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# SUMMARY
# HYDROLOGIC ASSESSMENT ACTIVITIES
# SAUKVILLE, WISCONSIN

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SUMMARY
HYDROLOGIC ASSESSMENT ACTIVITIES
SAUKVILLE, WISCONSIN

## INTRODUCTION

In response to Wisconsin DNR's concern over the presence of organic contaminants in ground water near the Village of Saukville's municipal well field, Freeman Chemical through its consultant, Olver Incorporated, submitted a proposal to assess ground water conditions at the Saukville site in April, 1983. The emphasis of the proposed detailed hydrogeologic study was on the correct location and operation of dewatering wells, identification of the ground water flow regime, and understanding of the interaction between shallow and deep aquifers (see the October 1, 1983 Olver report).

The proposed project approach was divided into four phases as follows:

Phase I - Preliminary Hydrologic Assessment

1. Literature search
2. Fracture trace analysis
3. Borehole geophysical surveys
4. Ground water level monitoring

Phase II - Ground Water Flow Regime Evaluation

1. Site topographic survey update
2. Exploratory drilling/piezometer installation
3. Ground water level monitoring
4. Shallow dewatering well installation
5. Laubenstein well pump test
6. Indicator waste quality testing
7. Interim report

Phase III - Testing of a Shallow Ground Water Protection System

Phase IV - Deep Ground Water Resources Evaluation

An interim report on progress of Phases I & II were issued by Olver on June 20, 1984 detailing the results of the geotechnical investigations, piezometer installations, ground water level monitoring, and ground water collection and analysis activities. In addition, preliminary assessments of the hydrologic regime at

Saukville were made. Soil boring and piezometer installation logs, chemical analyses, and ground water hydrographs were included. The report noted that the chronological sequencing of individual steps in Phases I and II had been modified in response to field conditions. Subsequently (July and August 1984), a pump test program designed to determine hydrologic characteristics (Transmissivity, Storage and Leakage) of the dolomite aquifer and the interrelationship of the shallow and dolomite aquifers was conducted using the Saukville municipal wells, the Laubenstein well, and site piezometers.

Details of the pump test program, data analysis procedures, data evaluation, and aquifer characteristics are presented in an accompanying report by Olver issued January 10, 1985.

GEOLOGY

The available literature suggests and the geotechnical data in these reports confirm that the Saukville site is underlain by a thin glacio-fluvial deposit capping thick, competent Silurian dolomite having an irregular (eroded and solutioned) upper surface. Figure 1 is a bedrock contour map constructed from the available auger and piezometer hole data. This map shows that the Freeman Chemical plant is sited on a local bedrock high, that overall the Silurian dolomite dips to the southeast at a 4 or 5 percent slope, and that bedrock depressions exist along an east-west line trending from PW-3 toward PW-8. These may represent sinks, or an old erosion channel, (Thalweg), or a vertical offset in the bedrock surface. The slope of the dolomite surface toward the river suggest but does not prove that the dolomite may be exposed in the Milwaukee River.

The "point" sample logs for the auger and piezometer holes suggest that the shallow glacial layers vary both vertically and horizontally from permeable sands and silts through dense clays typical of such deposits, but is generally floored by "hard pan" of lower permeability. Continuous sample and/or geophysical logs from which to determine the degree of lateral continuity and detailed vertical stratigraphic/permeability zoning are not yet available. Figure 2 is a surficial cover-thickness map of the site vicinity. This map suggests a possible thinning of the glacial sediment cover over the site. Examination of logs of Piezometers 1, 2, 3 and 14 suggest the presence of more permeable material parallel to and just east of the railroad grade.

