

Graduation Thesis

An Oil Field Brines Disposal System
For North Virden Field

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DESIGN OF A SALT WATER DISPOSAL AND GATHERING SYSTEM
FOR
THE NORTH VIRDEN OILFIELD, MANITOBA
(Including a discussion of the salt-water problem)

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Terminology Employed in this Report:

- (1) Battery: Any agglomeration of tanks contained within a single firewall, or contained within a circle of 250' radius, together with the manifolds, separators, treaters and other appurtenances thereto.
- (2) Bottom Hole Pressure: The natural pressure provided at the bottom of the drilled oil well.
- (3) Penalties: For the majority of the cases where a water penalty is imposed.

$$\text{Penalty Factor} = \frac{1}{1 + \frac{w/o}{2}}$$

where: w/o = water oil ratio for any given month.

Penalty Factor = Factor applied to the following month's allowable for the well in question.

The water penalty may be waived by the Board in cases where the water production is returned to the zone from which it was produced.

- (4) Gazetted: Regulations published in the Manitoba Gazette.
- (5) Board: The Petroleum and Natural Gas Conservation Board of Manitoba.
- (6) Pay Zone: The zone from which the oil is obtained.
- (7) Sand or Acid Frag: Sand is forced down under pressure to increase permeability.
- (8) Isopach Map: A map showing the thickness of formation at different points in an area. In this report the map is of the Ashville sand layer.
- (9) Stratagraphic Map: A map showing the depth to a formation at different points in an area. The depth is generally measured from the top of the Kelly Bushing to the top of the formation. In this report the formation is the Ashville sand formation.
- (10) Kelly Bushing: An elevation reference point on the drilling rig (similar to a bench mark).
- (11) bbl/hr: Barrels per hour.
- (12) p. p. m.: Parts per million.
- (13) Coning: A drawing up of the salt water through the oil layer, consequently cutting off the oil production.

Terminology cont'd:

Use of any of the terms in the report shall be referenced to this page thusly: Kelly Bushing^X

History of the Control of Salt Water Disposal in Western Canada:

Salt water disposal became a major problem in the oil business in Canada in 1948 with the Imperial Oil Ltd., discovery at Redwater near Edmonton, Alberta. Rapid development of the field caused a drop in the initial bottom hole pressure^x in the discovery well so that it was necessary to install mechanical pumping equipment. Reservoir studies indicated that a restricted water-drive was present. The Petroleum and Natural Gas Conservation Board of Alberta set up regulations whereby oil production from any one well would be penalized^x if produced water in excess of two percent of total production was not returned to the formation. For this reason and to protect surface plant and animal life a salt water system was devised. In the beginning water was trucked to the disposal wells by all operators, but as water production increased, this method of disposal became uneconomical and unsatisfactory. Thus in the Redwater area the Redwater Disposal Company Ltd., was incorporated in May 1952 by a majority of the operators to construct a system for disposal of salt water into injection wells.

This system was a gravity system, since past experience in salt water disposal in the U. S. A. had shown that operating costs for gravity systems are considerably lower than for high pressure systems. It has been a very successful design and has become a model after which many systems have been designed.

With the discovery of oil in Manitoba, it was necessary to set up a Conservation Board in this province. The task here was not as difficult since many climatic problems, etc., had been overcome by the Alberta Board. Consequently, the Manitoba Board^x gazetted^x a set of regulations largely copied from the Alberta Board's regulations. Some of these are included in this report in Appendix A.

It will be noted from these regulations that the main purposes of this control are:

- (1) To avoid contamination of fresh water streams or sands, and farming lands either present or potential.

cont'd...

(2) To ensure containment of salt water where surface disposal is satisfactory.

(3) To press for subsurface disposal where studies indicate its necessity.

It should be pointed out that there are other methods of disposing of salt water employed in Manitoba and the other prairie provinces. These are disposal by evaporation, and by seepage. Neither one of these methods have proved too successful in the climates encountered on the prairies and are only used where there is a very small amount of water produced at a well.

In Manitoba to date there have been disposal systems operating for some time in the Duly Field which is located to the South-West of the town of Virden (see Diagram 1a). There are also arrangements being made for the construction of a salt water disposal system in the South Virden Field, to the North-East of the town. The North Virden field has not yet had a design drawn; thus this report will be an original design for this field.

Injection to Disposal Wells:

Disposal wells offer the best solution to the salt water problem. These wells, which return the water production to some suitable horizon, comprise the only present acceptable method of handling large amounts of salt water the year round.

Any scheme which involves subsurface disposal must in all cases have prior Board^x permission. In granting or withholding this permission, the Board takes into consideration the following points:

- (1) Is the proposed disposal zone one which can accept large quantities of water without causing damage or altering the position of any gas or oil in the pool.
- (2) Is the proposed site the most efficient from an engineering standpoint. For example, could the water be injected into some other zone in the same area and perhaps be beneficial to the recovery of oil and/or gas.

cont'd...

(3) Is the suggested scheme suitable to be enlarged for disposal purposes for the entire field or pool and if not, can it be altered so that it will be adaptable to some future overall scheme.

(4) Is the scheme economic and sound from an engineering point of view.

One case arises when subsurface water disposal becomes necessary in a field or pool where an active water drive exists. In such a case, it is generally always best to return the water produced to the zone of production in such a manner as to prevent damage such as localized coning^x or the like. This may sometimes be accomplished by returning the water to the zone directly below the oil pool if a thick water section occurs below the oil. If not, the water is sometimes returned to the zone or the flank of the pool, preferably on the flank in the direction from which the water drive is active, if it is only active from one side.

Another case occurs in fields which produce considerable water and have no indication of a water drive, or lack the porosity or permeability or thickness of zone for water disposal. These fields present the problem of selection of a zone other than the production zone for subsurface water disposal. In considering other zones, it must be established that the proposed zone is not or will not be productive in the immediate area and that it contains sufficient reservoir space and permeability to warrant the project.

The latter was the case in the design submitted with this report. It will be observed from the geological chart (Diagram 1b) that the water was injected into the Ashville Sands formation, which is above the oil producing zone. This formation and the location of the injection well itself were selected from a study of isopach maps.

Disposal wells are costly to drill and for this reason, during the early stages of the development of a pool, the field engineer should always keep salt water disposal in mind when issuing abandonment programs. Casing pulling operations

should be deferred until it has been definitely established that the well can't be used in a disposal scheme even on a temporary basis.

Effectiveness of Control:

The Provincial Department of Health and Public Welfare has undertaken to determine how effective disposal of salt wastes has been in the province. This is done through a system of sampling points set up throughout the province. The work was started in the summer of 1955 and by the end of the summer of 1956 monthly samples were available from all oil producing areas in Manitoba.

The sampling points were selected at streams, farm water wells, creeks, etc., and once each month a water sample from each point was tested for chloride content. The results of these tests varied from area to area, but for the most part were constant at each sampling point from month to month. There were indications at one time that salt water wastes were getting into one of the creeks in the South Virden Field and upon advising the Board steps were immediately taken to rectify this situation. The tests also revealed that there had been a spill of salt water in the Tinston Area and resulted in the temporary shut down of several wells in that vicinity.

The North Virden Field for which the disposal system has been designed in this report, was found to have certain sampling points that were high in chloride content, but investigation revealed this had been the case before wells were drilled in the area. For this reason the Health Department is now endeavoring to set up control points in advance of drilling operations so that any minute increase in chlorides can be immediately detected.

In conclusion these tests have revealed that the Board Regulations in Manitoba are adequate and effective in controlling contamination of fresh water supplies.

North Virden Field:

The North Virden field is actually an extension of the Virden Roselea field in a northerly direction. The Virden Roselea field was discovered in July 1953 when Melvor Roselea No 1 was drilled in L.S.D. 9, Section 28, Township 10, Range 26 W.P.M. Accumulated production to the end of December 1956 for the discovery well was 90,656 barrels of oil and 9,917 barrels of water; while the total field production for the North Virden and Virden Roselea fields was 7,047,840 barrels of oil and 2,628,930 barrels of water. In December 1956 there were 227 producing wells in the Virden Roselea area and 167 producing wells in the North Virden area.

This report deals with the outlined area on the accompanying map (Map #1), and the design submitted is a proposed disposal system for 26 of the oil wells high in salt water production.

The geology of the area is covered in a report prepared by the Virden Geological Department of the California Standard Oil Co., and is shown in Appendix C. In brief, oil production in the area is obtained from one or all of four zones in the Mississippian Lodgepole formation, ie. Grinoidal member, Sandhill member, Oolitic member and Cherty Limestone member. This is illustrated in the chart shown in Diagram 1b.

