Gore District Council
Groundwater Catchment Areas
Description & Delineation.

Gore District Council

May 1995

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Gore District Underground Water Sources;
Groundwater Catchment Areas;
Description and Delineation.

1.0 Introduction.

As part of District Resource and Strategic Planning it is necessary to delineate the groundwater catchments on which a number of Council bores and wells draw upon. These bores serve several public water supplies and rural water schemes operated by the Gore District Council.

Gore Public Water Supply:
Cooper's Wells bore field near Whiterigg,
Jacobstown bore field north of Gore

Gore Emergency Supply: Oldham Street well.

Otama Rural Water Scheme:
Pyramid Bridge bore on the Mataura River

Otikerama Rural Water Scheme:
Otikerama bore by the Mataura River on the Gore - Mataura River Road.

The Jacobstown and Cooper's Wells bore fields, and the Oldham Street well were developed by Gore Borough Council prior to amalgamation. The Otama and Otikerama rural water schemes were developed by Southland County Council. The Pyramid bridge bore lies just outside the Gore District boundary, the rest of the water supply sources are located in proximity to Gore.

All water supply sources tap unconfined gravel aquifers. Each source aquifer is subject to some degree of vulnerability to contamination. Unconfined gravel aquifers are inherently more vulnerable to contamination than other types of aquifers being deeper, or having lower flow velocities. Hence, a knowledge of the hydrogeology and groundwater hydrology of the source aquifer is necessary to plan for the protection and husbanding of clean groundwater supplies.
**Location:** On the true left hand bank of the Mataura River, between Whiterigg and Knapdale. Bores sited in farm land being Crown land as the former Mataura River bed. Grid Reference NZMS: P45 958:524

**Aquifer:** Coarse gravel and sand of the Mataura River flood plain.
- Permeability: between 150 and 400 metres per day.
- Effective Porosity: 0.19, measured in long duration pumping test.
- Mean flow velocity: 1.6 metres per day (darcian estimation).

**Bore / Wells:** Originally 2 steel cased bores (1979) Nos 1 & 2
- Third bore developed (1982?) and named No. 1
- 2" piezometer located 5 metres from No. 1 bore.
- All bores 1.2 metre diameter, fitted with submersible pumps.

**Well Head Protection:** Bore tops proud of ground level (50 cm)
- Neoprene sealed lids fitted.
- Clay pans tamped into ground surface to prevent localised surface contamination.
- Area (40 x 90 metres) fenced around No. 2 bore.
- Convenant on land title restricts spreading of contaminants in immediate area.

**Additional Well Head Protection Measures.**
Location: 1 kilometre north of Gore on true right hand bank of Mataura River. Adjacent access road to Fulton Hogan gravel extraction plant.
Grid Reference NZMS: F45 962:503

Aquifer: Coarse gravel and sand of the Mataura River flood plain.
Permeability: High, >100 m/d
Effective Porosity: Approximately 0.20 on lithology
Mean flow velocity:

Bore / Wells: Originally 3 concrete lined wells
Subsequent bores (2 & 6) developed in slotted steel
4" observation well located 50 metres NE from No. 4 well.

Well Head Protection: Steel bores proud of ground surface.

Water Source(s): Part adjacent Mataura River, part soil drainage off adjacent pasture (see maps).
Evidence: Hydrochemistry & geology.
Physical Setting & Well Head Protection Area; Jacobstown Bore Field.
Location: On the true left hand bank of the Mataura River opposite the Gore sewage oxidation ponds. Access from the Gore - Mataura River Road.
Grid Reference NZMS: F45 964:463

Aquifer: Coarse gravel and sand of the Mataura River flood plain.
Permeability: High, >100 m/d
Effective Porosity: Approximately 0.20 on lithology

Bore: One 1.2 metre diameter steel bore.
Two submersible pumps mounted inside bore.

Well Head Protection: Steel bore proud of ground surface.
Hinged lock in place over lid.

