Note: The 'dry' gravels area is made up of sands and gravels believed to contain insufficient water to be withdrawn economically by a well.

LEGEND

- Approximate extent of Grimshaw Gravels Aquifer
- Approximate extent of 'dry' gravels
- Springs
- Buried channels
- Approximate extent of buried terrace gravels
- A — A' Cross section location (For detailed cross section, see Figure 1 on page 1 of report)

km 5 4 3 2 1 0 5 10 15 km

SCALE

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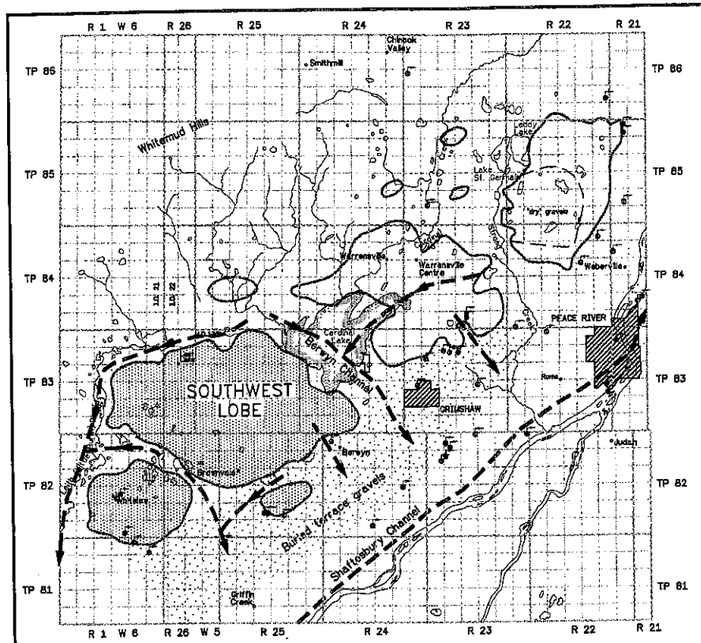
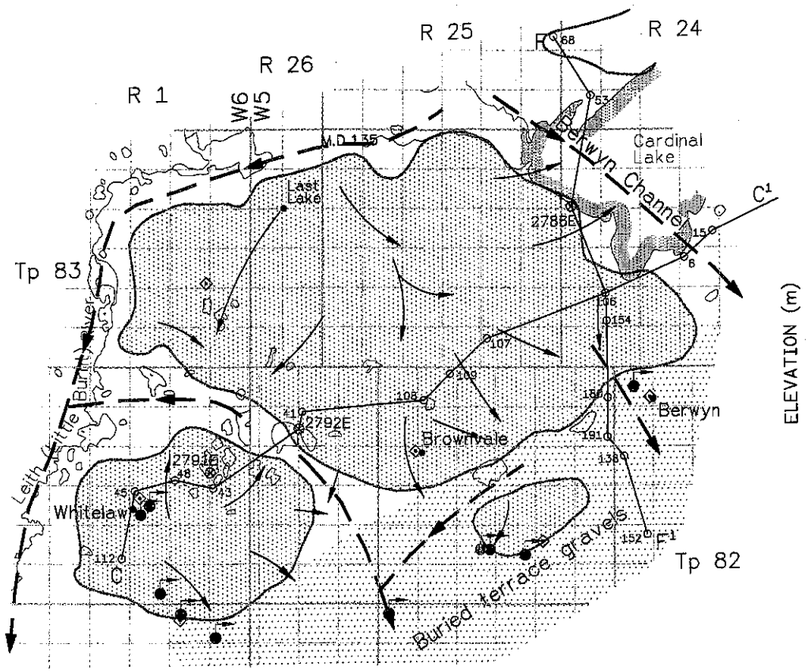
GRIMSHAW GRAVELS AQUIFER

LOCATION PLAN

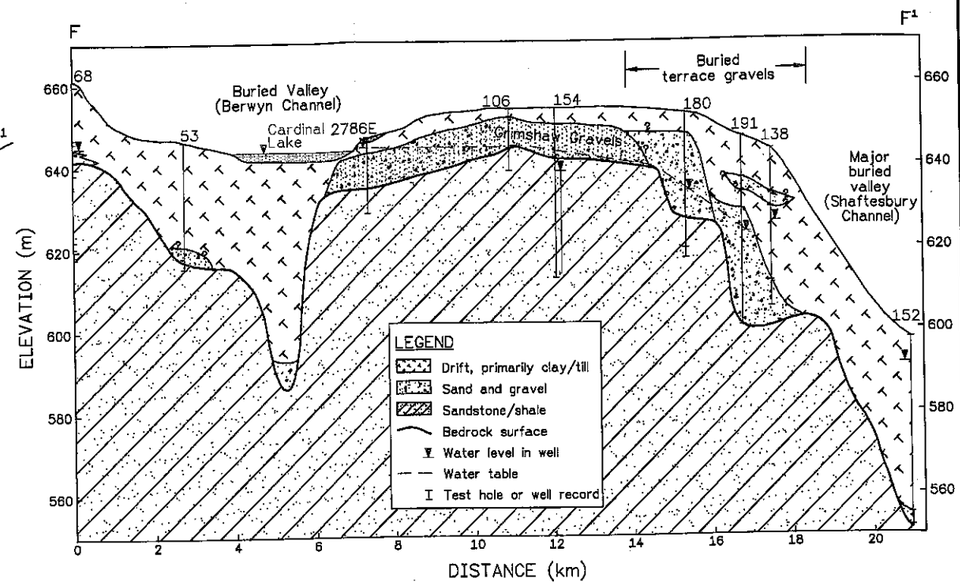
Scale	Date	PFRA No.	
AS SHOWN	JULY, 1996		FIGURE B1



LOCATION PLAN



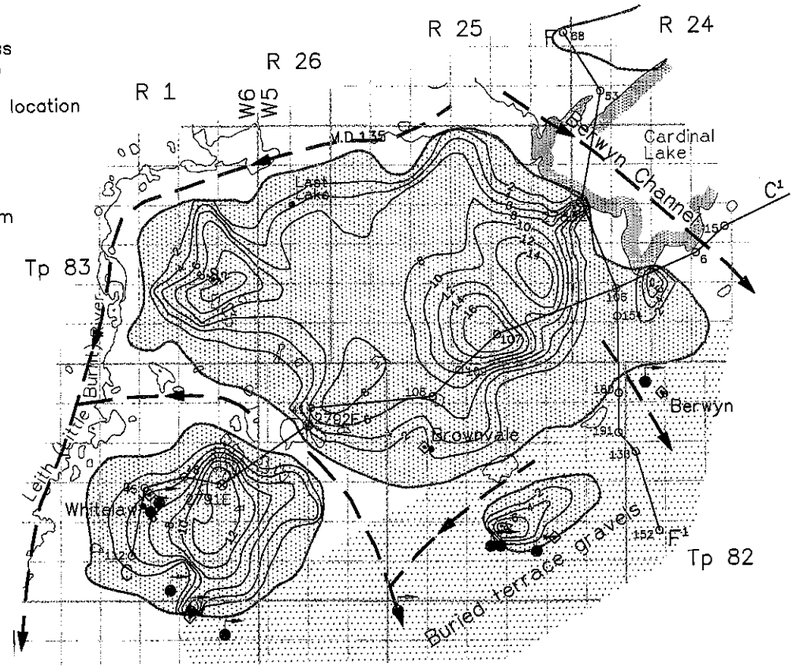
GEOLOGICAL CROSS SECTIONS



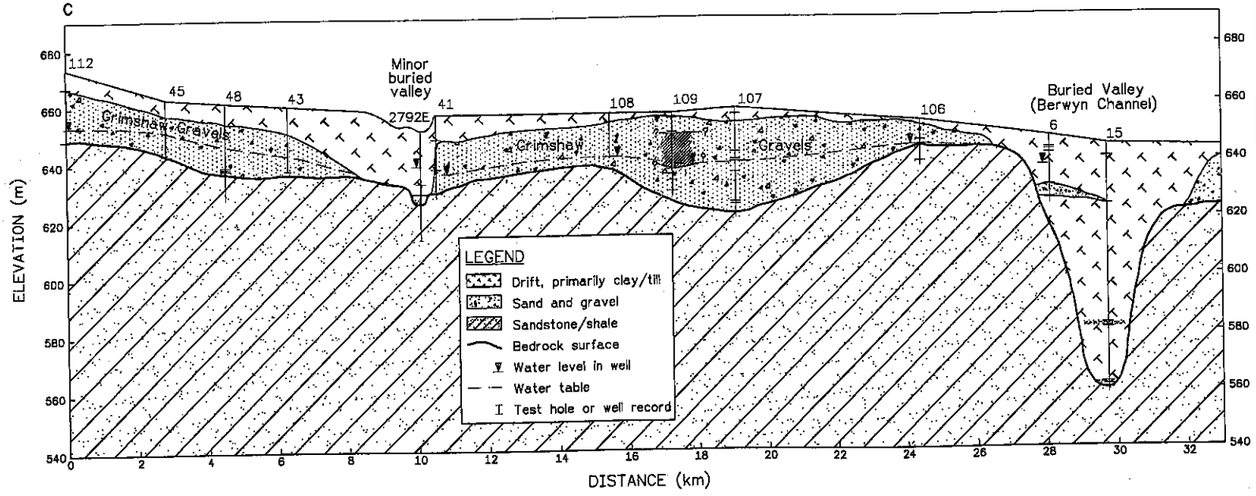
LEGEND

- Approximate extent of Grimshaw Gravels Aquifer
- Approximate groundwater flow direction
- Spring area
- Aquifer saturated thickness (Contour Interval = 2 m)
- Approximate buried valley location
- 184 Test hole/well site
- Municipal well
- 2791E 1994 Test drilling program

INTERPRETED GROUNDWATER FLOW DIRECTION



INTERPRETED SATURATED THICKNESS



Note: The shown preliminary maps and cross sections were prepared from selected drillers' logs filed with the Alberta Environmental Protection Groundwater Information Centre (GIC) to June 1995. Considerable geological interpretation was required to prepare these figures and additional test drilling and/or field surveying would be required to confirm that the geological conditions, groundwater levels and flow directions are as shown.