As shown in the geological report, Appendix C and the geological chart, Diagram 1b, disposal will be to the Ashville sand formation. The Ashville sand is from 0 to 65' thick in the North Virden area, as indicated on the Isopach Map (Map #2) and is encountered at about the 1200' level. Logs show that this sand is 25% to 35% porous and has good permeability. The method of selecting the best location for the disposal well into this formation is outlined in the design procedure and depends mainly on the thickness of the sand layer, porosity, and permeability.

Experience with the Ashville sand wells in the general area shows injection rates and pressure range from 110 bbl/hr by gravity at one well to 120 bbl/hr at 600 psi pump pressure at another well.

The produced water contains approximately 113,000 ppm dissolved solids, hydrogen sulphide and suspended solids; and of this approximately 76,000 ppm are Chlorides. The water is therefore highly corrosive and corrosion resistant materials are required throughout the system.

It is possible that water treatment will be required at the injection site and consideration has been given to providing complete treatment facilities. See appendix D and Diagram 2. However, these facilities will be installed only when the need for them becomes apparent.

The estimated costs of the various components of the system have been outlined in Appendix B.

Design Procedure:

In designing a gathering system it is first necessary to obtain elevations of the batteries, the proposed disposal well, and predominant topographical features through which the line may be laid. From this information it is determined whether or not a gravity system is feasible. Since there appeared to be considerable differential in elevation within the boundaries of the region being considered it was decided to take advantage of this grade and design the gathering system to flow by gravity. The minimum size of pipe available, 4 inches, was used for the main part of the line and the head loss was calculated by the Hazen and Williams equation with a C factor of 100. Cement asbestos pipe is used in Redwater and this, when new, has a C factor of up to 140. It has been their experience however, that a C factor of 100 is the maximum that can be economically maintained over the life of the field.

After the area to be served has been decided upon, from a study of the salt water production records, the lines must be located, profiles drawn, and the hydraulic gradients plotted. Line sizes and locations must be adjusted to fit terrain conditions. The hydraulic gradients are calculated using the maximum expected flow rates. Extensive reservoir studies on which to base maximum daily water production have not been made, but it is the opinion of the Virden officials that for design purposes 100 bbl/well/day will be satisfactory. Thus the proposed system, serving 26 wells, which means an ultimate water production of 2600 bbl/day, is designed for a capacity heavily in excess of the present water production of some 310 bbl/day (See Page). It is essential to over design the system to accomodate not only future increased water production from existing wells, but also water production that might be brought into the system from future additional wells. While the water flowing from the batteries in the lines is not expected to carry much suspended solid, provision must still be made for cleaning lines by installing scraper entrances and traps and by using full opening valves.

The produced water is highly corrosive and thus corrosion resistant materials must be used throughout the system. The specific gravity of the liquid is 1.07 and it has a freezing temperature of 16°F. Soil temperature surveys have indicated that a 5' cover is required to prevent freezing, except at road crossings, where a 7' cover is required because of greater frost penetration. At the crossings of roads, railroads and creeks, lines are encased in steel conduit to prevent failure due to settling.

The actual wellsite is located according to the capacity of the receiving formation and with reference to the system of gathering lines. An ideal procedure is to use an abandoned well, but within an economic distance of the region considered, no such wells existed, and thus it was decided that the well should be drilled and would be placed adjacent to the last battery of the gathering system if the sand formation was sufficiently thick to take the water at this location. Examination of the isopach map showed that the thickness of the strata was from 20 to 40 feet in the region of the proposed wellsite, and on the basis of experience of other systems this should be quite adequate. No exact location for the wellsite was given, but it is suggested that it should be within 100' of the last battery.

The accompanying diagram #2 illustrates a wellsite plant which conforms with present day basic design. This plant is suitable for the proposed disposal system. The plant consists of the three tanks shown, a well cellar housing the disposal well, and control equipment which is designed to provide continuous, unsupervised operation. The tanks are constructed of reinforced concrete, and are buried to prevent freezing as well as to provide the maximum elevation differential with the batteries. Water enters the tanks through a perforated header, and is retained in the tanks long enough to provide for settlement of the solids and flotation of any oil carried over from battery treating equipment.

The diagram also illustrates the layout of the tanks and shows an installation of filter tanks which might be added if the need for filtration arose. These tanks should be made of wood to avoid the effects of the corrosive action of the liquid.

The Ashville sand can accept water at the rate of 120 bbls/hr at a pressure of 600 psi. It is the opinion of the Virden officials however that a pressure of 1000 psi should be selected, even if it isn't at first required. A Wheatley pump is the most favourably priced pump and operating data indicate excellent pressure volume flexibility at low operating speeds. The pump will be equipped with bronze fluid ends, and corrosion resistant liners. The price of this pump, complete with 100 hp high starting torque motor, magnetic breaker switch, starter, float switch, pressure relief switch, and installation is \$12,000.

Salt Water Production & Well Elevations for Max 1956 Month - Oct

Well	License	Ground Elevation	K. B. Elevation	Water Production	Total Prod/Batt.
Calstan Scallion					
9-9(11-26)	667	1494	1504	690	
15-9 "	686	1499	1508	249	
16-9 " +	592	1498	1508	<u>1</u>	940
3-10 "	1184	1485	1495	1266	
6-10 "	827	1489	1500	1437	
12-10 "	810	1491	1502	204	
13-10 "	782	1492	1503	152	
14-10 "	682	1490	1500	90	
11-10 " +	731	1491	1501	<u>62</u>	3211
2-10 "	634	1480	1490	1020	
7-10 "	520	1482	1492	243	
8-10 "	452	1486	1496	233	
9-10 "	387	1491	1502	277	
10-10 "	603	1487	1497	260	
15-10 "	538	1490	1500	511	
16-10 "	619	1492	1502	1	
1-10 " +	424	1487	1499	<u>43</u>	2568
1-11 "	413	1473	1482	95	
2-11 "	404	1476	1485	1	
4-11 "	414	1481	1492	4	
5-11 "	372	1480	1489	46	
6-11 "	423	1479	1491	2183	
7-11 "	405	1479	1491	2	
8-11 "	443	1474	1484	1	
12-11 "	487	1485	1495	31	
3-11 " +	345	1472	1478.9	<u>45</u>	2388

Total October Production.....9127 barrels

+ Battery
 ° Kelly Bushing

Daily Production = 9127 = 310 barrels
 30

Design for 100 bbs/well/day = 2600 barrels/day

Sample Calculations:

The Williams and Hazen equation is widely accepted in determining the head loss in disposal systems for oil field wastes:

$$v = Cr^{0.63}s^{0.54}.001^{-0.04}$$

where v = Mean velocity of flow

C = "Coefficient of Retardation"

r = Mean hydraulic radius of pipe, or diameter $D/4$, in ft

s = Hydraulic grade or slope, in feet per foot of length of a pipe of uniform size

or

$$s^{0.54} = \frac{v}{C \left(\frac{D}{4}\right)^{0.63} \times 0.001^{0.04}}$$

$$= \frac{4^{0.63} v}{1.318 C D^{0.63}}$$

$$s = \frac{4^{1.167} v^{1.852}}{1.318^{1.852} C^{1.852} D^{1.167}}$$

$$= \frac{3.0236 v^{1.852}}{C^{1.852} D^{1.167}}$$

$$s_{1000} = \frac{3023.6 v^{1.852}}{C^{1.852} D^{1.167}}$$

(loss of head in feet per 1000 feet)

$$= \frac{K v^{1.852}}{D^{1.167}}$$

When $C = 100$

$K = 0.596$

1 barrel = 42 U. S. gals

1 U. S. gallon/min = $1 \times 2.228 \times 10^{-3}$ cu ft/sec

Proposed system uses 4" pipe, ID = 3.95" and 6" pipe, ID = 5.85"

Sample Calculations cont'd
Head Loss, Battery A to B:

3500' of 4" pipe, 3 wells @ 100 bbl/well/day = 300 bbl/day

$$q = \frac{300 \times 42 \times 2.226 \times 10^{-3}}{24 \times 60}$$

$$= 0.0186 \text{ cu ft/sec}$$

$$A = \frac{\pi}{4} \times \left(\frac{3.95}{12}\right)^2$$

$$= 0.085 \text{ sq ft}$$

$$v = \frac{0.0186}{0.085}$$

$$= 0.219 \text{ ft/sec}$$

$$s_{1000} = \frac{0.598 \times 0.219^{1.852}}{0.329^{1.157}}$$

$$= \frac{0.598 \times 0.06}{0.273}$$

$$= 0.1314 \text{ ft}$$

$$s = 0.1314 \times 3500 \text{ ft}$$

Head Loss, Battery B to C.

