1972-03-01

Subsurface Injection of Wastes: Lake Erie and Lake Ontario Basins: Report to the International Joint Commission

International Lake Erie Water Pollution Board
International Lake Ontario-St. Lawrence River Water Pollution Board

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REPORT
TO THE
INTERNATIONAL JOINT COMMISSION

SUBSURFACE INJECTION OF WASTES
LAKE ERIE AND LAKE ONTARIO BASINS

International Lake Erie Water Pollution Board
International Lake Ontario-St. Lawrence River Water Pollution Board

March 1972
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<td>31</td>
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The United States and Canada along with the Great Lakes States of Michigan, New York, Ohio, Pennsylvania and the Province of Ontario may permit subsurface injection of wastes as a method of disposal or storage. However, use of this method is generally only permitted where alternatives are not available, or injection of wastes can be shown to have the least detrimental effect on the environment. All jurisdictions have strict controls over design, construction, operation and abandonment of disposal wells, and may revoke permits issued in cases of non-compliance.

Some subsurface disposal problems have occurred in the following areas:

1. The Rocky Mountain Arsenal well near Denver, Colorado, was blamed for stimulation of earth quakes in 1962, 1963, and 1964 - 1966 in the Denver Area. The Earthquake Research Center (Menlo Park, California) has confirmed that the Denver area earthquakes were a function of time and injection.

2. The Hammermill Paper Company well at Erie, Pennsylvania, blew and spewed spent sulfite wastes into Lake Erie for several days in 1968. Corroded injection tubing and a chemical heat problem was implicated in the well failure.

3. Brine disposal into the Permian Basin in Texas and Oklahoma has increased salt-water seepage into streams. Leakage through abandoned unplugged wells is suspect.

4. Two crude-oil seeps and one natural-gas seep started from three abandoned wells in Port Huron, Michigan. The buildup of pressure from subsurface disposal of chemical wastes in the Sarnia, Ontario area is suspect.

5. The State of New York reports that earth tremors have been recorded on seismographs located in deep wells.

It is apparent that all jurisdictions are becoming more aware of the subsurface waste disposal problems as reflected in recent enacted and proposed legislation regarding control, monitoring and abatement of ground water pollution.
SUBSURFACE INJECTION OF WASTES
LAKES ERIE AND ONTARIO BASINS

INTRODUCTION

U. S. Environmental Protection Agency is opposed to the disposal or storage of wastes by subsurface injection without strict controls and a clear demonstration that such wastes will not interfere with present or potential use of subsurface water supplies, contaminate interconnected surface waters, or otherwise damage the environment. Where subsurface injection of wastes is practiced, it will be recognized as a temporary means of disposal to be discontinued when alternatives enabling greater environmental protection become available.

Proposed legislation now being considered requires that the EPA Administrator develop programs for eliminating or reducing groundwater pollution, monitoring of ground water and establish criteria of quality of groundwater.

Michigan Water Resources Commission is opposed to the disposal or storage of wastes by subsurface injection without strict controls and a clear demonstration that such wastes will not interfere with present or potential use of subsurface water supplies, contaminate interconnected surface waters, adversely affect other mineral resources or otherwise damage the environment. When subsurface injection of wastes is permitted, it should be recognized that it will be continuously evaluated in the light of changing technology and be discontinued when alternatives enabling greater environmental protection become available.

New York, the injection of liquid wastes into deep wells is considered a last resort after all other methods have been evaluated. The applicant must demonstrate that this method (1) is the optimal approach, and (2) has the least effect on the total environment. New York is presently re-evaluating their deep well policy due to seismographic information from monitoring the present wells.

Ohio permits disposal of certain industrial wastes to deep formations. The Mt. Simon (Cambrian) sandstone is the only formation which has received approval for the disposal of wastes. Applications must be approved by the Water Pollution Control Board, the Department of Health, and the Department of Natural Resources. The permit is issued by the Division of Oil and Gas in the Department of Natural Resources, with such conditions as may be necessary to protect health, safety or the conservation of natural resources.
Pennsylvania policy for approving a permit for a deep well disposal system considers alternative methods, geological studies, pretreatment, adequate monitoring and appropriate provisions will be made for plugging the wells when their use is discontinued. These considerations are to insure that such injection will not interfere with present or potential use of water and mineral resources or result in other environmental hazards.

Ohio River Valley Water Sanitation Commission (ORSANCO), a commission of eight states and the U.S. Government is considering a resolution that wastewater injection as a policy may be used when the regulatory authorities with legal jurisdiction have considered alternative methods, geologic and hydraulic conditions, type of wastes, monitoring devices and other engineering aspects of wastewater injection.

The Province of Ontario and the Government of Canada recognize the controlled use of deep wells for receiving waste or mineral waters as an acceptable method of disposal. However, in Ontario before a permit is issued, an extensive feasibility study is required. Permits are issued by the Department of Mines and Northern Affairs and the surface facilities must be approved by the Ontario Water Resources Commission. Both Provincial and Federal governments consider that subsurface injection should be limited to those wastes which cannot be economically and/or technologically treated at the surface by available methods.

Tables 1 and 2 indicate the controlling legislation and/or administering agency in each of the Provinces and States for subsurface waste-disposal.
### TABLE 1

Subsurface Waste-Disposal Legislation and Regulation in Canada

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific legislation for deep-well injection</td>
<td>No*</td>
<td>No*</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Established regulations and regulatory agency</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes (Proposed)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Regulation carried out under salt-water disposal regulations</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Legislation under which authority resides (or is assumed to reside)</td>
<td>Pollution Control Act</td>
<td>Oil &amp; Gas Conservation Regulations</td>
<td>Oil &amp; Gas Conservation Act</td>
<td>Clean Environment Act</td>
<td>Energy Act</td>
<td>Mining Act</td>
<td>Mining Act &amp; Water Act</td>
<td>Water Well Drilling Act Regulations</td>
<td>Water Resources &amp; Gas Drilling Act Regulations</td>
<td>Canada Oil &amp; Gas Drilling Act Regulations</td>
<td></td>
</tr>
<tr>
<td>Research capability in subsurface disposal field</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Number of industrial waste disposal systems</td>
<td>0</td>
<td>10</td>
<td>4</td>
<td>1</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* Except 'refinery wastes' which are covered under salt-water disposal legislation and regulations.
### Table 2
Subsurface Waste Disposal Legislation and Regulation

<table>
<thead>
<tr>
<th>State</th>
<th>Michigan</th>
<th>New York</th>
<th>Ohio</th>
<th>Pennsylvania</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific legislation for deep well injection</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Established regulations</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Statement on Policy</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No*</td>
</tr>
<tr>
<td>Responsible Regulating Agency</td>
<td>Dept. of Natural Resources</td>
<td>Dept. of Environmental Conservation</td>
<td>Dept. of Natural Resources</td>
<td>Dept. of Environmental Resources</td>
</tr>
<tr>
<td>Number of industrial waste disposal wells active</td>
<td>25</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

*There was a proposed policy statement - letter January 3, 1972.*
U. S. EPA policy regarding disposal of wastes by subsurface injection was issued by order CCM 5040.10 on October 15, 1970, under the Federal Water Quality Administration. This order was transferred to EPA by executive order when reorganization occurred forming EPA.

Proposed legislation has provisions for monitoring water quality and setting standards for ground water. This legislation implies EPA will have authority to prevent and abate pollution of ground waters. Subsequently, subsurface injection of fluid waste may be subject to EPA policy as well as state policies.

The following order is EPA policy regarding disposal of wastes by subsurface injection.

**STATEMENT OF POLICY**

EPA (FWQA) ORDER NO. CCM 5040.10

**Subject:** Policy on Disposal of Wastes by Subsurface Injection

1. **PURPOSE.** This order establishes EPA policy on the disposal of wastes by subsurface injections.

