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Golder Associates

REPORT ON

PRELIMINARY STEPS IN THE DEVELOPMENT OF A GROUNDWATER PROTECTION PLAN VILLAGE OF OLALLA

Submitted to:

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EXECUTIVE SUMMARY

Golder Associates Ltd. (Golder) has completed the initial phase of Groundwater Protection Planning (GWPP) for the Village of Olalla (Olalla). The work was completed under the direction of the Regional District of Okanagan Similkameen (RDOS). The aquifer in Olalla is located along the valley of Keremeos Creek and has not yet been characterized by the BC Ministry of Water, Land and Air Protection (MWLAP) under their province-wide Aquifer Classification Program. However, based on the review of well logs available for the area, the aquifer is considered to be an unconfined aquifer for the purposes of this GWPP. RDOS is the owner/operator of the municipal water distribution system in Olalla and is the primary water purveyor extracting groundwater from the aquifer within Olalla. They supply water for domestic use.

This first stage of this GWPP was generally limited to the characterization of the aquifer and determination of the approximate capture zones for the single community well which comprises the RDOS system. The assessment was based on the review of information from reports available for the area, climatic data, and a windshield survey through the Study Area. The overall GWPP process generally follows the well protection toolkit (WPT) process developed by MWLAP.

The following conclusions are made based on this initial phase of the GWPP process:

- The aquifer that supplies the Olalla community well extends along the valley of Keremeos Creek and for the purposes of the GWPP is considered to be unconfined throughout the Olalla area;
- Groundwater flow in the aquifer is from the north to the south, towards the Village of Keremeos and the Similkameen River and in the same general direction as the flow of Keremeos Creek;
- Water extraction from the community well increased dramatically from 2003 to 2004. Although the increase is unexplained, it is potentially due to reported losses within the distribution system;
- A preliminary water balance for the aquifer indicates that annual recharge to the aquifer is on the order of 3.8×10^6 m^3/yr (precipitation data) to 3.9×10^6 m^3/yr (Darcy Flux Method).
- A preliminary estimate of annual groundwater extraction from the aquifer is in the range of 4.6×10^5 m^3/yr to 6.9×10^5 m^3/yr.
- Based on the calculated recharge and extraction estimates, the resultant net surplus of the aquifer is estimated at 3.2×10^6 m^3/yr to 3.3×10^6 m^3/yr.

- The percentage of aquifer utilization within Olalla (based on 2004 water usage data) is estimated to be in the range of 12 % to 18 %. However, this estimate does not take into account water returned to the aquifer due to reported distribution losses.

- Preliminary calculations indicate that disposal to ground of domestic effluent (septic fields) occurs within the footprint of the 60-day capture zone for the Olalla community well.

- The preliminary calculation of the 5-year capture zone for the community well incorporates most of the Study Area, indicating that any high risk land use could potentially impact the production wells.

Specific issues of concern pertaining to the water supply within Olalla are as follows:

- As Olalla is a small community that relies solely on one community water well for all its domestic water, short-term and long-term contingency plans should be developed in the case that the well is compromised.

- It is generally accepted that a 60-day time of travel is required to provide effective renovation of bacteria and viruses within groundwater. As septic systems are likely located within the community well's 60-day capture zone, there is the possibility of a health risk to the community if the septic tanks or fields are not maintained regularly or functioning properly.

- There is a main transportation route (Highway 3A) within the 60-day and 1-year capture zones, which could represent a risk in the case of an accident or spill in these areas.

- There are private wells identified within Olalla, for which little information is available. These could represent a risk by providing a direct conduit to the groundwater if they are not properly cased, or in the case of abandoned wells, decommissioned. Focus should be on the wells identified on the western bank of Keremeos Creek.

- There was a dramatic increase in the extraction rate reported for the community well in 2004. It is uncertain if the increase reflects the actual water use or is due to large losses in the system. Large losses in the system do not necessarily pose a risk to the aquifer, as the "lost" water will recharge the aquifer. However, if the losses reflect the actual use, then water quantity issues may need to be a high priority in future GWPP.

The recommended action plan for further study is to continue with the Olalla Groundwater Protection Plan by completing the remaining steps of the WPT (Steps 3, 4, 5 and 6). The following provides the recommended steps in completing the Olalla Groundwater Protection Plan:

1. Expand the Technical Committee formed in this study to include interested community members, and local, regional and provincial government representatives to assist with the remaining tasks to be completed. This expanded committee can be referred to as the Community Planning Team as outlined in the WPT and assist with the remaining tasks to be completed;

2. With the assistance of the Community Planning Committee and RDOS, alternative community well site option(s) for a backup contingency well should be identified, and further assessed during the next steps;

3. Conduct a contaminant inventory (Step 3) within the community to identify potential threats that could impact the community well and alternative sites (identified in 2). The effort should concentrate on identifying contaminant sources (i.e. septic sources, unknown wells, historical high risk land uses and current potential risks) within the capture zones;

4. Develop management strategies (Step 4), which include designating groundwater protection area(s) and developing management strategies (i.e. education, permitting specific activities, training, zoning, etc.);

5. Developing a Contingency Plan (Step 5), that would identifies short-term and long-term alternative water supply sources in the event of a disruption to the water supply source and develop an emergency response plan; and

6. Develop a Monitoring Plan and Evaluate Plan (Step 6), since water quality monitoring is already conducted, this step would include a review of the scope of the current monitoring plan and an assessment of the monitoring results.