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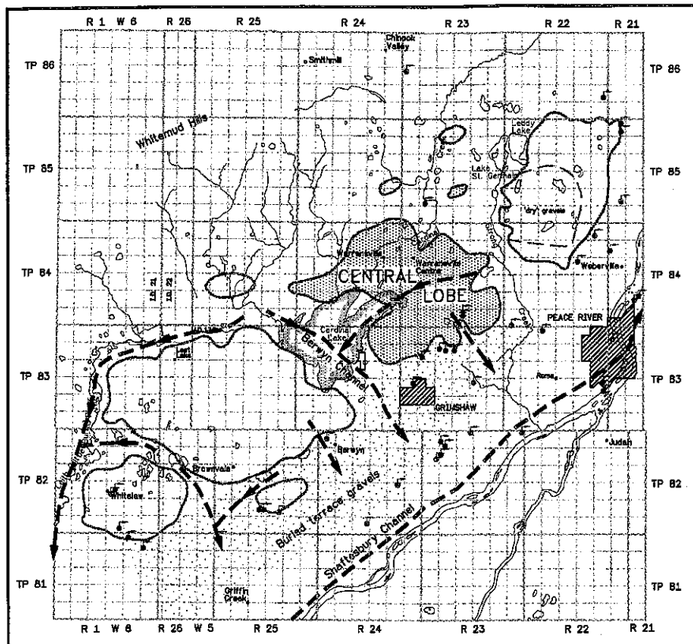
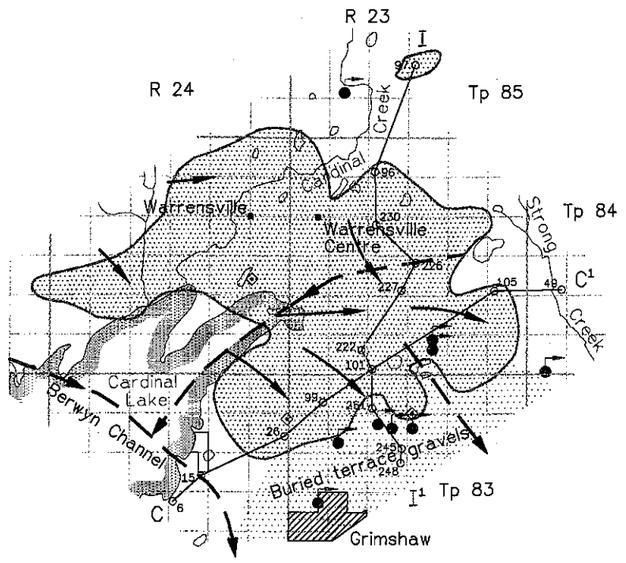
GRIMSHAW GRAVELS AQUIFER

SOUTHWEST LOBE

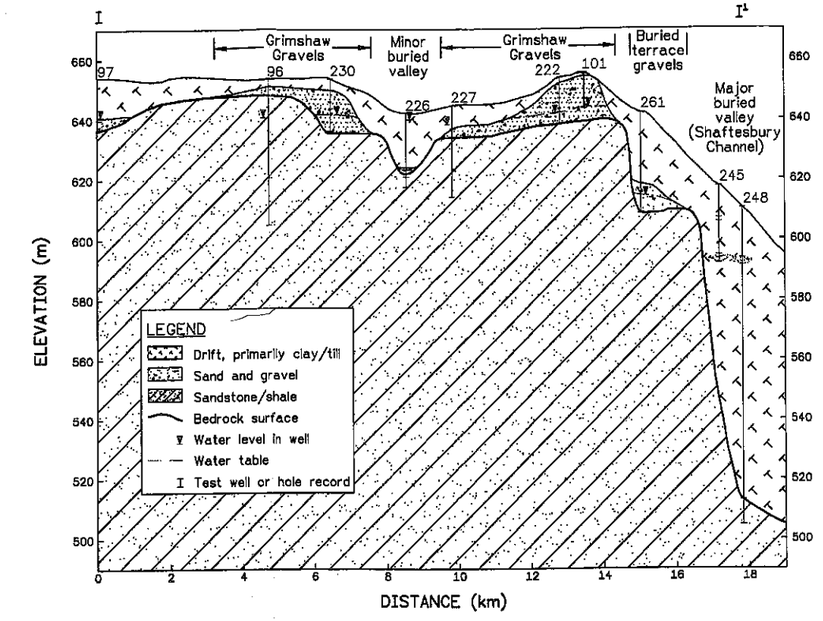
Scale	Date	PFRA No.	
AS SHOWN	JULY, 1996		FIGURE B2



LOCATION PLAN



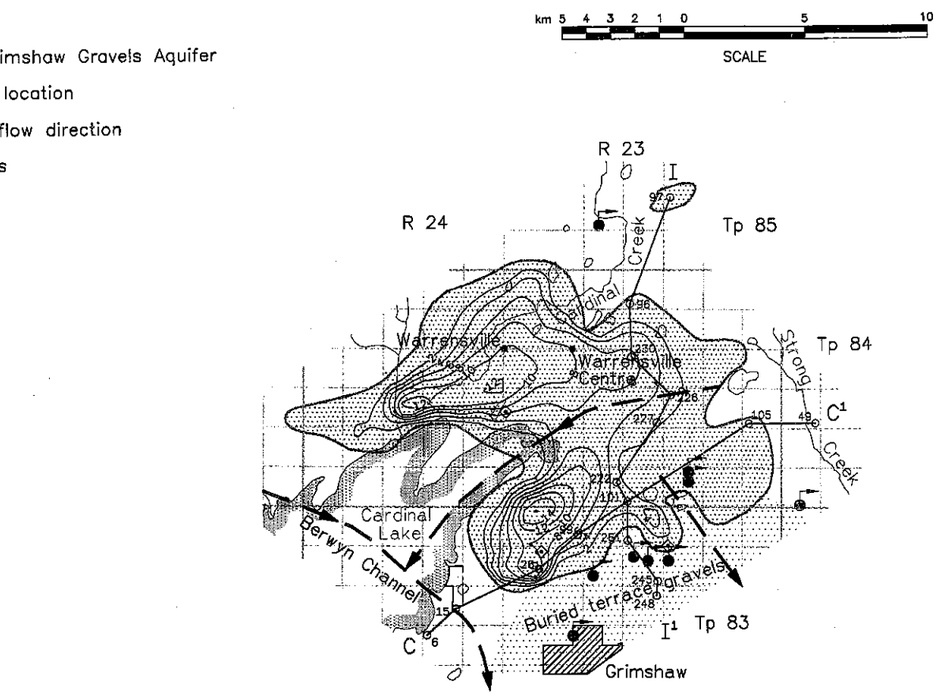
INTERPRETED GROUNDWATER FLOW DIRECTION



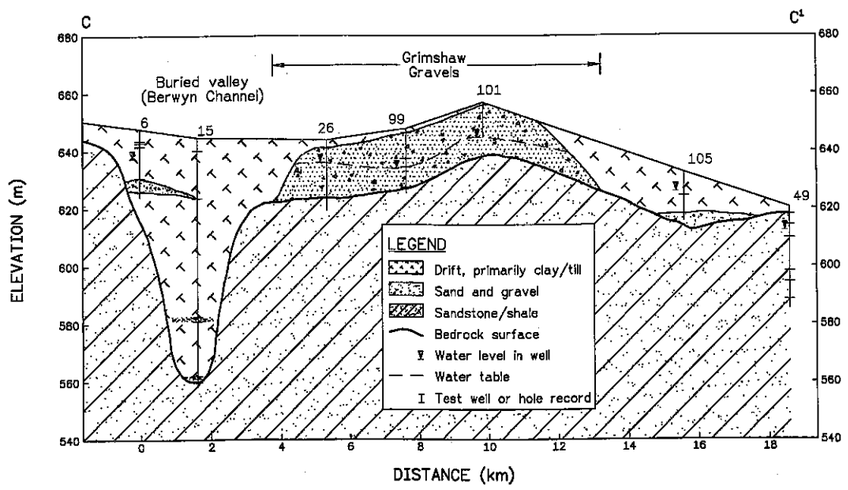
GEOLOGICAL CROSS SECTIONS

LEGEND

- Approximate extrent of Grimshaw Gravels Aquifer
- Approximate buried valley location
- Approximate groundwater flow direction
- Aquifer saturated thickness (Contour Interval = 2 m)
- Spring area
- Test hole/well site
- Municipal well



INTERPRETED SATURATED THICKNESS



Note: The shown preliminary maps and cross sections were prepared from selected drillers' logs filed with the Alberta Environmental Protection Groundwater Information Centre (GIC) to June 1995. Considerable geological interpretation was required to prepare these figures and additional test drilling and/or field surveying would be required to confirm that the geological conditions, groundwater levels and flow directions are as shown.

