u>

ii. Is greater than or equal to its practical quantitation limit (PQL).

d. The concentration of any constituent monitored at or beyond the zone of attenuation exceeds an AGQS.

e. For each sampling event, using the methods in Condition V.15 above, the permittee must determine if an observed increase in groundwater quality has occurred by comparing sample results from each downgradient well to the upgradient well's background data established during the first year of monitoring. This comparison must evaluate each parameter for each well.

17. For each round of sampling described in Condition V.15., the operator must determine if an observed increase has occurred within 45 days of the date the samples were collected. If an observed increase is identified, the operator must also notify the Agency in writing within 10 days and follow the confirmation procedures of 35 IAC, 811.319(a)(4)(B). The operator must also complete the confirmation procedures within 90 days of the initial sampling event.

18. Within 90 days of confirmation of any monitored increase, the operator shall submit a permit application for a significant modification to begin an assessment monitoring program in order to determine whether the solid waste disposal facility is the source of the contamination and to provide information needed to carry out a groundwater impact assessment in accordance with 35 IAC 811.319(b).

19. Issuance of this permit does not constitute acceptance of the permittee's contention as provided in Log No. 1991-365 that groundwater quality for this facility should be governed by the standards established pursuant to 35 Ill. Adm. Code 620.240, entitled "Class IV: Other Standards". All groundwater shall be considered Class I until the permittee provides appropriate justification for Class IV standards.

VI. CLOSURE/POST CLOSURE CARE

1. Upon completion of closure activities, the operator shall notify the Agency that the site has been closed in accordance with the approved closure plan utilizing the Agency's "Affidavit for Certification of Completion of Closure of Non-Hazardous Waste Facilities".

2. Inspections of the closed landfill shall be conducted in accordance with the approved post-closure care plan. Records of field investigations, inspections, sampling and corrective action taken are to be maintained at the site and made available to IEPA personnel. During the post-closure care period, these records are to be maintained at the office of the site operator.

3. If necessary, the soil over the entire planting area shall be amended with lime, fertilizer and/or organic matter. On sideslopes, mulch or some other form of stabilizing material is to be provided to hold seed in place and conserve moisture.

4. When the post-closure care period has been completed, the operator shall notify the Agency utilizing the Agency's "Affidavit for Certification of Completion of Post-Closure Care for Non-Hazardous Waste Facilities".

5. The current cost estimate for closure and post-closure of Parcel 1, provided in the Permit Application, Log No. 1991-365, pursuant to 35 IAC, 811.704, is $213,921.00. As part of (or prior to) the application for the first significant modification authorizing operation pursuant to 35 IAC, 813.203, the operator shall revise this cost estimate to reflect the modifications entailed by the permit conditions of Permit No. 1991-365-LFM. For example, there are leachate and groundwater monitoring parameters required by the permit conditions, which were not proposed in the permit application. The additional cost of analyzing for these parameters during the post-closure care period will increase the cost estimate for post-closure care.

6. The operator shall provide financial assurance for closure and post-closure care pursuant to 35 IAC, 811.700(b). Documentation of this financial assurance must be submitted with the application for the first significant modification to authorize operation. The receipt of waste, beyond those areas permitted for waste disposal in Item C of this permit letter, shall not be approved until adequate documentation of 35 IAC, 811.700(b) financial assurance has been provided. However, 35 IAC, 811.700(b) financial assurance shall be required only for those areas for which authorization to operate has been obtained or is being requested.

7. The operator shall increase the total amount of financial assurance so as to equal the current cost estimate within 90 days of an increase in the current cost estimate in accordance with 35 IAC, 811.701(b).

VII. REPORTING REQUIREMENTS

1. This landfill's annual report for the year ending March 31, shall be submitted to the Agency by May 1, pursuant to 35 IAC, 813.501. The annual report shall include:

   a. A waste volume summary which includes:

      i. Total volume of solid waste accepted at the facility during the past year in cubic yards as measured at the gate;

      ii. The remaining solid waste capacity in the unit in cubic yard as measured at the gate; and

      iii. A copy of all identification reports required under 35 IAC 811.404.

   b. Monitoring data from the leachate collection system and groundwater monitoring network, including:

      i. Graphical results of monitoring efforts;

      ii. Statistical summaries and analysis of trends;

      iii. Changes to the monitoring program; and

      iv. Discussion of error analysis, detection limits and observed trends.

   c. Proposed activities for the upcoming year including:

      i. Amount of waste expected;

      ii. Structures to be built; and

      iii. New monitoring stations to be installed.

   d. Any significant modification affecting the operation of the facility.

   e. The signature of the operator or duly authorized agent as specified in 35 IAC 812.104.

2. In addition to the annual report, the quarterly reports on the test results from groundwater and leachate monitoring shall be submitted to the Agency in accordance with the schedules described in Conditions IV.3. and V.15, pursuant to 35 IAC, 813.501.

The original and two (2) copies of all certifications, logs, reports and plan sheets and three (3) copies of groundwater monitoring chemical analysis forms which are required to be submitted to the Agency by the permittee should be mailed to the following address:

Illinois Environmental Protection Agency
Planning and Reporting Section
Division of Land Pollution Control -- #24
2200 Churchill Road
Post Office Box 19276
Springfield, Illinois 62794-9276

Very truly yours,

Lawrence W. Eastep

Lawrence W. Eastep, P.E., Manager
Permit Section
Division of Land Pollution Control
Bureau of Land

KES

LWE:KES:lat/sp/823Y,1-18

Enclosures:
1. Well Completion Report Form
2. Monitoring Well Plugging Procedures
3. Affidavit for Certification of Completion of Closure of Non-Hazardous Waste Facilities
4. Affidavit for Certification of Completion of Post-Closure Care for Non-Hazardous Waste Facilities

cc: LaSalle County Health Department
Bryan C. Johnsrud, P.E., Andrews Environmental Engineering, Inc.

ANDREWS ENVIRONMENTAL ENGINEERING INC. 3535 Mayflower Blvd., Springfield, Illinois 62707/(217) 787-2334

March 5, 1993

Mr. Lawrence W. Eastep, P.E.,
Permit Section Manager
Division of Land Pollution Control
**Illinois Environmental Protection Agency**
Post Office Box 19276
Springfield, IL 62794-9276

re: 0990800015 -- LaSalle County
Carus Disposal Area No. 2
Application for Significant Modification to Permit
IEPA-DLPC Log No. 1991-365

Dear Mr. Eastep:

On behalf of our client, Carus Chemical Company, enclosed herewith is an original and two (2) copies of Addendum 2 to the referenced application for the subject facility. This Addendum has been prepared to address each of the deficiencies/inadequacies related to the Hydrogeologic Investigations, Groundwater Impact Assessment, and Groundwater Monitoring Program, as identified by the staff of the Groundwater Assistance Unit.

The Addendum to the Report of Hydrogeologic Investigations is designed to augment the original report in the above referenced application. The Groundwater Impact Assessment and Groundwater Monitoring Program of this Addendum were written to completely replace the comparable Sections in the original submittal.

Addendum 1 was previously submitted to the Agency on November 30, 1992.

We believe the accompanying materials satisfactorily address the issues and concerns identified by the Agency. However, if any questions arise or further information or clarification is needed by your staff, please do not hesitate to contact us.

Sincerely,

Rhonald W. Hasenyager

Rhonald W. Hasenyager
Hydrogeologist
Division of Solid Waste Management

CC: Carus Chemical Company

Enclosures

RWH:njm

EXHIBIT
B

**Application for Significant Modification to Permit**
**Carus Disposal Area No. 2**

# ADDENDUM 2

## - TABLE OF CONTENTS -
**(In Order of Occurrence)**

# GROUNDWATER IMPACT ASSESSMENT

**ADDENDUM 2**

**to**

**Application for Significant Modification to Permit**

Carus Disposal Area No. 2

Ottawa Township
LaSalle County, Illinois

Prepared by:

Rhonald W. Hasenyager
Hydrogeologist
Division of Solid Waste Management
Andrews Environmental Engineering, Inc.

## TABLE OF CONTENTS

## APPENDICES

## LIST OF TABLES



## LIST OF FIGURES



## LIST OF PLATES

# GROUNDWATER IMPACT ASSESSMENT

## Introduction

Under the current Illinois Environmental Protection Agency (IEPA) and Illinois Pollution Control Board (IPCB) Regulations, a groundwater impact assessment is required pursuant to 35 IAC 811.117. An overview of the site geology, the formulation of a conceptual model, the conversion of the conceptual model into a mathematical framework, and the analysis of the transport processes shall be presented herein.

Since this format was not previously followed, all prior Groundwater Impact Assessments should be disregarded. Any former assumptions, data, model outputs, and/or conclusions were not used as part of this addendum, and should not be examined in conjunction with the review of this addendum.

## Site Geology

A thorough discussion of the site geology may be found in the Report of Hydrogeological Investigations (see original submittal dated 15 November 1991, Attachment 20; hereafter referred to as Original Report of Hydrogeologic Investigations, or ORHI). An overview, however, may be helpful in understanding the conceptual model used, and to elaborate on some of the model specific data needed.

The facility is located on the north bluffs overlooking the Illinois River flood plain. The bluffs have a thin veneer of Pleistocene ground moraine. This till has been eroded in some places, exposing the underlying bedrock.

Bedrock at the site consists of three distinct lithologies. The upper bedrock consists of Pennsylvanian shales and coal of the Carbondale Formation. The coal and the underlying clay have been removed by mining or has been eroded in many areas of the facility.

The second lithology present is the fine- to medium-grained sands of the Ordovician St. Peter Sandstone. The St. Peter Sandstone has been defined as the uppermost aquifer for the facility.

The final lithology present is the Lower Ordovician Shakopee Dolomite. The Shakopee Dolomite has been defined as the confining unit beneath the uppermost aquifer.

## Conceptual Model

### Conversion Assumptions

To adequately express the site geology within the context of a contaminant transport model, some simplifications to the site geology and facility design are necessary (see Figures 1 and 2).

Several assumptions were made in the conversion to this conceptual model. These are:

1) **All geologic units and earthen structures are homogeneous and isotropic with respect to all lithologic and hydrologic parameters.** — Most contaminant transport models are incapable of working with the small-scale changes for these parameters, seen within many geologic materials. Sensitivity analyses performed over the observed range of values should provide an adequate examination of the effects of this variability.

2) **The uppermost aquifer is of uniform thickness, or possesses a linear rate of change in thickness.** — The thicknesses used within the model is much thinner than actually present at the site. This thinning is used to restrict the mixing zone. The lower (or thinner) values used here provide a conservative estimate of the transport processes at the site. Sensitivity analysis provides a tool to appraise the effects of localized variability in this parameter.

3) **Transport of constituents through the unsaturated portion of the uppermost aquifer is vertical and instantaneous.** — There is a portion of the uppermost aquifer that is unsaturated. To assess the impact of the unit on the site, all constituents are instantly moved to the saturated portion of the aquifer. This provides a conservative approach to the model scenario, as the transport time through the vadose zone is not included in the impact assessment, and hence provides higher concentrations sooner than what might actually occur.

4) **Geologic and hydrologic parameters used are mean values for site specific data, or mean values taken from the literature for similar materials. Ranges for these values are also taken into consideration.** — The mean values analyzed provide a reasonable analysis of the site conditions. Transport through a geologic unit with a high variability of hydraulic conductivity, transmissivity, porosity, etc., will actually produce an "average" movement through the geologic unit.

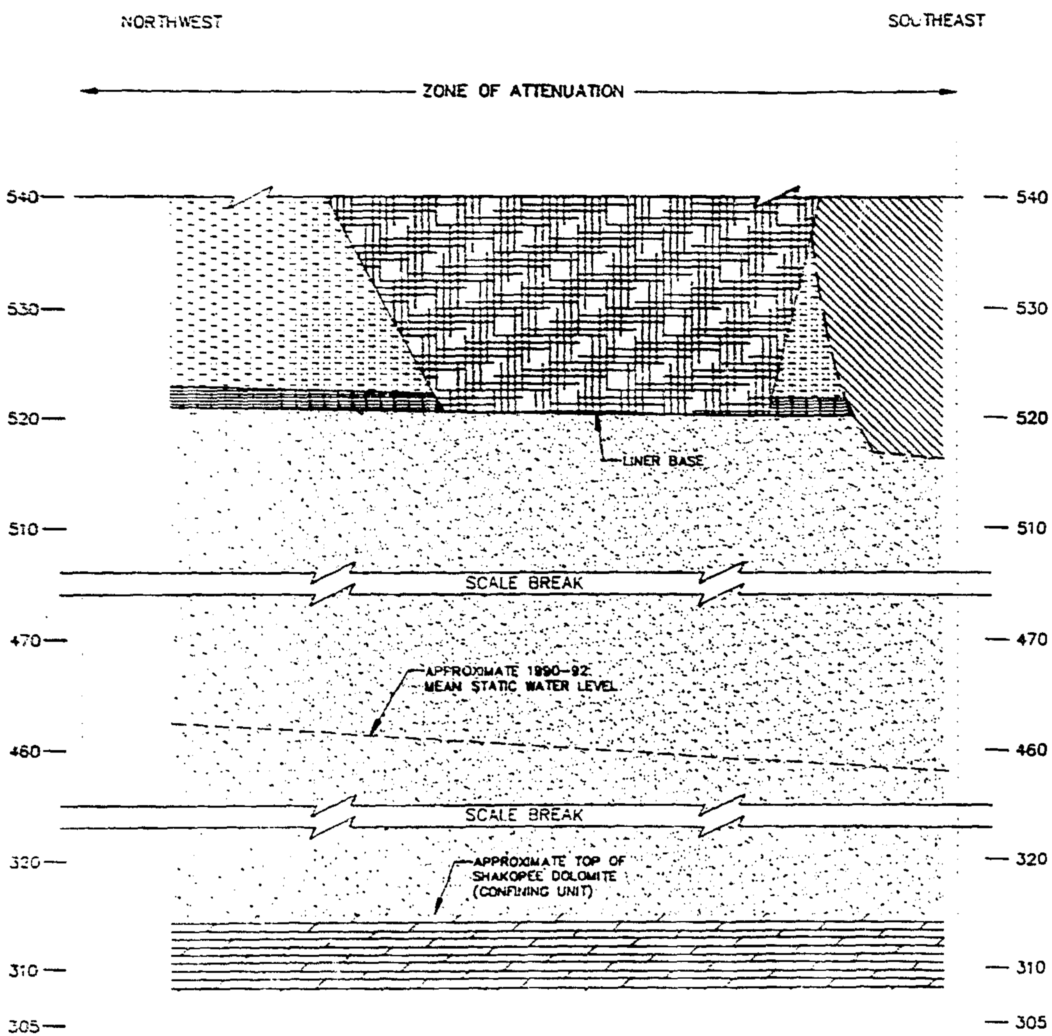
5) **The basal liner is 5 ft (feet) thick.** — This in the minimum thickness cited in the application.

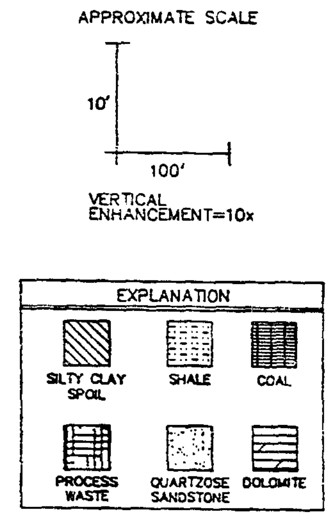
6) **The bottom of the uppermost aquifer is at 315 ft** MSL. —- This is an assumed elevation, and is based on interpolation of two (2) boring located east and west of the site. However, for modeling purposes, contaminant transport in the uppermost aquifer has been limited to the upper, saturated 50 feet of the aquifer. This thickness ranges from 53 to 47 feet.

7) **The flux through the liner is based on HELP model output.** — The rate, or flux through the liner is used in the transport model to provide a quantitative value for the amount of contaminant entering the system. This flux was assessed over the active life and 100 year post-closure period. This assessment includes turning off the leachate pumps, and allowing leachate levels to rise within the unit.

8) **All angles are assumed to be 90°.** — Providing right angle corners removes any extra thicknesses from the liner and other parts of the landfill. This makes travel distances small, and hence is a conservative assumption.