Either as part of the above study or as a separate study, an assessment should be completed to determine the cause of the dramatic water extraction rate increase from 2003 to 2004. This assessment should be completed before the development of management strategies to assist in the prioritization of management issues.

The final recommendation is to apply to MCAWS for further funding to complete the GWPP for Olalla.

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) is pleased to present this report, which outlines the initiation process of developing a Groundwater Protection Plan (GWPP) for the Village of Olalla (Olalla). This work was completed under the direction of the Regional District of Okanagan Similkameen (RDOS). RDOS is the owner/operator of the water system in Olalla. The GWPP is being developed in response to a directive by the Interior Health Authority (IHA), required for permit renewal to operate the Olalla municipal water system. It is also understood this document may be utilized as a supporting document for an application for an Infrastructure Planning Grant from the Ministry of Community, Aboriginal and Women's Services (MCAWS). The purpose of the grant would be to aid in funding further steps of the GWPP.

Olalla's sole source of municipal water is groundwater supplied from one water well, referred to as the community well. Currently, there is no treatment of the water source due to acceptable bacteriological results, however there is an on-going concern regarding the potential for bacteriological contamination. The residents of Olalla are strongly opposed to chlorination and hence protection of the water source is a high priority. Once contaminated, groundwater quality is exceedingly difficult, and sometimes impossible, to restore, with costs to develop alternative supplies being very high.

Given the dependence of the community of Olalla on groundwater as the sole source of domestic water, and the priority of the residents to avoid water chlorination, the implementation of a Groundwater Protection Plan is important. Implementation of groundwater protection measures will not only help to protect public health, but also protect ecosystems associated with streams and lakes that rely on groundwater as a source of recharge.

In order to achieve the greatest degree of groundwater protection, this GWPP is being developed by combining the strategies of both *wellhead protection* and *aquifer protection*. Wellhead protection involves the delineation of capture zones of community wells and the use of protection measures to manage activities within those zones. Aquifer protection consists of the delineation of entire aquifers and the implementation of protection measures in more vulnerable areas of those aquifers. While wellhead protection is considered essential for the protection of existing community well, aquifer-wide protection is important for areas of the aquifer that are currently supplied by private wells and areas where Olalla may wish to develop additional groundwater supplies in the future.

This work was authorized by Mr. Andrew Reeder of RDOS, in April 2004, in response to a proposal from Golder submitted on April 20, 2004. The work was commissioned on behalf of the Village of Olalla.

2.0 METHODOLOGY

The Ministry of Water, Land and Air Protection's (MWLAP's) Well Protection Toolkit (WPT) was used as a guide for Olalla GWPP. The WPT was developed jointly by MWLAP and the Ministry of Health in 2000, and consists of a six-step process created to assist communities that utilize groundwater to better manage and protect their drinking water sources.

The six steps outlined in the WPT are as follows:

Step 1. Form a Community Planning Team;
Step 2. Define the Well Protection Areas;
Step 3. Identify Potential Contaminants;
Step 4. Develop Management Strategies;
Step 5. Develop Contingency Plans; and
Step 6. Monitor Results and On-going Evaluation of the Plan.

Based on our experience, the process of completing the six steps of the WPT requires customization to meet the unique needs of each community and ensure the investment delivers the maximum protection of their water supply. For this study, the basic components of the first two steps (Steps 1 and 2) of the WPT were followed, but with emphasis on aquifer characterization as well as wellhead characterization. It is understood that further progress in the development of Olalla's GWPP (the completion of Steps 3, 4, 5 and 6) will be a function of funding availability.

The scope of work for this initial phase of the GWPP consisted of the following:

- Assist with the establishment of an Groundwater Protection Planning Committee (GPPC) with representation from the users of the aquifer, community members, government representation and technical experts;

- Assist the planning committee with the establishment of goals, determining information needs and the development of an action plan;

- Gather and review available information on the aquifer, prepare maps of the extent and sections through the aquifer to identify physical properties including aquifer thickness and flow direction;

- Identify data gaps and complete a field reconnaissance to collect additional information;

- Identify aquifer recharge and discharge areas, as well as an overall aquifer water balance, based on the established physical properties;
- Estimate with analytical methods, the extent of well head capture zones for the large capacity water wells using the Calculated Fixed Radius (CFR) method; and
- Report Preparation.

Issues related to the ability of the local aquifers to sustain the current and future water supply requirements of the District and water quality were not addressed in this study.

3.0 STUDY AREA

3.1 Location and Climate

Olalla is located in the southern Interior of British Columbia, along Highway 3A between Penticton and Keremeos (Figure 1). The majority of the Village is located on the western floodplain of Keremeos Creek. Keremeos Creek flows from north to south and is a tributary of the Similkameen River. Olalla Creek, a tributary of Keremeos Creek, drains from Apex Mountain and transects the community. The confluence of Olalla Creek and Keremeos Creek is located between 7th and 8th Streets.