4000' of 4" pipe, 6 + 3 = 9 wells, water production = 900 bbl/day

$$q = \frac{900 \times 42 \times 2.226 \times 10^{-3}}{24 \times 60}$$

$$= 0.0558 \text{ cu ft/sec}$$

$$A = 0.085 \text{ cu ft}$$

$$v = \frac{0.0558}{0.085}$$

$$= 0.645 \text{ ft/sec}$$

$$s_{1000} = \frac{0.598 \times 0.645^{1.852}}{0.329^{1.157}}$$

$$= 0.973 \text{ ft}$$

$$s = 3.89 \text{ ft}$$

Sample Calculations cont'd
 Head Loss, Battery C to D:

3500' of 4" pipe, 8 + 6 + 3 = 17 wells
 water production = 1700 bbl/day

$$Q = \frac{1700 \times 42 \times 2.226 \times 10^{-3}}{24 \times 60}$$

$$= 0.111 \text{ cu ft/sec}$$

$$A = 0.005 \text{ sq ft}$$

$$v = \frac{0.111}{0.005}$$

$$= 1.3 \text{ ft/sec}$$

$$s_{1000} = \frac{0.528 \times 1.3^{1.852}}{0.329^{1.167}}$$

$$= 3.56 \text{ ft}$$

$$s = 12.5 \text{ ft}$$

Discussion:

The submitted design for a salt water disposal scheme is typical of the methods employed in the prairie provinces for disposal of oil field wastes. The design can only be treated as a preliminary design for such a project, since to make the final design there would have to be more complete information regarding quantities of liquid, profile of proposed line, etc.

The quantity of water production was assumed to be 100 bbl/well/day for design purposes for the existing field. This production was heavily in excess of the present water production, but since no information was available for proposed future wells in the area, it was felt necessary to design for this quantity. To demonstrate the need to over-design such a disposal scheme, it has been noted that the Redwater system, within 2 years of the date it commenced operation, was having 4 times the original quantity of liquid tendered to it. As additional wells are brought into production within the region of the gathering system, tie lines could be laid into the original line from the wells, or batteries.

The profile of the line was plotted from the elevations of the wells and thus for practical purposes cannot be considered too reliable. It does indicate the general grade of the line however and shows why it is possible to design a gravity system for the gathering line. In practice, especially in the Virden area the salt water has been pumped from the battery treaters to a vertical boot, some 15 to 20 feet high to provide additional head before being led into the pipe line. These boots are made of wood and are some 12" in diameter. Asbestos-cement pipe can not be used for this purpose as it is not provided in adequate lengths, and a joint in such an installation is considered unsatisfactory.

Owing to the extremely corrosive nature of the salt water, material resistant to corrosion must be used throughout the system. For piping, transite pipe is very satisfactory,

but for pressure systems it may be necessary to use plastic or cement lined pipe at greater cost. In the Redwater disposal system a few failures occurred in the cement-asbestos gathering lines, particularly in areas where the overburden consisted of very rocky glacial till. As the pipe is very brittle and has poor flexural properties, extreme care must be taken in bedding the pipe in the ditch so it will not be in contact with rock or boulders. Failures, may result from non-uniform loading on the pipe length with settling of the backfill.

The liquid transported to the plant by pipe is not expected to contain many settleable solids, because of the semi-closed character of the gathering system. The disposal plant would be designed however, to handle liquids which would be trucked to the plant, in addition to the piped water. Whenever the brine comes in contact with air there is apt to be considerable precipitation of solids and it is thus frequently the case that brines delivered to a disposal plant by trucks will contain a higher percentage of solids. In addition to this precipitation the fluid becomes slightly more corrosive once it has been exposed to air. The Redwater system gave considerable operating difficulties due to corrosion in well tubing, steel fitting and steel vessels during the period when the water was being trucked. The semi-closed system, as it is called, and after which the submitted design is modelled, reduced this corrosion noticeably since there is very little contact made with air during the passage of the liquid through the pipes to the plant. The semi-closed system, by limiting the contact with air, also keeps the precipitation of solids to a minimum.

The high temperature, and high pressure treating equipment at the battery does not completely separate gas from the brine. Entrained or solution gas in the salt water accumulates at high points as the pressure and temperature decreases in the lines, sometimes causing pressure locks. To reduce occurrences such as these, vents must be installed on the high points in the line to bleed off any oil or gas that may still accumulate.

the cost of the injection well was not included in the report since figures were unavailable for this phase of the scheme. Drilling is expensive and it is likely that in an actual disposal scheme if any abandoned wells existed in the area they would be investigated for their suitability for receiving the salt water.

Conclusions:

The system as designed is a disposal system to the Ashville sand, but could also be used as an injection system to the Mississippian. Also, water to the Ashville sand aquifer could be used as storage until such time as water flood or injection programs were introduced in the field. At this stage the water from the Ashville sand could be re-produced and used as flooding or injection fluid. Such a technique is presently being used in the Daly field. The system as described is acceptable under Board Regulations and is in accordance with generally good oilfield Engineering Practices.

It is hoped that the report provides sufficient information to provide a brief outline of the problem of Oilfield Wastes and the current methods of handling them.

APPENDIX A

Regulations regarding salt water disposal practices in the Province of Manitoba:

In this section is outlined some of the provincial laws dealing with salt water disposal and some of the current interpretation of such laws in the Western Provinces.

1. Regulations of the Department of Mines and Natural Resources, Winnipeg, Manitoba.

(1) Regulations under the "Mines Act" 1940, M.S.M. Ch. 136,

(a) Part IV, Sec. 191

"The operator shall not permit any salt water or drilling fluid to flow over the surface of any land", and

(b) Part V, Sec. 209

"The Board, with the approval of the Minister, may..

(g) require the disposal into an underground formation or otherwise, in accordance with such terms and conditions as the Board may prescribe, of any water produced."

(2) The Pollution of Waters Prevention Act, S.M., 1935, Ch. 34 Part 1.

Sec. 3. "No person shall leave, deposit or throw or permit or cause to be left, deposited or thrown any manure, night soil, decayed or decaying matter, the carcass or offal of any animal or fish or part thereof, lime, chemical substances, drugs, poisonous matter, garbage, refuse, cans, bottles, rubbish or any other filthy or impure matter of whatsoever kind within two chains of the normal high water mark of any body of water or into the waters of or upon the ice of any body of water."

Sec. 4. "Notwithstanding the provisions of any other Act of the Legislature without a subsisting license from the commission no person either directly or indirectly shall discharge or drain or cause or permit to be discharged or drained any sewage or waste into any body of water."

(3) Regulations under "The Public Health Act" Part 3, Sec. 57.

"1. No person shall deposit or discharge into or on to the bank of any river, stream, lake, creek, spring, coulee, reservoir, pond or dug out, or on the ice, thereof, any manure, excreta, filth or refuse, of any nature whatsoever, nor permit the fouling or contamination of ice or water on any such body of water by the congregating or watering of stock at any water hole or place.

"2. No person, firm or corporation, shall commit any act which will or may contaminate any underground water supply, by the discharge of any sewage, surface drainage, liquid waste or filth into any well, abandoned well, hole or other opening, nor shall any person fill or replenish any existing well, except with water from an approved source satisfactory to the medical officer of health."

2. Copy of "an Order pertaining to Salt Water Disposal Order No. 1 SWD.

THE PROVINCE OF MANITOBA

THE MINES ACT
AND AMENDMENTS THERETO

THE OIL AND NATURAL GAS CONSERVATION BOARD

ORDER NO 1 SWD

An Order pertaining to salt water disposal.

By virtue of the powers conferred upon the Oil and Natural Gas Conservation Board by the Mines Act, 1940, being Chapter 136 of the Revised Statutes of Manitoba, 1940, as amended by Chapter 41 of the Statutes of Manitoba, 1951, the Board hereby orders:

1. On or before the thirteenth day of September A.S. 1954 there shall be submitted to the Board a plan for the disposal of all salt water produced from all oil wells in the Province of Manitoba in production as of the date of this order.
2. Said plan must provide that sufficient salt water disposal wells will be drilled, or otherwise completed, prior to the 1st day of November A.D. 1954 to provide proper subsurface disposal of the salt water produced from said wells.
3. Operators of oil wells coming into production subsequent to the date of this Order shall, within three months of the commencement of production, submit to the Board a plan providing for the disposal of salt water produced therefrom.
4. Where in the opinion of the Board the production of salt water so justifies, the Board may grant a temporary exemption from this order.