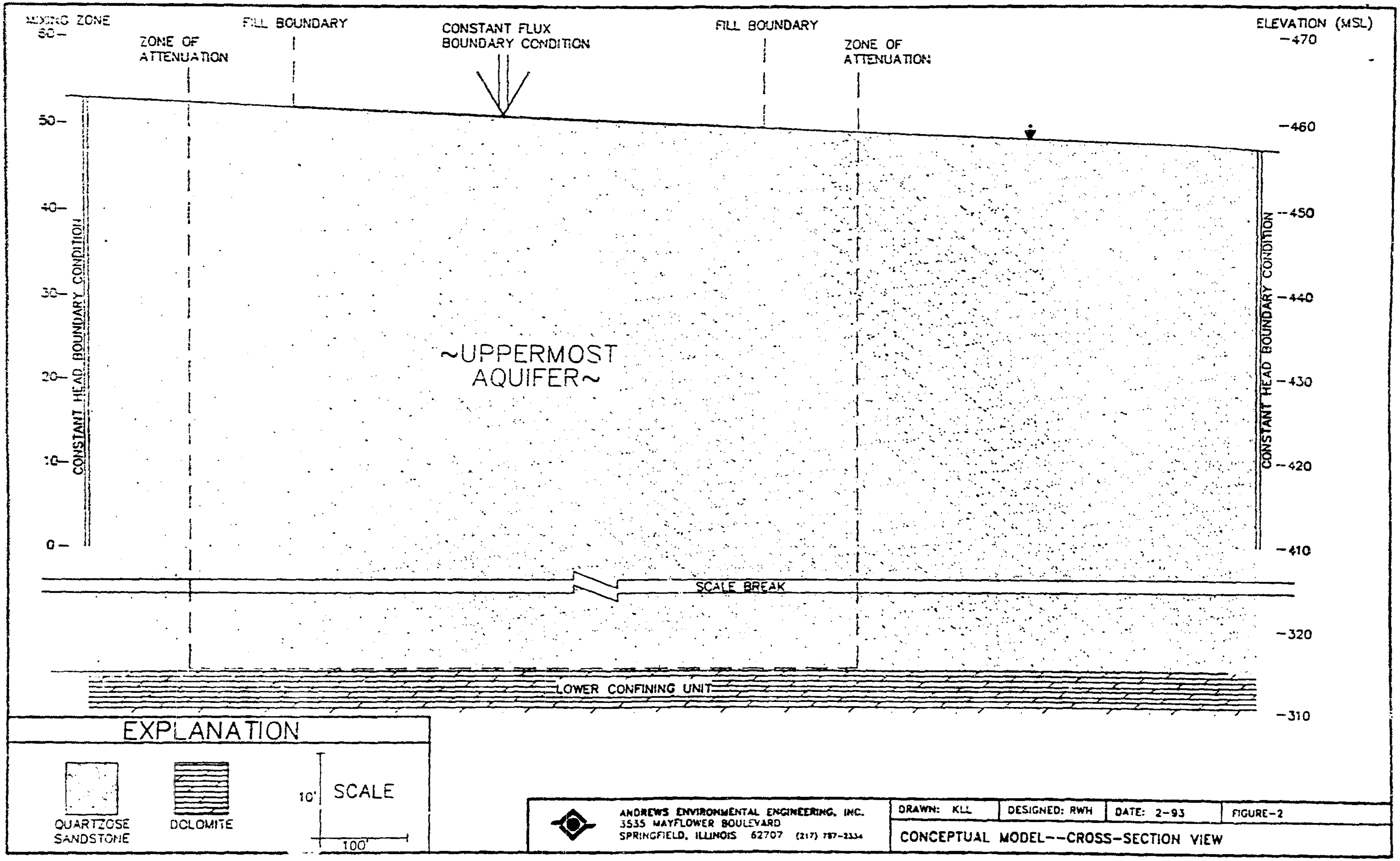
9) **External stresses on the system are constant.** — Stress on the model system over time can not be accurately estimated for the entire Groundwater Impact Assessment period. Therefore, potential changes in heads due to construction, weather, pumping, and other flux changes are ignored. However, 35 IAC 813.304 does provide a mechanism to reevaluate the site should any change in the parameters used within the impact assessment occur.




| | | | |
|---|---|---|---|
| CARUS DISPOSAL AREA NO. 2<br>OTTAWA TOWNSHIP, LASALLE COUNTY, ILLINOIS | | | |
| SCALE: AS SHOWN | APPROVED BY: | REVISED: | DRAWN BY: RWS |
| DATE: 3/93 | | | DESIGNED BY: RWH |
| ANDREWS ENVIRONMENTAL ENGINEERING, INC.<br>3535 MAYFLOWER BOULEVARD<br>SPRINGFIELD, ILLINOIS 62707 (217) 787-2334 | | | |
| REPRESENTATIVE GEOLOGIC CROSS-SECTION | | | FIGURE 1 |

REDUCED COPY




REDUCED COPY

**Transport Processes**

Using the design and geology simplifications presented in Figure 2 coupled with the analysis of groundwater flow information presented in the Original Report of Hydrogeologic Investigations, the transport process within the aquifer may be analyzed with respect to migration of the leachate constituents.

Within the aquifer, migration of contaminants is primarily controlled by mechanical dispersion. This can best be seen when the value for the coefficient of hydrodynamic dispersion ($D'_{ij}$) is analyzed. This coefficient consists of two parts $D'_{ij} = D_{ij} + (D^*_d)_{ij}$, where $D_{ij}$ is the coefficient of convective (or mechanical) dispersion, and $(D^*_d)_{ij}$ is the coefficient of molecular diffusion. $D_{ij}$, the coefficient of convective dispersion is defined as the product of the average linear velocity and the dispersivity ($D_{ij} = \bar{v}\, a_{ijkl}$) (Bear, 1972). As the velocity becomes smaller, the convective dispersion coefficient value approaches the value of molecular diffusion coefficient. As this occurs, diffusion becomes the dominant transport mechanism.

A simple calculation of the hydrodynamic dispersion can be used to assess which transport mechanism dominates. Table 1 shows the input parameters for the calculations.

| Layer | Dispersivity[1] | Hydraulic Conductivity[2] | Effective Porosity[3] | Gradient[4] | Molecular Diffusion[5] |
|---|---|---|---|---|---|
| Liner | 3.20 cm | $1.00 \times 10^{-7}$ cm/s | 0.34 | 1.2 | $4.4 \times 10^{-6}$ cm²/s |
| Sandstone | 286.07 cm | $6.16 \times 10^{-5}$ cm/s | 0.27 | 0.0087 | $5.6 \times 10^{-6}$ cm²/s |

**Table 1: Hydrodynamic Dispersion Calculation Input Parameters**

[1]after Neuman (1990), mean value. Liner = 5' liner. Ss = lateral zone of attenuation = 100'.

[2]Field determined value, see ORHI.

[3]after Sharp-Hansen *et al.* (1990), mean values.

[4]Liner = thickness w/ 1' head. Ss = determined from mean water levels.

[5]after Shackelford, (1990).

$$D'_{(liner)} = (1.0 \times 10^{-7}\ cm/s\ (1.20))\ /\ 0.34)\ 3.20\ cm + 4.4 \times 10^{-6}\ cm^2/s$$
$$= 1.13 \times 10^{-6}\ cm^2/s + 4.4 \times 10^{-6}\ cm^2/s$$
$$= 5.53 \times 10^{-6}\ cm^2/s$$

$$D'_{(ss)} = (6.16 \times 10^{-5}\ cm/s\ (0.0087))\ /\ 0.27)\ 286.07\ cm + 5.6 \times 10^{-6}\ cm^2/s$$
$$= 5.68 \times 10^{-4}\ cm^2/s + 5.6 \times 10^{-6}\ cm^2/s$$
$$= 5.73 \times 10^{-4}\ cm^2/s$$

As seen in the previous calculations, there is a dramatic impact on the liner scenario by including chemical diffusion into the calculation. The effective increase in the hydrodynamic dispersion over the mechanical dispersion is over 455%. In contrast, the effective increase of the hydrodynamic dispersion in the uppermost aquifer is only slight (0.9%). This therefore shows that the transport process is advection-dominated in the uppermost aquifer.

The migration of leachate constituents through the liner may be "ignored" by using a conservative approach within the modeling context. The first of these assumptions provides for constant source of contaminants. Next, leachate constituents are directly moved from within the unit to the aquifer at leachate concentrations, thereby completely short-circuiting any diffusion front. Lastly, leachate migration occurs beginning at day one (1) and continuing through the active life plus the one hundred (100) year model period.

The model needed for this transport scenario should provide adequate characterization of the processes associated with advection driven transport. Within the framework of the conceptual model (as shown in Figure 2), the two-dimensional transport model previously submitted should be adequate to properly characterize the impact of the facility on the site groundwater.

**Mathematical Model**

A two-dimensional, dispersive transport model capable of adequately representing contaminant transport is the U.S.G.S. two-dimensional solute transport and dispersion model (MOC) by Konikow and Bredehoeft(1978). This model provides for:

- continuous saturated aquifer,
- single phase flow,
- slightly compressible fluid,
- negligible thermal and density gradients,
- major components of flow normal to the grid plane,
- pumping/injection wells are fully penetrating,
- dispersion is a random process in the porous media,
- non-reactive solute,
- fluid density and viscosity independent of solute concentrations, and
- hydrogeologic properties not affected by contaminants (Hensel *et al.*, 1990).

The principal assumptions inherent in MOC are:

1) Darcy's Law is valid and hydraulic-head gradients are the only significant driving mechanism for fluid flow.
2) The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.
3) Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.
4) No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.
5) Ionic and molecular diffusion are negligible contributors to the total dispersive flux.
6) Vertical variations in head and concentration are negligible.
7) The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity (Konikow & Bredehoeft, 1978).

MOC was first presented by L. F. Konikow and J. D. Bredehoeft (1978) and has been updated and modified over time. The last modification by D. J. Goode and L. F. Konikow (1989) allows for decay and ion exchange as contaminant transport options. The model has been thoroughly tested (see Model Documentation supplied in other binder), and is probably one of the most widely accepted groundwater flow and contaminant transport models available. MOC has been calibrated in several field studies including the Rocky Mountain Arsenal (Konikow, 1977), the National Reactor Testing Station (Robertson, 1974), and Butler County Landfill, Ohio (Hudak, 1986).

The governing flow equation for MOC (Konikow & Bredehoeft, 1978), can be written in Cartesian tensor notation as:

$$\frac{\partial}{\partial x_i}\left(T_{ij}\frac{\partial h}{\partial x_j}\right) = S\frac{\partial h}{\partial t} + W$$

where:

| | |
|---|---|
| $T_{ij}$ | is the transmissivity tensor $[L^2T^{-1}]$, |
| $h$ | is the hydraulic head [L], |
| $S$ | is the storage coefficient [ - ], |
| $t$ | is time [T], |
| $W = W(x,y,z)$ | is the volume flux per unit area $[LT^{-1}]$, and |
| $x_i$ and $x_j$ | are the Cartesian coordinates [L]. |

The transport equation that describes dispersion of a non-reactive species in groundwater has been previously described (Bear, 1972; Bear & Verruijt, 1990) and several others. As used by MOC (Goode & Konikow, 1989), this equation is written as:

$$\frac{\partial C}{\partial t} + \frac{\rho_b}{\varepsilon}\frac{d\bar{C}}{\partial t} = \frac{1}{b}\frac{\partial}{\partial x_i}\left(bD_{ij}\frac{\partial C}{\partial x_j}\right) - V_i\frac{\partial C}{\partial x_i} + \frac{W(C - C')}{\varepsilon b} - \lambda C - \frac{\rho_b}{\varepsilon}\lambda\bar{C}$$

where:

| | |
|---|---|
| $\tilde{C}$ | is the concentration of solute sorbed on the porous medium [$MM^{-1}$], |
| C | is the concentration of the dissolved chemical species [$ML^{-3}$], |
| C' | is the concentration of the dissolved chemical in a source or sink fluid [$ML^{-3}$], |
| $D_{ij}$ | is a second-order tensor for the coefficient of hydrodynamic dispersion [$L^2T^{-1}$], |
| $V_i$ | is the fluid seepage velocity [$LT^{-1}$], |
| b | is the saturated thickness of the aquifer [L], |
| e | is the effective porosity of the aquifer [ - ], |
| $r_b$ | is the bulk density of the porous medium [$ML^{-3}$], and |
| l | is the decay rate constant [$T^{-1}$]. |

By using the conservative approach provided in the conceptual model coupled with conservative input parameters, the MOC should produce an appropriate representation of leakage from the proposed facility. A copy of MOC has already been submitted to the Illinois Environmental Protection Agency, Groundwater Assistance Unit in conjunction with the original application. This copy has been provided by Geraghty and Miller, Inc., Groundwater Modeling Group.

## Model Input and Sensitivity Analysis

Input parameters have for the most part been determined from samples collected at the site. These parameters include hydraulic conductivity, thickness of units, leachate concentrations, and groundwater concentrations. Parameters that are not site specific are taken from literature value for comparable materials The literature citations used for the impact assessment may be found in Appendix A.

A selection of model input parameters cannot be done without a discussion of the sensitivity analysis used to determine the viability of each parameter selected to be used in the baseline model. Therefore, along with the discussion of the source of input data will be a discussion of the selection process and a weighting of "confidence" or the Calibration Level the modeler has in the selected parameter. Concentration versus Time and Mass Balance Error % versus Time plots are presented in Appendix D. These graphs were used to assess the viability of each parameter selected for the baseline model. These plots were also used to assign Calibration Levels to each model parameter.

The Calibration Level is a weighting factor assign by the modeler. This level represents the confidence the modeler has in the data used within the Groundwater Impact Assessment. For internal model parameters (i.e.; TOL, CELDIS, etc.), the Calibration Level is selected based on the following criteria:

Level 1: Results of the sensitivity analysis produce the most stable mass balance error, and the highest predicted concentration at the end of the modeling period.

Level 2: Results of the sensitivity analysis produce the most stable mass error, but not the highest predicted concentration at the end of the modeling period.

Level 3: Results of the sensitivity analysis produce the highest predicted concentration at the end of the modeling period with no regard for the mass balance error.

For external or field parameters (i.e.; THCK, BETA, WT, etc.) the Calibration Level will use the same criteria as above, coupled with a modifier that is indicative of the modeler's confidence in the input parameter used. This appraisal is purely subjective, and represents the modeler's confidence in the parameter value selected. These modifiers are:

a: The input parameter accurately reflects actual site specific calibration to field conditions. Literature citations are not evaluated at this level.

b: The input parameter approaches the actual site specific calibration to field conditions, or is believed to reasonably reflect site conditions if the data is not from site specific sources.

c: The input parameter simply produces the most conservative value within the range of data selected. Site specific parameters are not evaluated at this level.

To provide an example of the Calibration Level, a hypothetical analysis of dispersivity may be used. Dispersivity was not determined from site specific data, a literature source was used. Sensitivity was performed over a range of reasonable values, and the value that produced the highest concentration at the end of the modeling period was selected. Therefore, the resulting Calibration Level would be 1c. That is, the value selected for dispersivity produces a stable value with a high final concentration, and since there is no site specific data, the parameter was selected as simply being the most conservative.

Table 2 lists the layer parameters used for the modeling scenarios with the range of values. The following sections will describe how each parameter was selected in more detail.

| Model Parameter | mean | minimum | maximum | Baseline model value | Calibration Level |
|---|---|---|---|---|---|
| Aquifer thickness | 53-47 ft. | 43-37 ft. | 63-57 ft. | 53-47 ft. | 2b |
| Boundary conditions | Combo. | Type I | Type II | Type I | 1b |
| Convergence criteria | | 0.0001 | 0.1 | 0.01 | 1- |
| Dispersivity | 5.50 ft | 2.25 ft | 15.6 ft | 15.6 ft | 3c |
| Dispersivity ratio | | 0.05 | 0.2 | 0.1 | 2b |
| Effective porosity | 0.27 | 0.12 | 0.41 | 0.27 | 2b |
| Gradient | 53-47 ft/grid | 52-48 ft/grid | 54-45 ft/grid | 53-47 ft/grid | 2b |
| Hydraulic conductivity | $4.52 \times 10^{-7}$ ft/s | $2.02 \times 10^{-6}$ ft/s | $6.75 \times 10^{-6}$ ft/s | $3.88 \times 10^{-5}$ ft/s | 2b |
| Initial no. of particles/node | | 4 | 16 | 4 | 1- |
| Liner flux rate | from HELP | -15% | +15% | from HELP | 2b |
| Max. cell distance/move | | 0.20 | 1.50 | 1.00 | 3- |
| Max. no. time steps | variable | 1 | 10 | variable | 2 |
| No. iteration parameters | | 5 | 9 | 7 | 1- |
| Storage coefficient | $1.0 \times 10^{-6}$ | 0.0 | 0.1 | 0.0 | 1c |
| Transmissivity | = k • h (from grid) | = k • h (from grid) | = k • h (from grid) | = k • h (from grid) | 2b |

**Table 2: Model Input Parameters**

**Model flow and transport grid**

The model node grid was devised to provide for two separate needs. First, node spacing must allow for concentration values to be calculated for several points within the zone of attenuation (per 35 IAC 812.316 (d)). Without a rather fine nodal spacing, determination of compliance would be difficult. Secondly, MOC averages concentrations over the aerial extent of the node cell. With larger nodal areas, it is possible that this averaging may produce a result that is in compliance with 35 IAC 811.317(b), but upon analysis with a finer resolution, would not actually be in compliance. With these points in mind, a model grid was designed to allow for the vendor's version of MOC to use minimal grid cell sizes (20' x 20'), within a maximized flow grid (50 x 70 cells) superimposed over the area of known groundwater data. A transport grid of equal dimensions is then placed within the flow grid (see Plate 1: Contaminant Transport Model Grid at end of report).