Olalla is considered a retirement-oriented community and consists mainly of residential homes. The businesses of Olalla consist of a trailer park and a restaurant with agriculture land use to the north and south of the Village boundaries. Figure 2 shows the Study Area considered for this GWPP. The Study Area extends across the width of the valley and includes the Village of Olalla and areas immediately north and south. The footprint of the Study Area is approximately 90 hectares.

The climate of Olalla consists of warm summers and cool, moist winters. The elevation of Olalla is approximately 520 masl (meters above sea level). The closest weather station to Olalla with a similar elevation is Hedley at 517 masl (located approximately 17 km due west of Olalla, on the western side of Apex Mountain). Based on the data provided by the Hedley climate station, as reported in "*Canadian Climate Normals, 1971 – 2000 for BC*" (Environment Canada), the average annual daily temperature is 8.3° C, with daily mean temperatures ranging from –4.0° C in January to 19.9° C in July. Total annual precipitation for the Hedley weather station is 376.8 mm.

3.2 Topography

Olalla is located in a narrow valley running north to south approximately 500 m in width. As shown in Figure 1, the valley is situated between Orofina Mountain to the east (peak elevation of approximately 1620 masl) and Apex Mountain to the west (peak elevation of approximately 2140 masl). The valley bottom is relatively flat and is bounded by the mountain slopes that rise steeply to the east and west.

The western portion of the Village along Highway 3A lies on the Olalla Creek Fan. The remainder of the Village lies 5 m to 10 m lower and within the floodplain of Keremeos Creek. Keremeos Creek likely eroded the Olalla Creek fan to the present topography.

The catchment areas of Olalla Creek and Keremeos Creek, upgradient of the Village, generate runoff from rainfall and snowmelt which contributes recharge water to the aquifer. Figure 3 shows the catchment area upgradient of the Study Area, which covers an area of approximately 180 km^2.

3.3 Surficial Geology

According to the BC Geological Survey website[1], the valley associated with Keremeos Creek is underlain primarily by glaciofluvial sediments from the Quaternary Period, comprised of alluvium and till.

Using well logs available from the internet-based Water Well Database maintained by MWLAP and information obtained directly from RDOS, one section of subsurface geology across the valley was prepared. The locations of the well examined are depicted in Figure 2. Copies of the related well log records are provided in Appendix I and a summary of the well information is presented in Table 1.

Cross section A-A' is looking north and transects the valley from the west to east. Figure 4 shows the orientation of the cross section, while the cross section is provided in Figure 5. Cross section A-A' includes information from the Olalla community well and other selected wells in the area. Based on an interpretation of the cross section and other wells in the area, the surficial geology in the area consists primarily of glacial and glacial-fluvial deposits of sand and gravel, with some minor clay and silt deposits.

3.4 Bedrock Geology

Apart from providing a physical boundary within which the unconsolidated sediments of the valley are situated, the bedrock in the Study Area is expected to provide minimal recharge to the local groundwater flow regime. The bedrock geology is therefore only described briefly.

[1] http://www.em.gov.bc.ca/Mining/Geolsurv/MapPlace/themeMaps.htm

The mountain slopes to the east and west of Olalla are part of the Shoemaker Formation, from the Permain to Triassic Periods, and includes chert, siliceous argillite and siliciclastic sedimentary rocks. The south area of Olalla contains a pocket formation within the Shoemaker Formation called the Olalla Plutonic Suite from the middle Jurassic period. It consists of syenitic to monozonitic intrusive rocks.

4.0 HYDROGEOLOGIC ASSESSMENT

4.1 Community Well

Olalla has only the community well that currently supplies the potable water to the community. This well has been in operation since 1998. A previous well immediately adjacent to Keremeos Creek used from 1986 to 1998 and was abandoned due to high iron content as well as an objectionable hydrogen sulphide odour (Kala, 1986).

The community well is located on a small triangular lot of Crown Land with the legal description of District Lot 18s, ODYD. It is located along the west side of Highway 3A on the 11th Street extension. Water is pumped from the community well to a closed reservoir located upgradient of the community well, adjacent to Olalla Creek and then piped to the community via gravity. Currently, the community water supply is of sufficient quality that no treatment is required.

4.2 Aquifer Characteristics

A search of the MWLAP's aquifer database indicated that the aquifer within the valley that Olalla is situated in has not yet been classified. The following review is based on available water well logs for wells completed in the area, which are depicted in Figure 2 and provided in Appendix I. Table 1 provides a summary of information pertaining to the wells in the area.

Surficial sediment deposits generally consist of sand and gravel in the northern area of Olalla. Wells advanced north of 5th Street within Olalla are unconfined, consisting mainly of sand and gravel with minor silt noted.

Wells located south of 7th Street indicate a layer of less permeable, finer-grained material (a combination of silts, clays and tight sand and gravel) from approximately 2 m to 29 m below ground, ranging in thickness from 2 m to 12 m. This layer may afford some protection due to lower permeability, however, it is not a well-defined confining layer in terms of spatial extent. Beneath the lower permeable layer is water-bearing sand and gravel within which all wells in the area appear to be completed.