Made at the City of Winnipeg, in the Province of Manitoba, this 17th day of August, A.D. 1954.

THE OIL AND NATURAL GAS CONSERVATION BOARD

The following is extracted from the Alberta Oil and Natural Gas Conservation Act of 1950 and is included here to help explain the problem of Salt Water Disposal.

GUIDANCE FRAMEWORK FOR SALT WATER DISPOSAL

To assist in maintaining a uniform practice throughout the Province (Alberta) in the handling of salt water disposal problems, and with a view to retaining a high standard of oilfield housekeeping, the Board has approved the following guidance framework for use by the field staff.

Two fundamental principles are to be applied:

Principle 1

All salt water must be contained in a satisfactory manner at all times. Reasonable safety factors to provide for such exigencies as Spring run-off, heavy rains, and sudden increases in W/O ratios must be allowed in all cases.

Principle 2

Where the amount of salt water produced into any one battery (and not disposed of by an approved salt water disposal scheme) is in excess of 600 barrels per month, the operator will be required to limit total fluid production to reduced salt water production to 600 barrels per month, unless he can show cause why his production should not be curtailed.

Within these principles the following guidance points are suggested:

1. Battery:

For the purpose of this framework, a battery shall be any agglomeration of tanks contained within a single firewall, or contained within a circle of 250 ft. radius, together with the manifolds, separators, treaters and other appurtenances thereto.

2. Number of pits:

One, only, per battery. Where flare pit is used for salt water disposal, none other is permitted.

3. Size of pits:

No salt water disposal pit shall have an area of greater than 6000 square feet.

4. Type of pit:

Pits should incorporate the following features:

- (a) Excavated
- (b) Walls least two feet above surrounding terrain
- (c) Walls constructed of clay, or equally suitable material, not brush, maskeg, black earth, etc.
- (d) Not located where exposed to excessive erosional effects from surface run-off.

5. Amount of Salt Water

Any battery into which is produced more than 600 barrels per month of formation water, which is not disposed of in a disposal system approved by the Board, shall be inspected and reported to the Board's head office in Calgary. Details such as rate of water increase, proximity to disposal well or systems, present method of handling water and other matters which may be considered relevant should be reported.

Acting on this report, the Board may request the operator to make other more satisfactory disposal arrangements before a stated deadline, or show cause why the wells should not have their production curtailed.

Interpretation of the Act and Regulations:

In Alberta, the rate of evaporation is not sufficient for satisfactory water disposal, and there appears to be no fully adequate method of disposal other than by subsurface means. It may therefore be inferred from item 5 above that the Board is thinking of subsurface disposal whenever water production exceeds 600 barrels per month per battery.

With regard to salt water disposal wells, the injection zone, the completion depth below the water-oil interface, and the amount of water that may be injected must be approved by the Board. The Board may also rule on the type of well completion.

In a field where subsurface injection of salt water has been undertaken and the receiving horizon will take large amounts of water, the Board may lower the maximum quantity of water which may be disposed of by surface means from 600 barrels to 300 barrels per month.

Measurement of Water:

The Board has certain requirements in respect to the measurement of water. Two methods of measuring individual well production are acceptable within certain limitations:

1. Line cuts, using a centrifuge
2. Measurement by means of a meter or by tank gauge

APPENDIX D

Water Treatment:

It is possible that water treatment will be required if difficulty is experienced in preventing plugging of the Ashville sand formation by scale or suspended solids such as iron sulphide. However, a simple installation will be made initially with additional treating facilities being installed when required. See Diagram 2

Diagram 2 illustrates a plant layout consisting of an oil skimming pit, a settling pit and a clear pit. This arrangement would handle some 3000 bbl/day which is a flow rate of 420 gals/sq ft/day. The average velocity would be around two feet per minute and would be sufficient to remove the heaviest particles. If the disposal formation tends to plug rapidly it is suggested that gravity sand filters be added with a filtration of 1-1/2 gal/min/sq ft of area. Wood tanks should be used to prevent corrosion. Gravity filters are recommended because:

- (1) The water cannot be forced through the filter.
- (2) Filter sands can be easily inspected visually and changed without difficulty.

If there is still clogging occurring, it may be necessary to chemically treat the water, which will precipitate out more solids.

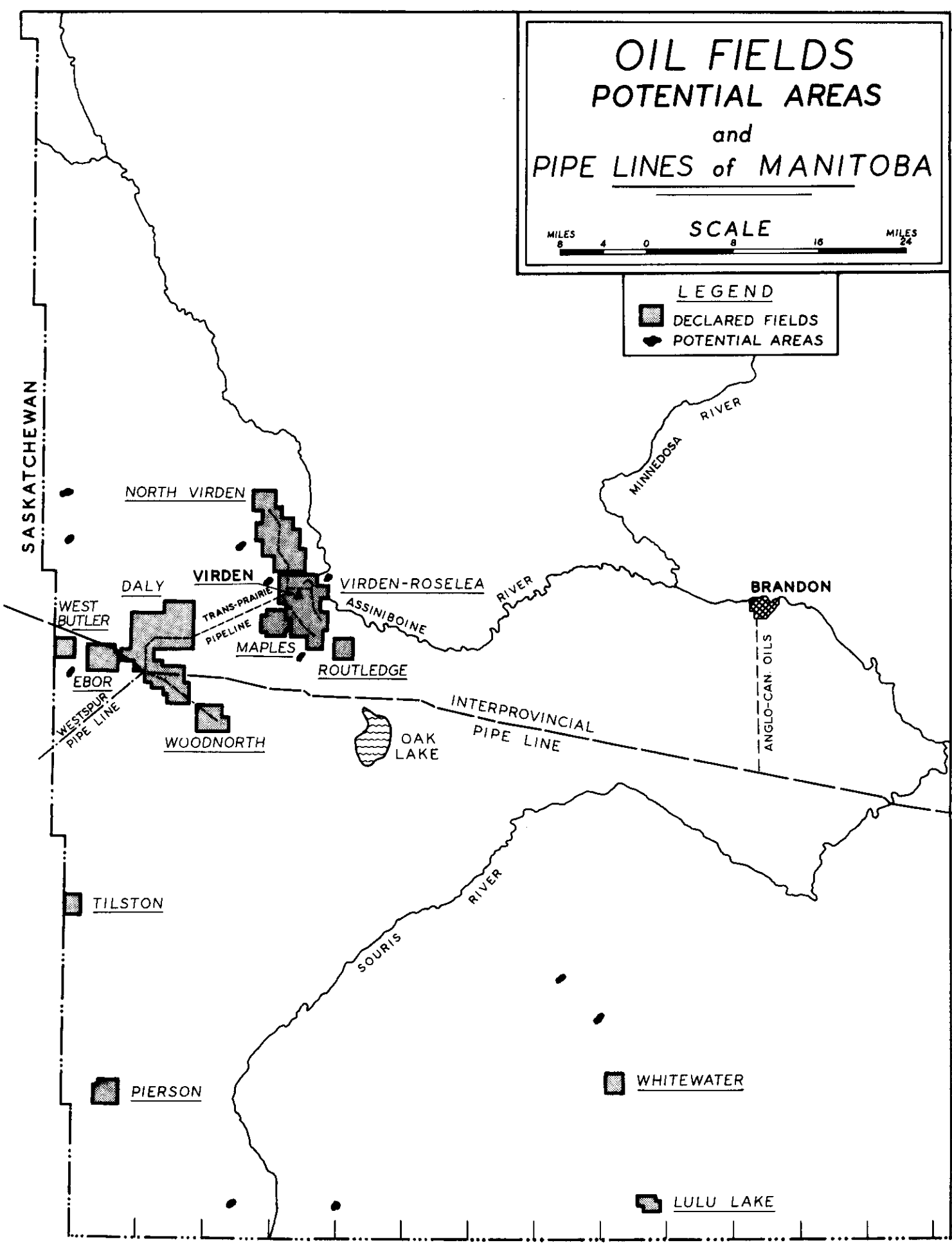
Backwashing is one of the most important factors in efficient filtration. The cleaning of the sand grains may be accomplished by high velocity backwashing. This is done by using raw unfiltered brine from the separators, which is admitted to the filter from the bottom through an appropriate distributing system that expands the bed vertically, causing the sand grains to scrub together vigorously.