Spatial errors are almost non-existent in MOC due to the finite difference solution method (iterative alternating-direction implicit) which is unconditionally stable for variations in time steps. To provide for stability within the transport equation, MOC has an internal procedure that divides the time step into smaller units until the solute transport solution is solvable. Therefore, variation over a range of time steps has very little impact on the results of the model.

**Aquifer thickness**

Actual aquifer thickness at the site is in excess of 200 feet. However, the saturated thickness of the sandstone is only about 150 feet. As stated in the discussion of the conceptual geology, the unsaturated portion of the sandstone has in effect been ignored.

To provide some understanding of the transport properties of the site, a mixing zone analysis was performed. This analysis was performed to determine the degree of vertical migration by potential leachate constituents, and to provide a "thickness" limit for the contaminant transport model. The model used for the Impact Assessment should only address the transport of contaminants within the mixing zone, to reduce the degree that dilution would occur within the aquifer.

The mixing zone analysis was performed in a similar fashion to how a well spacing determination would be performed. That is, a known concentration was moved from a source to a point, and the plume shape in the vertical plane was evaluated (in this study, the distance is 200 feet or about 15% of the model grid distance in the down-gradient direction). The time of transport is calculated, and then depths are determined for various distances at the specified time and concentration. Table 3 shows the results of this analysis. As can be seen in this table, the maximum plume depth is in excess of 52 feet. This value is the actual depth calculated, since the source was positioned to reasonably depict vertical migration through an unsaturated zone and then lateral transport in a saturated zone. That is why the source vertical dimension and location have been set to 0.01 meters. This "forces" the model to move the contaminants from a narrow band, instead of a wider "hole" as would be used in a well spacing determination.

PROJECT: **Carus Chemical Co.**
Mixing Zone Calculations
200 foot (60.96 meters) study distance

**Assumes that the leakage from the source is localized and relatively small compared to the horizontal flow through Xo,Yo.**
Solution is based on Eqn: 17.18 and 17.20 in Domenico and Schwartz (1990) **PHYSICAL AND CHEMICAL HYDROGEOLOGY.**

| CHEMICAL BEING MODELED | SOURCE CONC IN LANDFILL per mill (‰) | RATE OF SOURCE LEAKAGE litres/yr | RETARDATION FACTOR WITHIN AQUIFER | SOURCE SIZE y DIR. (Yo) m | SOURCE SIZE z DIR. (Zo) m | DEPTH OF SOURCE IN z DIR. m | AQUIFER THICKNESS (h) m | HYDRAULIC COND. AQUIFER (K) m/sec | HYDRAULIC GRADIENT (i) | EFFECTIVE POROSITY (Ne) | DARCY FLUX THRU AQUIFER m/yr | GROUNDWATER FLOW THRU Yo, Zo litres/yr | SOURCE CONCN WITHIN Yo, Zo mg/l (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hypothetical | 1,000.0 | 700,000 | 1 | 30.00 | 0.01 | 0.01 | 45.00 | 6.160E-06 | 0.00870 | 0.27 | 1.6901 | 507.02 | 700,000 |

= Observation Point Info =

| AVERAGE FLOW VELOCITY Unretarded m/sec | AVERAGE FLOW VELOCITY Unretarded m/yr | AVERAGE FLOW VELOCITY Retarded m/yr | LONGITUDINAL DISPERSIVITY COEF. - x (aL) m | TRANSVERSE DISPERSIVITY COEF. - y (aTy = %aL) 10.00% m | TRANSVERSE DISPERSIVITY COEF. - z (aTz = %aL) 1.00% m | DISTANCE IN FLOW DIRECTION (x) y=0, z=0 m | OFF CENTRE y m | OFF CENTRE z m | ARRIVAL TIME AT x (plug flow) years | TIME OF INTEREST FOR MODEL years | CONCN at x,y,z 3D-SOLN per mill (‰) | % PLUME WIDTH ft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.985E-07 | 6.2595 | 6.2595 | 28.15 | 2.8155 | 0.2815 | 60.96 | 0.00 | 0.00 | 9.74 | 0.55 | 1.00 | 0.0000 |
| | | | 28.15 | 2.8155 | 0.2815 | 1.52 | 0.00 | 4.23 | 0.24 | 0.55 | 1.00 | 13.6710 |
| | | | 28.15 | 2.8155 | 0.2815 | 3.05 | 0.00 | 5.95 | 0.49 | 0.55 | 1.00 | 19.5355 |
| | | | 28.15 | 2.8155 | 0.2815 | 6.10 | 0.00 | 8.34 | 0.97 | 0.55 | 1.00 | 27.3675 |
| | | | 28.15 | 2.8155 | 0.2815 | 9.14 | 0.00 | 10.10 | 1.46 | 0.55 | 1.00 | 33.1237 |
| | | | 28.15 | 2.8155 | 0.2815 | 12.19 | 0.00 | 11.49 | 1.95 | 0.55 | 1.00 | 37.7084 |
| | | | 28.15 | 2.8155 | 0.2815 | 15.24 | 0.00 | 12.64 | 2.43 | 0.55 | 1.00 | 41.4660 |
| | | | 28.15 | 2.8155 | 0.2815 | 18.29 | 0.00 | 13.58 | 2.92 | 0.55 | 1.00 | 44.5640 |
| | | | 28.15 | 2.8155 | 0.2815 | 21.34 | 0.00 | 14.35 | 3.41 | 0.55 | 1.00 | 47.0915 |
| | | | 28.15 | 2.8155 | 0.2815 | 24.38 | 0.00 | 14.96 | 3.90 | 0.55 | 1.00 | 49.0960 |
| | | | 28.15 | 2.8155 | 0.2815 | 27.43 | 0.00 | 15.42 | 4.38 | 0.55 | 1.00 | 50.5995 |
| | | | 28.15 | 2.8155 | 0.2815 | 30.48 | 0.00 | 15.73 | 4.87 | 0.55 | 1.00 | 51.6060 |
| | | | 28.15 | 2.8155 | 0.2815 | 33.53 | 0.00 | 15.88 | 5.36 | 0.55 | 1.00 | 52.1052 |
| | | | 28.15 | 2.8155 | 0.2815 | 36.58 | 0.00 | 15.87 | 5.84 | 0.55 | 1.00 | 52.0735 |
| | | | 28.15 | 2.8155 | 0.2815 | 39.62 | 0.00 | 15.69 | 6.33 | 0.55 | 1.00 | 51.4727 |
| | | | 28.15 | 2.8155 | 0.2815 | 42.67 | 0.00 | 15.32 | 6.82 | 0.55 | 1.00 | 50.2478 |
| | | | 28.15 | 2.8155 | 0.2815 | 45.72 | 0.00 | 14.73 | 7.30 | 0.55 | 1.00 | 48.3202 |
| | | | 28.15 | 2.8155 | 0.2815 | 48.77 | 0.00 | 13.89 | 7.79 | 0.55 | 1.00 | 45.5778 |
| | | | 28.15 | 2.8155 | 0.2815 | 51.82 | 0.00 | 12.76 | 8.28 | 0.55 | 1.00 | 41.8541 |
| | | | 28.15 | 2.8155 | 0.2815 | 54.86 | 0.00 | 11.24 | 8.76 | 0.55 | 1.00 | 36.8866 |
| | | | 28.15 | 2.8155 | 0.2815 | 57.91 | 0.00 | 9.21 | 9.25 | 0.55 | 1.00 | 30.2185 |
| | | | 28.15 | 2.8155 | 0.2815 | 60.66 | 0.00 | 6.71 | 9.69 | 0.55 | 1.00 | 22.0102 |

**Table 3: Mixing Zone Analysis**

On the basis of the results of the mixing zone analysis, the aquifer thickness was set to a maximum of 53 feet, and reduced in thickness to appropriately represent the change in gradient at the site. This approach there for limits the degree of dilution within the model, reasonably represents the actual mixing zone beneath the unit, and precludes having to have a precise elevation for the base of the sandstone aquifer.

To further assess the aquifer thickness, a sensitivity analysis was performed. The thickness was varied over a range of 20 feet (± 10 feet). The sensitivity analysis shows that a thinner aquifer produces concentrations at the end of the modeling period that are higher. The thicker aquifer produces lower concentrations. In this instance, model stability coupled with the mixing zone analysis were the driving criteria for parameter selection. Therefore, the Calibration Level selected is 2b.

**Boundary conditions**

Boundary conditions analyzed for this study are Type I (constant head), Type II, (constant flux), or a combination of Type I and Type II. Type I boundaries are set within MOC by setting the NODEID array for the boundary cells to a value other than zero (0). The leakance value is then set sufficiently high to produce value that is explicitly computed to equate to a constant head value (see Konikow & Bredehoeft, 1978; page 13 for details).

Type II boundaries are set by using REC to address the flux in (negative value) or out (positive value) of the aquifer. The appropriate number of cells is then used to produce the needed boundary. As a note, the entire model grid must be surrounded by no-flow boundaries, a type of constant flux boundary (see Konikow & Breadhoeft, 1978).

Sensitivity was performed on various combinations of Type I and Type II boundaries. Type I boundaries up-gradient and down-gradient were selected for the baseline scenario. This selection was made for three reasons. First, Anderson and Woessner (1992) state that, "Although hydrogeologically defensible, exclusive use of [all Type II] flux boundaries generally should be avoided for the following mathematical reason. The governing equation is written in terms of derivatives, or differences in head, so that the solution will be non-unique if the boundary conditions also are specified as derivatives." (They state earlier that Type II boundaries are derivatives of Type I boundaries). Second, using all Type I boundaries produced the highest concentrations. Third, the input values used in the model at the Type II boundaries were several orders of magnitude different from those calculated for actual site conditions [NOTE: for all scenarios, the flow system was calibrated to reproduce the heads at the up-gradient wells. To reproduce those heads using constant flux boundary conditions, the flux rates were increased]. Since the input values are not representative of the actual calculated flux values, the results from the use of Type II boundaries would be suspect. Calibration Level for this parameter is 1b.

**Convergence criteria**

The error tolerance or convergence criteria was studied over a range of input values. These values are 0.1, 0.01, 0.001, and 0.0001. Results of sensitivity on this parameter show very little variability in concentrations or mass balance error. However, 0.0001 produce some instability early in the model run, and hence the final concentration values may not be as accurate as the others. A value of 0.01 produced a slightly more stable result at the end of the model run, and hence was used as the input value for the baseline model. Since there is good error control and maximum concentrations resulted, Calibration Level for TOL is 1.

**Dispersivity**

Values for dispersivity were not determined from actual field tests. To assess the facility, a study distance was determined for the dispersivity equations. This study distance was determined to be 10% of the length of the unit (from up-gradient zone of attenuation to the down-gradient zone of attenuation), or 70 feet. This distance also coincides with the distance from the base of the invert to the monitoring line surrounding the unit. Neuman's (1990) study of dispersivity was used to calculate a dispersivity value. For the purposes of this study, sensitivity was performed on the lower 95% confidence level (2.25 ft.), the mean value (5.50 ft.), and the upper 95% confidence level (15.59 ft.). On the basis of sensitivity studies, the upper 95% confidence level was used in the baseline modeling scenario, resulting in a Calibration Level of 3c.

**Dispersivity ratio**

The dispersivity ratio is the ratio of the transverse dispersivity to the longitudinal dispersivity. This ratio has been traditionally assigned a value of 0.1 (Walton, 1980; Gelhar *et al.*, 1992). For the baseline model, this was the value used. Sensitivity was performed on values ranging from 0.05 to 0.2, resulting in a Calibration Level of 2b.

**Effective porosity**

Actual values for effective porosity were not available for the site. The most recent boring program is still several years old, and the samples did not survive intact due to the highly friable nature of the sandstone. To provide an alternative to having actual values for effective porosity, a literature search was made for specific yield ($S_y$) of similar geologic materials. Bear (1972) defined effective porosity as equivalent to specific yield or the "drainable water". Values of specific yield were found for a medium-grained sandstone in Anderson and Woessner (1992, after Morris & Johnson, 1967). These values range from 12% to 41% porosity, with a mean value of 27%.

Sensitivity analysis was done on the maximum, minimum, and mean values cited above. MOC appears to be extremely sensitive to the value assigned to POROS. The concentration produced by the mean value increased 330% over the concentration produced by the maximum value. The concentrations generated at POROS = 12% increased over 560% above the concentrations produced at POROS = 27%, and produced results that are incapable of passing the Impact Assessment. With the extreme variation in predicted concentrations, a narrowing of options is necessary to appropriately assess the site impact.

The St. Peter Sandstone in Illinois "... consists largely of fine to medium, well sorted, well rounded, frosted grains of quartz sand that is friable or weakly cemented." (Willman *et al.*, 1975, pg. 62). Since the sandstone is well rounded and well sorted, porosity reductions associated with the introduction of fines within the grain matrix should not be present. Also, the friable nature of the matrix show that pore size reduction by the introduction of cements are also not likely to occur, or are minimized. Mathematically, the porosity of a three-dimensional packing of spheres should range from 26% (rhombohedral packing), to 30.2% (tetragonal packing), to 39.5% (orthorhombic packing) (Berg, 1986; after Graton & Fraser, 1935). With the likelihood that low porosity values are limited based on sorting and cementation, the actual porosity values for the St. Peter Sandstone should be closer to those seen in the rhombohedral or tetragonal packing schemes. The mean value provides a realistic estimate that falls within the range of mathematical values. Using 27% produces a Calibration Level of 2b.

**Gradient/potentiometric surface**

The site gradient or potentiometric surface was determined by taking the mean value for each well in the uppermost aquifer from actual groundwater elevation over the past three (3) years. The results of this statistical analysis may be found in Table 4. The model was calibrated to the mean potentiometric surface by changing the input head elevations such that the two up-gradient wells located within the model grid produced similar elevations as the calculated values. Changes in the water table (WT) array within the model, must be made in conjunction with similar changes in the transmissivity (VPRM) array, and the aquifer thickness (THCK) array. This is due to the assumption that the aquifer water table and saturated thickness are the same. The transmissivity array change is needed to maintain a constant hydraulic conductivity across the model grid.

To provide a range of values to evaluate the Groundwater Impact Assessment, prediction limits were calculated for the groundwater elevations for each well. These prediction limits are based on a two-tail Student's t-test with a 95% confidence interval. The results of this analysis are also provided in Table 4. For the minimum gradient scenario, the lower prediction limit was used for the up-gradient wells, and the upper prediction limit was used for the down-gradient wells. This produces a shallow gradient across the site. For the maximum gradient scenario the opposite was used, that is, lower limits were used down-gradient, and upper limits were used up-gradient to produce a steeper gradient. Again, changes in the water table array are combined with changes in transmissivity and aquifer thickness. The sensitivity analysis shows that the steeper the gradient, the higher the resulting concentrations. Mass balance error under the three scenarios shows that there is considerable fluctuation in error values over the first 50 years for the minimum and maximum scenarios. Overall, the mean scenario appears to produce the more stable scenario. Although the maximum gradient scenario produces the highest concentrations, there is no evidence to show that this gradient can be expected at the site. Therefore, the mean gradient shall be used for the baseline scenario. This produces and Calibration Level of 2b.