Upon examination of the well construction details (Figure 3 of PHCL, 1988) for the community well, the static water level is at the same depth as the initial water-bearing sand and gravel layer, which would indicate an unconfined aquifer. The community well is advanced beneath a layer of "sharp sand and angular gravel with clay, brown" from 29.0 m to 34.8 m, which was initially assessed as providing "natural protection to the aquifer". Although it is possible that this layer may provide some natural protection against surface contamination, based on the information currently available, it should not be assumed in the GWPP process that the wells completed in the aquifer below this layer have limited vulnerability as the amount of protection is uncertain.

The aquifer transmissivity of the community well was reported to be 1490 m^2/day (PHCL, 1998). The transmissivity was recalculated using AQTESOLV, a commercial software package for pumping test analysis. A transmissivity of 1,140 m^2/day was calculated, which compared favourably to the reported value of 1,490 m^2/day.

The hydraulic conductivity of the aquifer was estimated to be 5×10^{-4} m/s by dividing the transmissivity by the aquifer thickness. The aquifer for the purpose of the GWPP was considered unconfined, therefore the aquifer thickness was estimated by the difference in depth between the screen bottom and the static water level (29.2 m). Grain size curves were analyzed to provide another estimate of hydraulic conductivity, d_{10} values ranged from 0.25 mm to 0.6 mm and using the Hazen formula, the hydraulic conductivity was estimated to be within the 3.6×10^{-3} m/s to 6.3×10^{-5} m/s range.

The depth to groundwater (piezonmetric surface) in the aquifer within Olalla ranges from approximately 2.4 m below ground surface in the southern area of Olalla (on the Keremeos Creek floodplain) to approximately 16.5 m below ground surface in the north area of Olalla (on the Olalla Creek Fan). The aquifer is recharged by precipitation falling upgradient of the Study Area.

4.3 Groundwater Flow Direction and Hydraulic Gradient

As shown in Figure 4, a plot of the piezometric surface was created using the static water levels provided in the available well logs. The static water levels are based on data provided by the drillers at the time the water wells were installed. As such, some variability in the water levels is expected based on the difference in measuring techniques, natural fluctuations in groundwater and other inaccuracies associated with estimating the elevation of the water wells. However, the data is considered sufficient to determine the approximate groundwater flow direction and hydraulic gradient.

Based on this information, the hydraulic gradient is estimated to be an average of 0.0125. The general groundwater flow direction in the area is to the south towards the

Similkameen River, which is in general agreement with the direction of flow in Keremeos Creek.

4.4 Water Balance

4.4.1 Recharge

For the purpose of this investigation, estimates of recharge to the aquifer in Olalla were calculated using two methods. One method considers climatic data for the area and estimates the amount of infiltration contributions to recharge. The other method is using the Darcy's flux estimation across a section of the aquifer.

In using climatic data, it was assumed that recharge to the aquifer was primarily via infiltration of total precipitation within the catchment areas that contributes surface flow to Keremeos Creek, upgradient of Olalla. Based on previous studies, as outlined in the following table, an assumption of 7% of total precipitation was used to estimate the recharge to the aquifer.

Location	Recharge Rate	Reference
Semi-arid Lillooet, B.C., alluvial fan (low angle)	24% (397 mm/yr)	Golder, confidential report
Prince George, B.C., valley bottom	17% (614.6 mm/yr)	Golder, confidential report
Semi-arid, West Texas, USA	2% (330 mm/yr – 560 mm/yr)	Wood and Sanford, 1995
Florida sub tropical, USA	0.2% to 0.3% (1400 mm/yr)	Fetter, 1988
High Plains (Colorado, Kansas, Nebraska, New-Mexico, Oklahoma, South Dakota, Texas, Wyoming; USA)	3.5%-6% (410 mm/yr -710 mm/yr) (average for entire area)	Fetter, 1988

As seen in the table above, a wide range of recharge rates can occur, from fractions of a percent of total precipitation in arid and semi-arid areas (where evaporation is high) to approximately 25 percent in some higher alpine areas and on flat lying alluvial fans. In the catchment area for Keremeos Creek there is a combination of steep mountain slopes and valley bottom, hence 7% was used as a median number between the higher infiltration rates on low angle, semi-arid Lillooet to the low infiltration rate of the semi-arid area in West Texas.

It was also assumed that the majority of the infiltration (approximately 80%) is concentrated in the alluvium sediments within the base of the valley. It is anticipated that the remainder of the infiltration (20%) recharges localized bedrock aquifer systems.

The watershed catchment area for Keremeos Creek upgradient of the Study Area, as shown in Figure 3, is approximately 180 km^2. As previously stated in Section 5.1, the mean annual precipitation in the Olalla area is estimated to be 376.8 mm/yr. Assuming that approximately 7% of this precipitation, or 26.4 mm/yr, is available as recharge and of this, 80% is directed to the alluvium sediments in this valley, a preliminary estimate of annual recharge to the aquifer within Olalla is 3.8×10^6 m^3/yr (1.04×10^4 m^3/day).

Note that this estimate of recharge is based on precipitation only and does not account for other sources of recharge to the aquifer such as return flow from septic fields, irrigation, distribution losses and run-off from surrounding uplands.