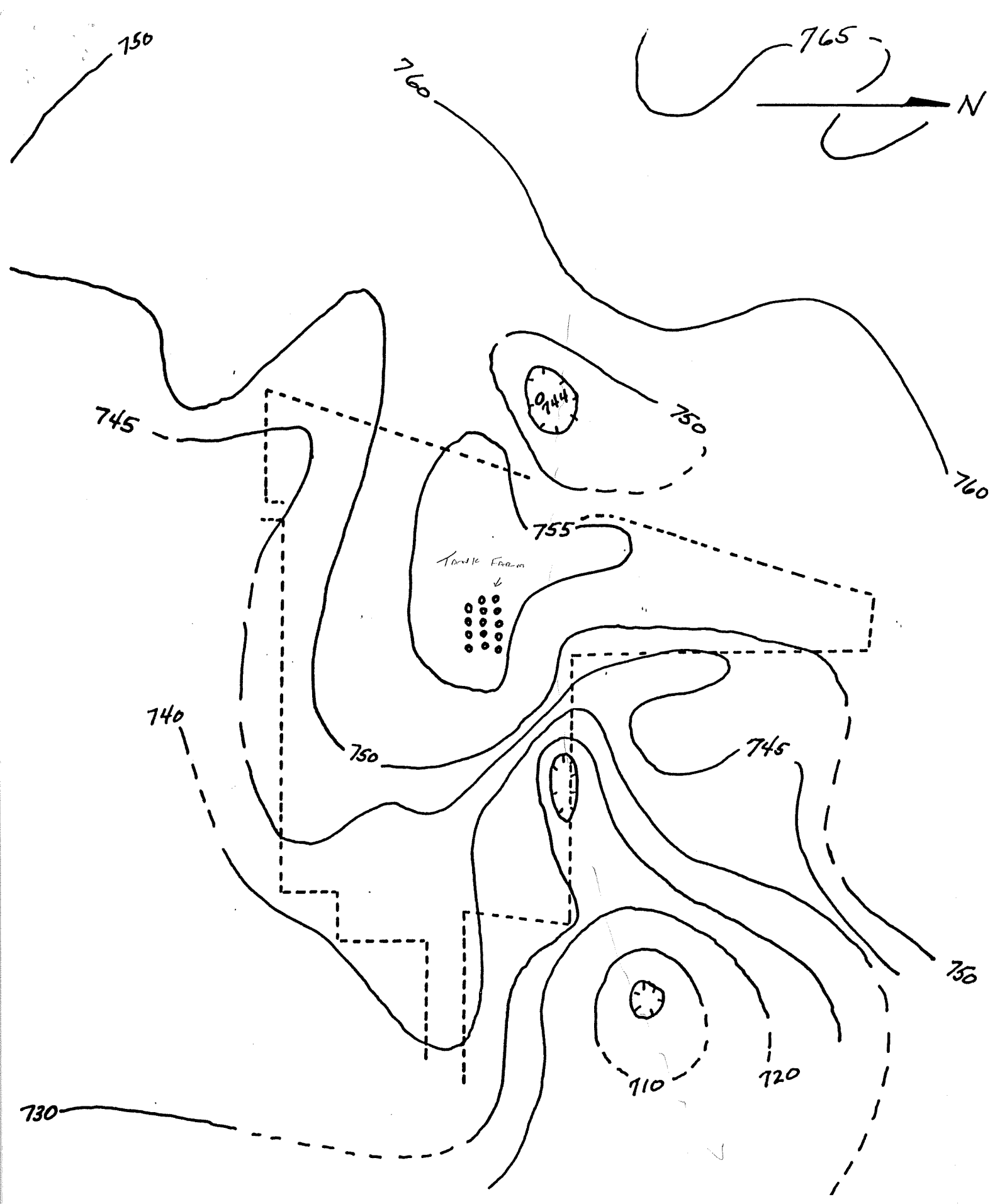


Figure 1.
Top of Bedrock Map
Saukville Site
Scale: 1"=200' Date: 1/10/85

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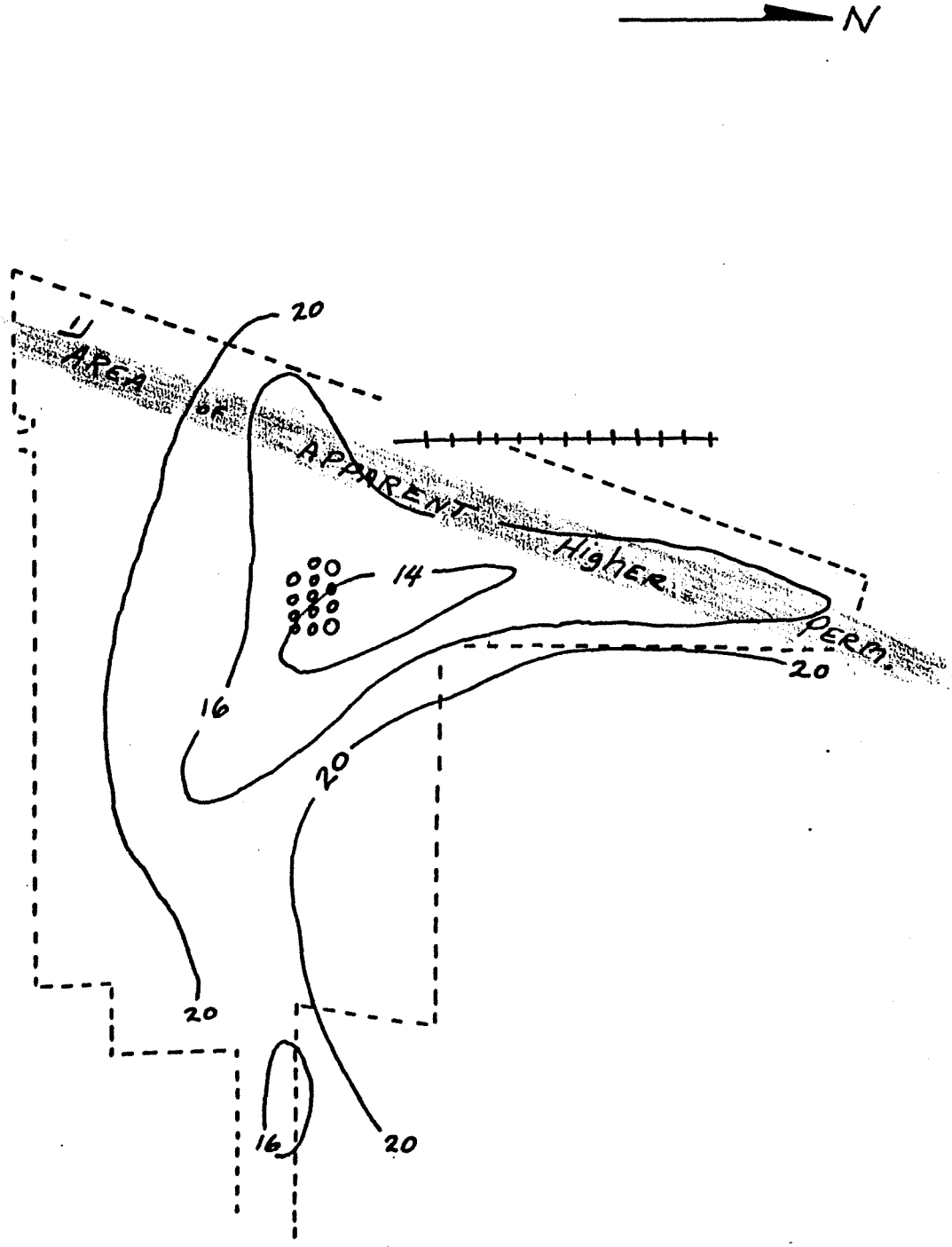