**Carus Chemical Co.**

Blank cell indicate water level below bottom of monitoring well.

| Quarter | Well # —> Date | G101* | P102 | P103 | G104 | G105 | G106 | G107 | G108* | G12D | G13D | G14D | G15D | G16D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan-93 | 11/20/92 | 524.69 | | | | | | | 524.09 | 456.30 | | | 463.00 | 461.64 |
| Oct-92 | 8/12/92 | 524.16 | | | 454.24 | | | | 521.88 | 456.01 | 451.63 | | 462.02 | 460.68 |
| Jul-92 | 5/27/92 | 525.13 | | | 455.06 | | | | | | | | 462.57 | 460.78 |
| Apr-92 | 2/19/92 | 525.06 | | | 455.70 | | | | 524.76 | 456.37 | 451.85 | | 462.52 | 460.46 |
| Jan-92 | 11/18/91 | 524.26 | | | 456.03 | | | | 521.23 | 456.77 | 454.16 | | 463.04 | 460.48 |
| Oct-91 | 8/27/91 | 523.16 | | | 457.17 | | | | 520.73 | 454.49 | 455.36 | | 463.36 | 460.95 |
| Jul-91 | 5/16/91 | 526.10 | | | 456.81 | | | | 526.28 | 458.04 | 455.83 | | 463.78 | 462.13 |
| Apr-91 | 2/22/91 | 523.90 | | | 456.31 | | | | 523.93 | 457.54 | 455.18 | | 463.36 | 461.58 |
| Jan-91 | 11/8/90 | 523.30 | | | 456.61 | | | | 522.63 | 457.69 | 455.53 | | 463.66 | 462.03 |
| Oct-90 | 8/1/90 | 524.70 | | | 456.81 | | | | 524.13 | 457.84 | 456.13 | | 463.66 | 462.38 |
| Jul-90 | 4/3/90 | 523.51 | | | 455.91 | | | | 523.64 | 457.02 | 453.40 | | 461.62 | 460.42 |
| **Mean Elevations** | | 524.36 | | | 456.07 | | | | 523.33 | 456.81 | 454.34 | | 462.96 | 461.23 |
| **Std. Dev.** | | 0.8878 | | | 0.8936 | | | | 1.7057 | 1.0751 | 1.6973 | | 0.7075 | 0.7388 |
| **N** | | 11 | 0 | 0 | 10 | 0 | 0 | 0 | 10 | 10 | 9 | 0 | 11 | 11 |
| **t-Value @ 95% interval** | | 2.2281 | | | 2.2622 | | | | 2.2622 | 2.2622 | 2.3060 | | 2.2281 | 2.2281 |
| ***Prediction Limit (upper)*** | | *524.96* | | | *456.70* | | | | *524.55* | *457.58* | *455.65* | | *463.44* | *461.73* |
| ***Prediction Limit (lower)*** | | *523.76* | | | *455.43* | | | | *522.11* | *456.04* | *453.04* | | *462.49* | *460.73* |

*Pennsylvanian/Ordovician interface

**Table 4: Statistical Analysis of Groundwater Elevation Data**

**Hydraulic conductivity/Permeability**

The values of hydraulic conductivity for the aquifer were determined by slug test (see Original Report of Hydrogeologic Investigations). A statistical analysis was made of the test results. The mean value was $2.02 \times 10^{-6}$ ft/s ($6.15 \times 10^{-5}$ cm/s) with a standard deviation of $1.10 \times 10^{-5}$ . The maximum observed hydraulic conductivity was $6.75 \times 10^{-6}$ ft/s, and the minimum observed value was $4.52 \times 10^{-7}$ ft/s. These values were input into the model framework as FCTR in the transmissivity grid. By using this technique coupled with setting the VPRM array equal to the THCK array, the permeability map, in the model output file, produces a constant permeability across the site with the value desired.

Sensitivity on the permeability shows that there is considerable variation in resultant concentrations at the end of each modeling scenario. That is, the higher the hydraulic conductivity, the higher the resultant concentrations. However, the mass balance error analysis shows that early in the model scenario the lower hydraulic conductivities are more stable, and this stability degrades as the flux from the landfill increases. Therefore, the mean value of permeability is the most stable over the entire model period. If future testing shows that the mean estimates are not appropriate to the site, then a reevaluation of the impact assessment shall be performed. On the basis of the sensitivity analysis, a Calibration Level of 2b has been assigned to hydraulic conductivity.

**Initial number of particles per node**

The initial number of particles per node (NPTPND) is an internal parameter used by MOC. This value provides the geometric dispersion of particles per grid cell when the model is initialized (see Konikow & Bredehoeft, 1978). Values for this parameter are 4, 5, 8, 9, and 16.

Sensitivity was performed on the full range of parameters. Variation in concentration is minimal over the modeled range of values (only 3.4‰). Variation in mass balance error was much more apparent, with NPTPND = 4 producing the most stable result, and NPTPND = 8 producing the overall least stable results. NPTPND = 4 was selected as being the most stable, and produced the highest predicted concentrations. Therefore, the Calibration Level for NPTPND is 1.

**Liner flux rate**

To provide a conservative approach to modeling the rate of seepage from the unit, the HELP model (Hydrologic Evaluation of Landfill Performance model, version 2.03) was used to calculate leakage rates for the proposed facility over the 118 year model period (see HELP model output files is Appendix C). This was necessary due to the way MOC treats constant concentration nodes within the model. In a constant concentration node, the actual assigned concentration is placed directly into the aquifer cell. This is not a realistic approach. A better approach is to produce a constant flux node that supplies a continuous concentration at a constant rate. This is the approach taken in this study.

To evaluate the seepage rate, HELP model runs were made to represent changes in the facility over the model period. The HELP model was initially calibrated using actual lab data for the layers of the unit were this data was available. The other layers used the default values from the HELP literature. After each HELP model run, the data from the end of one run was used as input for the next model period. When the HELP model reached the point where leachate collection was terminated, the drainage layer was changed to a vertical percolation layer, and the HELP model was run until the entire 118 year Groundwater Impact Assessment period was analyzed.

The results of the HELP model runs are located in Appendix C. The resultant percolation rates for the entire unit are divided by the area of the unit, and then multiplied by the area of a MOC grid cell (400 sq. ft.). This value is then used for the flux rates into the aquifer from the 410 constant flux nodes within the MOC grid. The following table shows the cell flux rates and the point in time the rate changes for the minimum standard scenario and the design standard scenario.

| Time | Flux rate (minimum standard) | Flux rate (design standard) |
|---|---|---|
| 1-70 years | 7.42 x $10^{-8}$ $ft^3/s$ | 7.42 x $10^{-8}$ $ft^3/s$ |
| 70-90 years | 7.11 x $10^{-7}$ $ft^3/s$ | 7.42 x $10^{-8}$ $ft^3/s$ |
| 90-100 years | 1.49 x $10^{-6}$ $ft^3/s$ | 7.42 x $10^{-8}$ $ft^3/s$ |
| 100-118 years | 1.88 x $10^{-6}$ $ft^3/s$ | 7.42 x $10^{-8}$ $ft^3/s$ |

Table 5: Liner Flux Rates Over Time

For the minimum design standard the flux rate varies, depending when in the post-closure period the model is addressing. The actual design standard allows for a constant flux rate of 7.42 x $10^{-8}$ $ft^3/s$ for the entire assessment period. The rate is fixed over the entire period to represent the collection of leachate for the entire 118 years. Since leachate is collected, HELP precludes a build up of head, no matter how long a time period.

To further represent leachate migration, the constant flux nodes are "staged" based on the cell staging plan (see Plate 1: Contaminant Transport Model Grid). This staging provides for a realistic migration of potential contaminants, instead of requiring the entire unit to induce contaminants from the beginning of the modeling period.

A sensitivity was performed on the flux rates used in the baseline model scenario. The input parameter was varied over an arbitrary limit of ± 15%. This value was selected simply to determine the degree of sensitivity within the model. As would be expected, higher flux rates produce higher concentrations at the end of the modeling period. Mass balance error analysis shows some interesting trends. Generally, the mean level produces the overall more stable results. At 70 years, the error associated with each scenario is considerably different than before or after. Lower flux rates produce a lower error, and larger flux rates produce a larger error. This is due the way MOC handles sharp concentration gradients. The model becomes less stable as a sharp gradient develops, as occurs at 70 years. Once the model is able to disperse the concentration front, the stability returns. Although the mean value does not produce the highest concentrations, it is overall the most stable. The HELP model should provide a reasonable estimate of leakage from the unit, until a better method becomes available. Until then, the Calibration Level assigned to the liner flux rate is 2b.

**Maximum cell distance per particle move**

The percent cell distance traveled per step (CELDIS) is an internal MOC parameter. This value sets the maximum distance a particle may travel per time step in each cell. The range of values for this parameter range from zero (0) to one (1), however realistic values range from 0.1 to 1.00. For the sensitivity analysis, values of 0.25, 0.50, 0.75, 1.00, and 1.50 were selected. 1.00 produced the highest concentrations even though 050 and 0.75 were the most stable. 1.00 was used in the baseline model with a Calibration Level for this parameter at 3.

**Maximum number of time steps**

The number of time steps (NTIM) used by MOC may be selected by the user, or if set to 1, MOC will calculate the number of time steps necessary to produce stable results (see Konikow & Bredehoeft, 1978). For sensitivity purposes, three scenarios were analyzed. The first sets NTIM = 1, and allowed MOC to calculate the stable number of steps necessary. The next scenario set variable time steps in increments to produce the 5 year increments required under 35 IAC 811 and 812 (NTIM = VARIABLE). The third scenario set NTIM to 10.

Sensitivity analysis was done using the three scenarios. Results show that the mass balance error for NTIM = 1 produces only 1 result for each time step used. This produces no data between year 20 and year 70, and may not give a genuine appraisal of the problem. Mass balance error comparison for the NTIM = VARIABLE scenario versus the NTIM = 10 scenario shows that in almost all instances the NTIM = VARIABLE scenario produces more stable results. This may directly impact the result of the concentration comparisons, too. The greater mass balance error associated with NTIM = 10 surely produces the greater concentration seen at the end of that model scenario. Therefore, NTIM = VARIABLE shall be utilized in the baseline model scenario. Calibration Level for this parameter is set to 2.

**Number of iteration parameters**

The number of iteration parameters (NITP) is an internal MOC parameter. A range of values was selected at 5, 7, and 9, with recommended values between 4 and 7.

Sensitivity was performed on the range of values. There was minimal variation in concentration and mass balance error among the three values selected. NITP = 7 produced the highest concentrations as well as producing the most stable mass balance errors, especially in the first 75 years of the model period. Therefore, the Calibration Level selected for NITP is 1.

**Storage coefficient and steady state versus transient flow**

Within the context of storage coefficient, the discussion of steady state flow versus transient flow should be addressed. Within MOC, aquifer storage and transient flow can not be separated. In other words, if transient flow is to be modeled, then a storage coefficient must be input. Conversely, if steady state flow is to be addressed, then there can be no storage coefficient.

Values for storage coefficient were not determined from actual field tests. Literature values for an unconfined sandstone also were not available, so values were selected over a wide range of known storage coefficients. The values selected range from 0.1 to $1.0 \times 10^{-6}$.

Sensitivity analysis shows that transient flow (over the entire range of storage coefficient values) increases the mass balance error within MOC, especially early in the model period. Even though there is an elevated error associated with transient flow, the concentration predicted at the end of the modeling period is still greatest under steady state flow (storage coefficient = 0.0). Therefore, steady state conditions shall be used in the baseline model scenario, and a Calibration Level of 1c is assigned.

**Transmissivity**

No direct analysis of transmissivity was performed. Since transmissivity is the product of permeability and head, it was deemed redundant to perform these analyses again. Since gradient, aquifer thickness, and hydraulic conductivity have Calibration Levels of 2b, transmissivity should retain the same level.

## Baseline Model Scenarios

The baseline scenarios used to evaluate the site utilize the data presented in Table 2. Pursuant to 35 IAC 811.317(a)(1), two baseline scenarios were used. A minimum standards scenario (MIN.* designation in model files), that uses the minimum design and regulatory requirements, and a design standards scenario (DSN.* designation in model files), that uses actual design specifications, and operating requirements. Since the overall design does not specify any greater tolerances than those specified in the regulations, the only difference in model scenarios is leachate collection and buildup.

In the minimum standard scenario, leachate shall be collected for 50 years, and then collection was stopped. HELP model runs were used to determine what the internal head, and liner flux shall be over the remaining model period. The design standard scenario addresses leachate collection for the entire 118 year impact assessment period.

The baseline model uses an initial leachate concentration of 1000 mg/l. This value was selected to provide a mechanism to evaluate all leachate constituents with only one model run. The 1000 mg/l value can be assumed to be 100% (or 1000‰) of the initial leachate concentration. Values predicted by the model at various points in time and space are therefore simply a percent (or permill) value of the initial concentration. The value predicted at the edge of the zone of attenuation or Compliance Prediction Factor (CPF) may be used for values that are in the parts per million (ppm) range, or for values in the parts per billion (ppb) range. The actual initial concentration value assigned is not important. It is only necessary that the value is large enough to produce a value within the model, at the point in question within the model framework, and using powers of ten makes the transformation to percentages easier (this technique may produce a Well Prediction Factor (WPF) at a specific monitoring point, also).

## Surrogate Modeling

For the purposes of the groundwater impact assessment, surrogates were used to aid in the characterization of leachate constituents. The parameters used for the surrogate modeling are listed in Table 6. The parameters addressed are leachate species, species concentration, retardation/partitioning coefficient ($K_d$), mobility, the statistically determined background water quality (at a 95% confidence level), the 35 IAC 620 Class I groundwater standard, the practical quantitation limit (PQL) or method detection limit (MDL), and the model produced concentration.

### Leachate Species

Compounds listed as leachate species are those chemical constituents and/or compounds that had values that were above detection in the leachate analysis. To put it simply, these are the compounds expected to be present in the leachate.

### Leachate Concentration

Concentrations are those values assigned based on a statistical analysis of the leachate data. The values in Table 6 are those calculated at the upper 95% confidence level (see Groundwater Monitoring Report in this Addendum for specific details).

### Retardation/Partitioning Coefficient ($K_d$)

For the purposes of the surrogate table, the $K_d$ values listed for Surrogate 1 were taken from a table in Dragun (1988). This table provides an observed range, a mean value, and standard deviation of observed data, for each listed constituent. In a conservative approach for Surrogate 2, the $K_d$ value selected was the lowest observed value listed in Dragun (1988) for Manganese.

### Mobility

Mobility of leachate compounds were taken from a table of values in Bagchi (1990). This list is strictly an empirical relationship, and has no real quantitative value. It is place herein as a reference and guideline, but has no direct impact on the results of the assessment.

| Compound | Leachate Concentration | $K_d$ | | Mobility | Background Quality | 35 IAC 620 Class I std. | PQL/MDL | Model Predicted Concentration |
|---|---|---|---|---|---|---|---|---|
| **Surrogate 1** | | | | | | | | |
| Aluminum | 51.00 | | | low | 12.857 | | | 1.887 |
| Beryllium | 0.02 | | | low | 0.002 | | | 0.00074 |
| Boron | 0.29 | | | high | 1.107 | 2.0 | | 0.011 |
| Cadmium | 0.16 | 6.69 | ± 2.5 | moderate | 0.033 | 0.005 | | 0.00592 |
| Calcium | 317.00 | 4.06 | ± 2.2 | high | 305.895 | | | 11.729 |
| Chloride | 76.40 | 0.0 [1] | | high [1] | 37.255 | 200.0 | | 2.827 |
| Chromium | 0.59 | 36.60 | ± 9.0 | high | 0.114 | 0.1 | | 0.022 |
| Cobalt | 0.46 | 54.60 | ± 9.9 | | 0.175 | 1.0 | | 0.017 |
| Copper | 0.51 | 22.12 | ± 3.0 | low | 0.207 | 0.65 | | 0.019 |
| Fluoride | 0.21 | | | high | | 4.0 | 0.03 | 0.00777 |
| Iron | 2.18 | 54.60 | ± 1.7 | moderate | 46.516 | 5.0 | | 0.081 |
| Lead | 0.36 | 99.48 | ± 5.5 | low | 0.099 | 0.0075 | | 0.013 |
| Magnesium | 168.00 | 5.47 | ± 1.6 | moderate | 133.421 | | | 6.216 |
| Manganese | 84.16 | 148.41 | ± 14.9 | high | 1.612 | 0.15 | | 3.114 [2] |
| Mercury | 0.0018 | | | high | 0.0014 | 0.002 | | 0.0001 |
| Nickel | 5.69 | | | moderate | 0.396 | 0.1 | | 0.211 |
| Nitrate, as N | 0.30 | | | high | | 10.0 | 0.1 | 0.011 |
| Potassium | 891.94 | 5.47 | ± 1.6 | moderate | 48.759 | | | 33.002 |
| Silver | 0.05 | 109.95 | ± 3.7 | | 0.084 | 0.05 | | 0.00185 |
| Sodium | 164.71 | | | high | 117.514 | | | 6.094 |
| Sulfate | 4272.90 | | | high | 1115.108 | 400.0 | | 158.097 |
| Zinc | 5.09 | 16.44 | ± 6.7 | low | 17.081 | 5.0 | | 0.188 |
| **Surrogate 2** | | | | | | | | |
| Manganese | 84.16 | 0.2 | | high | 1.612 | 0.15 | | 0.0252 [3] |

Table 6: Surrogate Parameters and Results.

[1] Input value for Surrogate 1 (baseline model scenario).
[2] Value based on Surrogate 1 input parameters exceeds background concentrations. Re-evaluate as new surrogate.
[3] Evaluation at actual leachate concentration exceeds model resolution. Actual concentration evaluated using Prediction Factor (PF).