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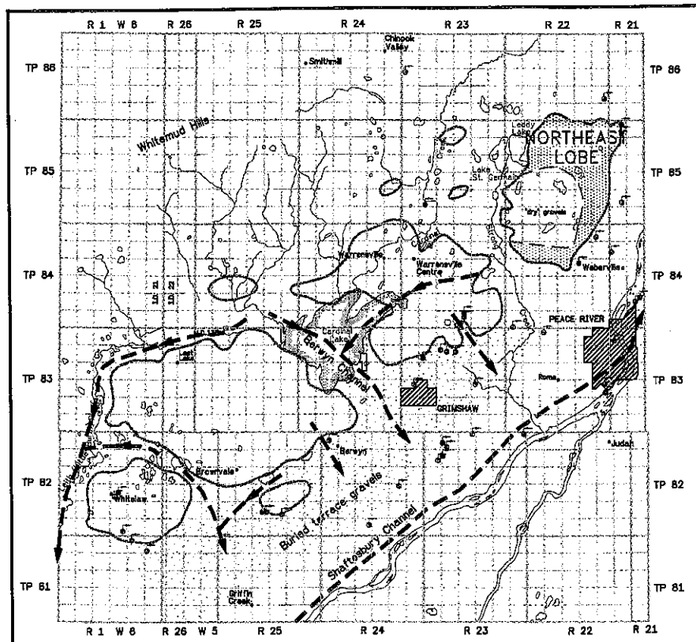
GRIMSHAW GRAVELS AQUIFER

CENTRAL LOBE

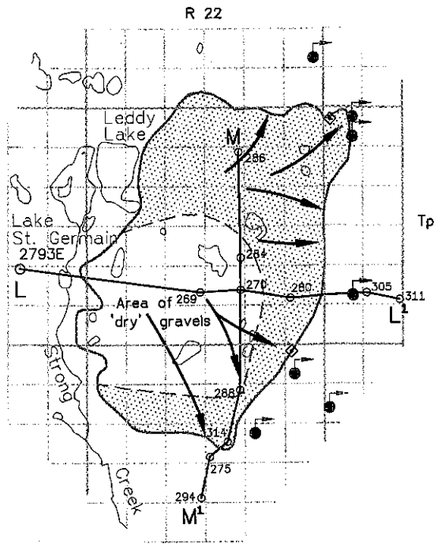
Scale	Date	PFRA No.	
AS SHOWN	JULY, 1996		FIGURE B3



LOCATION PLAN

LEGEND

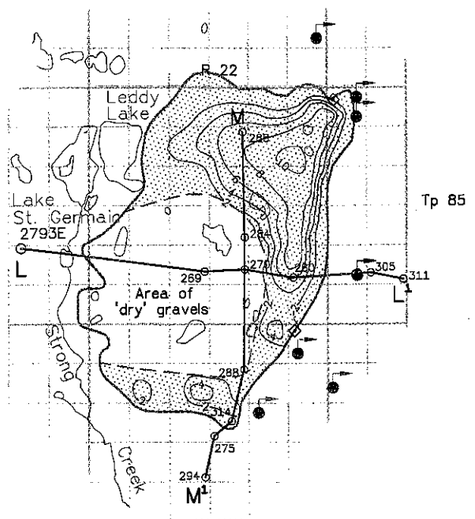
- Approximate extent of Grimshaw gravels Aquifer
- Approximate groundwater flow direction
- Spring area
- Aquifer saturated thickness (Contour interval = 2 m)
- Approximate buried valley location
- 184 Test hole/well site
- Municipal well
- 2793E 1994 Test drilling program



INTERPRETED GROUNDWATER FLOW DIRECTION

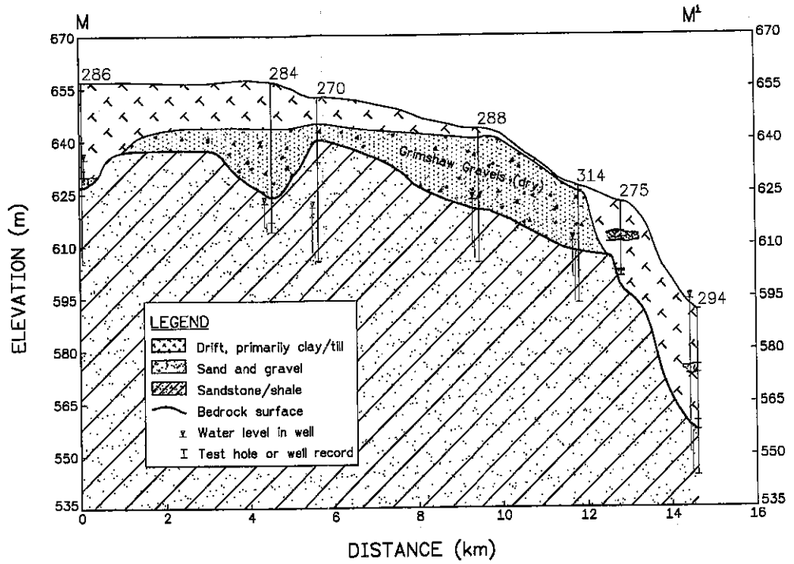
km 5 4 3 2 1 0 5 10

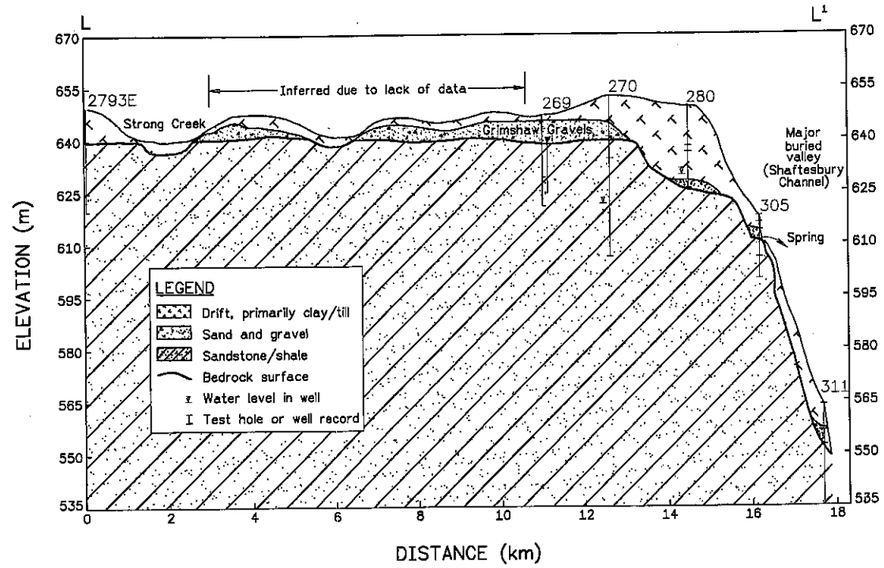
SCALE



INTERPRETED SATURATED THICKNESS

GEOLOGICAL CROSS SECTIONS





Note: The shown preliminary maps and cross sections were prepared from selected drillers' logs filed with the Alberta Environmental Protection Groundwater Information Centre (GIC) to June 1995. Considerable geological interpretation was required to prepare these figures and additional test drilling and/or field surveying would be required to confirm that the geological conditions, groundwater levels and flow directions are as shown.

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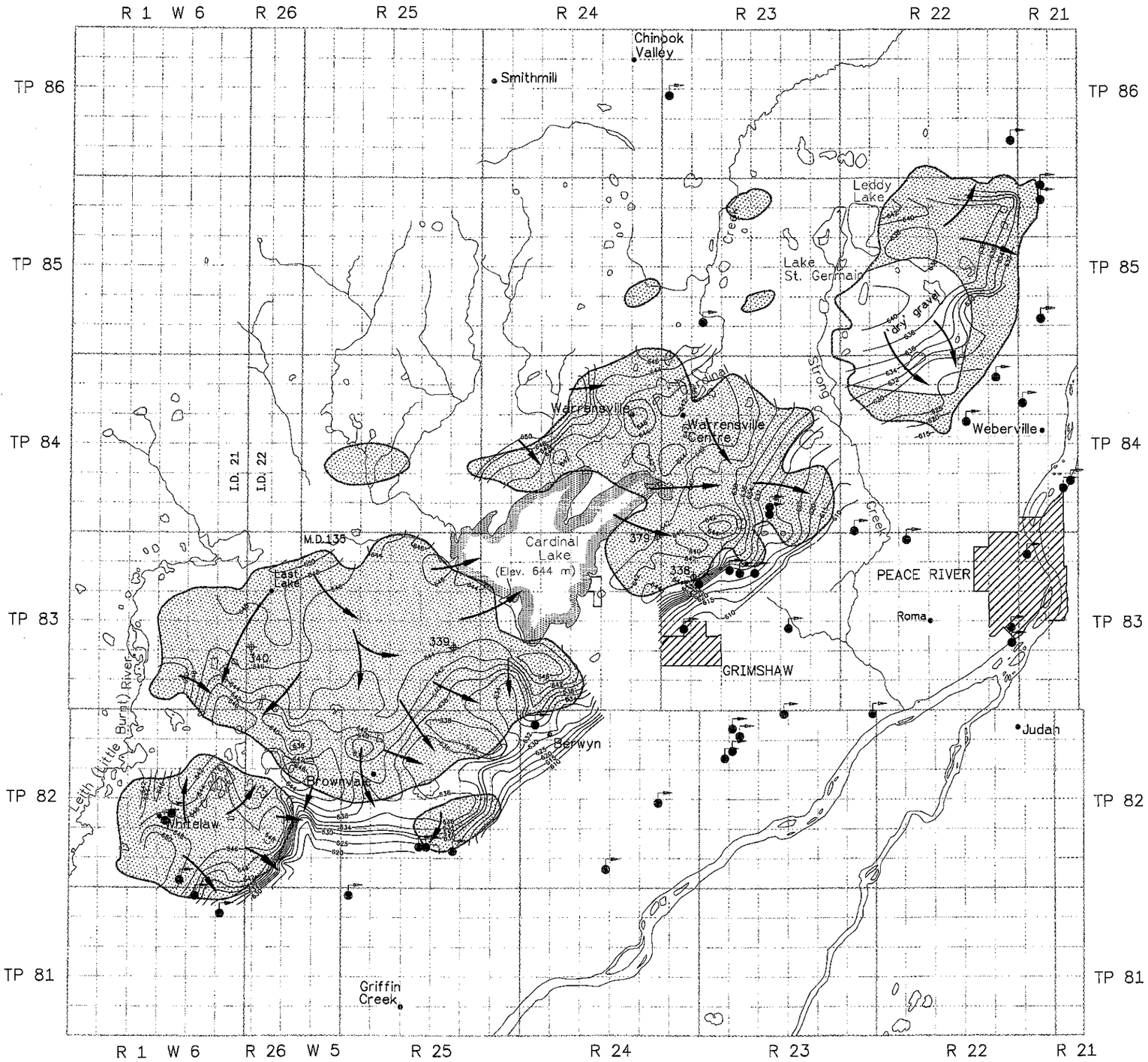
GRIMSHAW GRAVELS AQUIFER