OIL FIELDS POTENTIAL AREAS and PIPE LINES of MANITOBA



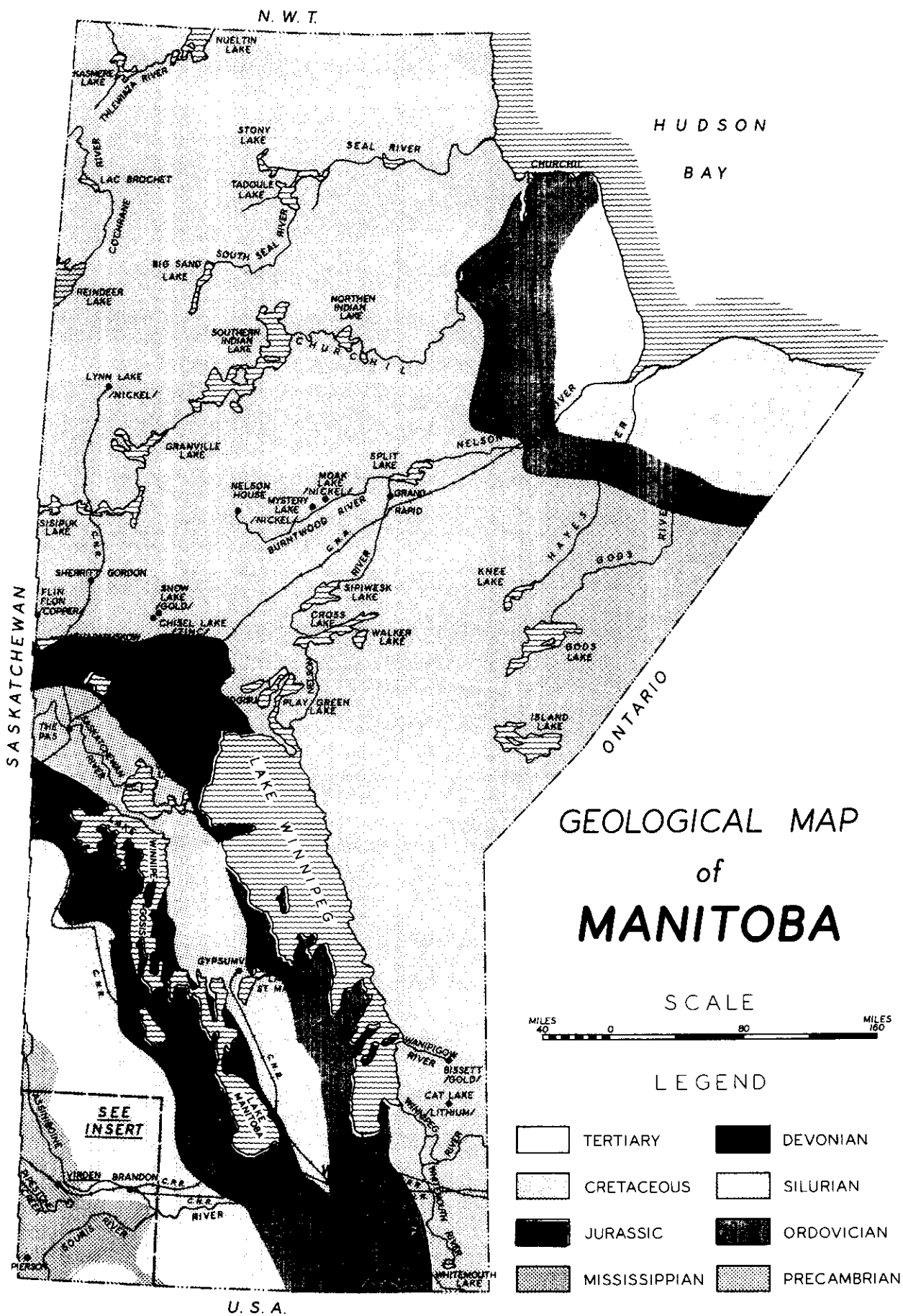
LEGEND

- DECLARED FIELDS
- POTENTIAL AREAS

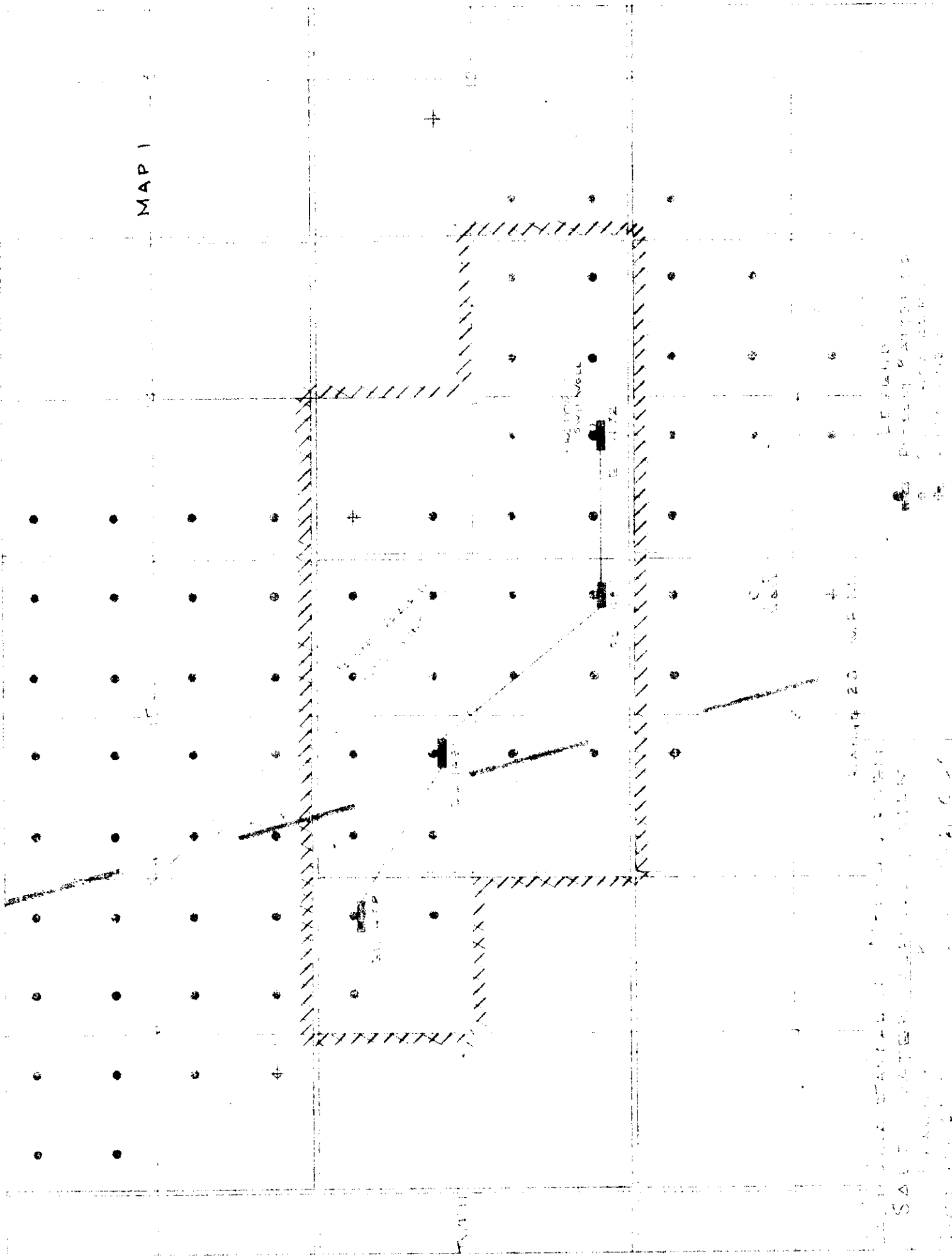


GEOLOGICAL FORMATIONS in Manitoba

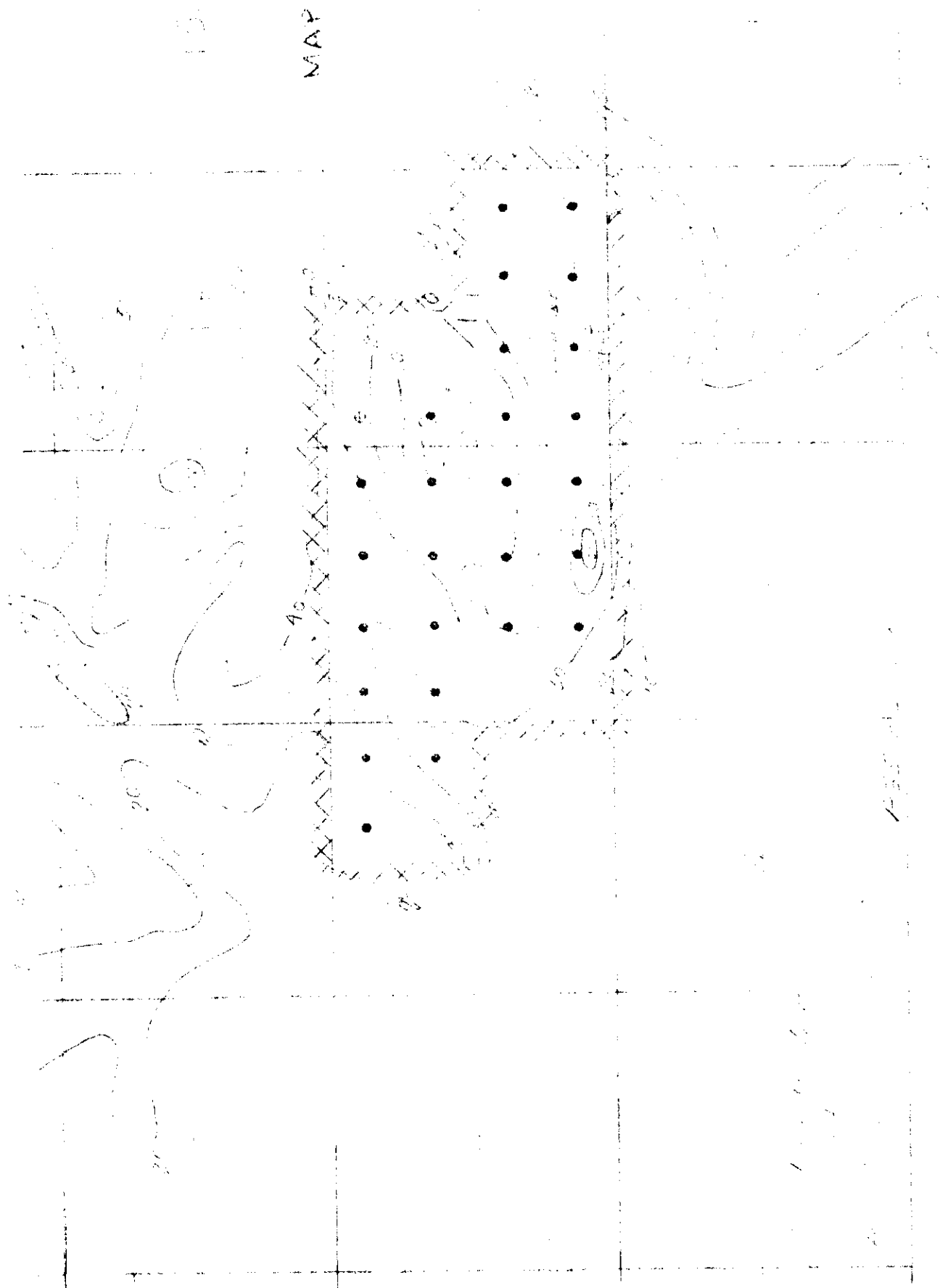
ERA	PERIOD	EPOCH	FORMATION	MEMBER	MAX THICK	BASIC LITHOLOGY
CENOZOIC	QUATERNARY	RECENT				TOP SOIL, DUNE SANDS.
		PLEISTOCENE	GLACIAL DRIFT		450'	CLAY, SAND, GRAVEL, BOULDERS, PEAT.
	TERTIARY	PLIOCENE				
		MIOCENE				
		OLIGOCENE				
		Eocene				
MESOZOIC	CRETACEOUS	UPPER	TURTLE MTN.		400'	SHALE, CLAY AND SAND. LIGNITE BEDS. LOCATED ONLY IN TURTLE MOUNTAIN.
			BOISSEvain		100'	SAND AND SANDSTONE, GREENISH GREY. LOCATED ONLY IN TURTLE MOUNTAIN.
			RIDING MTN.		1025'	GREY SHALES - NON-CALC. LOCAL IRONSTONE BENTONITE NEAR BASE. GAS FOUND.
			VERMILION RIVER	PEMBINA	515'	SHALE DARK GREY. CARBONACEOUS NON-CALC. BENTONITE BANDS.
				BOYNE		SHALE GREY SPECKLED. CALC. BENTONITIC SLIGHTLY PETROLIFEROUS.
				MORDEN		SHALE DARK GREY NON-CALC. CONCRETIONS. LOCAL SAND AND SILT.
			FAVEL	ASSINIBOINE KELD	130'	GREY SHALE WITH HEAVY CALCAREOUS SPECKS. BANDS LIMESTONE AND BENTONITE.
			ASHVILLE			SHALE DARK GREEN - NON-CALC. SILTY.
			ASHVILLE SAND			SAND ZONE - 0-90' F.S. QTZ & OR SS.
		LOWER CRETACEOUS	SWAN RIVER		250'	SANDSTONE AND SAND, QTZ. PYRITIC SHALE - GREY, NON-CALC.
	JURASSIC	UPPER JURASSIC	UNNAMED		650'	BANDED - GREEN SHALE AND CALC. SANDSTONE. BANDS OF LIMESTONE, VARI - COLORED SHALE.
		MIDDLE JURASSIC	JURASSIC LIME		150'	LIMESTONE, BUFF, AND SHALES, GREY.
			JURASSIC EVAP / U AMARANTH /		150'	WHITE ANHYDRITE AND/OR GYPSUM AND BANDED DOLOMITE AND SHALE.
			RED BEDS / L AMARANTH /		125'	RED SHALE TO SILTSTONE-DOLOMITIC.
	TRIASSIC					
PALAEOZOIC	PERMIAN					
	PENNSYLVANIAN					
	MISSISSIPPIAN	MADISON GROUP	CHARLES ?		70'	MASSIVE ANHYDRITE AND DOLOMITE.