Another method of estimating the recharge to the aquifer is to calculate the Darcy flux across the aquifer. This flux gives a cursory indication of the recharge which is required to sustain groundwater flow and the water levels in the aquifer. The Darcy flux is dependent on several aquifer characteristics, including transmissivity, aquifer width and the hydraulic gradient. The Darcy flux was estimated using information present in cross section A-A', with the following values assigned for the aquifer characteristics: a hydraulic gradient of 0.0125, an aquifer width of 750 m, and a transmissivity of 1,140 m^2/day. The resultant annual Darcy flux is approximately 3.9×10^6 m^3/yr.

A comparison of the two methods indicates that the recharge provided by the climactic data is within the range provided by the Darcy flux method. These methods provide an estimate of the annual aquifer recharge and are considered sufficient for preliminary water balance calculations.

4.4.2 Extraction

The groundwater extraction at the community well in Olalla is metered. Based on data provided by RDOS, the total reported extraction in 2003 was 27,179 m^3 (monthly average of 2,300 m^3) while the total reported groundwater extraction from January to October 2004 was 220,207 m^3 (monthly average of 18,350 m^3). Extraction data for November and December of 2004 was not yet recorded at the time of this report, however, using the average monthly extraction of the 2004 data, the total extraction for 2004 is estimated at 257,000 m^3.

There is a dramatic increase in water extraction reported from 2003 to 2004 which is not accounted for. The increase could be from a combination of influences such as:

- Reported pump problems in 2003 not reflecting the actual water demand for that year, and
- Reported unknown leaks in the reservoir and distribution system.

There are a number of other wells in Olalla, concentrated in the northern and southern boundaries of the Village. These wells are likely used for irrigation of pasture lands. Water use for agricultural purposes is estimated to range from 2.0×10^5 m^3/yr to 4.3×10^5 m^3/yr. This estimate was based on an irrigated crop water demand ranging from 51 cm to 72 cm per year applied over an estimated 40 hectares to 50 hectares of irrigated land within the Study Area. The irrigated crop water demand was calculated using the "Guide to Irrigation System Design with Reclaimed Water" (MAFF, 2001).

There are no industrial or other high capacity groundwater users within the immediate area of Olalla. Therefore, using the 2004 data, the total extraction for the Study Area by the community well and agricultural users are estimated to be within a range of 4.6×10^5 m^3/yr to 6.9×10^5 m^3/yr.

4.4.3 Surplus

The overall water balance in the area can be demonstrated from the following equation:

$$Q_{recharge} - Q_{extraction} = Q_{net\ surplus}$$

The aquifer recharge calculated in Section 4.4.1 ranged from 3.8×10^6 m^3/yr (precipitation data) to 3.9×10^6 m^3/yr (Darcy flux method).

The groundwater extraction from the aquifer at Olalla calculated in Section 4.4.2 was estimated to be within a range of 4.6×10^5 m^3/yr to 6.9×10^5 m^3/yr.

Based on these estimates, the total net surplus range of the aquifer in Olalla is 3.2×10^6 m^3/yr to 3.3×10^6 m^3/yr. Therefore, the percentage of aquifer utilization within Olalla is approximately 12 % to 18 %. However, if the large extraction increases in 2004 are due to losses within the distribution system, then a substantial amount of the extracted groundwater may be returned to aquifer and the actual utilization rate could be much lower. Using the 2003 extraction data provided by RDOS, the utilization rate ranged from 6 % to 12 %. Further refinement of the utilization rate requires further study as the development of management strategies dealing with quantity issues could become a high priority if the higher utilization rate is realistic.

5.0 WELL PROTECTION TOOLKIT

5.1 Step 1 - Community Planning

5.1.1 Initial Kickoff Meeting

The first step of the WPT is to form a community planning team. A kickoff planning meeting was held on April 16, 2004, and was attended by Mr. Andrew Reeder, Mr. Dave Gold and Mr. Micheal Firlotte of RDOS, Mr. Roger Mayer, the RDOS Regional Representative and Mr. Remi Allard of Golder. Representatives of IHA and MWLAP were invited to the meeting but did not attend. The purpose of the meeting was to review the terms of reference for the investigation and develop an action plan, as well as provide an overview of the WPT and discuss the roles and objectives of the community planning team.

During the initial planning meeting it was agreed that the development and implementation of the GWPP must include a wide range of community interests. Local government bodies, citizens, business owners and community groups all have an interest in protecting groundwater in the area for domestic and agricultural use. However, it was decided that the primary focus of groundwater protection planning at this point was technical and did not require the input from the general public and therefore, a Technical Committee would be formed at this stage. Input from the public would be solicited following the characterization of the wellhead and aquifer, with additional members added to the community planning team at a later date.

The Technical Committee would consist of the following persons:

Mr. Roger Mayer, Area G Representative, Regional District Okanagan Similkameen
Mr. Andrew Reeder, Regional District Okanagan Similkameen
Mr. Dave Gold, Regional District Okanagan Similkameen
Mr. Mickael Firlotte, Regional District Okanagan Similkameen
Mr. Stan Bobowski, Chair of Olalla Local Community Commission
Mr. Ron Johnson, Interior Health Authority
Mr. Des Anderson, Ministry of Water, Land and Air Protection (Kamloops)
Mr. Remi Allard, Golder Associates Ltd.