NORTHEAST LOBE

Scale	Date	PFRA No.	
AS SHOWN	JULY, 1996		FIGURE B4



How to use this figure:

This figure shows the general interpreted water table elevations as well as interpreted groundwater flow directions. In some areas such as the north half of the central lobe, reported water table elevations vary substantially from well to well. In these areas, substantial interpretation was required to "guess" which flow directions appeared most likely.

Data used to prepare figure

This figure was prepared from geological interpretation of selected drillers' logs filed with the Alberta Environmental Protection Groundwater Information Centre (GIC) to June 1995. The surveying of ground elevation at the location of an additional 100 or so existing wells that have reported water levels is required to confirm the interpreted groundwater flow patterns.

LEGEND

- Approximate extent of Grimshaw Gravels Aquifer
- 640 Water table elevation contours (metres)
- Apparent groundwater flow directions
- Springs
- 379 Alberta Environmental Protection observation well

km 5 4 3 2 1 0 5 10 15 km

SCALE

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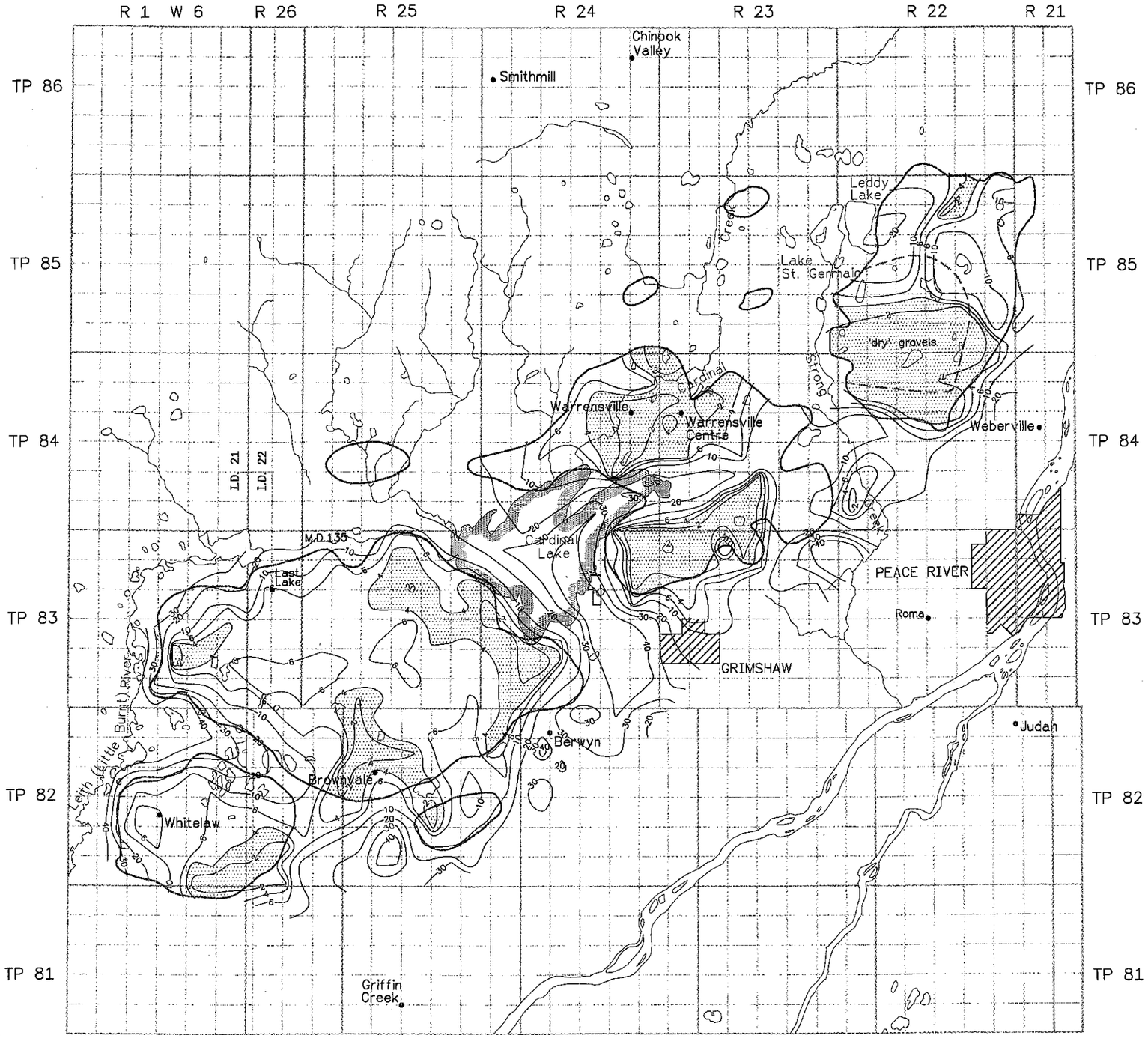
GRIMSHAW GRAVELS AQUIFER

WATER TABLE ELEVATION CONTOUR MAP

Scale	Date	PFRA No.	
AS SHOWN	JULY, 1996		FIGURE B5



How to use this figure:

This figure can be used as an initial guide for the assessment of the vulnerability of the Grimshaw Aquifer to groundwater contamination. Protection of the aquifer from potential contamination is generally dependent on the thickness and permeability of drift cover. Drift is generally referred to as unconsolidated glacial material deposited directly on the land surface. This material usually consists of silty to sandy clay. However, silt and sand lenses may be present.

This figure provides a general indication of where the more vulnerable areas are situated. Areas where the drift less than 4 metres thick are the most vulnerable to potential groundwater contamination.

Site–specific drilling and assessment by a qualified hydrogeologist would be required to confirm site suitability at specific locations.

Data used to prepare figure

This figure was prepared from geological interpretation of selected drillers' logs filed with the Alberta Environmental Protection Groundwater Information Centre (GIC) to June 1995.

LEGEND

- Approximate extent of Grimshaw Gravels Aquifer
- —4— Contour showing depth to clay cover
- Areas vulnerable to contamination: extent of clay cover less than or equal to 4 metres

Contour interval: 2,4,6,10,20,30,40 m

km 5 4 3 2 1 0 5 10 15 km

SCALE

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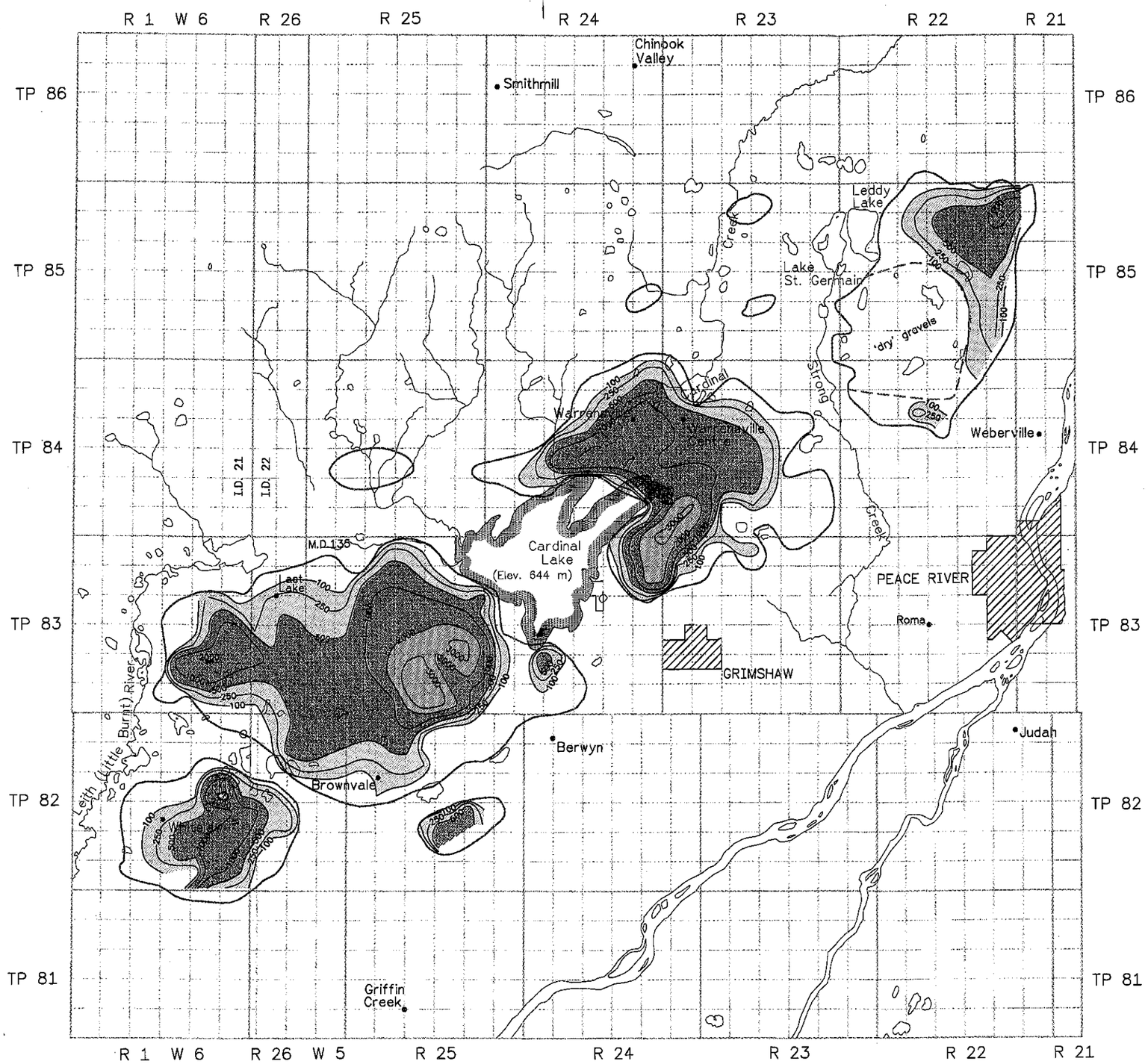
GRIMSHAW GRAVELS AQUIFER