			MISSION CANYON	MC - 5	400'	LIMESTONE - LIGHT BUFF, OOLITIC, FOSS, FRAG, CHERTY, BANDS SHALE AND ANHYDRITE. OIL PRODUCTION.
				MC - 4		
				MC - 3		
				MC - 2		
			LODGEPOLE	WHITEWATER LAKE	600'	LIMESTONE & ARG. LIMESTONE LIGHT BROWN AND REDDISH MOTTLED. ZONES OF SHALEY, OOLITIC, CRINOIDAL & CHERTY. OIL PRODUCTION.
				VIRIDEN		
				SCALLION ROUTLEDGE		
			BAKKEN	UPPER	70'	2 BLACK SHALES ZONES - SEPARATED BY SILTSTONE. OIL SHOW. HIGH RA KICK.
				MIDDLE		
				LOWER		
	DEVONIAN	SASK. GROUP	LYLETON		115'	RED SILTSTONE AND SHALE DOLOMITIC.
			NISKU		130'	LIMESTONE & DOLOMITE, YELLOW-GREY FOSS. POROUS. SOME ANHYD.
			DUPEROW		560'	LIMESTONE & DOLOMITE. ARG. & ANHYDRITIC IN PLACES.
			SOURIS RIVER 1-ST RED		390'	CYCLICAL SHALE, LIMESTONE & DOLOMITE. ANHYDRITE AND SALT LOCALLY.
			DAWSON BAY 2-ND RED		220'	LIMESTONE & DOLOMITE, POROUS. ANHYDRITE-LOCAL. SHALE RED & GREEN.
		ELK POINT G.	PRAIRIE EVAP.		400'	SALT & ANHYDRITE. DOLOMITE INTER-BEDDED.
			WINNIPEGOSIS		240'	DOLOMITE, LIGHT YELLOWISH BROWN REEFY.
			ELM POINT			LIMESTONE - FOSS.
			ASHERN		40'	DOLOMITE AND SHALE - BRICK RED.
	SILURIAN		INTERLAKE GROUP		450'	DOLOMITE YELLOWISH-ORANGE TO GREYISH-YELLOW FOSS. SILTY ZONES.
	ORDOVICIAN		STONEWALL		50'	DOLOSTONE, GREYISH YELLOW, BEDDED.
			STONY MOUNTAIN	GUNTON	100'	DOLOMITE - YELLOWISH - GREY SHALEY.
				PENITENTIARY		DOLOMITE - DUSKY - YELLOW FOSS.
				STONY MTN. SHALE		SHALE RED-GREEN FOSS. LIMESTONE BANDS.
			RED RIVER	SELKIRK	550'	LIMESTONE, YELLOWISH - GREY DOLOMITE MOTTLED.
				CAT HEAD DOG HEAD		
			WINNIPEG	UPPER UNIT	200'	SHALE, GREEN, WAXY, SANDSTONE INTERBEDDED.
				SANDSTONE		SAND, SANDSTONE, QUARTZOSE.
	CAMBRIAN					SAND, BLACK TO GREEN-GREY WAXY, CARBONACEOUS, SILTSTONE & CLAY, GREEN-GREY. VERY EDGE OF S.W. MANITOBA ONLY.
PRECAMBRIAN						ACID & BASIC CRYSTALLINES & METAMORPHICS.