Water Source: Seepage from adjacent Mataura River.
Evidence: Hydrochemistry & geology.
Physical Setting & Well Head Protection Area; Otikerama Scheme.
Otama / Pyramid Bridge Rural Water Scheme.

Location: Adjacent to the Pyramid bridge on the true right hand bank of the Mataura River.
Grid Reference NZMS: F45 851:692

Aquifer: Coarse gravel and sand of the Mataura River flood plain.
Permeability: High, >100 m/d
Effective Porosity: Approximately 0.20 on lithology
Mean flow velocity:

Bore: One 1.2 metre diameter steel bore.
Centrifugal surface pump mounted in pump house.

Well Head Protection: Steel bore lid sealed with neoprene.

Water Source: Seepage from adjacent Mataura River.
Evidence: Hydrochemistry.
Location: In the Gore District Council's yard in Oldham St. Situated 200 metres from the true right hand bank of the Mataura River.
Grid Reference NZMS: F45 965:483

Aquifer: Coarse gravel and sand of the Mataura River flood plain.
Permeability: High, >100 m/d
Effective Porosity: Approximately 0.20 on lithology

Well: One 1.5 metre diameter concrete well.
One surface centrifugal pump mounted alongside wellhead.

Well Head Protection: Surface drainage prevented from entering well by locked shed.

Water Source: Infiltration from Gore urban area.
Evidence: Hydrochemistry.
2.0 Investigations into Groundwater Supplies.

2.1 Field Investigations.

Field visits were made to each of the points of raw water supply from the ground. In addition, previous extensive investigations into contamination potential and capture zone delineation had been undertaken for the Cooper's Wells (Rekker, 1994; and Rekker, 1995).

Observations were backed up by sampling of adjacent groundwater and surface water. At the Jacobstown borefield land surveying of bore water levels and water levels in the nearby Mataura River was undertaken to estimate groundwater flow pattern.

In most cases, the results of analyses for the groundwater samples proved to be the most useful means of determining groundwater source. Basement rock geology was used at Otikerama, Jacobstown and Pyramid Bridge to constrain the potential capture zone.

2.2 Analyses.

Water samples taken from the bore water supplies, adjacent bores and nearby surface water sources were analyzed for a list of conservative tracers also indicative of pollution of groundwater.

- pH
- Electrical Conductivity
- Alkalinity
- Chloride
- Nitrate nitrogen
- Ammoniacal nitrogen

The similarity to potential water sources was assessed as were possible in situ transformations which could take place between the entry of the water to the aquifer and extraction at the bore or well.

Mass balances of the groundwater and potential sources were also undertaken.

2.3 Land Surveying.

Using the principal that water is not likely to flow up-gradient, comparisons were made of the static water levels of the bores or wells with adjacent water bodies. Estimates of river gradient and probable groundwater gradient were also made.
3.0 Investigation Findings.

3.1 Cooper's Wells.

Cooper's Wells are two large diameter steel bores equipped with large submersible pumps and connected to the East Gore reservoir by a buried pipeline. They draw on a thin gravel aquifer having a static water level about 3 metres below ground level. Nominal discharge is about 60 litres per second. The potential for the water quality to be affected by a change to dairy land use was assessed in 1994. This involved pumping tests, groundwater flow modelling, drilling of 24 piezometers, contouring of water table elevation, sampling of ground- and surface waters, and delineation of the waters contributing to the Cooper's Wells bore field.

Consequently, there has been a great deal of information uncovered on the bore field and the aquifer feeding it.

The information sheet covers much of the well head protection measures that are now in place for the Cooper's Wells bore field. They include identification of the soil drainage capture zone, identification of the Gold Creek contribution to groundwater drawn at Cooper's Wells, controls on dairy shed effluent spreading within the capture zone and monitoring of both land use and water quality in the Gold Creek catchment.

3.2 Jacobstown Bore Field.

The Jacobstown bore field is a collection of two wells and one bore drawing on a thin gravel aquifer. The nominal discharge of these sources combined is about 23 litres per second. A two-storied building houses a disused well and electrical controls for the pumping equipment. Water is pumped to the Croydon Reservoir above Gore.