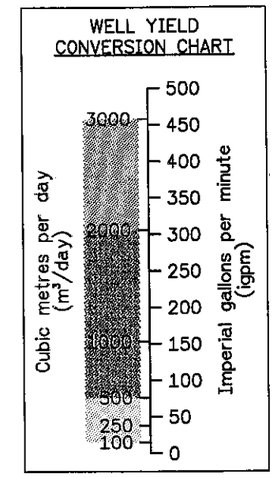
PRELIMINARY DRIFT COVER MAP

Scale	Date	PFRA No.	
AS SHOWN	JULY, 1996		FIGURE B6



POTENTIAL WELL YIELD

Potential well yield at a location depends on local aquifer conditions and on well construction methods. Based on the available water well data, the adjacent figure illustrates the potential well yield that may be possible at locations on the Grimshaw Gravels Aquifer.



LEGEND

- Approximate extent of Grimshaw Gravels Aquifer
- Potential well yield

Contour interval: 100, 250, 500, 1000, 2000, 3000 m³/day

km 5 4 3 2 1 0 5 10 15 km

SCALE

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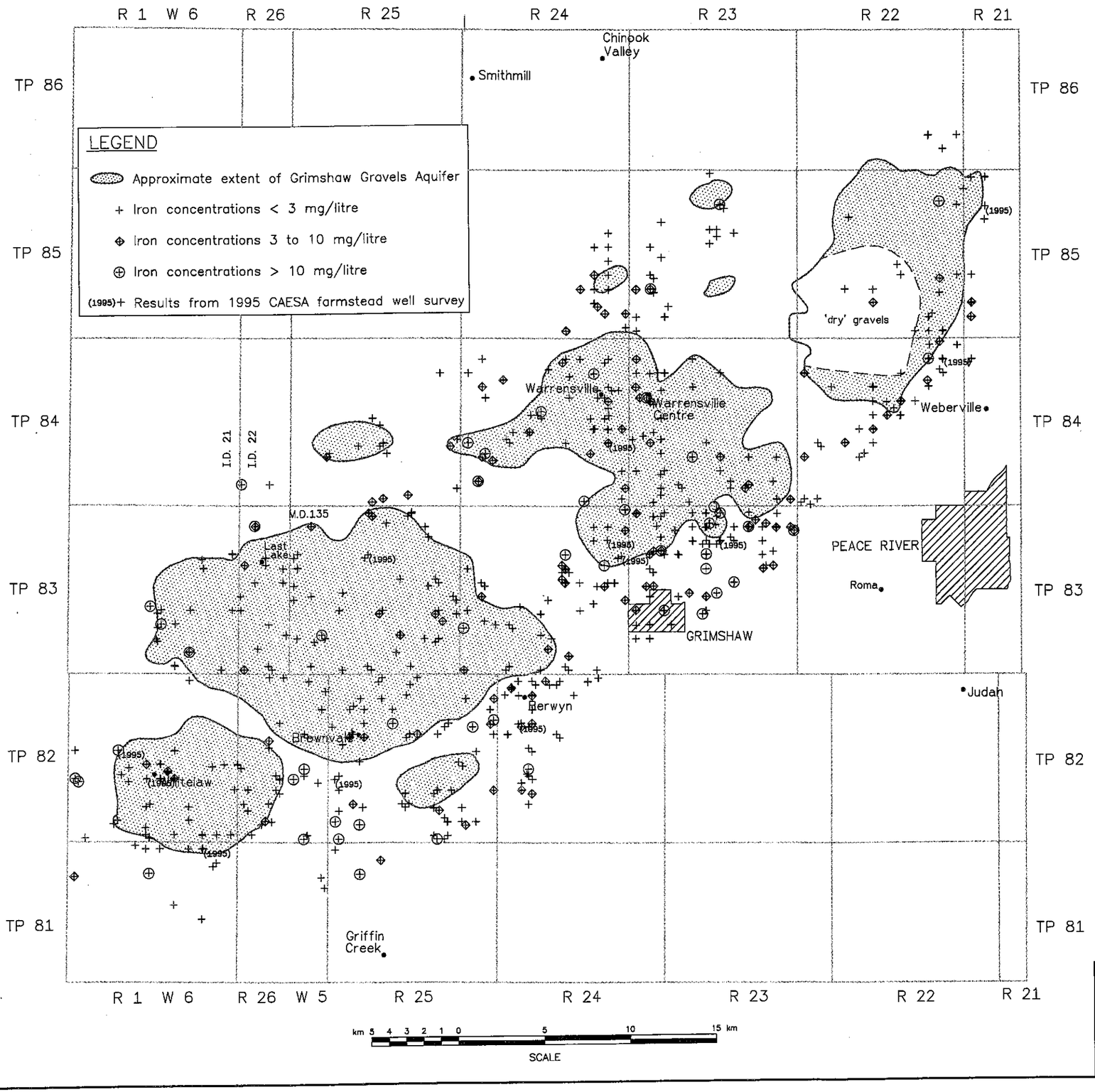
GRIMSHAW GRAVELS AQUIFER

POTENTIAL WELL YIELD MAP

Scale	Date	PFRA No.	
AS SHOWN	JULY, 1996		FIGURE B7



IRON

Background

Iron is one of the most common elements present in geological deposits, and almost all groundwater contains some iron. For domestic water supplies, the Canadian Drinking Water Guidelines recommend an iron concentration of no greater than 0.3 mg/L. Although iron does not constitute a health problem, iron concentrations greater than 0.3 mg/litre can stain laundry and plumbing fixtures, as well as impart an objectionable taste and colour to the water.

Iron concentrations, up to 3 mg/L, can generally be removed with conventional water softening equipment. Iron concentrations exceeding 3 mg/l require the use of special filters.

Current Situation

Assessment of iron levels is hampered by incomplete information on how the water was sampled. Water analyses carried out to date do not usually identify the precise point of sampling. A sample could have been taken directly from the well, from a tap, or after treatment. This information is important since iron can be added to water from metal parts within the distribution system (metal casings, pump parts, piping) or be removed by treatment components.

For the Grimshaw Gravels Aquifer, over 400 tests for iron have been conducted on both untreated and treated water. Recognizing the lack of information on how and where the water was sampled, about 80% of the samples tested had iron concentrations of less than 3 mg/L. The average reported iron concentration is about 0.4 mg/L. More precise sampling techniques are required to determine whether or not this represents a "true" average. The adjacent figure shows sample sites and test results for wells located both on and off the Grimshaw Gravels Aquifer. Iron concentrations of water samples taken during the 1995 CAESA farmstead water wells survey are identified with a '(1995)' subscript.

Management Considerations

A knowledge of regional iron levels can assist in locating potential well sites which may require little or no treatment for iron removal. Improved water sampling methods will assist in collecting reliable data. In order to measure accurate aquifer iron concentrations, the sample must be taken directly from the well. Standing water in the well must first be pumped out, before collecting the sample. A small quantity of acid should be added to the water sample to lower the pH. This will ensure that the iron does not precipitate or settle out, allowing for a reliable iron measurement. The 1995 CAESA farmstead water samples were collected in accordance with this procedure.

Source of Data: Alberta Environmental Protection Groundwater Information Centre Chemistry data file (to March, 1996).