**Background Quality**

Background quality refers to the background water quality at the site. The results of this analysis may be found in the Groundwater Monitoring Program as part of this Addendum. The value is the upper 95% confidence level compiled from the background water quality data collected on site.

**35 IAC 620 - Class I Standard**

The values presented here are the Class I groundwater standards pursuant to 35 IAC 620, as set forth by the Illinois Pollution Control Board. They are included here simply as reference, since the groundwater at the facility has been classified in the Groundwater Monitoring Program (this Addendum), as Class IV, or Other Groundwater.

**PQL/MDL**

Values for Practical Quantitation Limit (PQL) or Method Detection Limit (MDL) are provided for those leachate compounds not tested for in the background water quality study. The value for Nitrate (0.1 mg/l) is the lowest MDL value noted in the range of values presented in SW-846 (1986). The value for Fluoride (0.03) is the MDL used by National Environmental Testing, Inc. at their Rockford, IL office.

**Model Predicted Concentration**

Predicted concentration values for the constituents listed under Surrogate 1 were calculated at the down-gradient edge of the zone of attenuation at the end of the 118 year assessment period using the following formula:

$$C_p = C_o(CPF)$$

Where,

$C_o$ = the initial leachate concentration,

CPF = the Compliance Prediction Factor from the transport model, and

$C_p$ = the predicted concentration at the desired monitoring point.

The predicted concentrations for the leachate constituents in Surrogate 1 do not exceed the background water quality values, except for Manganese. A further assessment was made, using data specific to Manganese.

**Surrogate Model Results**

Two surrogates were required to determine compliance. The following are the combinations of parameters for the surrogate modeling scenarios:

1) Surrogate 1 – Anion/Cations
(all listed parameters)
Baseline concentration = 1,000‰ (or 100%) of initial concentration
Chloride retardation = 0.0
Chloride mobility = high

Model Predicted Concentration = 37.0‰ (or 3.70%) of initial leachate concentration for each parameter in Surrogate 1 list.

2) Surrogate 2 – Manganese
Initial concentration = 84.16
Manganese retardation = 0.2
Manganese mobility = high
Background water quality = 1.612 mg/l
Model Predicted Concentration = 0.3‰ of 84.16 mg/l or 0.0253 mg/l.

Numerical result of the surrogate modeling are presented in Table 6 along with the input parameters. To provide some sensitivity to the baseline model and the use of the Compliance Prediction Factor (CPF), the actual leachate concentration from three constituents were used in a sensitivity analysis. Sensitivity was performed on the low, mid, and high range of values to determine if the CPF produced reasonable and accurate results. The values selected were for Silver (at 0.05 mg/l), Chloride (at 76.4 mg/l), and Sulfate (at 4,272.90 mg/l). Results are presented in Table 7 for comparison.

| Constituent | Calculated Value | Modeled Value |
|---|---|---|
| Silver | 0.00185 mg/l (1.85 µg/l) | N/A (1.9 µg/l) |
| Chloride | 2.827 mg/l | 2.8 mg/l |
| Sulfate | 158.097 mg/l | 158.2 mg/l |

**Table 7: Prediction Factor (PF) Sensitivity**

Correlation between calculated and modeled values is good (within rounding error), with the exception of Sulfate. The Sulfate results are 0.1 mg/l higher for the modeled results. This variation is negligible. Variance between the two values is only 0.065%. However, the variation in mass balance error is much more substantial. The error associated with the prediction factor is -1.02, the error associated with the actual concentration is -1.24, producing a variance between values of 21.57%. The change in mass balance error is more than enough to produce the variation in values, and therefore, the calculated value is actually more accurate. Regardless, of the difference in values, the predicted concentrations are still an order of magnitude lower that the background water quality standard, and variations in a tenth of a milligram at thousands of milligrams per liter are trivial.

Silver, at ppm resolution, did not produce detectable levels in the model. MOC output files only produce concentrations to the tenths place holder. The calculated value is at the thousandths range. To compensate, the initial concentration was converted to ppb levels, and then used as input to the model (i.e., modeling µg/l as mg/l within the model). Using this higher resolution, results are again within rounding error (values in parentheses in Table 7).

Concentration versus Time and Concentration versus Distance profiles are presented in Appendix F for the two surrogate scenarios. The graphs show the breakthrough curves predicted by the model, and show results at various points within the zone of attenuation for each 5 year period. Results presented show what can be expected, with no unusual results. That is, Concentrations are highest near the fill boundary (0.0 feet distance) and lowest at the edge of the zone of attenuation (100.0 feet distance). The graphs represent the worst case concentrations found within the two-dimensional model.

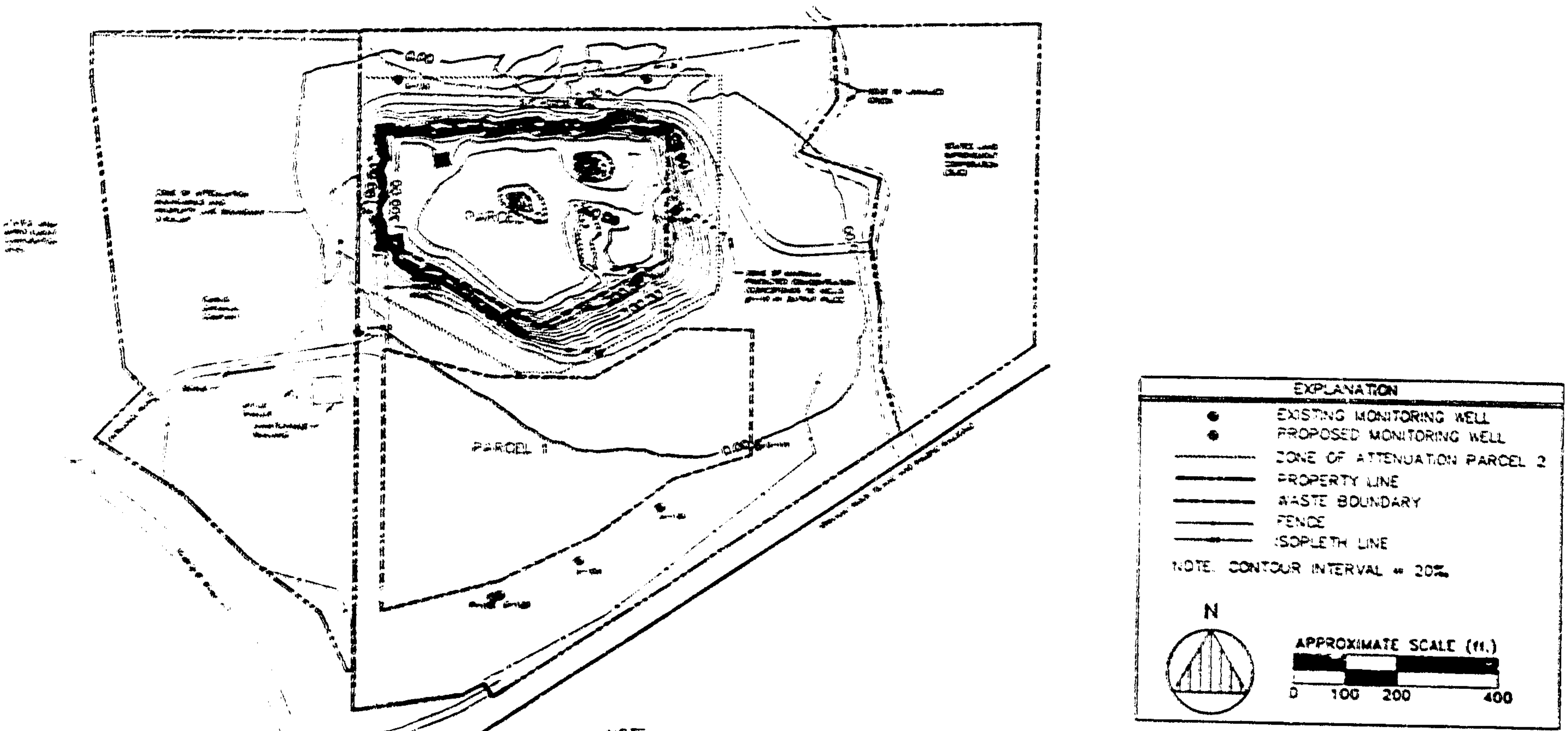
Isopleth maps of the results of the surrogate modeling are provided in Figure 2, 3, and 4. The isopleth maps represent the contaminant plume as a function of the initial concentration ($C_0$ = 1,000‰) and the associated permill isopleth. This provides a quick assessment of contaminant migration at any point, by simply multiplying the initial concentration by the permill isopleth value at the point of interest. The isopleth maps depicts the model generated plume with respect to the site boundaries and geometry at the end of each 118 year model period for the minimum standards/baseline scenario, the design standard scenario, and the manganese surrogate scenario.

In the model output files (may be found on the diskettes appended to the end of this report), are a series of Observation Wells. The observation wells in the output files for the Minimum Standard/Surrogate 1, the Design Standard, and the Surrogate 2 scenarios correspond two distinct groups of wells. The first group, (Obs. Well #1-10) are a line of grid cells, parallel to the model groundwater flow through the zone of attenuation, that correspond to the highest concentrations predicted by the model. It is this group of Observations Wells that produce the time and distance profiles presented in Appendices D, E, and F. The second group, (Obs. Well #11-16) correspond to G-130 to G135, respectively. The locations are such that the observation well is the point in the center of the grid cell that contains the actual location of the corresponding monitoring well.

Graphical and tabular results of the various analyses have been compiled, and are presented in Appendix E (for the Design and Minimum Standard Scenarios) and Appendix F (for the Surrogate Scenarios). As a result of the surrogate analysis, Table 6 clearly shows that the proposed facility shall be in compliance with existing groundwater quality standards and site background prediction standards at the end of the 118 year modeling period.

<u>Maximum Allowable Predicted Concentrations (MAPC)</u>

MAPCs have been calculated for each down-gradient monitoring point. As stated in 35 IAC 811.318(c), the calculation must be based on the same calculation method, data, assumption, etc., used in the impact assessment contaminant transport model. Therefore, MAPC runs for Chloride, Chromium, Manganese, Potassium, and Sulfate were made. The baseline model was allowed to run for a longer duration for each parameter, until the background water quality standard was reached at the zone of attenuation. The MOC




NOTE:
ISOPLETH CONCENTRATIONS ARE PERMILL VALUES OF INITIAL LEACHATE CONCENTRATIONS.
CONCENTRATIONS: C = Co(I/1000)
WHERE: C = ISOPLETH CONCENTRATION
Co = INITIAL LEACHATE CONCENTRATION
I = ISOPLETH VALUE

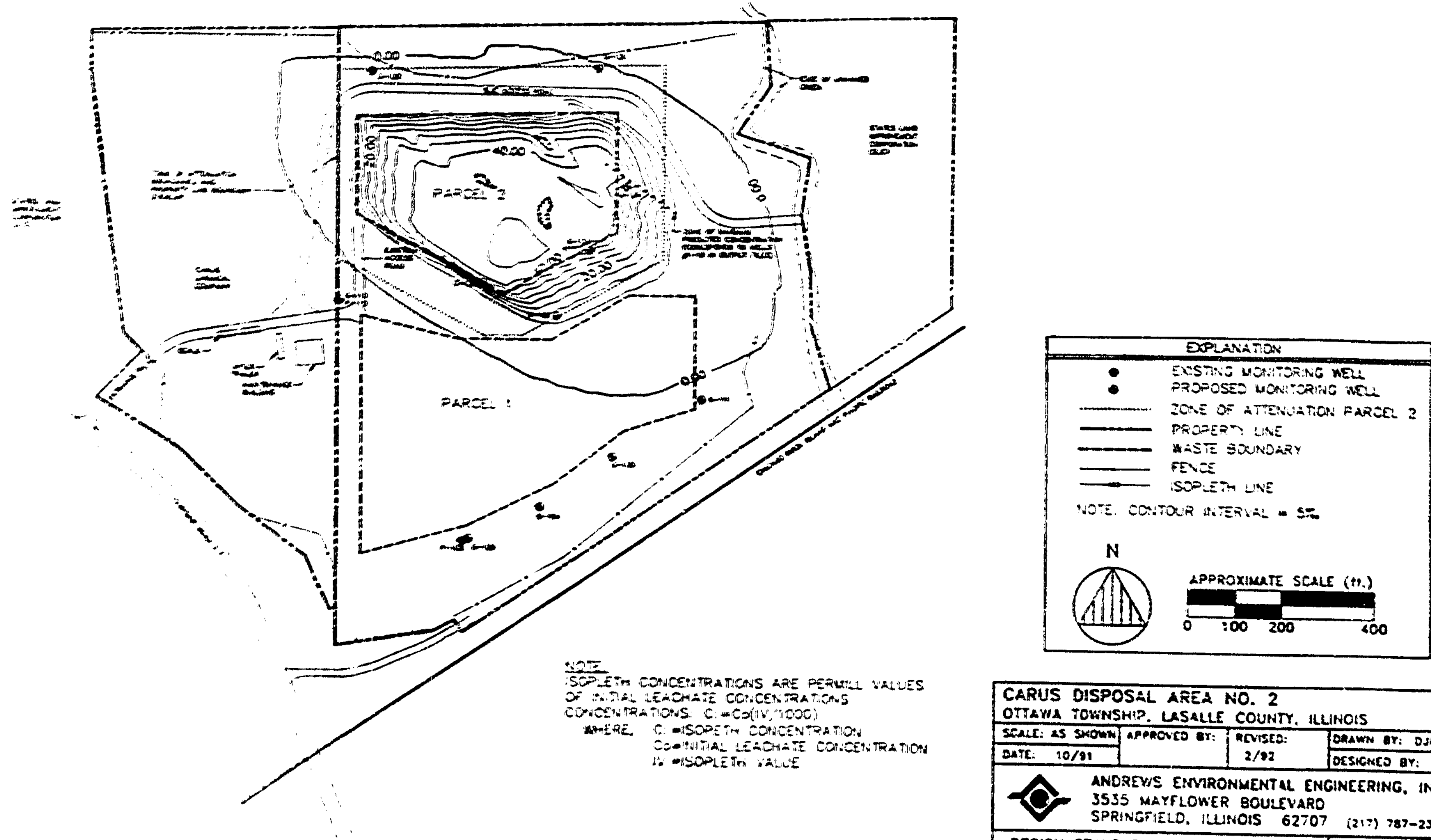
CARUS DISPOSAL AREA NO. 2
OTTAWA TOWNSHIP, LASALLE COUNTY, ILLINOIS

| | | | |
|---|---|---|---|
| SCALE: AS SHOWN | APPROVED BY: | REVISED: | DRAWN BY: DJM |
| DATE: 10/91 | | 2/92 | DESIGNED BY: RWH |