The objective of the Technical Committee was to understand the technical aspects of the aquifer(s) in the Study Area, prior to embarking on public workshops to solicit stakeholder input.

5.1.2 Aquifer and Well Head Concerns

A site reconnaissance visit to Olalla was conducted by Ms. Zee Marcolin of Golder on June 11, 2004 accompanied by Mr. Michael Firlotte and Mr. Dave Gold of RDOS.

Concerns identified during the kickoff meeting and the site reconnaissance visit regarding the aquifer and well head included:

- Old wells not properly abandoned or currently used and unknown wells not properly cased, acting as direct conduits for contaminants into the local aquifer;
- Inadequately renovated effluent from domestic septic fields migrating into the aquifer;
- Water levels are at a historic low with unknown effects on the water supply;
- The potentially large unknown losses in the reservoir and distribution system;
- Olalla does not have residential metering so there is no accountability of quantity usage; and
- Maintaining water quality as it currently does not require treatment.

5.1.3 Action Plan and Objectives

The action plan outlined at the kickoff meeting was to first characterize the aquifer before approaching the public, to enable officials to be confident in answering the public's questions during the process.

The committee decided that the general objective of the GWPP will be to protect groundwater quality and quantity. More specific objectives and an action plan would be determined once the initial phase of the Study was completed and the aquifers characterized. Tools that would be examined in the future to assist in the protection of the groundwater source would likely focus on public education, management tools (bylaws, rezoning, etc.), and a more detailed analysis of Best Management Practices in the agricultural community.

5.2 Step 2 - Define Well Protection Area Based on Capture Zone Analyses

5.2.1 General

During the pumping of a water well, groundwater is removed from a finite volume of the aquifer. In the initial phases of pumping, the drawdown cone created by the well expands and groundwater is removed from storage within the aquifer (due to pore drainage, aquifer matrix compression, and water compressibility). In later stages, once the drawdown cone attains sufficient dimensions and/or intersects a water body, groundwater flows radially towards the well and the aquifer is replenished by recharge due to precipitation and/or leakage from streams, rivers, and geologic units bounding the aquifer.

To efficiently manage and protect a groundwater supply, an understanding of the well "capture zone" and the "time of travel" zones are required. A "capture zone" is the area of an aquifer from which all groundwater will eventually arrive at the well, even after a considerable amount of time. A "time of travel" zone is the area of an aquifer from which groundwater will be derived in a predefined amount of time. For example, if a contaminant is released within the 1-year time of travel zone, it can be expected to arrive at the well within approximately 1 year. Once the capture zone and time of travel zones are estimated, the appropriate monitoring and protective measures can be implemented.

Golder carried out a preliminary analysis of time related capture zones for the community well. The following section outlines the methodology used, the results and the limitations of the analysis.

5.2.2 Capture Zone Methodology

Several methods of capture zone analysis are provided within the WPT including: 1) Calculated Fixed Radius, 2) Analytical Equations, 3) Analytical Groundwater Flow Models and 4) Numerical Flow and Transport Models. The methods vary in their accuracy and applicability. Method 1, or the CFR method, is the least technically rigorous as it uses only the pumping rate and an estimate of the aquifer porosity and thickness to approximate a circular well capture zone. The remaining methods are based on hydrogeological principles, with Method 2 being used to represent relatively simple groundwater regimes, while Methods 3 and 4 are capable of representing more complicated stratigraphy, hydrogeologic boundaries, and variable pumping scenarios and can be used as a forecasting tool. Although more technically rigorous, Methods 3 and 4 require considerably more effort and data regarding hydrogeologic conditions.

Both the CFR method and the Analytical Equations for Capture Zone Determination method were considered when calculating the capture zones for this study. It was determined that the Analytical Equations would not be applicable to the community well of Olalla due to the close proximity to Keremeos and Olalla Creeks. The capture zones calculated by this method would not account for the influence of these surface water sources on the well. Also, the transmissivity of the aquifer is high, producing thin, elongated capture zones stretching very long distances. Due to the shape of the bedrock confined valley, the capture zones predicted by the model would be inaccurate due to interference from the surrounding bedrock.

Due to the inadequacies of using the Analytical Equations method for the Study Area and given the information currently available for the aquifer within the Study Area, the CFR method was considered to be the most applicable.

The CFR method is defined by the following equation:

$$r = \sqrt{\frac{10038 \ * Q * t}{n * b}}$$

Where:

r = calculated fixed radius around the pumping well dependant on t (m)

Q = pumping rate (L/s)

t = travel time (usually in years)

n = aquifer porosity (assumed to be 0.25 for sand and gravel aquifer)

b = aquifer thickness or screen length (m)

The travel time zones for the community well were computed for:

- 60 days – approximate time required by biological pathogens moving in groundwater to degrade;
- 1 year – intermediate time selected based on the hydrogeological conditions prevailing in the area;
- 5 years – the average time considered necessary to implement groundwater remedial measures in response to a contamination event (according to the U.S. Environmental Protection Agency); and
- 10 years - the time considered to be a rough approximation of the ultimate extent of the capture zone.