2. **BACKGROUND.**
   a. The disposal and storage of liquid wastes by subsurface injections are being increasingly considered, especially by industries facing enforcement of water quality standards. This is because of the diminishing capabilities of surface waters to receive effluents without violation of standards, and the apparent lower costs of this method of disposal over conventional and advanced waste treatment techniques.

   b. The effects of underground pollution and the fate of injected materials are uncertain with today's knowledge. These wastes could well result in serious pollution damage and require a more complex and costly solution on a long-term basis.

   c. Improper injection of municipal or industrial wastes to the subsurface could result in serious pollution of water supplies or other environmental hazards.

3. **POLICY.**
   a. EPA is opposed to the disposal or storage of wastes by subsurface injection without strict controls and a clear demonstration that such wastes will not interfere with present or potential use of subsurface water supplies, contaminate interconnected surface waters, or otherwise damage the environment.
b. All proposals for subsurface injection of wastes shall be critically evaluated to determine that:

(1) Alternative measures have been explored and found less satisfactory in terms of environmental protection;

(2) Appropriate preinjection tests have been made to allow prediction of the fate of wastes to be injected;

(3) There is adequate evidence to demonstrate that such injection will not interfere with present or potential use of water resources nor result in other environmental hazards;

(4) Best practical measures for pretreatment of wastes have been applied;

(5) The subsurface injection system has been designed and constructed using the best available techniques, equipment, and design criteria;

(6) Provisions for adequate and continuous monitoring of the injection operation and resulting effects of the injection on the environment have been made; and

(7) Appropriate provision will be made for plugging such wells at horizons below present or potential sources of water supply when their use for disposal is discontinued.

c. Where subsurface injection of wastes is practiced, it will be recognized as a temporary means of ultimate disposal to be discontinued when alternatives enabling greater environmental protection become available.

4. IMPLEMENTATION. EPA will apply this policy to the extent of its authorities in conducting all program activities, including regulatory activities, research and development, control of pollution from Federal installations, technical assistance to the States, and the administration of the construction grants, State program grants, and basin planning grants programs.
The Michigan Water Resources Commission policy statement on disposal of wastes by subsurface injection is as follows:

**BACKGROUND.** The disposal and storage of liquid wastes by subsurface injection are continuously being considered, especially by industries with wastes that are not conducive to conventional treatment. The effects of underground injection and the fate of injected materials are uncertain without extensive evaluation of the many aspects of such systems. Improper injection of municipal or industrial wastes into certain earth strata could directly and indirectly result in serious pollution of water supplies or other public health and environmental hazards.

**STATEMENT OF POLICY.** The Michigan Water Resources Commission is opposed to the disposal or storage of wastes by subsurface injection without strict controls and a clear demonstration that such wastes will not interfere with present or potential use of subsurface water supplies, contaminate interconnected surface waters, adversely affect other mineral resources or otherwise damage the environment.

All proposals for subsurface injection of wastes shall be critically evaluated to determine that:

1. Alternative measures have been explored and found less satisfactory in terms of environmental protection.

2. Appropriate evaluations and preinjection tests have been made to allow prediction of the fate of wastes to be injected as well as the effect of such operations upon the natural conditions in the subsurface.

3. There is adequate evidence to demonstrate that such injection will not interfere with present or potential use of water resources nor result in other environmental hazards.

4. All needed measures for pretreatment of wastes have been applied.

5. The subsurface injection system has been designed and constructed using approved techniques, equipment, and design criteria.

6. Provisions for adequate and continuing monitoring of the injection operation, periodic reservoir analysis and resulting effects of the injection on health and resource values have been made.

7. Appropriate provision will be made for plugging such wells at horizons below present or potential sources of water supply when their use for disposal is discontinued.
Where subsurface injection of wastes is permitted, it should be recognized that it will be continuously evaluated in the light of changing technology and be discontinued when alternatives enabling greater environmental protection become available.

There are twenty-five wastewater disposal wells located in the State of Michigan. The injected wastes include activated industrial sludge, phenol, brine, propylene oxide, methyl cellulose, cuprous ammonium, caustics, mineral acids, aldehydes, ketones, steroids, sodium ions, acetate, chlorides, brine, laundromat wastes and liquid wastes from the manufacture of coke.

The disposal wells are summarized in Table 3.
<table>
<thead>
<tr>
<th>Location</th>
<th>Company</th>
<th>Date Drilled</th>
<th>Depth(ft) DZ-TD *</th>
<th>Geology of Disposal Area</th>
<th>Type of Waste &amp; Gallon Per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bay City</td>
<td>Bay City Refining Co. (Div. of Dow Chemical Co.)</td>
<td>1954</td>
<td>4026-4710</td>
<td>Devonian Sandy Limestone and Sandstone</td>
<td>Phenol, acid and spent caustic - 64,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1959</td>
<td>4497-1605</td>
<td>Devonian Sandstone</td>
<td>Standby for above well.</td>
</tr>
<tr>
<td>Union Lake</td>
<td>Blunk Laundromat Service</td>
<td>1967</td>
<td>1774-1840</td>
<td>Devonian Sandstone</td>
<td>Laundry waste - 7,920</td>
</tr>
<tr>
<td>Holland</td>
<td>Chemtron Corporation (Holland Succo Div.)</td>
<td>1965 (1966)</td>
<td>4608</td>
<td>Cambrian Sandstone</td>
<td>Contaminated dilute sulfuric acid - 36,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1969</td>
<td>- 5910</td>
<td>Devonian Sandstone</td>
<td>Saline and acidic wastes.</td>
</tr>
<tr>
<td>Midland</td>
<td>Dow Chemical Co.</td>
<td>1969</td>
<td>- 4500</td>
<td>Devonian Limestone</td>
<td>Bromine process brine - 430,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1965 (1960)</td>
<td>3865</td>
<td>Devonian Limestone</td>
<td>Oil refining wastes and salt solution from mining operations - 288,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1951 (1961)</td>
<td>4925-5150</td>
<td>Devonian Sandstone</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1952 (1960)</td>
<td>3580-3740</td>
<td>Devonian Limestone</td>
<td>Standby well</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1964</td>
<td>3915-3930</td>
<td>Devonian Limestone</td>
<td>Waste treatment activated sludge - 86,400</td>
</tr>
</tbody>
</table>

* DZ - Disposal Zone
TD - Total Depth
(1966) - Year Disposal Started
### Michigan Waste Disposal Wells