MAP 1

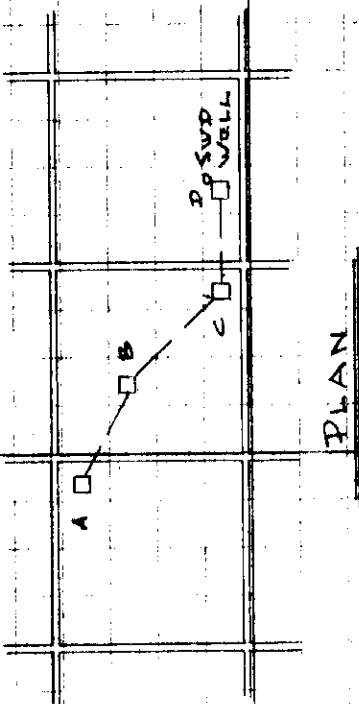


MAP 2

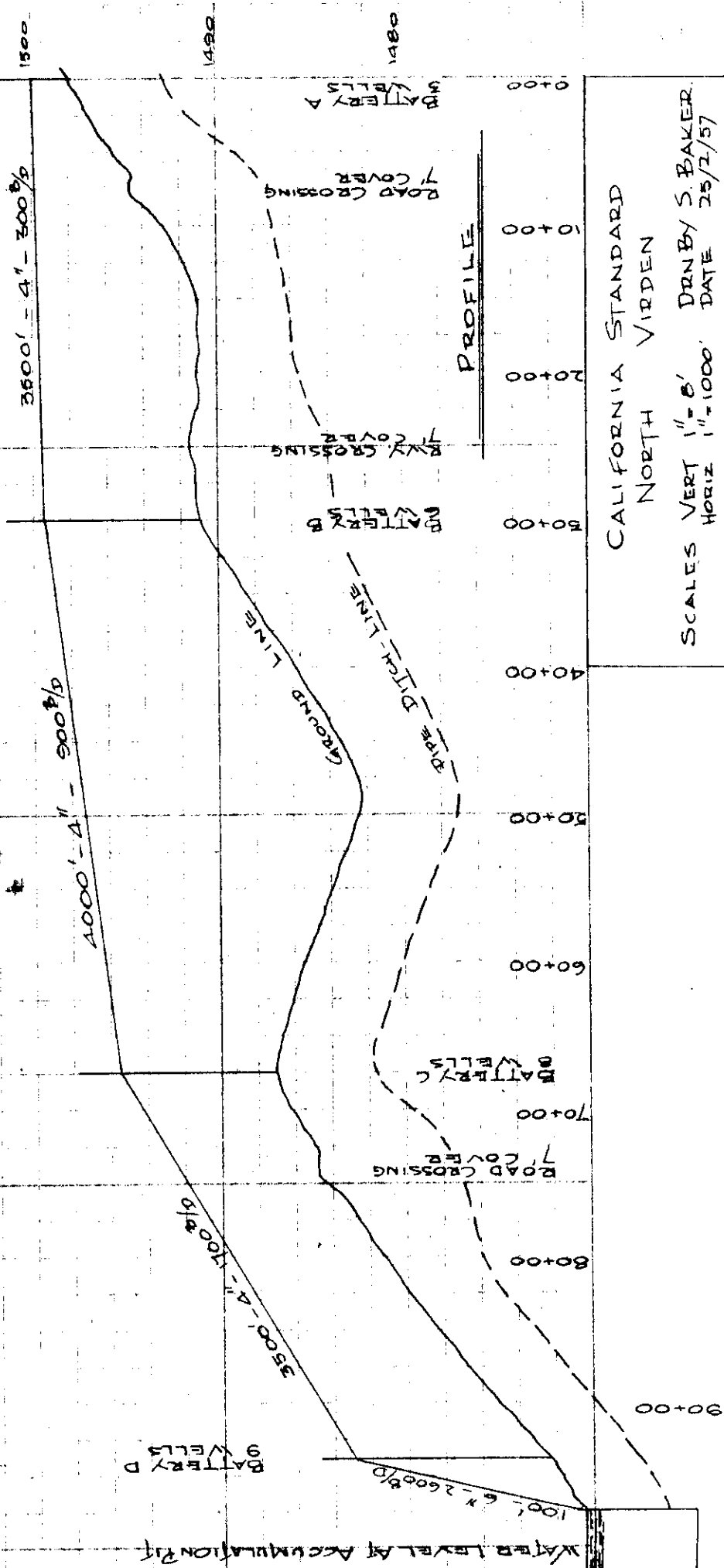


DATE: 10/10/10 11:15 AM

PROFILE & HYDRAULIC GRADIENT OF PROPOSED PIPE - LINE



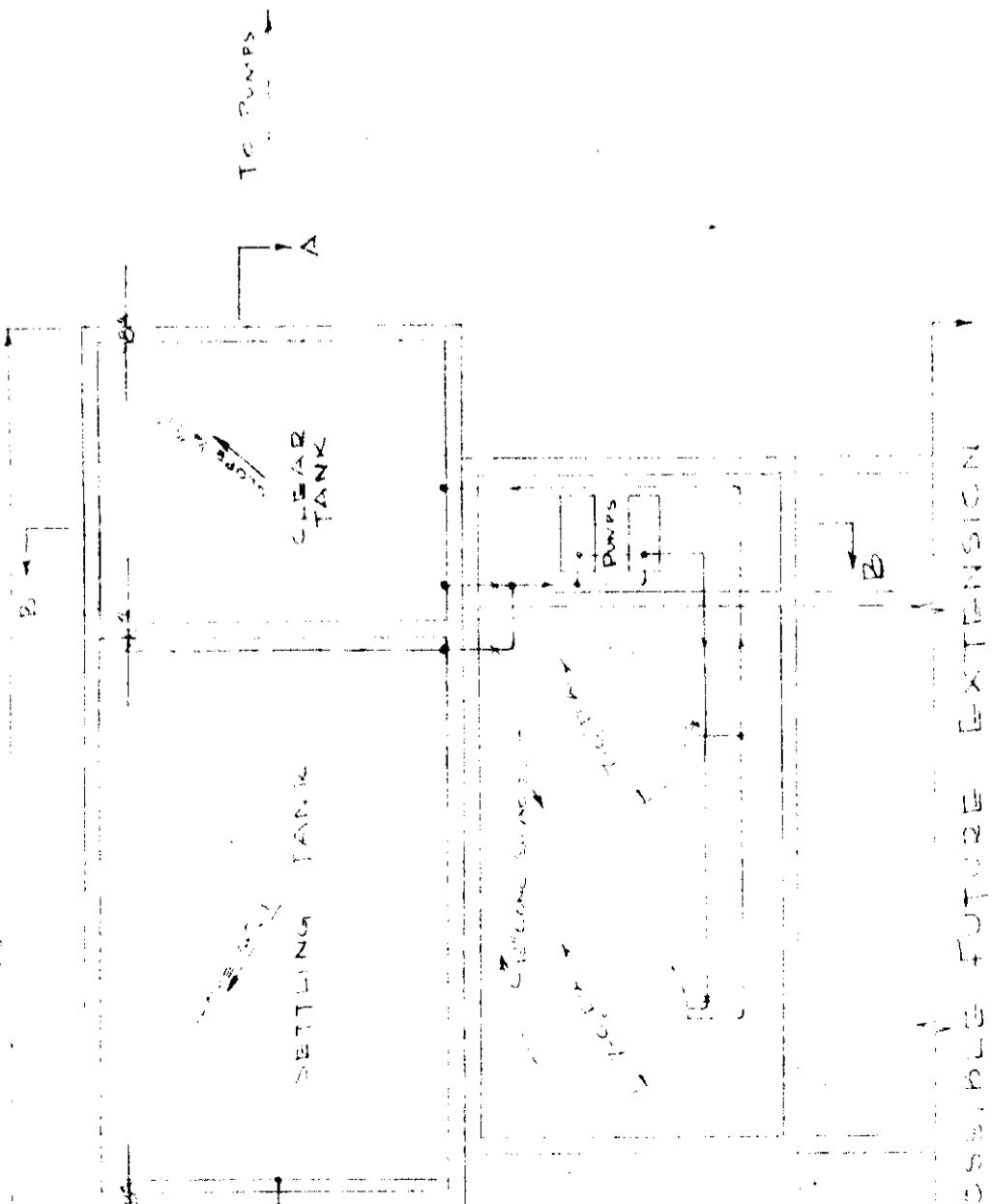
PLAN



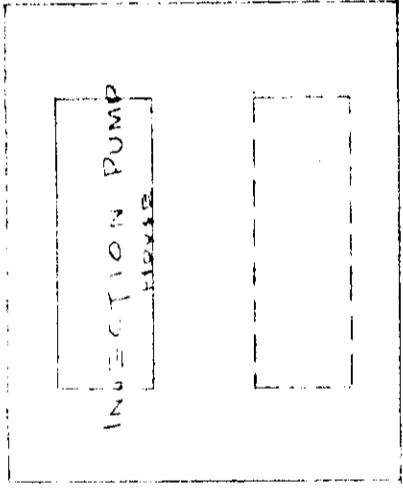
CALIFORNIA STANDARD
NORTH VIRDEN

SCALES VERT 1"=8' DIBBY S. BAKER
HORIZ 1"=1000' DATE 25/2/57

50' 0"

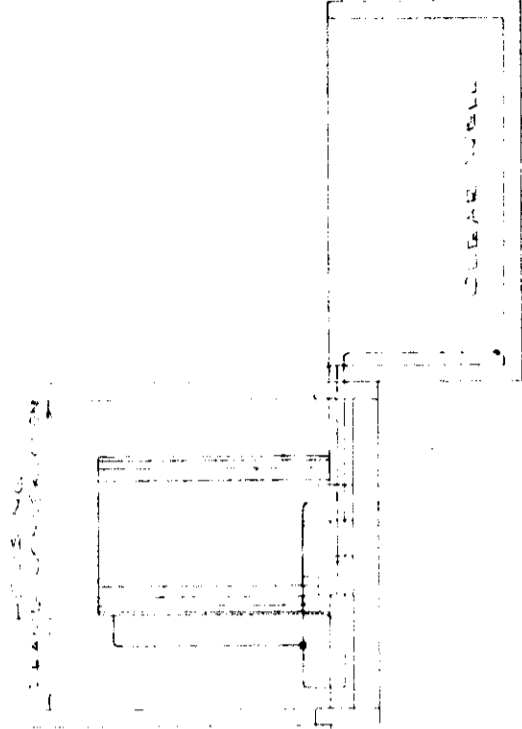


POSSIBLE FUTURE EXTENSION