An initial visit was made to Jacobstown in January 1994. Measurements were made of the depth and static water level in the 6 wells and bore at the Jacobstown bore field. Subsequently, the bore field was visited in late April 1995. Further measurements of water level and samples were taken. A survey of the basement rock geology was undertaken and records of gravel extraction in the area were accessed.

The information sheet shows the basic data for the bore field. Drilling information suggests that drilling was pursued through the Quaternary gravels until the "rotten rock" of the underlying lignite and greywacke basement. The depth of the gravels are quite variable as can be seen in table 3.1 below.
<table>
<thead>
<tr>
<th>Bore / Well</th>
<th>Total Depth (m) w.r.t ground level</th>
<th>Static Water Level (m MSL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1</td>
<td>8.55</td>
<td>-</td>
</tr>
<tr>
<td>No. 2</td>
<td>6.86 (Base elevation 67.7 m MSL)</td>
<td>-</td>
</tr>
<tr>
<td>No. 3</td>
<td>12.1 (Base Elevation 63.08 m MSL)</td>
<td>69.91</td>
</tr>
<tr>
<td>Crusher well</td>
<td>8.25 (Base elevation 66.08 m MSL)</td>
<td>70.91</td>
</tr>
<tr>
<td>Observation well</td>
<td>9.00 (Bottom elevation 63.76 m MSL)</td>
<td>69.77</td>
</tr>
</tbody>
</table>

The thickness of the gravels corrected from total depth would appear to have some degree of relief over short distances. The base of the gravels appears to deepen in the north of the bore field. Information and photographs of past gravel extraction in the area shows that there is a buried lignite seam reef just below ground level only ten metres south of number's 5 and 6 wells. Several similar lignite seam reefs were observed in the bed of the Mataura River which was at very low flow at the time. Staff from Fulton Hogan Ltd's gravel pit commented that these lignite seam outcrops exerted much control over the depth of gravels available for gravel extraction.

A bluff about 150 metres to the west from the bore field is composed of the basement greywacke rock. Bore field operators commented that the bore closest to this bluff (bore No. 2) tended to drawdown considerably more than the others leading to the water level dropping below the pump intake. Re-development had failed to correct this problem. The presence of an impermeable barrier to groundwater flow on one side is probably responsible for this.

In view of the geological constraints on groundwater flow, there would seem to be little alternative to the capture zone for the Jacobstoun bore field being located to the north.

A sample of Jacobstoun groundwater was taken and analyzed. It can be compared with the water chemistry of the Mataura River in table 3.2 below.
### Table: Constituent Comparisons

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Jacobstown groundwater (brackets: mass in 2,000 m³/d drawn by bores)</th>
<th>Mataura River water (brackets: mass in 2,000 m³/d drawn by bores)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.09</td>
<td>8.02</td>
</tr>
<tr>
<td>Electrical Conductivity (µS/cm)</td>
<td>146</td>
<td>76</td>
</tr>
<tr>
<td>Chloride (g/m³)</td>
<td>10 (20 kg/d)</td>
<td>5 (10 kg/d)</td>
</tr>
<tr>
<td>Alkalinity (g/m³)</td>
<td>46</td>
<td>26</td>
</tr>
<tr>
<td>Nitrate nitrogen (g/m³)</td>
<td>1.17 (2.3 kg/d)</td>
<td>0.58 (1.15 kg/d)</td>
</tr>
<tr>
<td>Ammoniacal nitrogen (g/m³)</td>
<td>0.022</td>
<td>0.011</td>
</tr>
</tbody>
</table>

Comparing the Jacobstown groundwater with groundwater chemistry from other bore it is apparent that the Jacobstown groundwater is not typical of most groundwaters in unconfined aquifers of the area. Typical groundwater compositions of this type are:

<table>
<thead>
<tr>
<th>pH</th>
<th>5 - 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Cond.</td>
<td>250</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>60</td>
</tr>
<tr>
<td>Chloride</td>
<td>25</td>
</tr>
<tr>
<td>Nitrate-N</td>
<td>4</td>
</tr>
<tr>
<td>Ammonia-N</td>
<td>0.01</td>
</tr>
</tbody>
</table>

The pasture north of the Jacobstown borefield is under dairy grazing. The low nitrate nitrogen concentration of 1.17 g/m³ is not consistent with groundwater beneath such dairying land. The water chemistry is strongly suggestive of groundwater drawn at Jacobstown being a mixture of Mataura River water with minor amounts of native groundwater.

In order to determine the proportion of this mixture a mass balance is shown below

\[ \Delta C = \frac{M}{Q} \]

Where:
- \( \Delta C \) = Change in concentration (g/m³)
- M = Mass of constituent (kg/d)
- Q = Quantity of diluting water (m³/d)
- \( \Delta M \) = Change in mass of constituent (kg/d)
  (from river water to groundwater)
\[ M_{\text{Cl}} = 10 \text{ kg/d} \]
\[ \Delta M_{\text{Cl}} = 5 \text{ kg/d} \]
\[ Q = \Delta M_{\text{Cl}} / C \]
\[ = 5,000 \text{ gCl}^- / 25 \text{ gCl}^- / \text{m}^3 \]
\[ = 200 \text{ m}^3/\text{d} \]
\[ M_{\text{NO}_3} = 2.3 \text{ kg/d} \]
\[ \Delta M_{\text{NO}_3} = 1.14 \text{ kg/d} \]
\[ Q = \Delta M_{\text{Cl}} / C \]
\[ = 1140 \text{ gNO}_3\text{-N} / 4 \text{ gNO}_3\text{-N} \]
\[ = 285 \text{ m}^3/\text{d} \]

Both the mass balances for chloride and nitrate nitrogen place the quantity of native groundwater mixing with Mataura River water at between 200 and 300 cubic metres per day out of a total 2,000 cubic metres per day drawn at Jacobstown. If the soil drainage / infiltration rate to groundwater is of the order of 10 cubic metres per hectare, then the land-based capture zone is between 20 to 30 hectares in extent.

\[ \text{Extent of Capture Zone} = Q / q \]
\[ = 300 \text{ m}^3/\text{d} / 10 \text{ m}^3/\text{d/ha} \]
\[ = 30 \text{ ha} \]

The information sheet for Jacobstown bore field shows the position of the capture zone and the reach of the Mataura River which infiltrates into the gravels to be drawn at the bore field.

3.3 Pyramid Bridge Bore.

The Pyramid Bridge bore supplies the Otama Rural Water Scheme. The bore and pump house lie on the western abutment of the bridge crossing the Mataura River at Pyramid. The bore lies about 100 metres from the bank of the Mataura River.

The bore is 8.1 metres deep with a static water level at about 1.9 metres below ground level. The bore operator commented that the level in the bore correlated strongly with the river level.
Samples were taken from the bore and from the adjacent Mataura River. A further sample was taken from a farm house located on the flood plain about 400 metres to the west. Table 3.4 shows the results of analysis.

<table>
<thead>
<tr>
<th>Constituent (sampled 27/4/95)</th>
<th>Pyramid bore</th>
<th>Mataura River</th>
<th>Farm bore</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.43</td>
<td>7.16</td>
<td>6.44</td>
</tr>
<tr>
<td>Electrical Cond</td>
<td>77</td>
<td>60</td>
<td>76</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>29</td>
<td>23</td>
<td>29</td>
</tr>
<tr>
<td>Chloride</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Nitrate-N</td>
<td>0.81</td>
<td>0.53</td>
<td>0.75</td>
</tr>
<tr>
<td>Ammonia-N</td>
<td>0.006</td>
<td>0.008</td>
<td>0.11</td>
</tr>
</tbody>
</table>

The similarity shown in all samples suggests the Mataura River as the source of both groundwaters. The groundwaters at Pyramid are certainly quite dissimilar to groundwaters replenished from soil drainage.