ANDREWS ENVIRONMENTAL ENGINEERING, INC.
3535 MAYFLOWER BOULEVARD
SPRINGFIELD, ILLINOIS 62707 (217) 787-2334

MINIMUM DESIGN/SURROGATE 1
ISOPLETH MAP

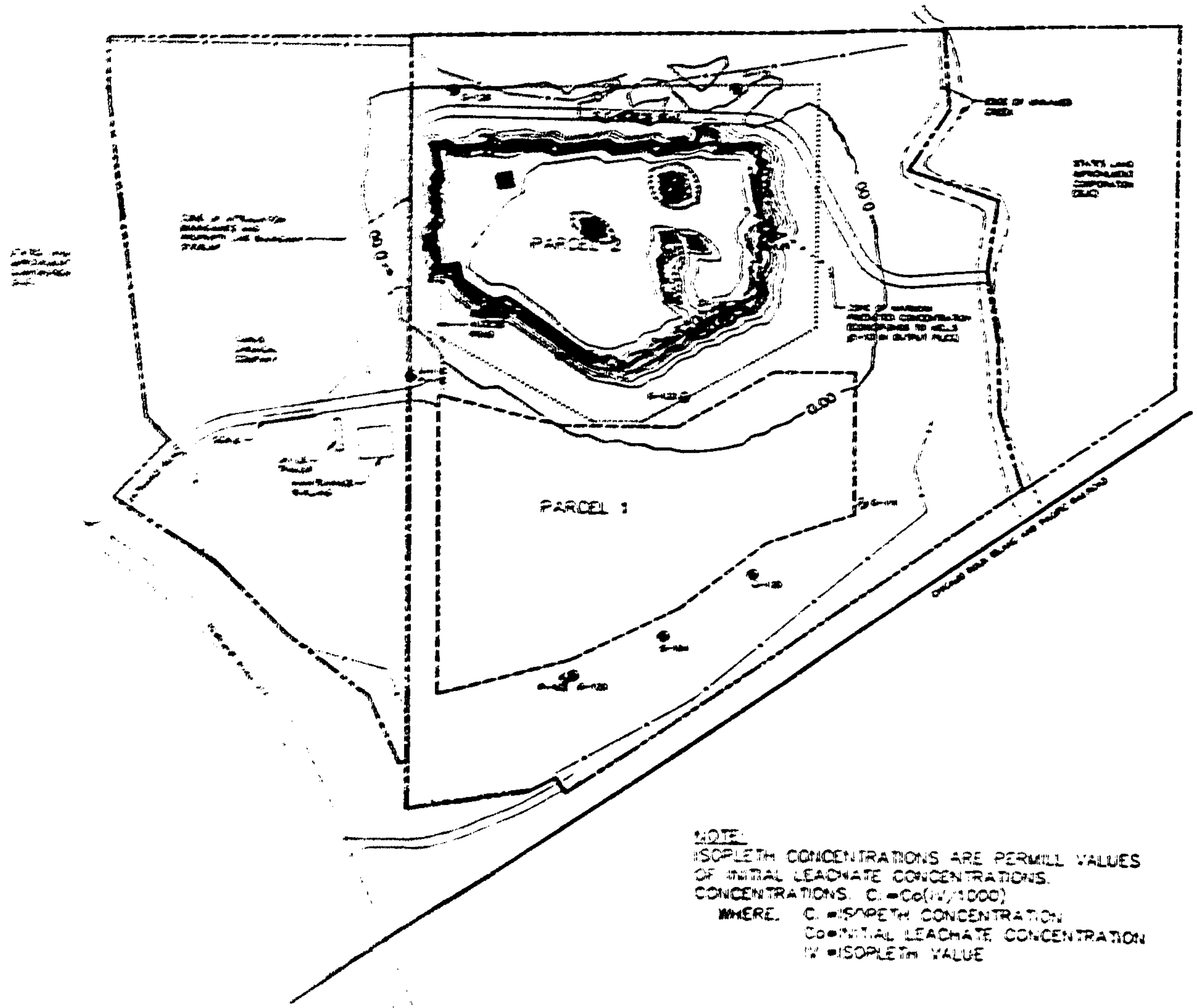
FIGURE-3




NOTE:
ISOPLETH CONCENTRATIONS ARE PERMILL VALUES OF INITIAL LEACHATE CONCENTRATIONS
CONCENTRATIONS: $C = Co(IV/1000)$
WHERE: C = ISOPLETH CONCENTRATION
Co = INITIAL LEACHATE CONCENTRATION
IV = ISOPLETH VALUE

| | | | |
|---|---|---|---|
| CARUS DISPOSAL AREA NO. 2<br>OTTAWA TOWNSHIP, LASALLE COUNTY, ILLINOIS | | | |
| SCALE: AS SHOWN | APPROVED BY: | REVISED: 2/92 | DRAWN BY: DJM |
| DATE: 10/91 | | | DESIGNED BY: RWH |
| ANDREWS ENVIRONMENTAL ENGINEERING, INC.<br>3535 MAYFLOWER BOULEVARD<br>SPRINGFIELD, ILLINOIS 62707 (217) 787-2334 | | | |
| DESIGN STANDARD SCENARIO<br>ISOPLETH MAP | | | FIGURE-4 |

REDUCED COPY




NOTE:
ISOPLETH CONCENTRATIONS ARE PERMILL VALUES OF INITIAL LEACHATE CONCENTRATIONS.
CONCENTRATIONS: $C_i = Co(IV/1000)$
WHERE: $C_i$ = ISOPLETH CONCENTRATION
Co = INITIAL LEACHATE CONCENTRATION
IV = ISOPLETH VALUE

**EXPLANATION**

- EXISTING MONITORING WELL
- PROPOSED MONITORING WELL
- ZONE OF ATTENUATION PARCEL 2
- PROPERTY LINE
- WASTE BOUNDARY
- FENCE
- ISOPLETH LINE

NOTE: CONTOUR INTERVAL = 10%.

N

APPROXIMATE SCALE (ft.)

0 100 200 400

| | | | |
|---|---|---|---|
| CARUS DISPOSAL AREA NO. 2<br>OTTAWA TOWNSHIP, LASALLE COUNTY, ILLINOIS | | | |
| SCALE: AS SHOWN | APPROVED BY: | REVISED: 2/97 | DRAWN BY: DJM |
| DATE: 10/91 | | | DESIGNED BY: RWH |
| ANDREWS ENVIRONMENTAL ENGINEERING, INC.<br>3535 MAYFLOWER BOULEVARD<br>SPRINGFIELD, ILLINOIS 62707 (217) 787-2334 | | | |
| SURROGATE 2/MANGANESE ISOPLETH MAP | | | FIGURE-5 |

REDUCED COPY

observation well value associated with the corresponding proposed monitoring well was then used as the MAPC for that constituent at the specified well.

Table 5, in the Groundwater Monitoring Program (this Addendum) contains a list of the detection monitoring parameters, and the associated MAPC for each down-gradient monitoring well. Appendix G contains the concentration versus time profiles for each constituent.

MAPCs were not calculated for the bi-annual organics testing. For the purposes of this application, the MAPC shall be the Practical Quantitation Limit (PQL) as given in 35 IAC, Part 724, Appendix I for any organic parameter that is also determined to be associated with the leachate generated at the facility.

## Contaminant Transport Appraisal

The assumptions inherent in MOC should be addressed to see if simplifications within the conceptual model, the conversion to mathematical model, or any external parameters have produced a potential problem within the contaminant transport model framework. Model provisions and assumptions shall be addressed one at a time to determine the adequacy of this impact assessment.

### Inherent Assumptions

Continuously saturated aquifer — Within the confines of the impact assessment, the aquifer is always saturated. The site does have an unsaturated zone between the base of the proposed unit, and the top of the aquifer. However, the conceptual model accounts for this vadose zone, by assuming that it does not exist, and contaminants are directly and instantaneously moved from the unit to the aquifer. If vadose zone transport were to be assessed, concentrations of contaminants would be dispersed through the vadose zone, and longer periods of time would elapse before contaminants would be detected at the edge of the zone of attenuation. Ignoring the vadose zone, in the context of this assessment is conservative.

Single phase flow — Based on the leachate analysis, there are no multi-phase components present.

Slightly compressible fluids — Again, there are no leachate components that would indicate that this were not true.

Negligible thermal and density gradients — The Carus Disposal facility is an inorganic monofill. There is no biological or geothermal activity to produce heat, and concentrations in the leachate are not high enough to produce severe density gradients either within the liner, or aquifer.

Major components of flow are normal to the grid plane — To comply with this inherent provision, the model grid was rotated to provide for parallel flow.

Pumping and injection wells are fully penetrating — That is, the wells are fully penetrating the modeled thickness of the aquifer. Since the model uses injection wells as the mechanism for contaminant migration out of the landfill, fully penetrating well appear to present a problem. The transport properties of the site were analyzed to provide for a mixing zone beneath the unit. The mixing zone model used, shows that the contaminant plume reaches a thickness of 52 feet, within 100 feet of the source. Since the mixing zone model shows that any discharge from the unit will be fully incorporated within the mixing zone by the time the edge of the zone of attenuation is reached, fully penetrating well is not a completely unrealistic assumption.

Dispersion is a random process in the porous media — There is nothing within the conceptual model or observed at the facility that would dispute this statement.

Non-reactive solute — That is, no reaction occurs that affects the solute concentration. No known reactions are present at the facility.

Fluid density and viscosity are independent of solute concentrations — Same as above. No known reactions or interactions are present at the facility.

**Hydrogeologic properties are not affected by the contaminants** — Since the aquifer at the site is composed almost entirely of quartzose sand, it would be very unlikely that there would be any interaction at all. The only interaction that may occur would be the dissolution of the carbonate cement matrix that binds the sandstone due to the low pH of the groundwater. As far as the transport of contaminants, this would increase porosity. As seen in the sensitivity analysis, increases in porosity, produce decreases in concentrations. Therefore, by assuming this interaction does not occur, the impact assessment results are conservative.

## Sensitivity Discussion

Calibration Levels and parameter selection developed from the sensitivity analysis should be addressed. Parameter selection for all internal parameters was driven by selecting those values that produced the highest concentrations and generated the most stable mass balance error, hence the preponderance of Calibration Level 1 values. Site specific values do not produce such clear cut selections. In most instances, the production of higher concentrations was the main goal in parameter selection. However, reasonable model values must also be a consideration. An attempt has been made to provide a quantitative evaluation of the parameter selection process utilizing the Calibration Levels. Most site specific values have Calibration Levels of 2b, and have been assigned this level due to site specific data, or the logical elimination of the alternatives. Overall, the parameter selection process should produce conservative estimates of concentration at the facility.

A review of the outputs, and specifically the concentration versus time plots, do not show anything that is extremely unusual. There are two points to note when reviewing the concentration versus time plots. First, the leachate buildup within the unit can be seen in these plots. There is a distinct upswing in concentration at about 75 years, or shortly after the "pumps" are turned off. The next major upswing occurs shortly after 100 years, or when the waste layer in the HELP model become fully saturated.

The second point, relates to the rather unusual characteristics of the concentration versus time curve for G-135. The very shallow slope of the concentration curve, coupled with the dramatic steepening of the slope may be related to its location with respect to the landfill. Although G-135 is closer to the unit than any other monitoring well, the phasing of waste does not place waste adjacent to the monitoring well for almost fifteen years. However, once the waste is place adjacent to G-135, coupled with the increased flux produced by the termination of leachate collection quickly produces high concentrations at the well.

## Conclusions

A groundwater impact assessment was performed for the Carus Disposal facility in Ottawa Township, LaSalle County, Illinois. This impact assessment reviewed the site geology and hydrology to produce a conceptual model for the site. This conceptual model was then analyzed to see what type of transport model would best represent the site. The model selected was Konikow and Bredehoeft's U.S.G.S. two-dimensional flow and transport model known as MOC. It provided the best solution to the diffusion dominated environment at the facility.

Sensitivity analysis was performed on both the internal and hydrogeologic data used in the model. This sensitivity analysis not only addressed variation in concentrations, but also address the variance in the mass balance error percentages as well. A baseline model scenario was developed from the sensitivity analysis to provide a conservative model framework for the impact assessment. Surrogates were developed from this baseline model to adequately express all leachate constituents within the conceptual model framework. Based on these surrogate scenarios, this facility does not produce a statistically significant increase over background concentrations over the life, post-closure care, and 100 year modeling periods, pursuant to 35 IAC 811.317 and 811.320.

## REFERENCES CITED


Anderson, M. P. and W. W. Woessner, 1992, Applied Groundwater Modeling: Simulation of Flow and Advective Transport, Academic Press, Inc., San Diego, CA, 381 p.

Bagchi, A., 1990, Design, Construction, and Monitoring of Sanitary Landfills, John Wiley & Sons, New York, NY, 284 p.

Bear, J., 1972, Dynamics of Fluids in Porous Media, American Elsevier Publishing Co., Inc., New York, N.Y., 764 p.

Bear, J., and A. Verruijt, 1990, Modeling Groundwater Flow and Pollution, D. Reidel Publishing Co., Boston, MA, 414 p.

Berg, R. R., 1986, Resevoir Sandstones, Prentice-Hall, Inc., Englewood Cliffs, N.J., 481 p.

Domenico, P. A., and F. W. Schwartz, 1990, Physical and Chemical Hydrogeology: John Wiley & Sons, New York, N.Y., 824 p.

Dragun, J., 1988, The Soil Chemistry of Hazardous Materials, Hazardous Materials Control Research Institute, Silver Spring, MD, 458 p.

Gelhar, L. W., C. Welty, and K. R. Rehfeldt, 1992, A critical review of data on field-scale dispersion in aquifers, Water Resources Research, American Geophysical Union, Washington, D.C., 28(7), pp 1955-1974.

Goode, D. J., and L. F. Konikow, 1989, Modification of a method-of-characteristic solute-transport model to incorporate decay and equilibrium-controlled sorption or ion exchange, United States Geological Survey Water-Resource Investigations Report 89-4030: United States Geological Survey, Denver, CO., 65 p.

Hensel, B. R., R. C. Berg, and R. A. Griffin, 1990, Numerical estimates of potential for groundwater contamination from land burial of municipal wastes in Illinois, Illinois Geological Survey, Hazardous Waste Research and Information Center, Environmental Geology 134, Illinois State Geological Survey, Urbana, IL, 84 p.

Hudak, P. F., 1986, Conjunctive Use of Groundwater Flow and Mass Transport Models in Simulation of Contaminant Migration, Butler County Landfill, Ohio, unpublished M. S. Thesis, Wright State University, 160 p.

Konikow, L. F., and J. D. Bredehoeft, 1984, Computer model of two-dimensional solute transport and dispersion in ground water, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 7, Chapter C2: United States Government Printing Office, Washington, D.C., 90 p.

Konikow, L. F. , 1977, Modeling chloride movement in the alluvial aquifer at the Rocky Mountain Arsenal, Colorado, United States Geological Survey Water-Supply Paper 2044, United States Geological Survey, Denver, CO., 43 p.

## REFERENCES CITED

(cont.)


Neuman, S. P., 1990, Universal scaling of hydraulic conductivities and dispersivities in geologic media, Water Resources Research, 26(8): American Geophysical Union, Washington, D.C., pp. 1749-1758.

Robertson, J. B., 1974, Digital modeling of radioactive and chemical waste transport in the Snake River Plain aquifer at the National Reactor Testing Station, Idaho, United States Geological Survey Open-File Report IDO-22054, United States Geological Survey, Denver, CO., 41 p.

Schackelford, C. D., 1990, Laboratory diffusion testing for waste disposal -- a review, Journal of Contaminant Hydrology, Elsivier Science Publishers, Amsterdam, Netherlands, (pre-print copy).

Sharp-Hansen, S., C. Travers, and P. Hummel, 1990, A Subtitle D Landfill Application Manual for the Multimedia Exposure Assessment Model (MULTIMED), Environmental Research Laboratory, U.S. Environmental Protection Agency, Athens, GA., 209 p.

Walton, W. C., 1988, Practical Aspects of Groundwater Modeling, third edition, National Water Well Association, Dublin, OH, 587 p.

Willman, H. B., E. Atherton, T. C. Buschbach, C. Collinson, J. C. Frye, M. E. Hopkins, J. A. Lineback, and J. A. Simon, 1975, Handbook of Illinois stratigraphy: Illinois State Geological Survey Bulletin 95, Illinois State Geological Survey, Urbana, IL., 261 p.

Addendum 3 70-115A1 (SM)
File Copy BEE

ANDREWS ENVIRONMENTAL ENGINEERING INC. 3535 Mayflower Blvd., Springfield, Illinois 62707/(217) 787-2334

July 6, 1993

Mr. Lawrence W. Eastep, P.E.
Permit Section Manager
Division of Land Pollution Control
Illinois Environmental Protection Agency
2200 Churchill Road
Post Office Box 19276
Springfield, IL 62794-9276

RECEIVED
JUL 06 1993
IEPA - BOL
PERMIT SECTION

re: 0990800015 -- LaSalle County
Carus Disposal Area No. 2
Application for Significant Modification to Permit
IEPA-DLPC Log No. 1991-365

Dear Mr. Eastep:

On behalf of our client, Carus Chemical Company, enclosed herewith is an original and two (2) copies of modifications to Addendum 2 to the referenced application for the subject facility.

The following modifications address the concerns and/or deficiencies noted by the Groundwater Assistance Unit, Permit Section, Division of Land Pollution Control, through various telephone conversations.

1. MAPC values for all leachate constituents and biennial organic constituents.

   a. MAPC values may be found for leachate constituents in Appendix F of the Groundwater Impact Assessment, Addendum 2. MAPC values for each downgradient well is included with the graph for each constituent.

   b. MAPC values for the biennial organic testing may be found in Appendix G, Groundwater Monitoring Program, Addendum 2. The values for the organic parameters from 40 CFR 141.40 and 35 IAC 620 are the Practical Quantitation Limits (PQL) as listed in the IEPA draft Attachment A dated November 1992.

   c. MAPC values for Quarterly Indicator Parameters may still be found in Table 5 of the Groundwater Monitoring Program.

2. Justification of Quarterly Indicator Parameters.

   An enhanced discussion of the selection of Indicator Parameters may be found on Page 17 of the Groundwater Monitoring Program.

EXHIBIT
C

3. Selection of Groundwater Standard as Class IV for the uppermost aquifer.

   Page 16 of the Groundwater Monitoring Program contains additional points on the choice of a Class IV Groundwater Standard for the facility.

4. Replacement of G-104, G-12D, and G-13D with nested wells.

   A discussion of the merits of well replacement has been added to Page 10 of the Groundwater Monitoring Program.

The additions and substitutions necessary are described in Changes to Addendum 2, attached herewith. This information only pertains to the Groundwater Impact Assessment and the Groundwater Monitoring Program. Andrews Environmental Engineering, Inc. shall provide additional information requested in conjunction with the engineering and design aspects of the facility by the end of July.