#### Table 3 (Continued)

<table>
<thead>
<tr>
<th>Location</th>
<th>Company</th>
<th>Date Drilled</th>
<th>Depth(ft) DZ-TD *</th>
<th>Geology of Disposal Area</th>
<th>Type of Waste &amp; Gallons Per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dearborn</td>
<td>Ford Motor Co.</td>
<td>1956</td>
<td>482-550</td>
<td>Devonian Sandstone</td>
<td>Liquid waste in manufacture of coke - 50,000</td>
</tr>
<tr>
<td>Mattawan</td>
<td>Glaser Crandell Co.</td>
<td>1958</td>
<td>- 1496</td>
<td>Devonian Limestone</td>
<td>Pickle process waste - 108,000</td>
</tr>
<tr>
<td>Montague</td>
<td>Hooker Electro Chemical Co.</td>
<td>1953</td>
<td>1703-2066</td>
<td>Devonian Limestone</td>
<td>Brine - Sodium sulfate, Sodium chloride, and Calcium sulfate - plugged and capped in 1969</td>
</tr>
<tr>
<td>Alma</td>
<td>Leonard Refining Co.</td>
<td>1957</td>
<td>1030-1271</td>
<td>Mississippian Sandstone</td>
<td>Same as above.</td>
</tr>
<tr>
<td>St. Louis</td>
<td>Michigan Chemical Corp.</td>
<td>1967</td>
<td>1422-3762</td>
<td>Devonian Dolomite and Limestone</td>
<td>Refinery waste - 36,000-43,200</td>
</tr>
<tr>
<td>Reed City</td>
<td>Miller Industries, Inc.</td>
<td>1951</td>
<td>- 1271</td>
<td>Devonian Dolomite and Limestone</td>
<td>Waste brines from processing of natural brine - 388,000</td>
</tr>
<tr>
<td>Muskegon</td>
<td>Parke, Davis &amp; Company</td>
<td>1951</td>
<td>1124-1635</td>
<td>Devonian Dolomite and Limestone</td>
<td>Nothing as yet.</td>
</tr>
<tr>
<td>Holland</td>
<td>Parke, Davis &amp; Company</td>
<td>1951</td>
<td>1124-1635</td>
<td>Devonian Limestone and Dolomite</td>
<td>Sodium, acetate, chloride, azonia, bromide, and unidentified organic compounds. Manufacture waste of Chloromycetin - 43,200</td>
</tr>
</tbody>
</table>

* DZ - Disposal Zone  
  TD - Total Depth  
  (1966) - Year Disposal Started
### Michigan Waste Disposal Wells

#### Table 3 (Continued)

<table>
<thead>
<tr>
<th>Location</th>
<th>Company</th>
<th>Date Drilled</th>
<th>Depth(ft)</th>
<th>Geology of Disposal Area</th>
<th>Type of Waste &amp; Gallons Per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferndale</td>
<td>Reichhold Chemical Inc.</td>
<td>1951 (1952)</td>
<td>693-1053</td>
<td>Devonian Dolomite and Sandstone</td>
<td>Phenols - 5,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Plugged and capped in 1957.</td>
</tr>
<tr>
<td>Detroit</td>
<td>Semet-Solvey Div. (Allied Chemical Corp.)</td>
<td>1969</td>
<td>- l110</td>
<td></td>
<td>Metallurgical coke plant wastes - 100,000 to 150,000</td>
</tr>
<tr>
<td>Kalamazoo</td>
<td>The Upjohn Company</td>
<td>1954</td>
<td>1276/1175-1476</td>
<td>Devonian Sandy Limestone, Sandstone &amp; Dolomite</td>
<td>Brine - Chemical waste from manufacture of cortical steroid products - 75,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1954</td>
<td>1270/1530-1532</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wyandotte</td>
<td>Wyandotte Chemicals Corp.</td>
<td>1966</td>
<td>850-1400</td>
<td>Silurian Evaporites</td>
<td>Process wastes containing 3% solids. 548,000-1,548,000 Into 2 wells</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Both are connected and pumped simultaneously.</td>
</tr>
</tbody>
</table>

---

*DZ - Disposal Zone
TD - Total Depth
(1966) - Year Disposal Started*
The utilization of deep well injection is a specialized method of waste disposal with limited application as a last resort and it must be demonstrated that this is the optimal approach considering all other disposal or treatment methods.

Certain general conditions can be indicated for any application of this method and a number of criteria must be met before any consideration should be given. However, each application is unique and must therefore stand or fall on its own merits.

New York's Deep Well Injection policy as stated in their Environmental Health Manual, Pure Waters, is as follows:

**STATEMENT OF POLICY**


A. The injection of liquid wastes by deep wells is considered a last resort after all other methods have been evaluated; it is a method for gaining long-term storage rather than treatment. The applicant must demonstrate that this method (1) is the optimal approach, and (2) has the least effect to the total environment.

B. Fresh ground waters and potential mineral resources which may be subject to future development must be protected against any adverse effect by the disposal of wastes into the subsurface.

C. It is incumbent upon the applicant to obtain a competent geologist and a professional engineer for the necessary studies, design and preparation of reports and plans. This should include, but not be limited to the environmental, economical and technical implications.

D. Continuous injection at critical input (hydraulic parting) pressures is prohibited and will not be approved.

E. A permit must be issued prior to the construction and operation of any disposal of wastes through deep well injection.

F. Concurrence must be obtained from the Division of Oil and Gas of the Conservation Department and the office of the State Geologist of the Education Department.

New York has two wastewater disposal wells located in the Buffalo-Niagara Falls area. The industries which have the wells are Hooker Chemical Corporation at Niagara Falls and Bethlehem Steel Company at Lackawanna. Test wells have been drilled, however they have been shut-in and no permits to operate have been issued by the state. New York is presently re-evaluating their subsurface injection policy due to recent developments in detection of tremors in this area.
Disposal of certain industrial wastes into deep formations is permitted in Ohio. The approval of such disposal method requires the concurrence of the Department of Natural Resources, the Ohio Water Pollution Control Board and the Department of Health. The permit for the construction of the well is issued by the Division of Oil and Gas in the Department of Natural Resources. The following sections of the Ohio Oil and Gas Code 1509 are pertinent to disposal wells.

**STATEMENT OF POLICY**

1509.051 Liquid disposal permit

No person shall use a well for the injection of sewage or any liquid used in or resulting from any process of industry, manufacture, trade, business, or agriculture, without having a liquid disposal permit issued by the chief of the division of oil and gas, and the original permit or a true copy thereof displayed in a conspicuous and easily accessible place at the well site.

A permit to drill a new well, drill an existing well deeper, or to reopen a well, is a liquid disposal permit if the permit was issued in satisfaction of the requirements of section 1509.081 of the Revised Code, or if a permit authorizing such use has been issued under section 1509.21 of the Revised Code, or if such use is approved by the chief under section 1509.22 of the Revised Code. (132 v S226. Eff. 6-26-67)

1509.06 Application for permit

An application for a permit to drill a new well, drill an existing well deeper, reopen a well, plug back a well to a different source of supply, or use a well for injection of a liquid for which a permit is required by section 1509.051 of the Revised Code, shall be filed with the chief of the division of oil and gas upon such form as the chief prescribes and shall contain the following information:

(A) The name and address of the owner;

(B) The signature of the owner or his authorized agent. When an authorized agent signs an application it shall be accompanied by a certified copy of his appointment as such agent.

(C) The names and addresses of all persons holding the royalty interest in the tract upon which the well is to be drilled or within a proposed drilling unit;

(D) The location of the tract or drilling unit on which the well is to be drilled identified by section or lot number, city, village, township, and county;
(E) Designation of well by name and number;

(F) The geological formation to be tested or used and the proposed total depth of the well;

(G) The type of drilling equipment to be used;

(H) The name and address of the corporate surety and the identifying number of the bond;

(I) The plan for disposal of water and other waste substances resulting, obtained, or produced in connection with exploration, drilling, or production of oil or gas.

(J) If the well is for the injection of a liquid, identify of the geological formation to be used as the injection medium and the composition of the liquid to be injected.

Each such application shall be accompanied by a map, on a scale not smaller than four hundred feet to the inch, prepared by an Ohio registered surveyor, showing the location of such well and containing such other data as may be prescribed by the chief. If the well is or is to be located within the excavations and workings of a mine the map shall also include the location of such mine, the name of the mine, and the name of the person operating the mine.