On the basis of water chemistry the Pyramid Bridge bore is found to be drawing on water replenished by infiltration from the Mataura River upstream of the Pyramid Bridge. Only minor quantities of soil drainage shows an influence in the measured groundwater chemistry. The inferred capture zone extending to the source Mataura River is shown on the information sheet for the Pyramid Bore.

3.4 Otikerama Bore.

The Otikerama bore adjacent to the Gore - Mataura River Road supplies the Otikerama Rural Water Scheme. The bore lies approximately 100 metres from the Mataura River.

The bore is about 7.8 metres deep with a static water level of 3.43 metres below the bore collar. The bore water level drops approximately 1 metre when the pump is on.

The Otikerama bore is sited on the flood plain of the Mataura River at an elevation of about 67.9 metres above mean sea level. Basement greywacke rocks crop out of the bed of the river and in the hill side to the east of the bore. The bore is drilled into a gravel beach between the river and the hills. Any land-based replenishment of groundwater between these boundaries would be restricted to infiltration through the surface of the gravel beach.

Samples were taken from the bore and the adjacent river. The results are recorded in
table 3.5 below.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Otikerama bore</th>
<th>Mataura River</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampled 26/4/95</td>
<td>6.12</td>
<td>8.02</td>
</tr>
<tr>
<td>pH</td>
<td>98</td>
<td>76</td>
</tr>
<tr>
<td>Electrical Cond</td>
<td>32</td>
<td>26</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Nitrate-N</td>
<td>0.45</td>
<td>0.58</td>
</tr>
<tr>
<td>Ammonia-N</td>
<td>0.004</td>
<td>0.011</td>
</tr>
</tbody>
</table>

Given the geological setting and similarity in water chemistry, the source of the Otikerama bore is inferred to be the Mataura River.

### 3.5 Oldham Street Well.

The Oldham Street well has served as town supply in the past. It presently stands as a back-up, emergency supply for Gore. It was last used in connection with pumping tests being held at the town's principal water source, Cooper's Wells. During the stabilisation period before the pumping test at Cooper's Wells, the Oldham Street bore produced water at a rate of 44 litres per second.

The well is 5.4 metres deep with a static water level of 3.2 metres below the well head. The well was dug into Quaternary gravels of the rank 1 terrace on which much of commercial Gore is sited. The Mataura River is approximately 300 metres to the east.

A sample of well water was taken. The results, along with the results for bore waters in 1962, are shown in table 3.6 below.
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Oldham St bore</th>
<th>Flemings bore</th>
<th>Oldham St bore</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.08</td>
<td>6.0</td>
<td>6.2</td>
</tr>
<tr>
<td>Electrical Cond</td>
<td>246</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>49</td>
<td>92</td>
<td>52</td>
</tr>
<tr>
<td>Chloride</td>
<td>21</td>
<td>43</td>
<td>21</td>
</tr>
<tr>
<td>Nitrate-N</td>
<td>3.33</td>
<td>4.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Ammonia-N</td>
<td>0.0012</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

These results are consistent with the groundwaters being replenished from soil drainage of the surrounding land surface. There are also indications that the groundwaters, particularly more recently, are affected by urban runoff. The elevated nitrate is such an indication of urban runoff infiltrating into the aquifer. There are few indications in the water chemistry that the river provides significant infiltration to groundwater drawn at Oldham Street.

A capture zone or well head protection zone could not be delineated based on available information. Nor, could such a zone be readily, or reliably, delineated by other means.

The largest threat to the quality of groundwater under Gore is thought to be bacteria and leaked petroleum products (and their solutes). Checks have been made with service stations at Gore to determine what leakage containment measures are employed under the Department of Labour guidelines for underground petroleum storage systems. Bacteria could be derived from a multitude of sources. Leakage of foul sewer pipes has been identified as a significant source in other cities.
4.0 Secure Groundwater & Secure Well Head Status.