If any questions arise, or further information or clarification is needed by your staff, please do not hesitate to contact me.

Sincerely,

Rhonald W. Hasenyager
Hydrogeologist
Division of Solid Waste Management

CC: Carus Chemical Company
Kenn Smith

Enclosures

RWH:njm

# CHANGES TO ADDENDUM 2

# CARUS CHEMICAL COMPANY

**Reports of Hydrogeologic Investigations:**

None

**Groundwater Impact Assessment:**

1. Insert new graphs behind existing graphs in Appendix F.

2. Insert new tables behind existing graphs in Appendix F.

3. Append new diskettes to end of Section.

**Groundwater Monitoring Program:**

1. Replace List of Figures.

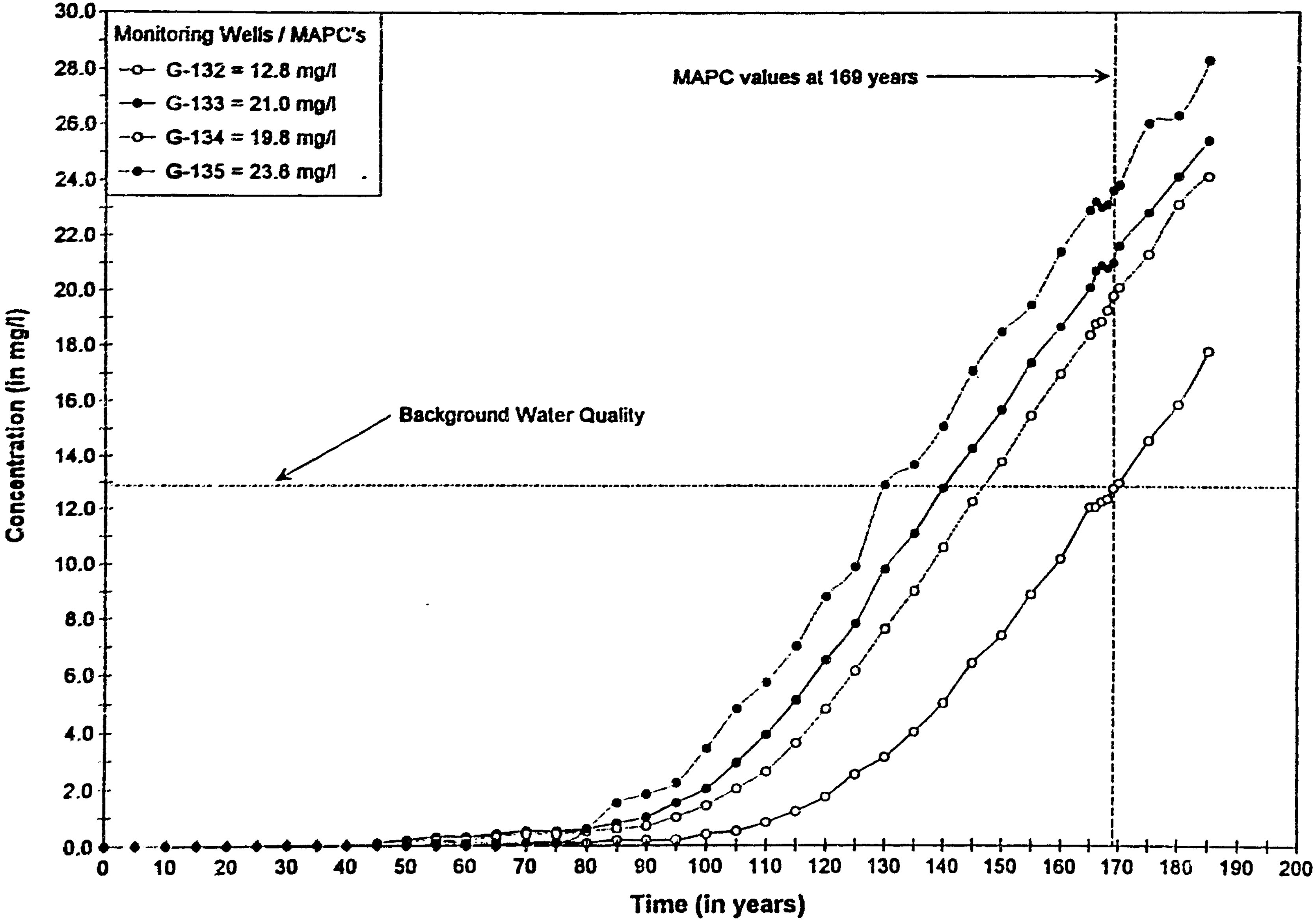
2. Replace List of Appendices.

3. Replace Pages 10 and 11.

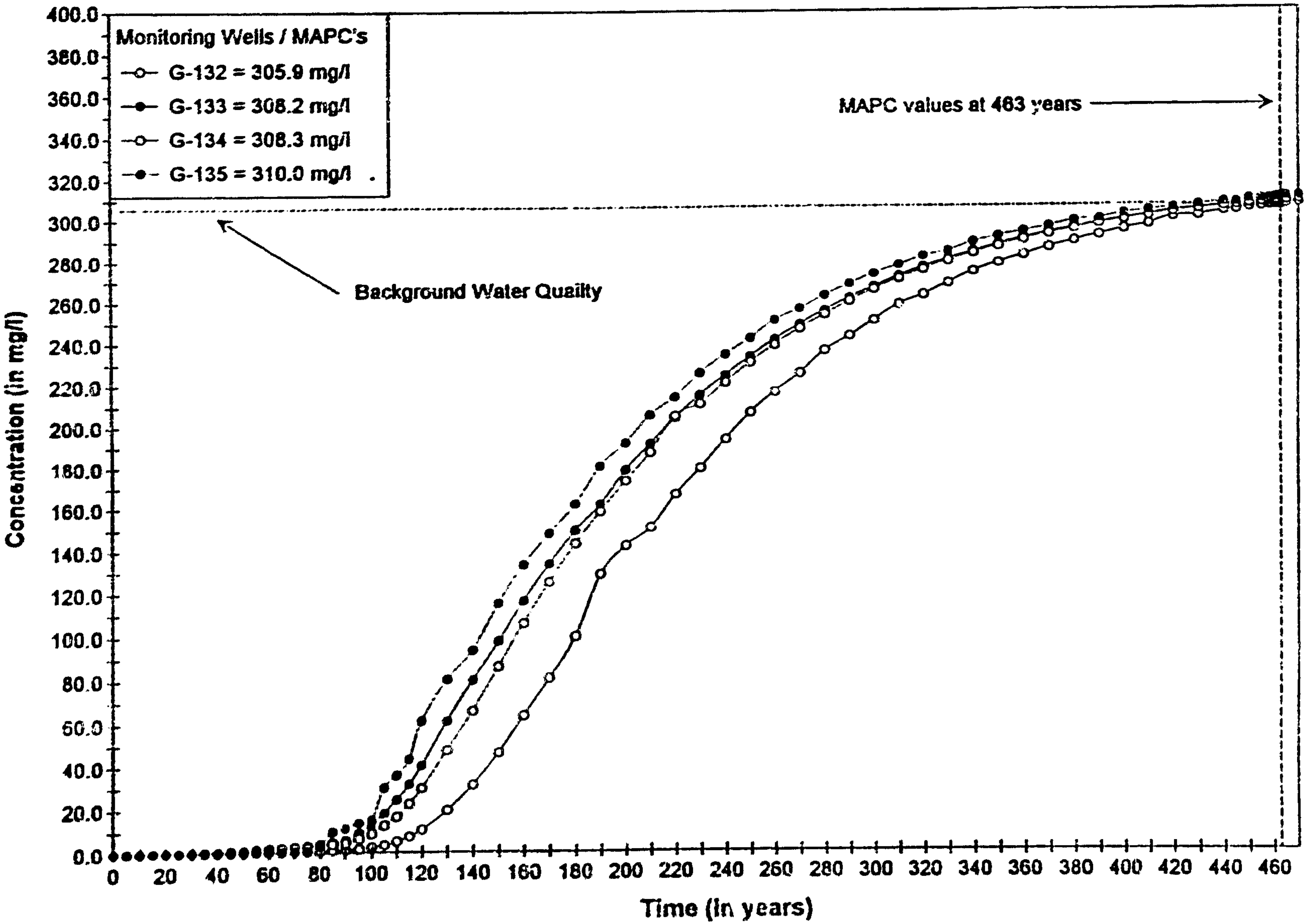
4. Remove Pages 16 and 17. Insert new Pages 16, 16a, and 17.

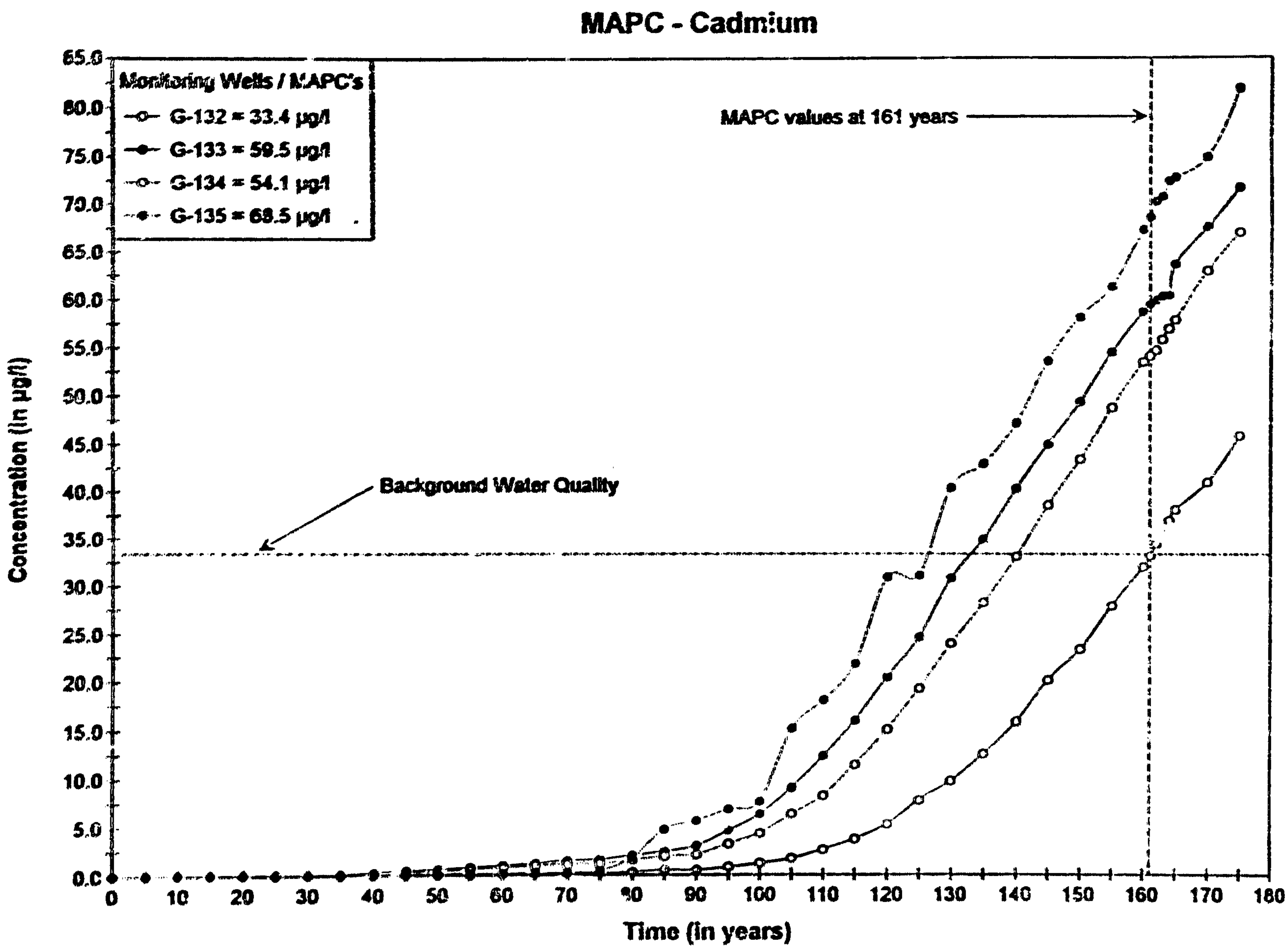
5. Replace Appendix G.