Each application to drill or reopen a well, except a well drilled or reopened for purposes of section 1509.22 of the Revised Code, shall also be accompanied by a fee of thirty-five dollars for a well two thousand or more in depth, or twenty dollars for a well less than two thousand feet in depth or for a well for injecting as into or removing gas from an underground gas storage reservoir. If for any reason the permit is denied, such fee shall be returned to the applicant. (132 v S 226. Eff. 6-26-67. 131 v H 231;)

1509.081 Approval of application for liquid disposal permit; suspension or cancellation; appeal.

Upon receipt of an application for a permit to drill a new well, drill an existing well deeper, reopen a well, or use a well for injection of a liquid for which a permit is required by section 1509.051 of the Revised Code, other than one which comes within the requirements of section 1509.21 of 1509.22 of the Revised Code, the chief of the division of oil and gas shall determine whether the proposed injection would present an unreasonable risk that waste or contamination of oil or gas in the earth will occur. If he determines such risk to exist, he shall make an order rejecting the application. If he determines such risk not to exist, he shall transmit copies of the application and the map required by section 1509.06 of the Revised Code to the water pollution control board, the director of health, the chief of the
division of geological survey, the chief of the division of water
and, if so required by section 1509.08 of the Revised Code, to
the chief of the division of mines.

The chief of the division of geological survey shall approve the
application unless he determines that the proposed injection
would present an unreasonable risk of loss or damage to valuable
mineral resources.

The chief of the division of water shall make a report and recom-
mendation to the director of natural resources.

The water pollution control board shall approve the application
if it determines that the proposed injection will not cause
pollution as defined in division (A) of section 711.01 of the
Revised Code.

Upon approval by the water pollution control board, the depart-
ment of health under section 3701.19 of the Revised Code, the
chief of the division of geological survey, and by the chief of
the division of mines if required by section 1509.08 of the
Revised Code, the chief of the division of oil and gas shall issue
a liquid disposal permit with such conditions as may be necessary
to protect health, safety, or the conservation of natural resources,
including all conditions appended by the water pollution control
board and the department of health.

If the chief is unable to obtain the required approvals, he shall
issue an order denying the application. In an appeal from such
an order where the application was denied because of lack of
approval by an agency or agencies other than the division of oil
and gas, the appeal shall be taken under section 119.12 of the
Revised Code as if the order had been made by the agency whose
approval is lacking.

The chief of the division of oil and gas may adopt rules and
regulations for the administration and implementation of this
section as may be necessary to protect health, safety, or the
conservation of natural resources.

The chief may order that a liquid disposal permit be suspended
and that operations cease if he determines that the well is
being operated in violation of law, regulation, order, or
condition of the permit. Upon service of a copy of the order
upon the permit holder, his agent, or assignee, the permit and
operations thereunder shall be immediately suspended without
prior hearing, and shall remain suspended until the violation
is corrected and the order of suspension is lifted. If a
violation is the second within a one-year period, the chief may,
after hearing, revoke the permit.
The chief may order that a liquid disposal permit be suspended and that operations cease if he has reasonable cause to believe that the permit would not have been issued if information available at the time of suspension had been available at the time a determination was made by one of the agencies acting under authority of this section. Upon service of a copy of the order upon the permit holder, his agent, or assignee, the permit and operations thereunder shall be immediately suspended without prior hearing, but a permit may not be suspended for such reason without prior hearing unless immediate suspension is necessary to prevent waste or contamination of oil or gas, pollution as defined in division (A) of section 6111.01 of the Revised Code, damage to valuable mineral resources, or danger to human life or health. If after hearing the chief determines that the permit would not have been issued if the information available at the time of the hearing had been available at the time a determination was made by one of the agencies acting under authority of this section, he shall revoke the permit.

A revocation of permit shall not prejudice the right of the holder to obtain another permit. When a permit has been revoked, the permit holder or other person responsible therefore shall immediately plug the well.

In an appeal from an order of suspension or revocation where the order was made because of objection of an agency or agencies named in this section other than the division of oil or gas, the appeal shall be taken under section 119.12 of the Revised Code as if the order had been made by the agency upon whose objection the order was based. (1969 H 1. Eff. 3-18-69. 132 v S 226)

Ohio has required many safeguards for injection wells. Essentially all of the procedures recommended in the literature are required including casing cemented through fresh water, long string of casing cemented to surface, adequate monitors of casing and tubing pressures with shutdown alarms, filtration of wastes, extensive engineering and geologic reports both before and after well construction, limits on injection pressure, and periodic (monthly) reports on all aspects of well operation. In addition, the only formation approved for disposal is the deepest reservoir, the Mt. Simon (Cambrian) sandstone. No disposal is allowed where nearly possibly unplugged wells are present.

Although it is difficult for a regulatory agency to obtain the necessary expertise to judge this matter, an attempt is made to discourage injection where alternative waste treatment methods are reasonably applicable.

There have been no instances of pollution of surface waters or fresh water aquifers from deep disposal in Ohio. In most cases, if an unforeseen accident were to occur and wastes escaped to surface waters, it would mark a return to the disposal method practiced prior to deep injection. That is to say, surface waters received the
untreated liquid wastes before the deep wells were in operation anyway. Such accidents are considered unlikely in Ohio because of the rigorous safeguards applied.

The Ohio Division of Oil and Gas has issued 9 disposal permits. Five wells are active, two are pending completion, one is just starting construction and one well has been abandoned.

Disposal wells in Ohio are summarized in Table 4.
### Ohio Waste Disposal Wells

**Table 4**

<table>
<thead>
<tr>
<th>Location</th>
<th>Company</th>
<th>Date</th>
<th>Depth (ft)</th>
<th>Geology of Disposal Area</th>
<th>Type of Waste &amp; Gallons Per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perry</td>
<td>Calhio Div. of Stauffer Chemical</td>
<td>1971</td>
<td>5600</td>
<td>Cambrian-Mt. Simon sandstone</td>
<td>NaCl - 25,000 ppm (60-100 gpm proposed)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Organics 4,200 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2-72 not in operation</td>
</tr>
<tr>
<td>Cleveland</td>
<td>International Salt Co.</td>
<td>Unknown</td>
<td>1435</td>
<td>Oriskany</td>
<td>Natural brine re-injected</td>
</tr>
<tr>
<td></td>
<td>(old well re-worked)</td>
<td></td>
<td></td>
<td></td>
<td>15 gpm (proposed)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2-72 not in operation</td>
</tr>
<tr>
<td>Lima</td>
<td>Vistron Div. of Sohio</td>
<td>1968</td>
<td>3200</td>
<td>Cambrian-Mt. Simon sandstone</td>
<td>Acrilonitrile waste, sulfate solution with HCN - 6 to 8 million gallons per month</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1969</td>
<td></td>
<td></td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1971</td>
<td></td>
<td></td>
<td>Same as above - estimated</td>
</tr>
<tr>
<td></td>
<td>spudded</td>
<td></td>
<td></td>
<td></td>
<td>5 million gallons per month.</td>
</tr>
</tbody>
</table>

* DZ - Disposal Zone
  TD - Total Depth
Pennsylvania policy for deep well disposal usually means subsurface storage of waste and does not represent waste treatment. The policy, which has not yet been adopted by the Pennsylvania Environmental Quality Board, is as follows:

**Policy for Deep Well Disposal**

Deep disposal wells are usually means of subsurface storage of waste and do not represent waste treatment. In all cases where subsurface disposal is being considered, the following conditions should be assured:

1. That alternative measures have been explored and found less satisfactory in terms of environmental protection.

2. That appropriate geologic studies and pre-injection tests have been made to allow prediction of the fate of the injected wastes.

3. That there is adequate evidence to demonstrate that such injections will not interfere with present or potential use of water and mineral resources, or result in other environmental hazards.

4. That the best practical measures for pre-treatment and concentration of wastes have been applied.

5. That subsurface injection systems have been designed and constructed using the best available techniques, equipment, and design criteria.

6. That provisions for adequate and continuous monitoring of the injection operation and resulting effects on the environment have been made.

7. That appropriate provisions will be made for plugging such wells with cement from the bottom to the surface to insure maximum safety when their use for disposal is discontinued.