4.1 Definition.

Secure groundwater is defined as:

Water contained beneath the land surface which is abstracted via a secure well-head. It must not be under the direct influence of surface water or demonstrate any significant and rapid shifts in characteristics such as turbidity, temperature, conductivity or pH which correlate to any climatological, surface water conditions or land use practices. There must also be no insects or macro-organisms such as algae, organic debris or large diameter pathogens. Compliance with these requirements must be reliably demonstrated. If any doubt remains that the groundwater is secure, checks should be made that the water has been in the aquifer for more than 1 year.

(Department of Health, 1995)

A pre-requisite for secure groundwater is that it is drawn from a secure well-head. A secure well-head is defined as follows:

A well-head which incorporates appropriate measures to prevent or minimise the risk of groundwater contamination. Measures include:

- A sealed pumping and piping system including backflow prevention devices
- Seals between the well casing, pipework and surrounding ground
- Restrictions on any potentially contaminating land use or activity.

(Department of Health, 1995)

Water supplies drawn from secure groundwater through a secure well-head is considered to be a safe water source requiring less treatment, less frequent monitoring and scoring better water supply grades.

4.2 Security of Gore Water Supplies.

The above definitions and criteria can be used in assessing the security of each water supply bore field or well.
4.2.1 Cooper's Wells.

Reference should be made to reports on this supply (Rekker, 1994; and Rekker, 1995). The supply was found to be drawn from an unconfined gravel aquifer. The groundwater was replenished by a mixture of soil drainage and creek infiltration. Being unconfined, the aquifer contains waters of mixed age, from one month the several years old.

The permeability, porosity and groundwater gradient data is contained in the aforementioned reports and summarised in the information sheet for Cooper's Wells. Surface water was found only to replenish groundwater, no direct connection with the bores was found.

The mean groundwater flow velocity is about 3 metres per day. The distance from the bore field to the closest point of surface water infiltration on Gold Creek is 700 metres. The mean residence time for Gold Creek infiltrated water is then about 230 days. Controls are attached to potentially contaminating land uses:

- Toxic substance handling, storage, application or disposal is prohibited within a buffer zone to the bore field (covenant to land title).
- The discretionary activity, dairy shed effluent application, is opposed within the capture zone.

Means of securing the well-head are employed and detailed in the information sheet.

Monitoring of the water quality and telemetry of water level is employed for both bores. Stability is evident in both the quality and groundwater level (after drawdown effects are removed).

Cooper's Wells come within the category of secure groundwater drawn through a secure well-head.

4.2.2 Jacobstown Bore Field.

Jacobstown draws a mixture of Mataura River water and pasture soil drainage. Groundwater infiltrating from the river travels at least 500 metres to the bore field. At a groundwater flow velocity of about 4 metres per day, the river-derived water would be resident in groundwater for about 125 days before being drawn into the bores or wells.

Monitoring of the water quality and telemetry of water level is employed for both bores. Reasonable stability is evident in both the quality and groundwater level (after drawdown effects are removed).
However, further monitoring as to the stability of water quality is needed before any definitive assessment on the security of the groundwater and well-head can be given. Well-head protection measures could also be improved in terms of sealing off surface runoff.

4.2.3 Pyramid Bridge Bore.

Pyramid Bridge bore draws on water infiltrating from the Mataura River. The minimum residence time between the river and the bore is in the order of one month. The bore responds rapidly to changes in river level. Turbidity has not been observed in bore water.

Well-head protection measures appear adequate.

Further monitoring as to the stability of water quality is needed before any definitive assessment on the security of the groundwater and well-head can be given.

4.2.4 Otikerama Bore.

Otikerama bore draws on water infiltrating from the Mataura River. The minimum residence time between the river and the bore is in the order of one week.

Well-head protection measures appear adequate. Some clay-sealing around the immediate bore head would be beneficial to well-head security.