5.2.3 Capture Zone Results

Capture zones were estimated for the community well using the calculated fixed radius method (CFR). The CFR method of analyses depicts capture zones as being circular, and tends to over estimate areas with relatively flat hydraulic gradients, and underestimate areas with steeper gradients.

The estimated capture zones for the community well are shown in the following table. The pumping rate used for the well was the reported maximum yield indicated in the pumping test completed at the time of construction (44L/s or 700 USgpm). The 60-day and 1-year capture zones are illustrated in Figure 6 and the 5-year and 10-year capture zones are illustrated in Figure 7.

Capture Zone Time Frame	Calculated Fixed Radius (CFR)
60-days	100 m
1-year	246 m
5-years	551 m
10-years	713 m

The results for the 60-day capture zones (Figure 6) indicate that there are likely septic tanks and fields within this boundary since there is no community treatment system in Olalla. These will require identification and classification in Step 3 (identify potential contaminants) of the WPT. The 1-year capture zone, also provided in Figure 6, extends into the higher density residential area of Olalla and has a sizable overlap with Highway 3A, indicating that transportation of dangerous goods may be an issue. It also overlaps with Keremeos Creek, which will likely start to influence the capture zone area by providing recharge to the community well. Therefore, the 1-year capture zone should be considered the outer accuracy limit of the CFR method in relation to the community well.

The 5-year and 10-year capture zones are presented in Figure 7. They are considered to be preliminary, and not likely representative of local groundwater conditions because they do not take groundwater flow direction into consideration and they overlap with other influencing hydrologic parameters (the steep side slope of the valley, which for practical purposes represents a bedrock boundary and Keremeos and Olalla Creek). However, these capture zones indicate that most of the community on the western bank of Keremeos Creek is likely within the ultimate capture zone for the community well.

5.2.4 Calculated Fixed Radius Method - Analytical Limitations

It should be noted that the CFR method used to estimate the capture zones for the community well is a calculation that is based on simple physical assumptions of the aquifer system. This method assumes the aquifer is uniform and is generally used when the hydraulic gradient is low and the aquifer thickness can be estimated. Note that this method of capture zone analyses does not account for the following:

- seasonal fluctuations in precipitation and recharge from surface water bodies (streams, creeks, rivers or lakes);
- interferences due to bedrock or stratigraphy changes;
- interactions with other wells;
- dispersion, retardation or degradation of contaminants in groundwater; and
- changes in pumping rates, based on daily and seasonal variations controlled by water supply demands and down time due to maintenance.

The CFR method is considered fairly accurate for travel times up to one year; however, travel time capture zone distances in excess of one year begin to decrease in accuracy as other physical characteristics of the aquifer (hydraulic gradients, stratigraphy changes at increased distances from the well) are not taken into consideration using the CFR method. Also, once the CFR capture zones overlap with surface water bodies or physical boundaries, they are considered invalid. The capture zone areas can be further refined by using other capture zone calculation methods, such as numerical modeling.

6.0 CONCLUSIONS

Based on the results of this Study, the following conclusions are made;

- The aquifer that supplies the Olalla community well extends along the valley of Keremeos Creek and for the purposes of the GWPP is considered to be unconfined throughout the Olalla area;
- Groundwater flow in the aquifer is from the north to the south, towards the Village of Keremeos and the Similkameen River and in the same general direction as the flow of Keremeos Creek;
- Water extraction from the community well increased dramatically from 2003 to 2004. Although the increase is unexplained, it is potentially due to reported losses within the distribution system;

- A preliminary water balance for the aquifer indicates that annual recharge to the aquifer ranges from 3.8×10^6 m³/yr (precipitation data) to 3.9×10^6 m^3/yr (Darcy Flux Method).

- A preliminary estimate of annual groundwater extraction from the aquifer is in the range of 4.6×10^5 m^3/yr to 6.9×10^5 m^3/yr.

- Based on the calculated recharge and extraction estimates, the resultant net surplus of the aquifer is estimated at 3.2×10^6 m^3/yr to 3.3×10^6 m^3/yr.

- The percentage of aquifer utilization within Olalla (based on 2004 water usage data) is estimated to be in the range of 12 % to 18 %. However, this estimate does not take into account water returned to the aquifer due to reported distribution losses.

- Preliminary calculations indicate that disposal to ground of domestic effluent (septic fields) occurs within the footprint of the 60-day capture zone for the Olalla community well.

- The preliminary calculation of the 5-year capture zone for the community well incorporates most of the Study Area, indicating that any high risk land use could potentially impact the production wells.

7.0 ACTION PLAN FOR FURTHER STUDY

The recommended action plan for the Olalla GWPP is to continue with the remaining steps of the WPT (Steps 3, 4, 5 and 6).

It is not considered necessary for Olalla to expand upon Step 2 by developing a numerical groundwater flow model, as the additional information gained would not warrant the additional expense involved. Determination of the 60-day and 1-year capture zones using the CFR method is considered sufficiently accurate for the purposes of the Olalla GWPP. This is due to a relatively flat topography and the position of Olalla within a narrow valley with well defined boundaries (i.e. mountain slopes).