Figure 2:
Thickness of Surficial Cover
Over Dolomite
Saukville Site
Date: 1/10/85

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1 From inspection of boring log notes.

## HYDROLOGY

Piezometer water-level data collected to date indicate that ground water head at the Freeman - Northern Signal site in the shallow glacial materials is generally 0 to 6 feet higher than at the glacial sediment/dolomite contact at the site. This difference changes with the season, is less pronounced toward the Milwaukee River and may be reversed near the river. No piezometers isolated only in the underlying dolomite have as yet been constructed at the Freeman site to determine the potential head difference across the surficial aquifer/dolomite aquifer contact.

Results of the "summer of 1984" pump tests demonstrate that the dolomite aquifer is semi-confined by the surficial glacial materials and that recharge to the dolomite occurs during pumpage - probably from the Milwaukee River.

Water level data collected to date from the site piezometers indicate that a ground water divide exists across the site which trends in a north-northeasterly direction. West and northwest of this divide ground water aparrently flows northward in response to the drawdown cones of MW 2, 1, and 4. Figure 3 is a water level contour map for May, 1984. (See also Figure 1 of the January 10, 1985 report). East of the site the shallow ground water gradient is toward the Milwaukee River.

Figure 4 is a contour map of all available water level data from auger holes, piezometers, and wells constructed in the fall of 1983. Although this map does not strictly represent one point in time, it does suggest that the water table gradient in the surficial materials is much more complex than that represented by Figure 3 and that a drawdown cone may exist around the unpumped Laubenstein well.

## WATER QUALITY DATA

Results of chemical analyses from the periodic sampling of the shallow piezometers indicate organic solvents, phenols and trichloroethylene are present in the shallow aquifer. Although the data are not sufficiently detailed to be contourable the higher concentrations tend to occur in the vicinity of the Freeman