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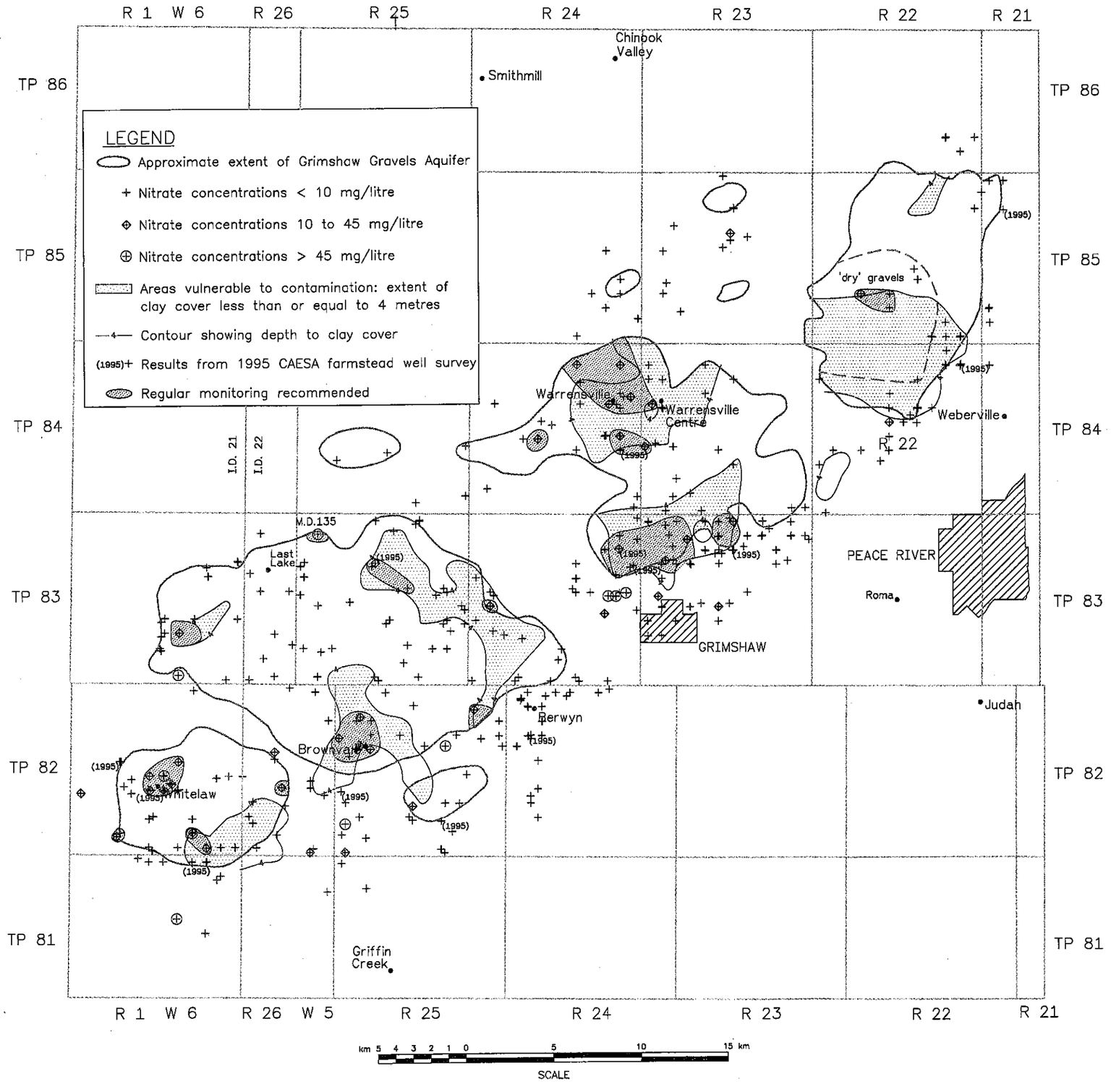
GRIMSHAW GRAVELS AQUIFER

WATER QUALITY MAP: IRON CONCENTRATION

Scale	Date	PFRA No.	
AS SHOWN	JULY, 1996		FIGURE B8



NITRATE

Background

Unlike most other minerals in groundwater, nitrate is not dissolved primarily from the minerals in geological deposits. Nitrate is leached downward into groundwater from sources, such as: a) surplus nitrogen fixed to soil by plants, such as alfalfa and legumes; b) animal wastes; c) fertilizers; d) sewage effluent from lagoons, septic fields, septic tanks, effluent irrigation; e) industrial waste chemicals. Elevated nitrate concentrations can occur from either direct discharge of contaminated surface water around a well or by natural infiltration by "contaminated" water into an aquifer.

The Canadian Drinking Water Guidelines recommend nitrate concentrations of less than than 45 mg/L. Concentrations higher than this are undesirable, since they may have a **toxic effect** on infants or young children. High nitrate concentrations can also be dangerous to people with low stomach acid levels. Cattle can be affected by concentrations of nitrate that exceed 100 mg/L. A high nitrate level should also be considered as a warning that harmful (pathogenic) bacteria may be present and testing should be carried out to assess this possibility.

Nitrate can only be removed by demineralization or distillation processes.

Current Situation

For the Grimshaw Aquifer, over 300 tests for nitrate have been carried out. Over 80% of all tests measured less than 5 mg/L. The average nitrate concentration is about 0.6 mg/L. In general, elevated nitrate levels appear to coincide with areas of reduced clay cover. Reported incidences of nitrate concentrations are shown on the adjacent figure, which includes all historical nitrate levels. However, more recent tests from the same well may indicate lower levels. This figure includes tests taken both on and off the Grimshaw Gravels Aquifer. Samples of higher nitrate concentration, as identified in the 1995 farmstead well water quality survey, are identified with a '(1995)' subscript.

Management Considerations

Sites with elevated nitrate levels represent areas that are more sensitive to groundwater contamination. In these areas, an increased level of care is required to ensure contamination does not occur. These areas should be regularly monitored to determine if nitrate levels are above the acceptable standard, and whether they are increasing or decreasing.

Source of Data: Alberta Environmental Protection Groundwater Information Centre Chemistry data file (to March, 1996).

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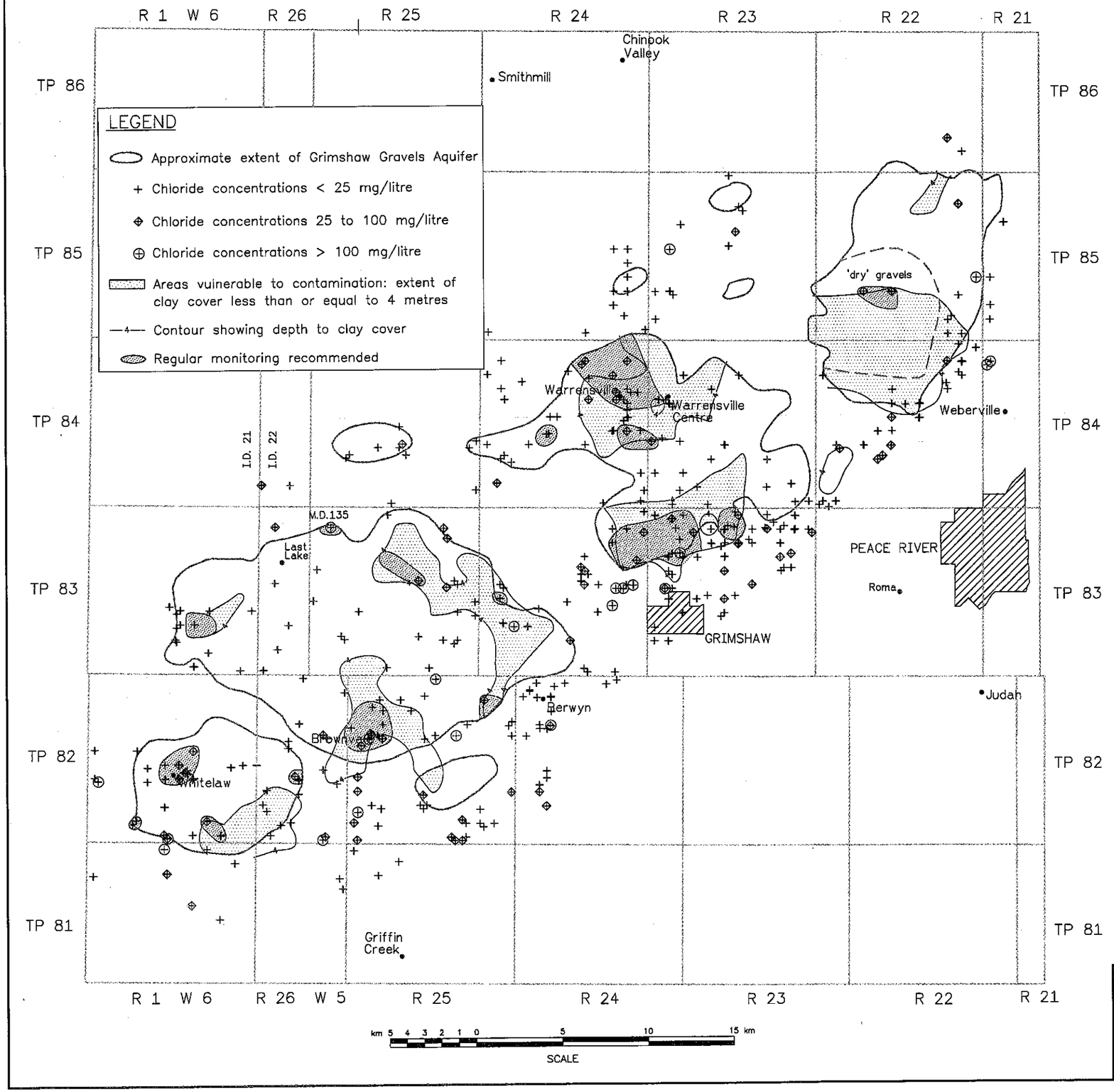
GRIMSHAW GRAVELS AQUIFER

WATER QUALITY MAP: NITRATE CONCENTRATION

Scale	Date	PFRA No.	
AS SHOWN	JULY, 1996		FIGURE B9



CHLORIDE

Background

Chloride in groundwater generally originates from two main sources: a) dissolution of salts in geological deposits, such as marine shales or near-shore siltstones or sandstones; or b) downward leaching of near-surface contaminants into groundwater, such as from landfills, sewage, or road salts.