8. That all monitoring wells upon completion of disposal operation be plugged to insure maximum safety or upon the decision of the Department of Environmental Resources.

Pennsylvania has three wastewater disposal wells located in the Great Lakes Basin. These wells are owned by Hammermill Paper Company at Erie, Pennsylvania, and were used for the injection of spent pulping liquor. However, the wells are no longer being used for waste disposal.
ORSANCO, a commission with representatives from eight states and the U. S. Government, was developed to administer and enforce the provisions of the Ohio River Valley Water Sanitation Compact. As part of this Commission, an advisory committee was appointed to develop a resolution regarding the use of injection wells for the disposal of wastewaters.

SUGGESTED RESOLUTION

SUBSURFACE INJECTION OF INDUSTRIAL WASTEWATERS

WHEREAS: Subsurface injection is a technically acceptable method of wastewater disposal or long-term storage whereby pollutants can be removed from the surface environment and placed in remote underground locations, which are of no value for other purposes; and

WHEREAS: The techniques, trained personnel and organizations are available within the ORSANCO district for evaluation of the geologic and engineering feasibility of subsurface disposal and for determination of the risks, if any, that may exist to public health and to the environment;

NOW, THEREFORE: Let it be resolved that the Ohio River Valley Water Sanitation Commission does declare as a policy that wastewater injection may be used when the regulatory authorities with legal jurisdiction have considered other alternative methods of waste management, and then, after weighing all available evidence, have determined that:

I. Geologic and hydrologic conditions will, beyond a reasonable doubt, provide adequate protection of the public and natural resources.

II. The volume, chemical and physical composition, and toxicity of the fluid to be injected are compatible with the geologic and hydrologic conditions;

III. The necessary safety factors and monitoring devices are incorporated in the design of the injection well and its auxiliary facilities;

IV. The waste injection system will be operated in a manner compatible with the geologic conditions, waste character, and system construction;

V. An approved alternative plan for waste management is available in the event that operational problems occur during the use of the injection system;

VI. The injection well will be properly plugged and marked before abandonment;
VII. A permanent public record will be kept which documents the complete operational history of the injection system.

If ORSANCO adopts the advisory committee's resolution, the states of New York, Pennsylvania and Ohio will have to consider legislation regarding the policy of injection wells as established under the ORSANCO pact.
The accelerating rate of production of industrial wastes, of ever-increasing complexity and toxicity, makes it imperative that methods of waste management are developed that are both safe and effective. As far as liquids and solids are concerned, the disposal of waste can take place either on the surface (e.g. sanitary landfill, sewage lagoons, discharge into rivers or lakes), or below the surface (injection into deep wells, placement in mined cavities, or injection in shales as a waste/grout mixture). In view of the growing concern about the existing industrial pollution of air, soil and surface waters, the subsurface disposal of industrial waste is rapidly becoming an alternative with considerable attraction for those in the waste-management field. In many cases it is not only technically feasible, but also economically attractive, especially when new standards for surface-water quality necessitate extensive capital lay-outs for new waste-treatment facilities.

What must not be overlooked, however, is that use of the method will result in irreversible pollution of a number of subsurface formations. In addition, the representation of the method as either final or permanent is unrealistic, in view of the fact that injected waste may be subject to dispersal by diffusion and convection in natural subsurface flow systems.

Early recognition of the hazards presented by the subsurface disposal method, and of its consequences, is imperative. Therefore it is necessary to gain a better understanding and more detailed knowledge of the behavior of injected waste. Through subsequent legislation and regulation it should be possible to avoid the costly mistakes, serious accidents and often irreversible damage to the environment that can result from subsurface disposal operations that are hastily conceived, inadequately investigated, improperly equipped and insufficiently monitored.

The number of waste-disposal wells in Canada is not very large as yet. There are 31 registered disposal wells, distributed as follows: 16 in Ontario, 10 in Alberta, 1 in Saskatchewan and 1 in Manitoba. Details about these wells are given in Table 5. Disposal depths in Ontario are disturbingly shallow, generally less than 1,000 feet. In the Western Canada Sedimentary Basin depths range from 1,373 to 5,087 feet (top of disposal interval). This difference reflects the difference in available sediment thickness in the two areas.

Information supplied by the Provincial agencies indicated that only one province, Ontario, has legislation specifically dealing with subsurface disposal of industrial waste. Like the legislation of Ohio and Missouri, it is based largely on the pioneering legislation in this field by the State of Texas. Other provinces control subsurface disposal of industrial waste through legislation and regulations set up for related activities, such as control of disposal of oil-field waters or control of surface-water pollution. Although the latter approach may be less satisfactory than the use of specific legislation, it should be noted that in no case can subsurface disposal be carried out legally without the permission of some governmental regulatory agency.

Table 1 shows the legislative situation in Canada early in 1970. Only two provinces, Ontario and Quebec, have significant references to deep-well disposal of industrial waste in their statutes. Two others, Prince Edward Island and Nova Scotia have a single-line statement disallowing pollution through wells.

As far as regulation and control are concerned, only Ontario has invested authority in a regulatory agency. Quebec is in the process of writing regulations and presumably these will be in operation soon. Alberta, Saskatchewan and Manitoba do not have specific legislation for subsurface disposal of industrial wastes, but they do have legislation and supporting regulatory machinery for the control of subsurface disposal of salt water from oil-field operations. Manitoba has included "refinery wastes" in this legislation. New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland do not have any established regulatory machinery for this purpose, but neither do they have any waste disposal wells in their territories.

The Canada Water Act (Bill C-1971) provides "for the management of the water resources of Canada including research and the planning and implementation of programs relating to the conservation, development and utilization of water resources."

Groundwater provides about 10 per cent of the municipal water supplies that serve communities with a population of 1,000 or more, as well as a similar or larger proportion for smaller communities. In addition, large unrecorded industrial and agricultural water supplies are obtained from groundwater resources. Groundwater thus forms a significant part of the water resources of Canada, and as such its conservation is provided for under the Canada Water Act.

Subsurface disposal of liquid waste constitutes a potential threat to both surface and underground water resources. Subsurface disposal of liquid waste could thus be subject to control under the terms of the Canada Water Act. Regulations made under the Canada Water Act in the
field of subsurface disposal of waste would apply to all territories under Federal jurisdiction; to cases with international implications; and to cases involving more than one province. The Canada Water Act could, moreover, be used as a basis for a Federal-Provincial cooperative effort toward the formulation of country-wide, uniform regulations to deal with subsurface waste disposal.

CONCLUSIONS from Department of Energy, Mines and Resources Technical Bulletin Number 49 are as follows:

1. The storage capacity of geological formations is a limited natural resource, re-usable when used for gas or fresh-water storage, but not re-usable after use for the disposal of wastes.

2. Subsurface disposal of waste does not constitute permanent disposal in the strictest sense of the word. Rather, it detains waste in transitory storage; it may lead to irreversible pollution of a portion of the subsurface environment; injected waste may also reappear at the surface.

3. The volume of waste that can be injected under safe injection pressures is limited to that which can be provided by compression and displacement of original formation fluids and by compression of the formation rock; this represents only a fraction of the aggregate pore space.

4. Subsurface disposal should only be allowed for "natural" fluids and some classes of "foreign" fluids; a waste classification system should be established on the basis of quantitative criteria, to enable a rational evaluation of individual cases.

5. Subsurface disposal of any waste should be discontinued as soon as an economical alternative treatment and/or disposal method, or a re-use or recovery process becomes available, for such waste.

6. Proper management of subsurface space and the establishment of priorities for its use should preferably be approached on a regional basis.

7. A regional subdivision of the country, e.g., into "potential", "limited" and "closed" disposal regions, should be established; for this purpose some quantification of the qualitative criteria given in Chapter IV may be necessary.