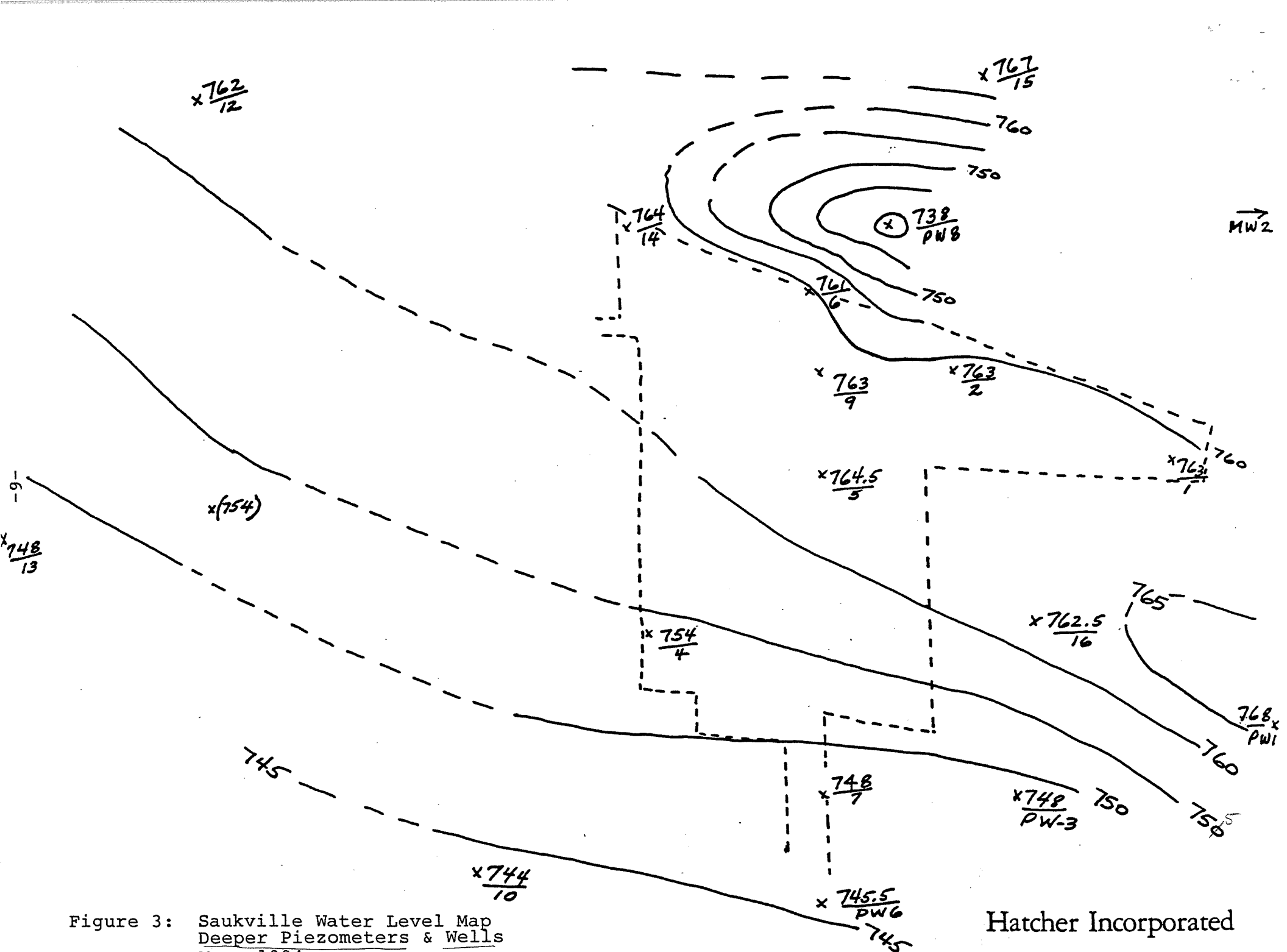


Figure 3: Saukville Water Level Map
Deeper Piezometers & Wells
May, 1984

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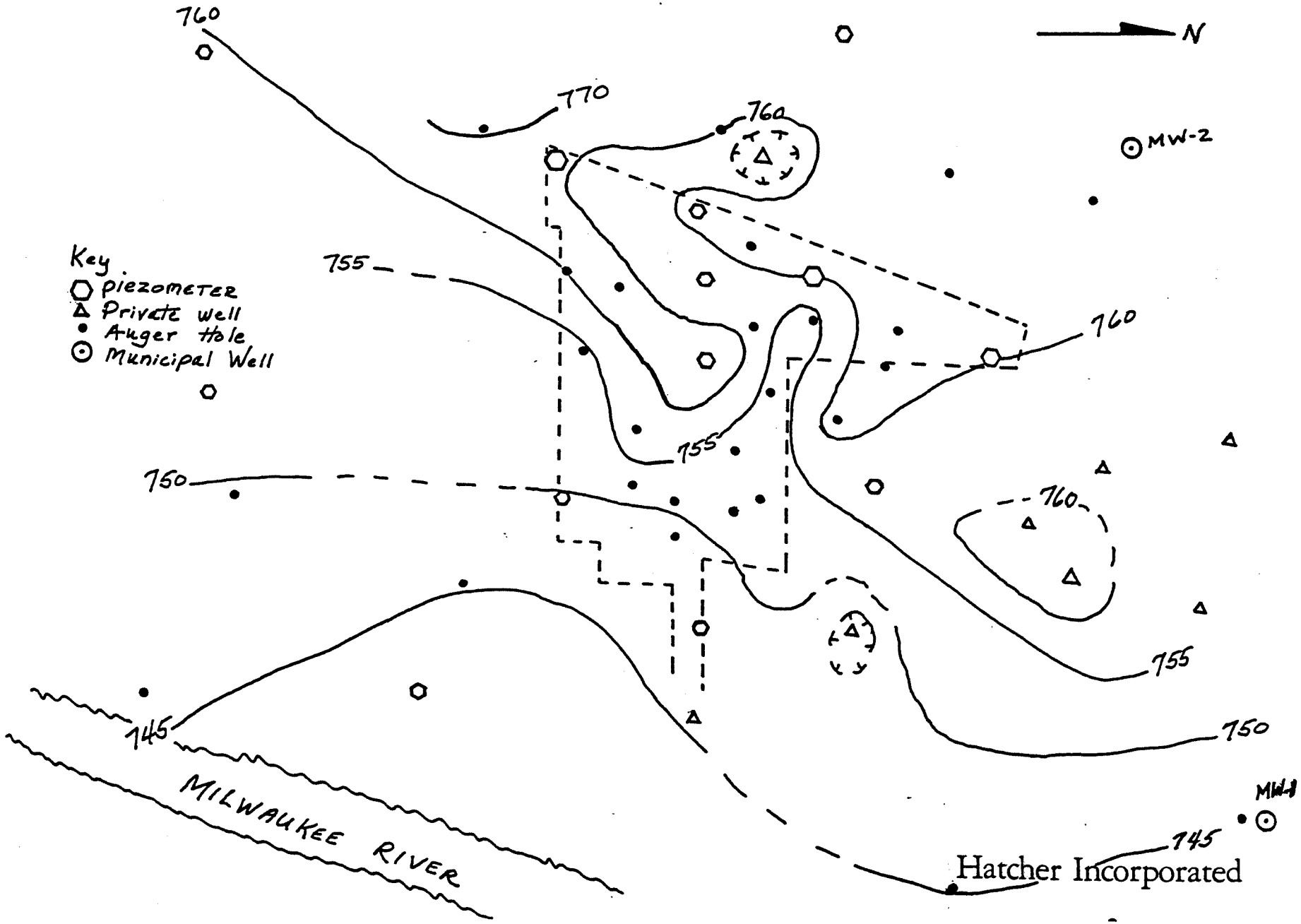
Figure 4: Approximate Water Level Map
Fall - 1983
Shallow Aquifer



and Northern Signal sites. Analyses of water from the Laubenstein well pump test indicate contamination of the dolomite aquifer at that point. With regard to chlorinated solvents, the chemical analyses to date indicate that only dichloroethylene is found beneath the Freeman site. Trichloroethylene has been identified in the Laubenstein well on the Northern Signal property and in MW-2.