TO DISPOSAL WELL

TO DISPOSAL WELL

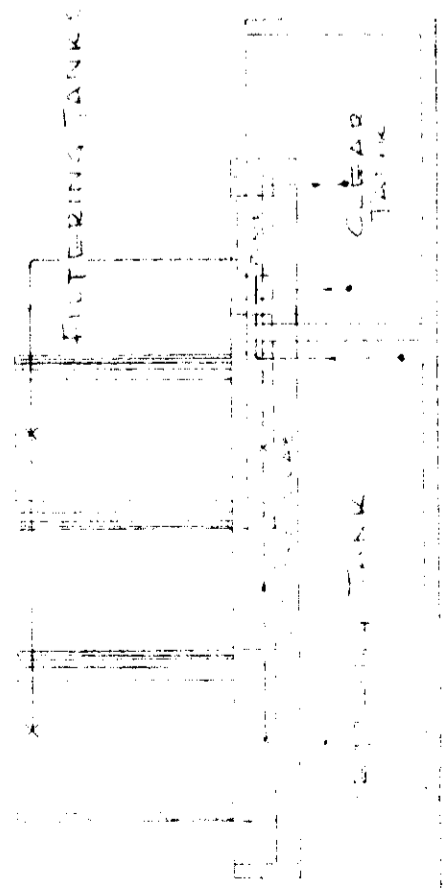


FUTURE EXTENSION

TO DISPOSAL WELL

TO DISPOSAL WELL

ELEVATION B-B

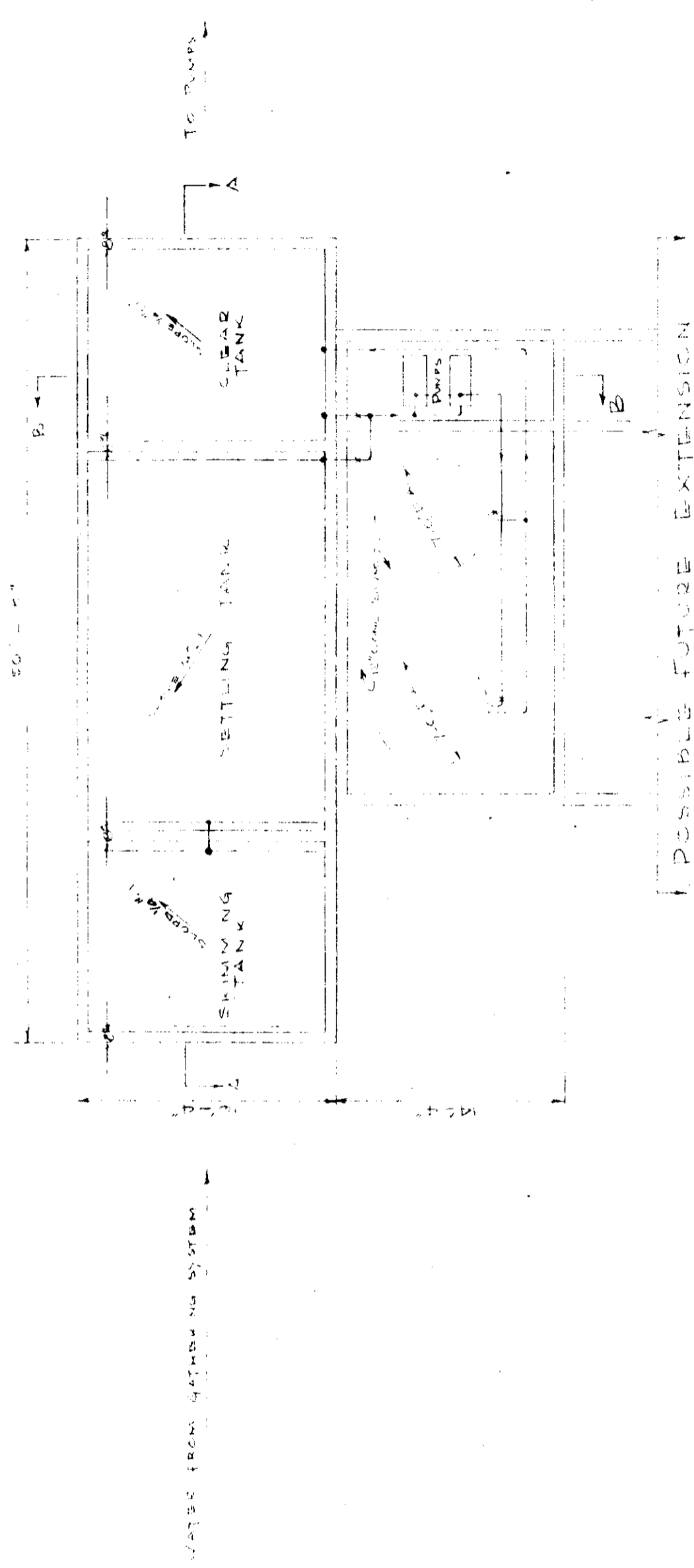


ELEVATION A-A

DIAGRAMMATIC SECTION

SKETCHING & SETTLING TANKS CONSTITUTE
BUILT WATER DISPOSAL SYSTEM

SCALE 1/8" = 1'-0"
DRAWN BY OPERATOR



REFERENCES

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their field engineers.