## MAPC - Aluminum

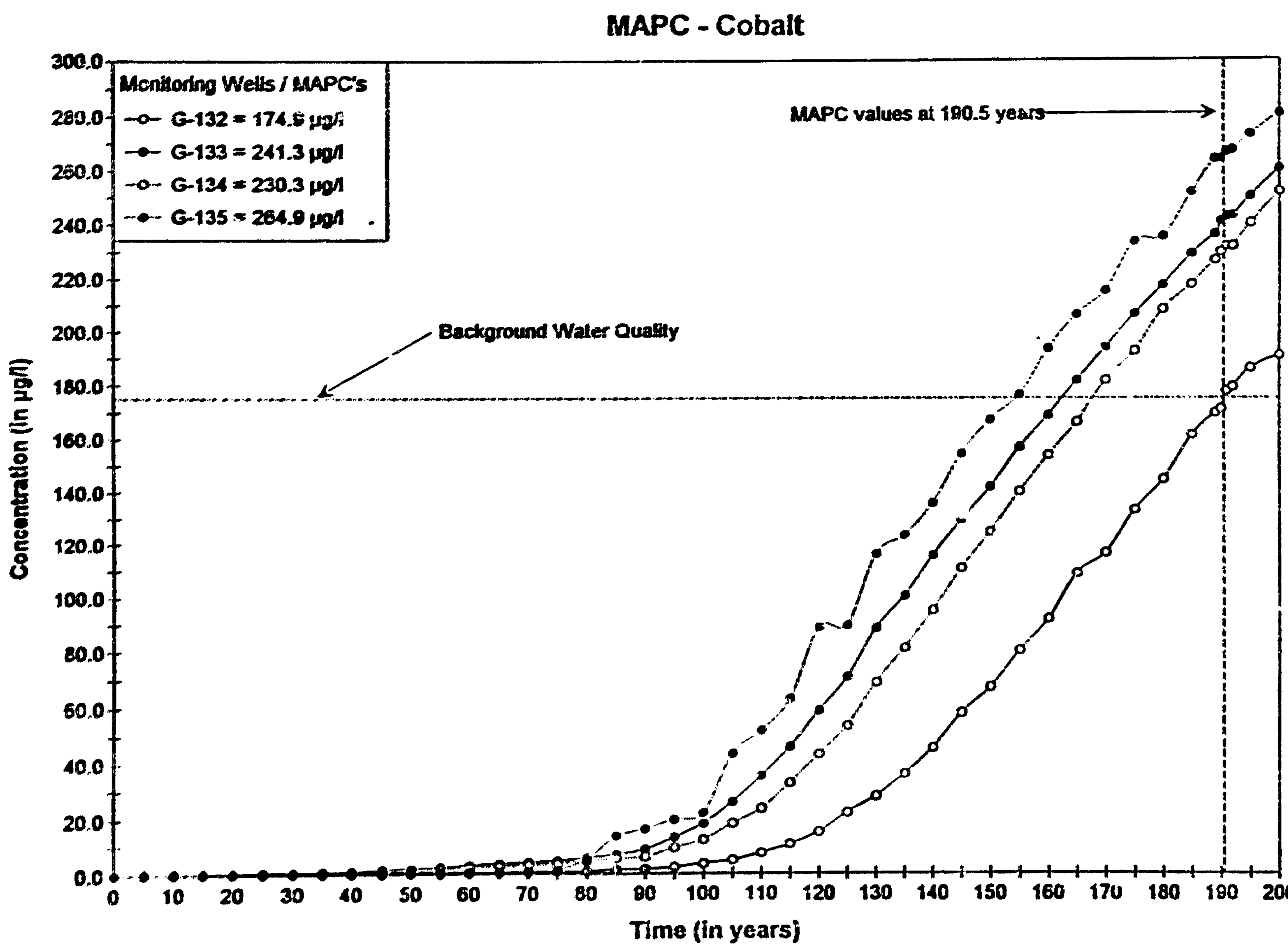


# MAPC - Calcium



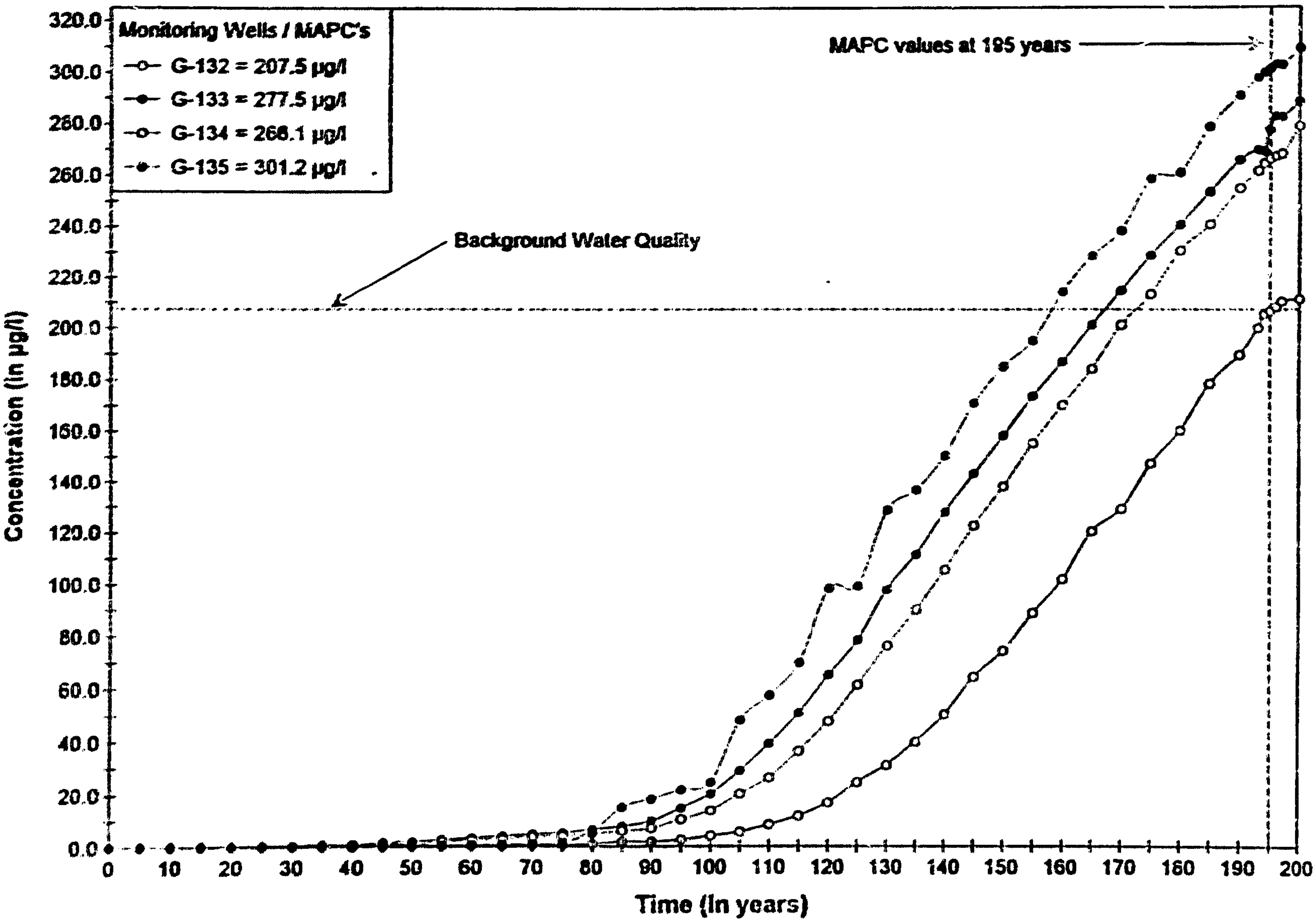


MAPC - Cadmium
Monitoring Wells / MAPC's
G-132 = 33.4 µg/l
G-133 = 59.5 µg/l
G-134 = 54.1 µg/l
G-135 = 68.5 µg/l
MAPC values at 161 years
Background Water Quality
Concentration (in µg/l)
Time (in years)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
75.0
80.0
85.0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180

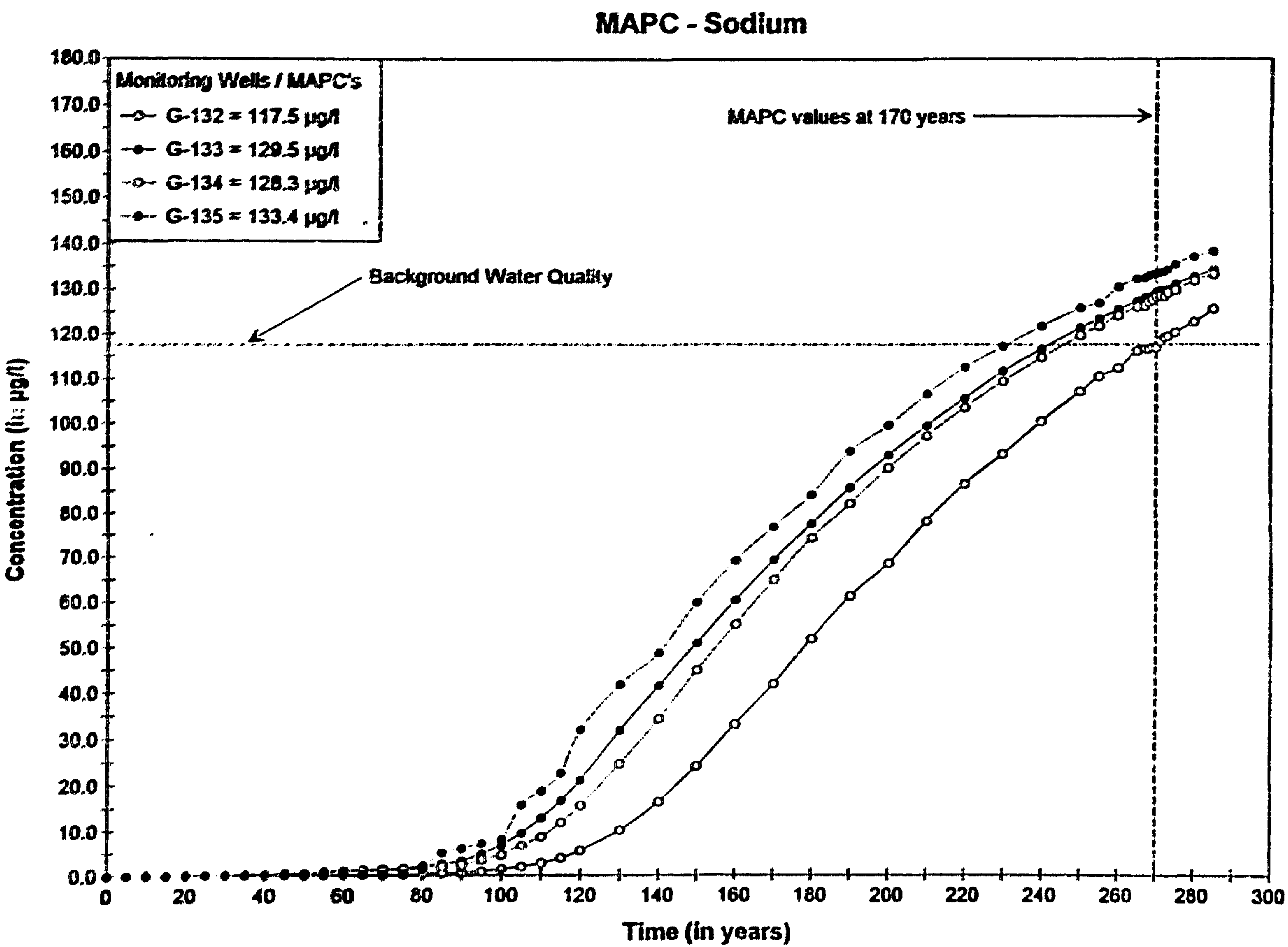


MAPC - Cobalt
Monitoring Wells / MAPC's
G-132 = 174.9 µg/l
G-133 = 241.3 µg/l
G-134 = 230.3 µg/l
G-135 = 264.9 µg/l
MAPC values at 190.5 years
Background Water Quality
Concentration (in µg/l)
Time (in years)
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
220.0
240.0
260.0
280.0
300.0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200

## MAPC - Copper

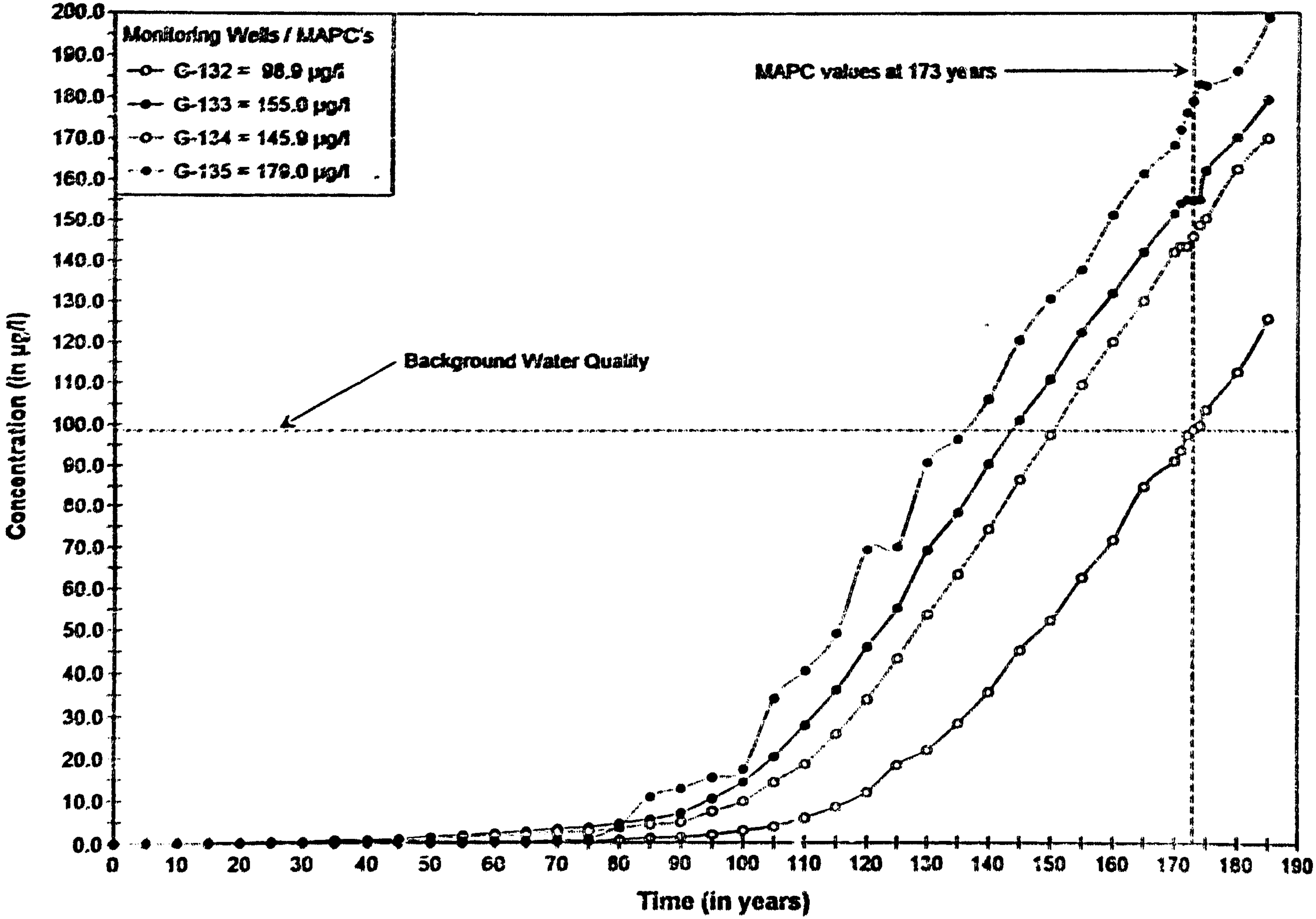


Monitoring Wells / MAPC's
G-132 = 207.5 µg/l
G-133 = 277.5 µg/l
G-134 = 266.1 µg/l
G-135 = 301.2 µg/l
MAPC values at 195 years
Background Water Quality
Concentration (in µg/l)
Time (in years)
320.0
300.0
280.0
260.0
240.0
220.0
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200

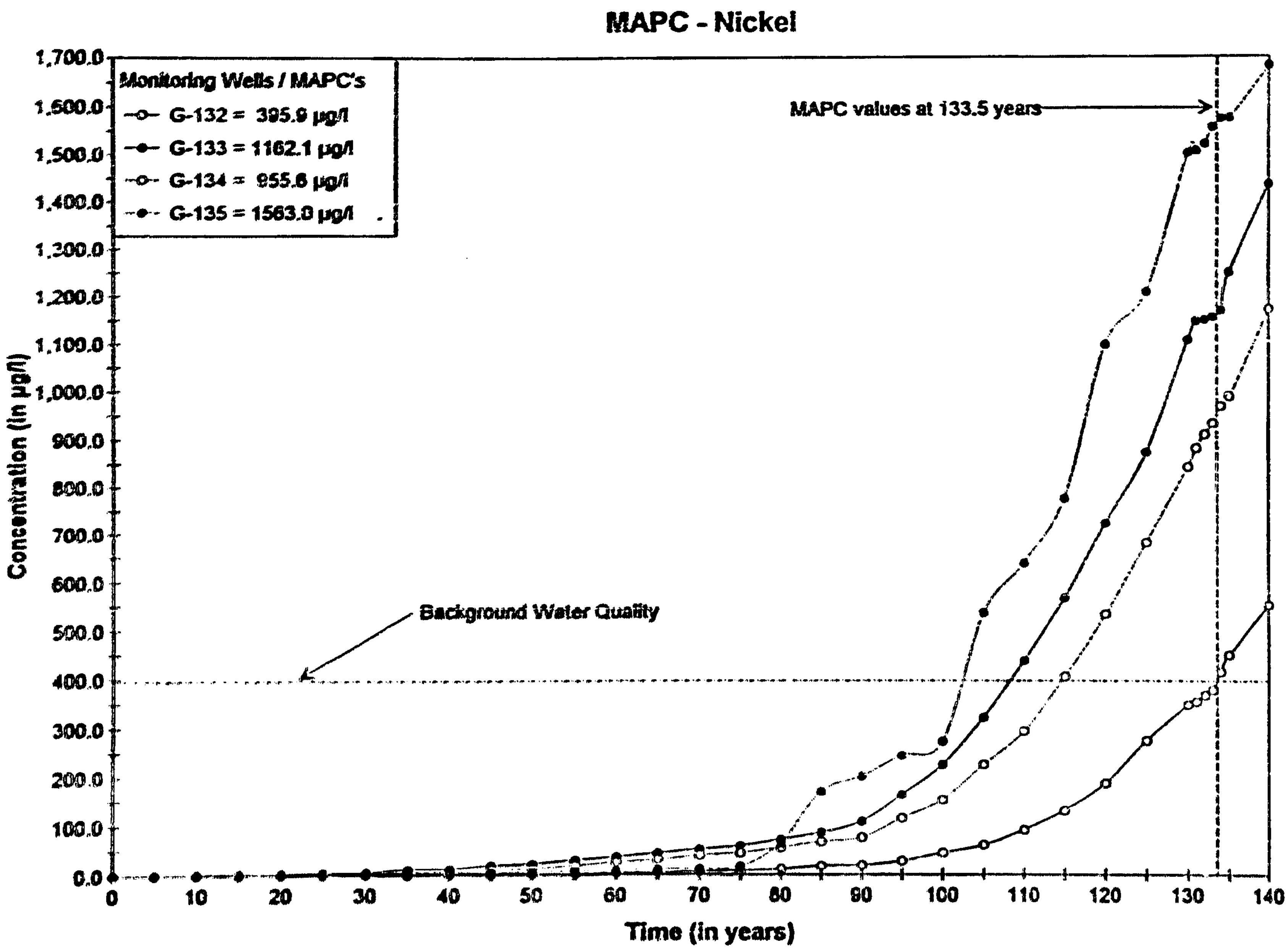


MAPC - Sodium
Monitoring Wells / MAPC's
G-132 = 117.5 µg/l
G-133 = 129.5 µg/l
G-134 = 128.3 µg/l
G-135 = 133.4 µg/l
MAPC values at 170 years
Background Water Quality
Concentration (in µg/l)
Time (in years)
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

# MAPC - Lead



Monitoring Wells / MAPC's
G-132 = 98.9 µg/l
G-133 = 155.0 µg/l
G-134 = 145.9 µg/l
G-135 = 179.0 µg/l
MAPC values at 173 years
Background Water Quality
Concentration (in µg/l)
Time (in years)
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190



MAPC - Nickel
Monitoring Wells / MAPC's
G-132 = 395.9 µg/l
G-133 = 1162.1 µg/l
G-134 = 955.6 µg/l
G-135 = 1563.0 µg/l
MAPC values at 133.5 years
Background Water Quality
Concentration (in µg/l)
Time (in years)
1,700.0
1,600.0
1,500.0
1,400.0
1,300.0
1,200.0
1,100.0
1,000.0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140