Soil samples taken during the soil exploration and piezometer installation phases were routinely sniffed and given a qualitative odor classification. The results of that survey are presented as Figure 5. This map suggests on the basis of sample odor that a contaminate plume exists in the shallow aquifer at the Freeman - Northern Signal site.

AQUIFER TESTS

Recent aquifer tests of municipal wells in the dolomite aquifer at Saukville demonstrate that it exhibits considerable local variability in yield. This variability is probably related to variability in fracture frequency, solutioning, and recharge opportunity at each well site. Too, transmissivity and storage coefficient values calculated from the test analyses also reflect aquifer anisotrophy; i.e., aquifer T&S differ depending on the direction of the observation well(s) used in the test analyses.

Table II of the January 10, 1985 Olver report and reproduced herein indicates that the T of the dolomite aquifer ranges from 140 to 4,450 $ft^2$/day..

The rapid response of the Laubenstein well and the smaller delayed response of the site piezometers to pumping in nearby municipal wells indicates that the Laubenstein well and the site is at least partially in their drawdown cone of influence. Thus any pollutants in the dolomite in this drawdown cone can move toward the pumped municipal wells.

The potential for leakage of contaminated ground water from the shallow aquifer into the underlying dolomite at the Freeman - Northern Signal sites is indicated because

(1) the aquifer tests show the dolomite aquifer to be partially confined and,

(2) because the vertical head gradient from top to bottom of the shallow aquifer is downward.

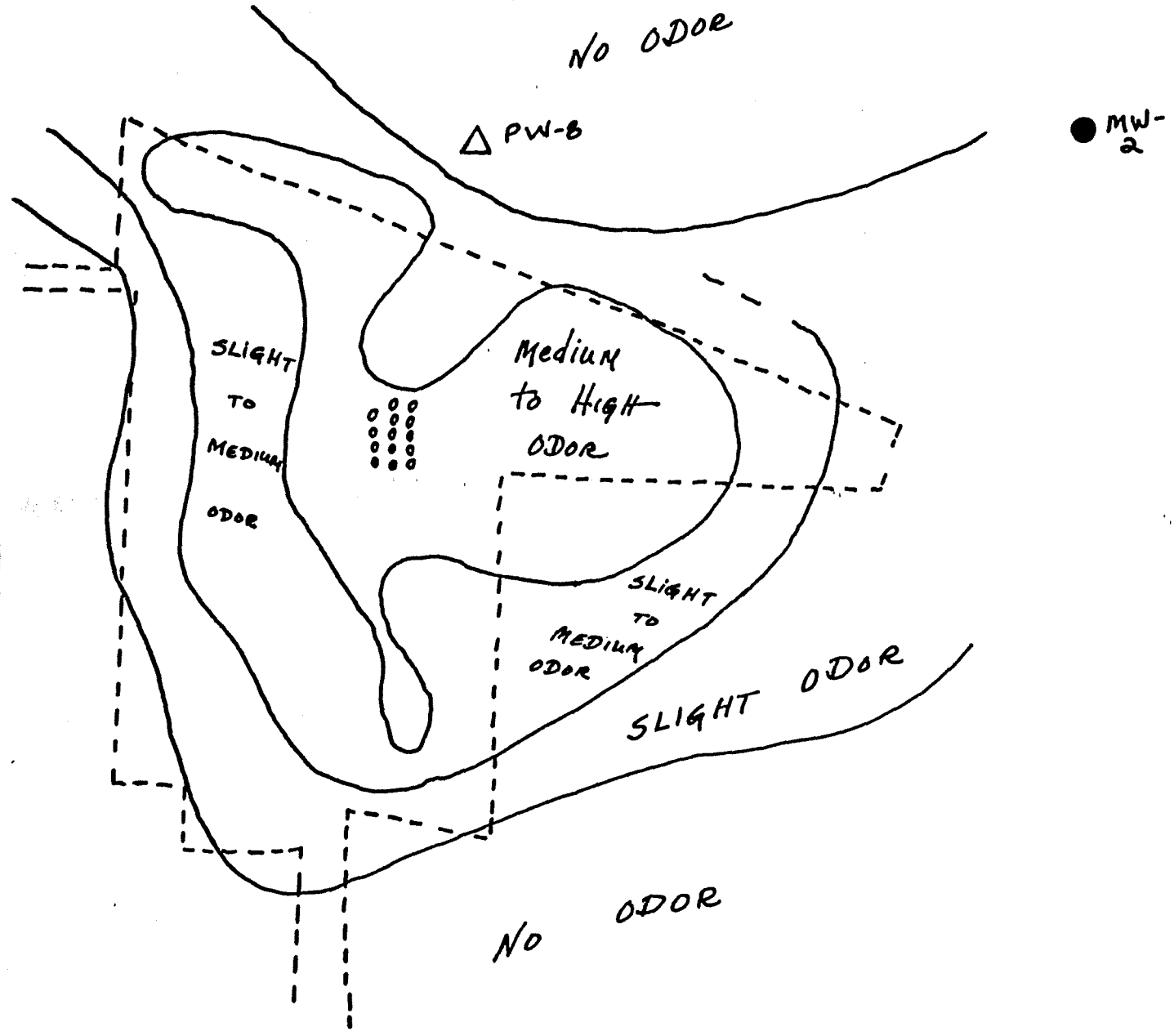



Figure 5: Qualitative Odor Map - Soil
Saukville Site
Date: 1/10/85 Scale: 1"=200'