The Canadian Drinking Water Guidelines recommend chloride concentrations of less than 250 mg/L. While not unhealthy, chloride concentrations greater than 250 mg/L can impart an objectionable taste to water.

Current Situation

For the Grimshaw Aquifer, over 325 tests for chloride have been carried out. Over 80% of all tests measured less than 20 mg/L. The average chloride concentration is about 5 mg/L. In general, the higher chloride levels coincide with wells completed in either buried valley or bedrock aquifers, or areas of reduced clay cover. The approximate test results and location of wells where samples were tested for chloride are shown on the adjacent figure. This figure includes tests taken both on and off the Grimshaw Gravels Aquifer.

Management Considerations

Elevated chloride levels may be the first sign of possible contamination. An increase in chloride levels may occur from upward migration of groundwater from underlying aquifers, or from surface sources of contamination. Often elevated nitrate levels together with elevated chloride levels is a more positive indication of groundwater contamination than the presence of nitrate alone. Areas where regular monitoring of chloride levels are recommended are shown on the attached figure.

Source of Data: Alberta Environmental Protection Groundwater Information Centre Chemistry data file (to March, 1996).

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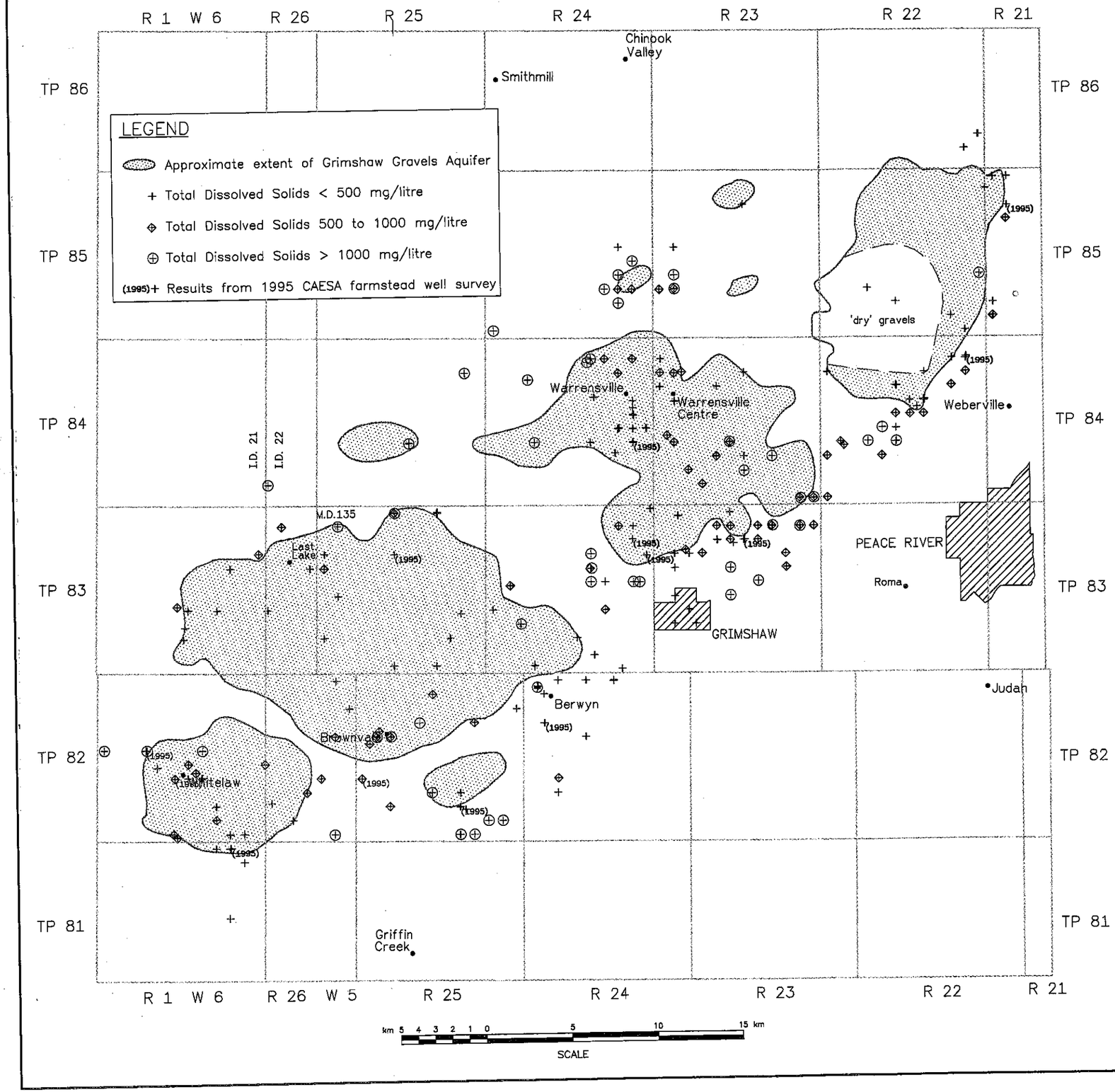
GRIMSHAW GRAVELS AQUIFER

WATER QUALITY MAP: CHLORIDE CONCENTRATION

Scale	Date	PFRA No.	
AS SHOWN	JULY, 1996		FIGURE B10



TOTAL DISSOLVED SOLIDS (TDS)

Background

Groundwater is not pure because it contains dissolved minerals. A chemical analysis of groundwater is required to determine the "quality" of groundwater sampled. Parameters such as hardness and iron concentrations, as well as other constituents such as chloride, sulphate, sodium, calcium and magnesium are measured. The type and amount of these dissolved minerals can affect the usefulness of groundwater.
If certain minerals are present in excessive amounts, water quality problems can occur. These include an objectionable taste or colour, laxative effects, excessive hardness, or encrustation and corrosion of the well and components of the distribution system.

The total amount of all constituents is expressed as total dissolved solids (TDS). TDS will vary depending on the route and rate at which groundwater moves through geological deposits. For drinking water, the Canadian Drinking Water Guidelines recommend a TDS of less than 500 mg/L. While higher levels are not necessarily unhealthy, some additional treatment would generally be recommended. In Alberta, TDS levels over 1000 mg/L are considered high.

Current Situation

For the Grimshaw Aquifer, the amount of total dissolved solids, in submitted groundwater samples, has been calculated for over 180 samples. TDS typically ranges from less than 400 to 600 mg/L, with over 80% of all tests reporting less than 600 mg/L. In general, higher TDS values were noted for wells completed partially or completely in bedrock strata or in the buried valleys that divide the Grimshaw Gravels Aquifer into separate lobes. Reported TDS values are shown on the adjacent figure. This figure includes tests taken both on and off the Grimshaw Gravels Aquifer. TDS concentrations, as identified in the 1995 CAESA farmstead water well survey, are identified with a '(1995)' subscript.

Management Considersations

The total dissolved solids for groundwater within the Grimshaw Gravels Aquifer is generally considered to be excellent. However, a water analysis is still recommended at sites considered for well development to determine if any type treatment would be required. Areas on the aquifer where elevated levels of TDS occur may be an indication that: the water quality in the aquifer is being influenced by the underlying bedrock deposits or the well is located in an isolated "pocket" of gravel.

Source of Data: Alberta Environmental Protection Groundwater Information Centre Chemistry data file (to March, 1996).

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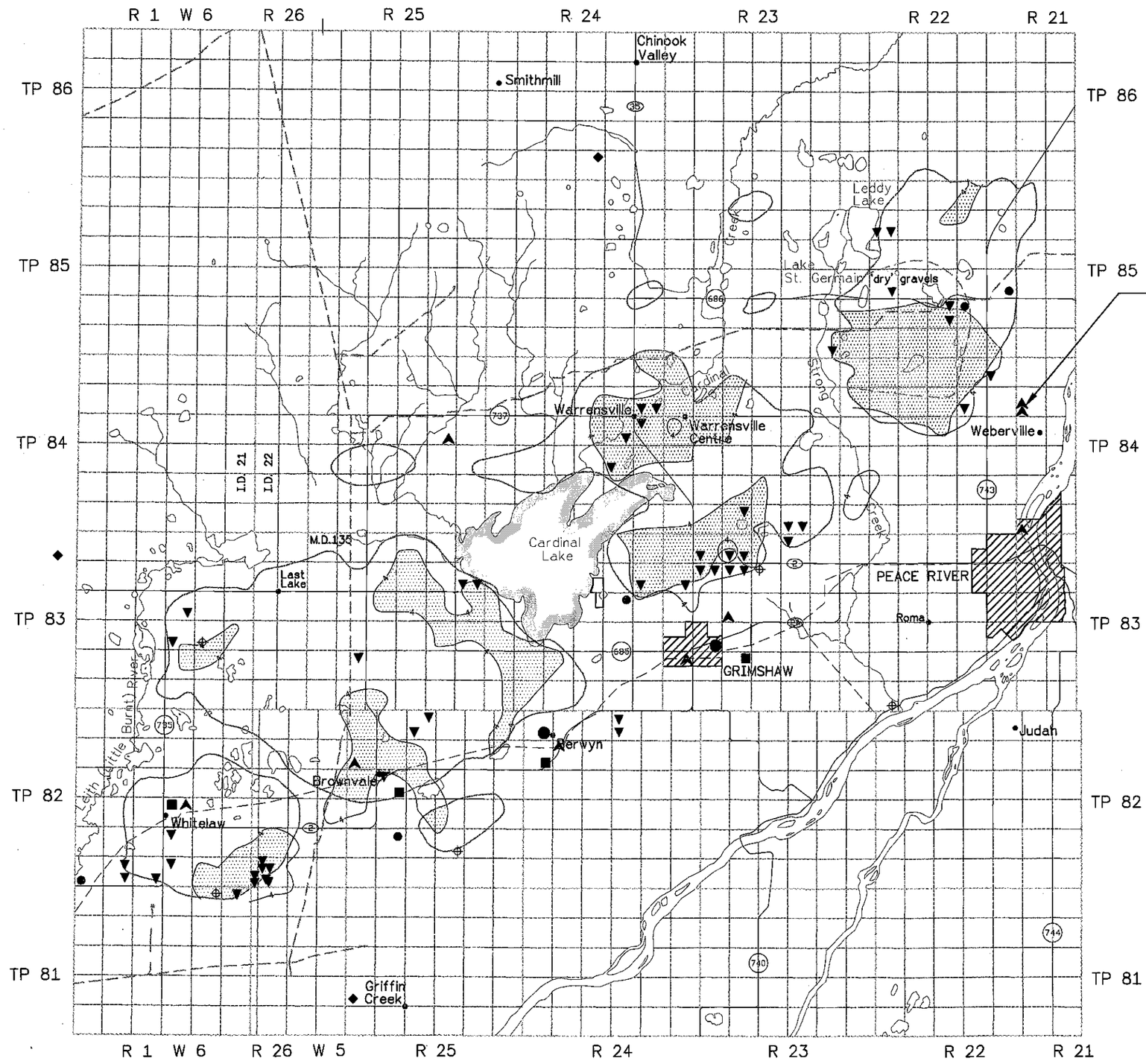
GRIMSHAW GRAVELS AQUIFER