Further monitoring as to the stability of water quality is needed before any definitive assessment on the security of the groundwater and well-head can be given.

4.2.5 Oldham Street Well.

The Oldham Street well shows no indications of being influenced by the Mataura River. Some indications of urban runoff are evident in water chemistry.

Further monitoring as to the stability of water quality is needed before any definitive assessment on the security of the groundwater and well-head can be given. Sampling and analytical screening for faecal coliform, priority 1 determinands, and petroleum hydrocarbons is recommended.
5.0 Conclusions.

All groundwater supplies drawn from shallow unconfined gravel aquifers for Gore District Council have some degree of vulnerability to surface contamination.

Cooper's Wells bore field, the principal source for Gore, draws on water infiltrated through pasture and from a perennial creek. It is the most secure of the five bore fields assessed and merits secure groundwater and well-head status. Nitrate contamination is thought to be unlikely since the discovery of creek infiltration. The capture zone is about 162 hectares in extent oriented to the north.

Jacobstown bore field draws on Mataura river water with a 125 day residence in groundwater. Minor amounts of soil drainage supplement the river water.

The Pyramid Bridge bore draws on water infiltrating from the nearby Mataura River with a short residence as groundwater. It has a small river-marginal capture zone.

The Otikerama bore also draws on water infiltrating from the nearby Mataura River with a short residence as groundwater. The capture zone occupies a gravel beach by the Mataura River.

The Oldham Street well appears to be derived from soil drainage and shows some signs of urban runoff. The capture zone could not be determined.

None of the bore fields or wells assessed cause significant adverse effects to the environment, or nuisance to other water users.
7.0 References Cited.


Appendix I;
Surveyed References / Water Levels at Jacobstown bore field.

<table>
<thead>
<tr>
<th>Bore / Well</th>
<th>NZMG Coordinates</th>
<th>WL</th>
<th>WL</th>
<th>TD</th>
<th>TD</th>
<th>RL</th>
<th>mE</th>
<th>mN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well 1</td>
<td>75.01 2196244.31 5450429.3</td>
<td>5.27</td>
<td>69.91</td>
<td>12.1</td>
<td>63.08</td>
<td>74.53</td>
<td>2196187.38</td>
<td>5450436.82</td>
</tr>
<tr>
<td>Well 2</td>
<td>75.18 2196149.64 5450381.09</td>
<td>6.86</td>
<td>67.67</td>
<td></td>
<td></td>
<td>74.33</td>
<td>2196232.19</td>
<td>5450352.43</td>
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<tr>
<td>Well, crusher</td>
<td>74.33 2196232.19 5450352.43</td>
<td>3.42</td>
<td>70.91</td>
<td>8.25</td>
<td>66.08</td>
<td>72.76</td>
<td>2196172.22</td>
<td>5450487.19</td>
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<tr>
<td>Observation well</td>
<td>72.76 2196172.22 5450487.19</td>
<td>2.99</td>
<td>69.77</td>
<td>9</td>
<td>63.76</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

River Survey Sites.
Mataura River # 1 71.67 2196366.71 5450578.92 71.67 Downstream
Mataura River # 2 71.76 2196225.79 5451144.56 71.76
Mataura River # 3 72.21 2196219.98 5451477.62 72.21 Upstream

LEGEND:

RL = Reference level in metres above Mean Sea Level
WL = Water level in metres below ground level (bgl), or above Mean Sea Level on 27 April 1995.
TD = Total depth in metres below ground level (bgl), or above Mean Sea Level (Elev.).

Water level contouring using Well 3 and observation bore water levels indicates a groundwater flow direction to the south west. River water level elevations lie above those of the Jacobstown bore field and consequently support the inference of infiltration from the Mataura River.

Comparison of the total depths of the bores and wells at Jacobstown reveals two distinct depth levels tapped. The upper level lies at 66 - 67 metres elevation. Well 3 and the observation well tap the lower level at about 63 metres elevation. This explains the rise in water table elevation from the Well 3 and observation well to the downstream crusher well.