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TABLE II
HYDROGEOLOGIC ASSESSMENT AT SAUKVILLE, WISCONSIN
MUNICIPAL WELLS PUMP TEST SUMMARY

| TEST DATE | TEST TYPE[1] | PUMP. WELL | ANALYTICAL METHOD[2] | OBSERVATION WELL(S) | T ($ft^2$/day) | S | B | |
|---|---|---|---|---|---|---|---|---|
| 5/23 | C.D. | MW-1 | H-M | MW-3 | 685 | $7.2 \times 10^{-5}$ | 1.0 | [3] |
| 5/23 | C.D. | MW-1 | H-M | Laubenstein | 195 | $1.7 \times 10^{-8}$ | 30 | |
| 5/23* | REC. | MW-1 | H-M | Laubenstein | 140 | $1.5 \times 10^{-8}$ | 15 | |
| 5/23 | REC. | MW-2 | J-L | MW-2 | 510 | $1.3 \times 10^{-6}$ | N/A | |
| 5/23 | C.D. | MW-1 | H-J | MW-2&3,Laub. | 230 | $1.7 \times 10^{-5}$ | N/A | |
| 5/23 | REC. | MW-2 | H-M | Laubenstein | 540 | $1.5 \times 10^{-5}$ | 1.5 | |
| 5/24 | C.D. | MW-2 | J-L | MW-2 | 460 | $2.7 \times 10^{-4}$ | N/A | |
| 5/24 | C.D. | MW-2 | H-M | MW-1 | 1,100 | $1.5 \times 10^{-4}$ | 0.3 | |
| 5/24 | C.D. | MW-2 | H-M | Laubenstein | 520 | $5 \times 10^{-7}$ | 7 | |
| 5/24 | C.D. | MW-2 | H-J | MW-1 & Laub. | 2,200 | $8.1 \times 10^{-6}$ | N/A | [3] |
| 5/22 | REC. | MW-4 | H-M | MW-1 | 1,908 | $1.5 \times 10^{-7}$ | 1.5 | |
| 5/22 | C.D. | MW-4 | J-L | MW-4 | 4,400 | $5.5 \times 10^{-6}$ | N/A | |
| 5/22 | C.D. | MW-4 | H-M | MW-3 | 4,250 | $8.5 \times 10^{-5}$ | 0.7 | |
| 5/22 | C.D. | MW-4 | H-M | MW-1 | 1,750 | $8.5 \times 10^{-7}$ | 1 | |
| 5/22 | C.D. | MW-4 | H-M | Laubenstein | 950 | $1.4 \times 10^{-7}$ | 20 | |
| 5/22 | C.D. | MW-4 | H-J | MW-1&3,Laub. | 4,450 | $1 \times 10^{-6}$ | N/A | |
| 5/23 | REC. | MW-4 | H-M | MW-1 | 1,760 | $1.3 \times 10^{-6}$ | 0.7 | |
| 5/23 | REC. | MW-4 | H-M | Laubenstein | 1,650 | $1.3 \times 10^{-6}$ | 7 | |
| 5/23¶ | C.D. | MW-4 | H-M | Laubenstein | 920 | $4.0 \times 10^{-5}$ | 0.5 | |
| 5/23¶ | C.D. | MW-4 | H-M | MW-2 | 290 | $2.1 \times 10^{-5}$ | 0.5 | |

NOTES:

1) C.D. = Constant Discharge / REC. = Recovery
2) H-M = Hantush Modified / H-J = Hantush-Jacob / J-l = Jacob-Lohman
3) Pump test encountered possible recharge boundaries
T = Transmissivity ( $ft^2$/day)
S = Storage Coefficient (dimensionless)
B = Leakage Coefficient (see Table I) (dimensionless)

* Determined from record of MW-2 Recovery Test.
¶ Determined from record of MW-1 Pump Test.

MW-1 - ~100 gpm
MW-2 - ~200 gpm
MW-4 - ~900 gpm
} City use.

The quantity of leakage from the site is governed by the potential head, the permeability of the surficial cover, and the available precipitation. If infiltration through the surficial cover is as much as 10 percent of the available 30 inches of average annual precipitation, then infiltration to the dolomite aquifer is a maximum of about 232 gal/day/acre. (Note: the area in which sample odor was detected = ±11.5 acres - the area of strong odor = ±5.0 acres).

## SUMMARY OF PROGRAM TO DATE

The program to date has accomplished some major elements of the original project, in particular, identification of ground water pollutants and the hydraulic properties of the deep aquifer. The major findings are:

1. The principal aquifer at the Freeman site is a Silurian Dolomite whose weathered, irregular upper surface is overlain by a thin glacial sediment cover of lower permeability.

2. The packer tests and crude geophysical logs of the Laubenstein well indicate that water in the dolomite may occur in distinct fractures and/or solution cavities.