8. Prospective disposal formations with "potential" and "limited" disposal regions should be zoned, e.g., as "favorable", "restricted" and "closed", for the purpose of subsurface disposal. Such zoning, as well as formation and site selection for particular disposal projects, should be based on quantitative criteria similar in nature to the qualitative criteria of Technical Bulletin No. 49.
9. All phases of a subsurface disposal project, from conception to abandonment, should be subject to regulation and control, to prevent failures and the creation of unnecessary environmental hazards.

10. Where injection is feasible, the economic advantages will soon be recognized by a wide range of industries, especially those under pressure to reduce surface-water pollution.

11. Economic advantages of the method are so pronounced under present regulations, that the more restrictive approach encourages in this report, to ensure environmental protection, will not put the method out of the economic reach of industry. Justification of deep-well injection on a strictly financial basis should not be allowed.

12. The role of government in the field of subsurface waste disposal must be underlain by an environment-oriented philosophy, which can tolerate the method only if full protection of the public interest in the environment can be assured.

13. As of January 1970, there were 31 industrial-waste disposal wells in Canada; an increase in this number in the future is to be expected.

14. Only two provinces in Canada have legislation specifically covering deep-well injection of industrial wastes. Only Ontario has invested authority in a functioning regulatory agency; Quebec is in the process of establishing such an agency. The prairie provinces carry out a regulatory program under the authority of oilfield water-disposal statutes. The very real differences between saline-water and industrial-waste injection should be taken into account in future legislation, and in the design of scientific research programs.

15. Future legislation and regulations will have to reflect the position that subsurface storage capacity is a limited resource that should be conserved for maximum beneficial use.

16. Country-wide uniformity in basic regulations for the waste-disposal field would simplify enforcement and control by the limited professional manpower available.

17. The feasibility of centralized or cooperative injection facilities will have to be investigated; industries that produce wastes qualified for subsurface disposal could be encouraged to locate near "favorable" zones in "potential" disposal regions.

18. Research is urgently required on a number of waste-disposal problems identified in Chapter X of Technical Bulletin No. 49.
<table>
<thead>
<tr>
<th>Province</th>
<th>Well No.</th>
<th>Area</th>
<th>Formation</th>
<th>Disposal Depth (Ft.)</th>
<th>Inj. Rate (gpm)</th>
<th>Inj. Press (psi)</th>
<th>Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontario</td>
<td>1</td>
<td>Sarnia</td>
<td>Detroit River</td>
<td>900</td>
<td>36</td>
<td>420</td>
<td>Spent refinery caustic</td>
</tr>
<tr>
<td></td>
<td>2-6</td>
<td>Sarnia</td>
<td>Detroit River</td>
<td>700</td>
<td>10-30</td>
<td>300-350</td>
<td>Spent refinery caustic</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Sarnia</td>
<td>Detroit River</td>
<td>800</td>
<td>50</td>
<td>225</td>
<td>Spent refinery caustic</td>
</tr>
<tr>
<td></td>
<td>8-9</td>
<td>Sarnia</td>
<td>Detroit River</td>
<td>800</td>
<td>80</td>
<td>180</td>
<td>Phenols</td>
</tr>
<tr>
<td></td>
<td>10-12</td>
<td>Sarnia</td>
<td>Salina Salt</td>
<td>1900</td>
<td>-</td>
<td>Gravity</td>
<td>Steam condensate water, with ammonia &amp; CO₂</td>
</tr>
<tr>
<td></td>
<td>13-14</td>
<td>Sarnia</td>
<td>Detroit River</td>
<td>800</td>
<td>90</td>
<td>380</td>
<td>Hydrocarbon Chlorides &amp; ethers, phenols</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Sarnia</td>
<td>Detroit River</td>
<td>800</td>
<td>30</td>
<td>Gravity</td>
<td>Spent caustics and sulfuric acid</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Sarnia</td>
<td>Detroit River</td>
<td>850</td>
<td>4</td>
<td>275</td>
<td></td>
</tr>
<tr>
<td>Alberta</td>
<td>17</td>
<td>Edmonton</td>
<td>Nisku</td>
<td>3438-3580</td>
<td>21</td>
<td>-</td>
<td>Alkaline brine, chlorinated phenols</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Edmonton</td>
<td>Nisku</td>
<td>4215-4385</td>
<td>63</td>
<td>-</td>
<td>Undefined plant residue</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Edmonton</td>
<td>Nisku</td>
<td>4253-4334</td>
<td>-</td>
<td>-</td>
<td>Undefined refinery wastes</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Edmonton</td>
<td>Nisku</td>
<td>4130-4150</td>
<td>23</td>
<td>-</td>
<td>Undefined refinery wastes</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Edmonton</td>
<td>Nisku</td>
<td>4176-4180</td>
<td>32</td>
<td>-</td>
<td>Refinery process water and spent lye</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>Red Deer</td>
<td>Viking</td>
<td>5135-5162</td>
<td>-</td>
<td>50</td>
<td>Sulfuric acid from alkylation of butane and butylenes</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>Edmonton</td>
<td>Nisku</td>
<td>4045-4150</td>
<td>291</td>
<td>-</td>
<td>Undefined refinery wastes</td>
</tr>
<tr>
<td></td>
<td>24-26</td>
<td>Lloydminster</td>
<td>Sparky</td>
<td>2104-2851</td>
<td>19</td>
<td>-</td>
<td>Undefined refinery wastes</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>27</td>
<td>Regina</td>
<td>Nisku</td>
<td>3800</td>
<td>35</td>
<td>-</td>
<td>Spent caustic</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>Regina</td>
<td>Blaimore</td>
<td>3565</td>
<td>50</td>
<td>-</td>
<td>Waste water</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>Saskatoon</td>
<td>Blaimore</td>
<td>2000</td>
<td>29</td>
<td>-</td>
<td>Phenolic, non-phenolic and organic wastes</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Esterhazy</td>
<td>Interlake</td>
<td>3850-4037</td>
<td>600</td>
<td>900</td>
<td>Waste potash brine NaCl (+MgCl₂, MgSO₄)</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>Virden</td>
<td>Lodgepole</td>
<td>2080-2142</td>
<td>&lt;1</td>
<td>&lt;1000 psi</td>
<td>Undefined refinery waste</td>
</tr>
</tbody>
</table>

Sources of Data: Ontario: (81); Alberta, Saskatchewan, Manitoba: Provincial Agencies
ONTARIO (Revised March 1972)

DEEP WELL DISPOSAL OF INDUSTRIAL WASTES IN ONTARIO

Introduction

With the increasing public awareness of pollution problems and the solutions available, it is essential that the use of the subsurface for waste disposal be considered in light of all alternative methods and that a realistic and coordinated program of waste disposal be developed.

The injection into deep wells of liquid industrial wastes that cannot be economically and/or technologically treated at surface by present-day methods is an expedient method of disposal and can be considered as an acceptable practice provided that the chemical quality of surface and ground water is assured and valuable mineral resources are not lost. Existing government regulations recognize the controlled utilization of deep wells for receiving waste or mineral waters as an accepted method of disposal.

The subsurface formations used for this purpose are a natural resource of limited capacity. The resource is not renewable, but is one which requires careful use and conservation.

History of Deep Well Disposal in Ontario

The first subsurface disposal wells in Ontario were developed by Imperial Oil Limited at their Sarnia refinery between the years 1958 to 1960 with the drilling of six wells, including one observation well. Since that time, twelve additional industries have developed seventeen wells for this purpose. All wells have been completed in the Detroit River Group of formations of Devonian age with the exception of three which utilize a brine cavity in the Salina formation of Silurian age and one to the Cambrian formation.