WATER QUALITY MAP: TOTAL DISSOLVED SOLIDS

Scale	Date	PFRA No.	
AS SHOWN	JULY, 1996		FIGURE B11



How to use this figure:

Unless proper care is taken, point sources which may potentially contaminate groundwater include: waste disposal sites; chemical or fuel storage sites; sewage lagoons; oil or gas pipelines; oil, gas, or water wells; feedlots; accidental spill sites along roads, in farmyards, etc. Since the Grimshaw Aquifer is predominantly an unconfined aquifer, it is vulnerable to contamination from these sources. The locations and types of some of the more prominent types of potential point contamination sources are shown on the adjacent figure. To give a preliminary indication of the level of protection against groundwater contamination, these potential contamination sources are shown along with the preliminary clay cover map. Additional field investigations and analysis, under the direction of a professional hydrogeologist, would be required to evaluate the contamination risk at any specific existing or proposed site.

This site is inactive as a modified landfill. It is still being used to store dry waste such as brush, car bodies, old appliances, building site waste, etc.

Data used to prepare figure

This figure was prepared from known potential source of contamination identified by Cowan (1994). The following sources were used to verify and add information in February 1998.

Fuel Tanks – Petroleum Tank Management Association of Alberta
– Tank Management Systems.

Gravel Pits – Alberta Environmental Protection
– Environmental Management System.
– Land Status Automated System
– Air Photo – review

Landfills – Peace Health Region

LEGEND

- Approximate extent of Grimshaw Gravels Aquifer
- Sewage lagoon
- 1 – 4 fuel storage tanks
- 5 – 53 fuel storage tanks
- Gravel pit
- Inactive landfill
- Active landfill
- Groundwater pesticide analysis site
- Areas vulnerable to contamination: extent of clay cover less than or equal to 4 metres
- —4— Contour showing depth to clay cover (metres)
- Primary and Secondary Paved Roads
- Northwestern Utilities Limited 3" and 4" diameter natural gas pipeline
- Gas Pipeline – NOVA Gas Transmission Ltd. transports sweet natural gas. Sweet refers to gas that contains no water, hydrogen sulfide, or hydrocarbon liquids.

Note: Fuel storage tanks on farms, for individual farm use and at isolated construction projects, are not required to be registered.

km 5 4 3 2 1 0 5 10 15 km
SCALE

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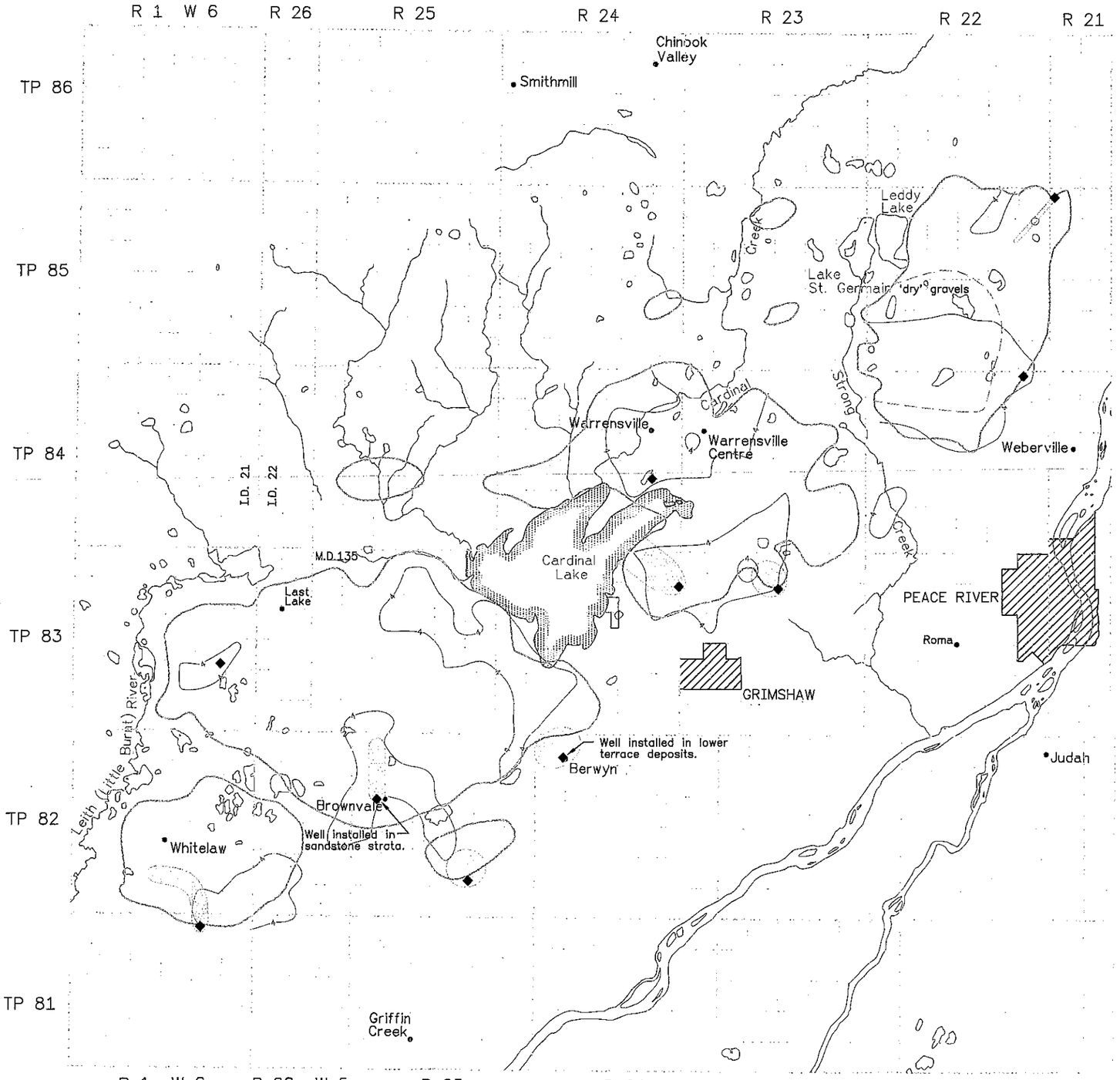
GRIMSHAW GRAVELS AQUIFER

POTENTIAL POINT SOURCES OF CONTAMINATION

Scale	Date	
AS SHOWN	July, 1996 Updated – March, 1998	FIGURE B12



How to use this figure:

A well capture zone is defined as the area that specifically contributes recharge water to a pumping well. Potential contaminants within the capture zone can move along the same flow paths as the recharge water to the well. Accordingly, these areas should be designated as wellhead protection areas with appropriate protective management practices put in place to prevent any contaminants from reaching the well.

Preliminary capture zones for the higher-use municipal wells are shown on the adjacent figure. All municipal wells are completed in the Grimshaw Gravels Aquifer except where shown otherwise. For municipal wells with average groundwater use less than 40 m^3/day (6 igpm), well capture zones are too small to be shown on a map of this scale.

These capture zones are preliminary only as our current knowledge of groundwater flow directions and local aquifer conditions is insufficient to more accurately define the capture zones. More detailed field investigations are required to confirm the 'final' well capture zone areas that should be used for each municipal well.

LEGEND

- Approximate extent of Grimshaw Gravels Aquifer
- ◆ Municipal well
- Preliminary well capture zones
- Areas vulnerable to contamination: extent of clay cover less than or equal to 4 metres
- —4— Contour showing depth to clay cover (metres)

km 5 4 3 2 1 0 5 10 15 km

SCALE

CAESA

Alberta Agriculture, Food and Rural Development
Alberta Environmental Protection

PFRA Prairie Farm Rehabilitation Administration
Earth Sciences Division

Agriculture Canada

GRIMSHAW GRAVELS AQUIFER

PRELIMINARY WELL CAPTURE ZONES

Scale	Date	PFRA No.	
AS SHOWN	JULY, 1996		FIGURE B13