3. The pump test and piezometer data indicate that part of the site is in the municipal well field cone of influence.

4. Results of the recent pump tests demonstrate that water in the surficial glacial materials occurs under unconfined water table conditions and that the Dolomite Aquifer is semi-confined by the overlying less permeable glacial materials.

5. The pump test data analyses indicate that T&S of the Dolomite Aquifer range from 140 to 4,450 $ft^2$/day and $1.5 \times 10^{-4}$ to $1.7 \times 10^{-8}$, respectively.

6. Rapid responses of the Laubenstein well to precipitation events indicate there is high permeability interconnection between the well bore and the shallow sediments or that surface water is leaking down along the outside of the casing.

7. The depression in the water table contour map (Figure 3) between the Laubenstein well and MW-2 indicates that either recharge to the dolomite is occuring from the overlying sediments through infiltration at the glacial sediment-weathered dolomite contact in that area or, ground water in the glacial materials is flowing toward the Laubenstein well where it may leak down around the casing into the dolomite, then toward MW-2. In either event this situation provides a pathway for migration of pollutants toward MW-2.

8. Water level measurements from the piezometer nests indicate that there is a downward component of ground water flow through the surficial glacial materials. However, the potential difference in head and the magnitude and direction of any flow between the surficial materials and the dolomite is not known.

9. The overall character, permeability, and depth of the glacial materials is generally known from the many borings and piezometer well data, but the detailed spatial distribution and permeability of individual units that may actually store, transmit, or retard movement of pollutants in the surficial material is <u>not</u> documented.

10. The chemistry of pollutants in the surficial glacial materials and in the dolomite at the Laubenstein well is largely known, but the spatial distribution of pollutants is not.

## PROGRAM GOALS AND MISSING DATA

The overall goal of the Saukville ground water asssessment program is to identify, recommend, and implement a remedial activity or series of activities which will remove the contaminants from the soil and ground water and isolate these contaminants from the Village water supply. To meet this goal, Hatcher Incorporated continues to pursue the original strategy proposed in April 1983. Specifically, this strategy is to implement a ground water management scheme consisting of a dewatering/injection system which will remove/detoxify the contaminated water underlying the affected area. In order to complete the identification of the viable remedial alternatives and to design and implement a suitable remedial technique(s) the following data needs must be met:

1. The geohydrology of the very localized ground water system directly underlying the two plant sites and the shallow water table/dolomite aquifer

interrelationship must be characterized more accurately. Whereas the studies to date have given us considerable information on the characteristics of the deep aquifer feeding the Village's well system, the project activities thus far have not generated specific information on the shallow aquifer necessary to design and implement a dewatering system.

2. The three dimensional extent of any plumes associated with chemical spills at both locations must be characterized more accurately. The auger-piezometer sample log data indicate the possible occurence of geological conditions within the glacial sediments that tend to both produce localized pockets of contamination as well as provide more permeable pathways for contaminate migration. Too, contamination is known to exist in the dolomite at the Laubenstein well but the degree of concentration and extent elsewhere is not known.

3. The rate of contamination movement and pathway direction must be measured. Any remedial solution(s) proposed must be based upon an understanding of the specific rate and direction of pollutant flow and extent of dispersion. These data are also required to determine the location and proposed pumping rate(s) of a dewatering/injection system.

In summary, the following data are missing:

- o The spatial distribution and chemical composition of pollutants in both the water table and dolomite aquifers.
- o The permeability, head, and spatial distribution of the critical, controlling glacial sedimentary facies.
- o The difference in head between the dolomite and glacial material over the area of concern.
- o The areal and temporal distribution of potentiometric head of the dolomite aquifer in the site area.
- o The detailed topography and character of the glacial sediment-dolomite contact and the character of the depressions or offsets at the glacial sediment/bedrock contact on the east edge of the Freeman property.
- o The causal hydrologic factors responsible for the drawdown cone or gradient change in the surficial glacial materials in the vicinity of the Laubenstein and MW-2 wells.

- o For the Laubenstein well, the distribution of dolomite fractures and/or solution cavities, and the degree of integrity of the casing seal.

- o The nature, occurrence, and movement of ground water in the dolomite, whether by interstitual, interfractural movement, or through solution openings.

RECOMMENDED SCOPE OF WORK

To acquire the above missing data, Hatcher Incorporated proposes the following approach:

The spatial distribution of critical glacial facies be delineated with a combination of (1) comprehensive borehole logging in all available bore holes, piezometers, and private wells, (2) some additional augering and continuous split spoon sampling in any areas where subsurface data is found to be deficient, and, (3) seismic refraction profiling.

nat. γ
Density
Neutron
↓
Use radioactive source

A well point water sample conductivity/temperature survey is proposed at approximately 20 points in the shallow sediments in suspected and identified plume areas to better define the spatial distribution of pollutants in the shallow aquifer. Soil and water samples will be taken from additional wells drilled for other purposes.

Use of OVA

Temporary driven pts to target layers

The permeability (hydraulic conductivity) of critical sedimentary facies and of the dolomite will be determined by a series of constant-head permeability tests on all piezometers and new wells. In addition, a limited number of samples will be collected for lab permeability analysis. These measurements will be augmented with limited pump tests where practical.