At present, fourteen wells are in operation utilizing the Detroit River Group, and two in the Salina salt. Five wells are on a stand-by basis. One recently became unserviceable and has been plugged.

Although not falling into the same category as an industrial waste well, there are in addition 14 brine disposal wells disposing limited quantities of produced oil field brine - nine into the Detroit River Group and five into the Guelph formation. (See Table 6)
Potential Effects on Fresh Water Supplies

The escape of wastes or displaced formation liquids from disposal wells through unplugged or inadequately plugged test wells or from the receiving formations can cause pollution of ground or surface waters. Unlike surface-water pollution, which can often be readily seen, measured and remedied, the pollution of ground water is enduring and rehabilitation of any polluted aquifer would be virtually impossible. Ground water which is potable or which could be of economic importance, either now or in the future, should be protected.

Injection of wastes into subsurface formations will increase pressures within these formations, will alter the natural hydraulic conditions and will lead to displacement of formation fluids and migration of the wastes themselves. The nature and extent of these effects depend upon the characteristics of the rock formations and the hydraulic conditions existing within them.

Areas in which waste disposal wells can be utilized require careful selection based on geology and hydrology. To serve as a waste disposal zone, a geologic formation must have sufficiently large extent and permeability to readily accept wastes, must be capped by a thick, relatively impermeable formation which has a large lateral extent and must not contain potable or reasonably usable waters. The cap rock must hydraulically separate the disposal formation from ground water aquifers of economic importance in both vertical and horizontal directions as migration of the injected waste and displacement of the natural formation fluids can occur. In southern Ontario, there are several formations which locally possess the necessary characteristics to varying degree. These include: the Detroit River Group of formations, the Guelph and Amabel formations and the Cambrian formations. In some parts of the Province, these formations contain potable ground water supplies and commercial quantities of oil and gas.

The present deep-well disposal program in southwestern Ontario utilizes the relatively shallow Detroit River Group of formations at depths which vary from about 500 feet to 950 feet (with the exception of one well into the Cambrian at 3,400 feet). About 30 miles east of the disposal area, potable or near-potable water is obtained from the Detroit River Group of formations. The potential for up-dip migration of the waste and formation fluids to the potable zone is unknown and requires further study. The present problems which are being experienced with waste returns have demonstrated that the presence of inadequately plugged wells threaten the quality of surface and ground waters in the area.
There has been no evidence to date which indicates subsurface potable waters have been polluted due to deep well disposal but the possibility is very real and the consequences could be extremely severe. Potable ground water in Ontario must be preserved and particularly in southwestern Ontario because of its relative scarcity locally and the lack of an immediate economic alternative should pollution occur.

In view of the present problems associated with deep well disposal into the Detroit River Group of formations and the relative shallowness of this zone, priority is being given to determining the suitability of the much deeper Cambrian formations for disposal purposes.

Problem Areas

Since 1966, three problem areas have resulted from subsurface disposal operations, two with the refinery complex in Sarnia and the other with the CIL wells in the Township of Sombra. Fortunately, little detectable damage to water resources had resulted and the problems have apparently been resolved. However, the effects if any on potable ground water supplies are not known. These problems are justifiably of concern to both the Province of Ontario and the State of Michigan.

In 1966, Imperial Oil Enterprises Limited, Sarnia, experienced one of its first problems with deep well disposal when phenolic wastes migrated from the disposal zone up an unrecorded and unplugged well to surface beneath a building. The well was subsequently located and plugged.

Subsurface disposal operations in the Sarnia area may have created an outbreak problem in Port Huron, Michigan in 1967, when 11 old, unplotted wells began to flow water and oil. It is understood that these wells have now been plugged by the State.

The third problem occurred recently with the CIL operation near Courtright. Fluids began flowing from two old plugged wells located within one mile of and up-dip from the disposal wells. The flowing wells had originally been plugged using lead plugs above the Detroit River Group and did not contain cement as is now required. The wells were re-entered and properly plugged with CIL assuming full responsibility.

An old brine well drilled about 1900, located north of Marine City, Michigan, and two miles southwest of the CIL Plant, began flowing at about the same time as the recent CIL problem. The Department examined this well and measured the flow at one-half gallon per minute and recorded at 14 psi shut in pressure. Information obtained from the Department of Natural Resources, State of Michigan,
suggest that on two tests drilled for oil and gas in the Marine City area, brine from the Detroit River Group flowed from the wells. The Department of Natural Resources considers this to be an abnormal occurrence for wells drilled in the Marine City area. The outbreaks in Michigan may have been related to the CIL disposal wells at Courtright.

The immediate problem with utilizing the Detroit River Group for waste disposal is the existence in certain areas of either unplotted, unplugged or improperly plugged wells. These wells are often incapable of withstanding the increased formation pressures due to injection and hence may allow the vertical migration of injected waste and/or displaced formation fluids onto the ground surface or into potable ground water zones.

Disposal in these areas has been restricted by volume and will shortly be prohibited. Many other areas of the Detroit River Group are not plagued with this problem and could provide a safe place to store certain industrial wastes provided that there is a reasonable assurance that there will be no significant vertical or lateral migration of the waste or poor quality formation fluids into surface waters or potable ground water aquifers. Where lost circulation zones occur, these still provide excellent disposal reservoirs provided wastes are injected under gravity. If injection pressure is not required, excessive pressure build-up in older wells should not occur.

Current Regulations and Procedures for Subsurface Disposal in Ontario

The responsibility for regulating the subsurface disposal of industrial wastes in Ontario rests with the Department of Mines and Northern Affairs and the Ministry of the Environment.

The Department regulates the drilling, completing, testing, and abandonment of disposal wells. The Ministry regulates the overall operation and issues certificates of approval.

The role of the Department, with respect to subsurface disposal of wastes, is to provide those individuals considering disposal with all available geological and hydrological data for any given area or formation being contemplated and to assist them in any way it can. The Department makes available all pertinent geological and completion data on nearby wells, core analyses, water analyses, updated well maps, various computer programs and relevant data on existing disposal operations in the Province.

The Department also has a sample repository in London, Ontario, where all drill cuttings and a large quantity of core are maintained and are available for study.
The Ministry requires a feasibility study on all disposal proposals. The onus is on the applicant to provide in the study sufficient information to indicate that the operation will be adequately engineered to safeguard all valuable mineral resources and potable water supplies and that the injected fluids will be confined to the receiving formation. With specific types of waste disposed of in certain areas, lateral confinement of the waste may have to be assured but generally this is not a requirement.

**Requirements of an Application to Dispose**

The following procedures are presented as a guide to companies or individuals applying for a subsurface disposal permit.

In Ontario, the guidelines described are minimal requirements and may be further expanded depending upon a particular application.

1. Review with the Department and the Ministry the potential and feasibility of a selected area and formation.

2. Submit a feasibility study of the entire project to the Department and the Ministry.

3. The feasibility study should include the following:
   - Detailed description of the geology of the area under consideration and depth of fresh water sources.
   - Location of all wells within a 1-1/2 mile radius that penetrated the proposed disposal horizon and an indication of whether or not these wells have been properly plugged.
   - Anticipated daily volumes to be injected, (maximum and minimum) yearly volumes and expected life of project.
   - Anticipated injection pressures (maximum and minimum).
   - Complete chemical, physical and biological analyses of fluids to be injected. Anticipated compatibility with fluids in the formation.
   - Names of all mineral owners within a one-mile radius of the proposed well.
   - Anticipated hydrology of proposed formation and expected performance.
(h) Proposed casing program including weight, grade, size and cementing program. (Note: Injection casing will require cement to surface.) Indication whether or not tubing is to be used, if it will be set on a packer and type of fluid to be placed in annulus.

(i) Outline of testing procedure, coring and logging programs.

(j) Description of monitoring program.

Once the study has been reviewed and approved, the applicant may apply for a permit to drill a well in accordance with the procedure for any oil and gas well. An abandonment bond of $500.00 will be required if the applicant is not both the landowner and owner of the mineral rights of the tract where the well is situated. The permit as issued is only for the drilling of the well and is not a permit for disposal.

The data to be submitted will include the data as required for all wells. These data include geological tops, casing, coring log and treatment data, and oil, gas and water shows. In addition, the following data will be required.

(1) Schematic drawing of the well.

(2) Injection intervals or perforations to be used.

(3) Results of injectivity tests and a measure of the critical input pressure.

(4) Porosity, permeability and lithology of injection interval.

(5) Formation fluid sample.

(6) Results of waste compatibility with formation fluids.

(7) Formation pressure and measure of hydrostatic head.

(8) Anticipated rate of injection and injection pressure.

(9) Formation temperature.

(10) Calculated rate of fluid displacement by injected waste and direction of dispersion.

(11) Surface installations:

(a) Description of pretreatment process of wastes and facilities to be used including flow diagram.

(b) Description of type of materials to be used in equipment and transmission lines.
(c) Description and location of any waste retention ponds.

After the above data has been reviewed and approved, a permit to dispose will be granted. The permit may be subject to specific requirements or limitations as the Minister deems necessary and may include:

(a) Maximum well-head injection pressures.

(b) Maximum volumes to be injected.

(c) Certain monitoring procedures as injection rates, injection pressures, annulus pressures and specific time intervals of reporting.

(d) The drilling and monitoring of one or more observation wells into the receiving formation and/or the deepest overlying fresh water horizon.

(e) A specific chemical composition of the injected fluid.

(f) Requirement of certain tests or surveys from time to time to establish the condition of the well.

(g) A condition that the operation of any disposal well may be limited or terminated and the well plugged if this action is found to be in the public interest.

Proposed Changes to Existing Policy

There has been increasing public concern for the safety of water supplies in the area where wastes are injected. Although this concern may not be fully justified in view of the safeguards provided through present procedures, the existing program has been reviewed with the object of providing an even greater factor of safety. As a result of this review, the Province is proposing to adopt the following program:

(1) Pressure wells into the Detroit River Formation in the St. Clair River Area.

No waste will be discharged into these wells after 1972, except in an emergency with the Minister's approval.

(2) Pressure wells into the Detroit River Formation in all Other Areas.

No waste except brine will be discharged into these wells after 1972. Brine discharge will not be permitted after 1973.
(3) **Vacuum Wells into the Detroit River Formation.**

No waste except brine will be discharged into these wells after 1973. After this date, they may continue to be used for the disposal of brine and as a stand-by system for emergency use with the Minister's approval until alternative disposal methods become available.

(4) **Wells into the Cambrian Formation.**

Wells into the Cambrian formation can be used for all wastes. This program has been discussed in detail with the industries involved and the industries, in an effort to comply with it, have made substantial progress in engineering and installing facilities to treat wastes on the surface that are presently being injected.

Consideration is also being given to the establishment of a fund built up by contributions of the operators of disposal wells which could be used to provide an alternative water supply in the unlikely event that a supply was affected by a deep well operation.
Table 6
Industrial Subsurface Disposal Wells in Ontario

<table>
<thead>
<tr>
<th>Company</th>
<th>No. Wells</th>
<th>Waste Description</th>
<th>Township</th>
<th>Formation</th>
<th>Disposal Depth</th>
<th>Injection Pressure PSIC</th>
<th>Injection Rate U.S.GAL/MIN</th>
<th>Total Injection M.M.BB 6/30/71</th>
<th>Date of System</th>
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<tbody>
<tr>
<td>Polymer</td>
<td>1</td>
<td>Spent Refinery Caustic</td>
<td>Sarnia</td>
<td>Detroit River</td>
<td>900'</td>
<td>450</td>
<td>38^2</td>
<td>0.72</td>
<td>1961 (Abandoned) June 1970</td>
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<tr>
<td>Imperial</td>
<td>5 OBS</td>
<td>Spent Refinery Caustic</td>
<td>Sarnia</td>
<td>Detroit River</td>
<td>700'</td>
<td>380</td>
<td>30</td>
<td>29.5</td>
<td>1958-60</td>
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<tr>
<td>Sun</td>
<td>1</td>
<td>Spent Refinery Caustic, Phenols</td>
<td>Sarnia</td>
<td>Detroit River</td>
<td>800'</td>
<td>188</td>
<td>24</td>
<td>2.9</td>
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<td>Shell</td>
<td>2</td>
<td>Phenols</td>
<td>Moore</td>
<td>Detroit River</td>
<td>800'</td>
<td>150</td>
<td>90</td>
<td>5.4</td>
<td>1965</td>
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<td>Dow</td>
<td>3</td>
<td>Waste Oils</td>
<td>Sarnia</td>
<td>Salina Salt</td>
<td>1,900'</td>
<td>Vacuum</td>
<td>-</td>
<td>0.060</td>
<td>1968</td>
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<tr>
<td>C.I.L.</td>
<td>2</td>
<td>Steam Condensate water with ammonia and CO_2</td>
<td>Sombra</td>
<td>Detroit River</td>
<td>800'</td>
<td>280</td>
<td>75</td>
<td>4.8</td>
<td>1968</td>
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<td>Goodfellow</td>
<td>1</td>
<td>Hydrocarbon-Chlorides, Hydrocarbon-Ethers, Phenols</td>
<td>Moore</td>
<td>Detroit River</td>
<td>800'</td>
<td>Vacuum</td>
<td>55</td>
<td>0.05</td>
<td>1964</td>
</tr>
<tr>
<td>Thompson</td>
<td>2</td>
<td>Spent Caustics and Sulphuric Acid</td>
<td>Emmisk.</td>
<td>Detroit River</td>
<td>850'</td>
<td>275</td>
<td>1^1</td>
<td>0.20</td>
<td>1965</td>
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*Static Pressure
1 Intermittent
<table>
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<tr>
<th>Company</th>
<th>No. Wells</th>
<th>Waste Description</th>
<th>Township</th>
<th>Formation</th>
<th>Disposal Depth</th>
<th>Injection Pressure PSIG</th>
<th>Injection Rate U.S.GAL/MIN</th>
<th>Total M.M.BBLS</th>
<th>Date of System</th>
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<td>Marcus</td>
<td>1</td>
<td>Spent Refinery Caustic, Brine</td>
<td>Emmisk. Detroit River</td>
<td>700'</td>
<td>145</td>
<td>126(^2)</td>
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<td>Ram</td>
<td>1</td>
<td>-</td>
<td>Sombra Detroit River</td>
<td>720</td>
<td>Vacuum</td>
<td>-</td>
<td>NIL</td>
<td>1970</td>
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<tr>
<td>Cambrian</td>
<td>2</td>
<td>Brine</td>
<td>Sarnia Detroit River</td>
<td>(600)</td>
<td>Vacuum</td>
<td>38</td>
<td>0.7</td>
<td>1970 (1971)</td>
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<tr>
<td>Prefontaine</td>
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<td>-</td>
<td>Moore Detroit River</td>
<td>(600)</td>
<td>Vacuum</td>
<td>-</td>
<td>NIL</td>
<td>1970</td>
<td></td>
</tr>
<tr>
<td>Kiser</td>
<td>1</td>
<td>-</td>
<td>M.Rosfield Cambrian</td>
<td>3,400'</td>
<td>(800)</td>
<td>(170)</td>
<td>NIL</td>
<td>1971</td>
<td></td>
</tr>
</tbody>
</table>

*Static Pressure
1 Intermittent