Gradient in dolomite

The ground water chemistry, areal potential head difference, and interaction between the water table aquifer and the dolomite which determines the "downward leakage into the dolomite problem" will be determined by construction of six new piezometers isolated in the upper 50 to 100 ft. of the dolomite at existing piezometer sites.

The character and topography of the bedrock upper surface will be further detailed by augmenting the existing data points with detailed seismic profiling and any additional depth data derived from new piezometer construction.

The geometry of the Laubenstein/MW-2 well drawdown cone will also be further defined by either observation of nearby piezometer fluctuations while the Laubenstein well, new dolomite piezometers, and MW-2 wells are pumped, or by shallow exploratory drilling to determine the character of the surficial sediment - dolomite contact in that area, or both.

We propose that the Laubenstein well undergo a week long pump test to a) determine the effect of long-term pumpage on water quality and water volume available from that well and, b) to further define leakage between the dolomite and the shallow aquifer. Before conducting a pump test the "apparent leaking around the casing" problem will be solved by actual well repair or isolation of that well bore interval with a suitable packer.

Additional studies in the Laubenstein well and in any additional dolomite piezometers will be made including: flowmeter and temperature logging while pumping, and detailed caliper, neutron, and density logging to determine location and character of water bearing openings and conditions of the casing seal, cause of unpumped drawdown cone in the surrounding water table aquifer, and the potential for well repair.

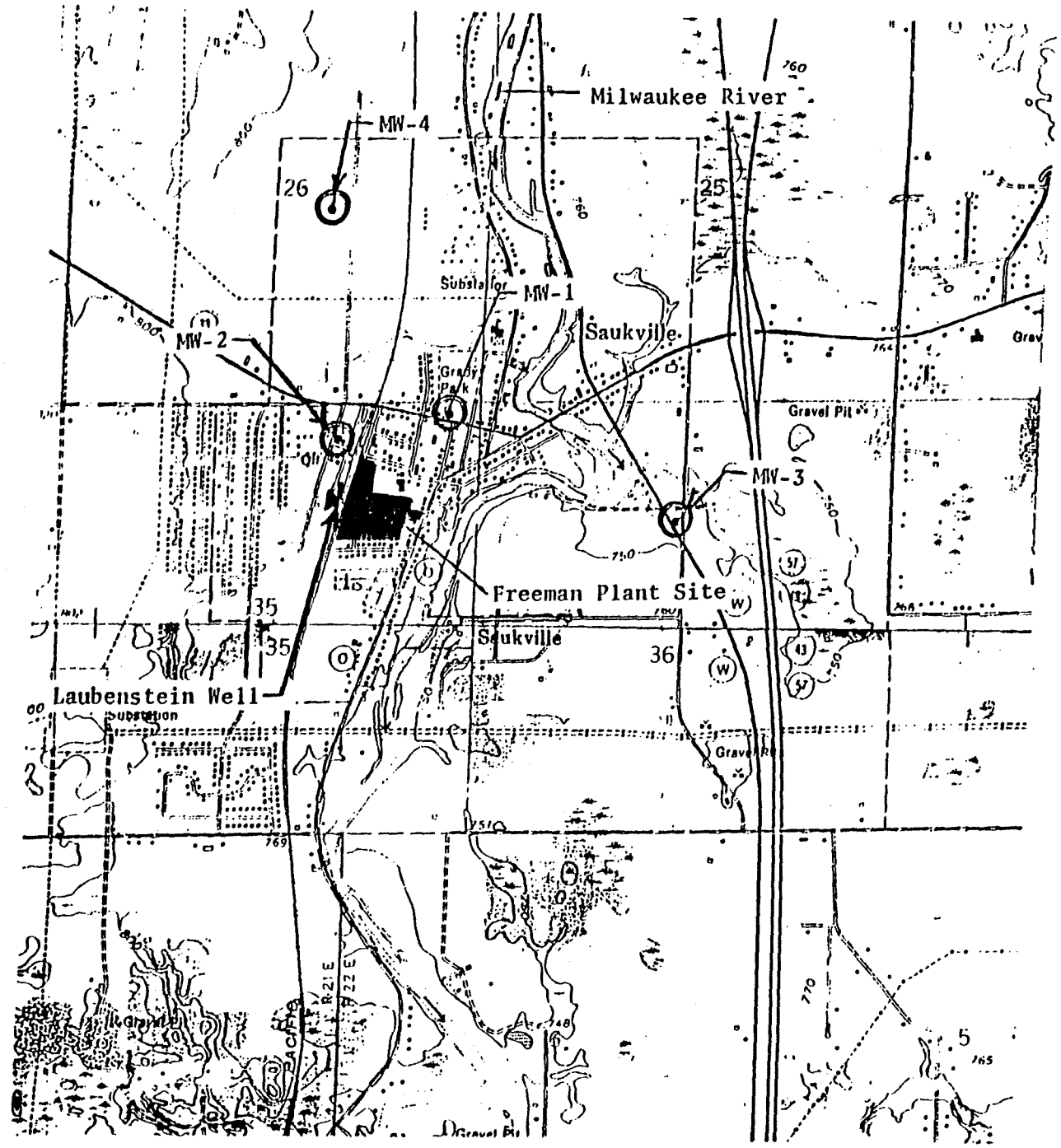


Figure 6
Index Map
Saukville Area