Normally, the 5-year and 10-year capture zones are considered inaccurate as this method does not take groundwater flow direction into consideration and, in the case of Olalla, the aquifer boundaries start to overlap with the CFR (i.e. Keremeos and Olalla Creek and bedrock boundaries). The 5-year and 10-year capture zones calculated for the Olalla community well indicate that most of the community is within the capture zone, therefore a conservative measure would be to include all of the community when developing the GWPP further.

Due to the relatively small size of Olalla and the reliance of one well to supply the community, it is possible that the remaining steps of the WPT can be completed as one project. At the initiation of the project, the Technical Committee should be expanded to include interested community members, and local, regional and provincial government representatives to assist with the remaining tasks to be completed. This expanded committee can be referred to as the Community Planning Team as outlined in the WPT. The team should meet at key points in the project to review information and provide input into the remaining tasks and assist with public education.

It is then recommended that site options for an alternative site for a backup contingency well (Step 5) be identified before further action is taken. Finding an alternative well site for a backup contingency well is especially important for Olalla as it is reliant on one well for their community water supply. Once alternative site options are identified, they can then be further scrutinized in the next steps to further refine the best option.

The next recommended step is to conduct the contaminant inventory (Step 3 of the WTP). The contaminant inventory should include the following:

- identify all septic tanks and disposal fields within the 60-day capture zone for the community well and assess the time of travel (including vertical) to the community well. Should the time of travel be less than 60 days than management strategies (Step 4) can be assessed. These could include the consideration of installating a common septic system outside the 60-day capture zone, the relocation of a new community well located away from all septic systems, the installation of sentinel monitoring wells, or public education regarding the proper maintenance and construction of septic systems;

- conduct a survey to determine if there are other unidentified wells in the area still in use or abandoned. Also determine if the other wells identified in the area are still in use. RDOS should ensure that all abandoned wells identified are properly decommissioned according to legislation if not already done;
- conduct a survey of all transformers in the vicinity of the wells to confirm that no leakage is occurring and implement an annual monitoring plan if necessary;
- perform a search of the MWLAP databases for waste and spills and the site registry of contaminated sites;

- conduct a review of the current and historical land uses, including lands located within the agricultural land reserve (ALR), and specifically for those properties which are located within the community well capture zone and identify potential issues with agricultural chemicals used and any other potential risks to the community well and alternative backup well site(s).

- interview long-time residents of Olalla to identify former gas stations or other areas of historical concern.

- review the stormwater drainage and waste disposal methods within Olalla and assess any risks to the community well and alternative backup site(s)

As the area of Olalla is relatively small and there is no industry within the community, the level of effort for a detailed contaminant inventory will not require a substantial effort. However, the inventory is still important as the community well is the only community water source and there are risks that should be formally identified (i.e. reports of historic gas stations, septic systems, potential spills on the highway, etc.), assessed and an action plan formulated.

Once the contaminant inventory is completed, the remaining tasks of the WPT would use this information to complete the remaining task, which include:

- Developing Management Strategies (Step 4), which include designating groundwater protection area(s) and developing management strategies (i.e. education, permitting specific activities, training, zoning, etc.);

- Developing Contingency Plans (Step 5), that would identify short-term and long-term alternative water supply sources in the event of a disruption to the water supply source and develop an emergency response plan; and

- Developing a Monitoring Plan and Evaluate the GWPP (Step 6), since water quality monitoring is already conducted, this step would include a review of the scope of the current monitoring plan and an assessment of the monitoring results.

It is also recommended that the dramatic increases in extraction from the community well be assessed to determine if it is from actual water usage or due to losses in the reservoir and distribution system. Although the water utilization estimate of 12 % to 18% is within a reasonable range for aquifer use, it could fast approach the generally recommended maximum of 30 % extraction from an aquifer depending on future development and water use patterns. If it reflects actual usage, than addressing water quantity would need to be a high priority when developing management strategies (i.e. metering, restricting certain types of high water use developments, etc.).

The final recommendation is to apply to MCAWS for further funding to complete the GWPP for Olalla.

8.0 LIMITATIONS AND USE OF REPORT

This report was prepared for the exclusive use of the Village of Olalla and RDOS. In evaluating the requirements for groundwater protection, Golder Associates Ltd. has relied in good faith on information provided by sources noted in this report. We accept no responsibility for any deficiency, misstatements or inaccuracy contained in this report as a result of omissions, misstatements or fraudulent acts of others.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

9.0 CLOSURE

We trust that this report meets your current requirements. Should you have any questions or comments please do not hesitate to call.

GOLDER ASSOCIATES LTD.

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ZM/RA/JS/jb

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REFERENCES

Kala Groundwater Consulting Ltd. (Kala), 1986. Olalla Improvement District Groundwater Development Program.

Ministry of Agriculture, Food and Fisheries (MAFF). 2001. Guide to Irrigation System Design with Reclaimed Water, Irrigation Fact Sheet. Victoria, BC.

Pacific Hydrology Consultants Ltd. (PHCL), 1998. Completion Report Installation and Testing of a Water Supply Well for the Community of Olalla.

Stanley Associates Engineering Ltd. (Stanley). 1996. Regional District of Okanagan-Similkameen Olalla Water Study

Table 1 - Summary of Known Wells
Olalla, British Columbia

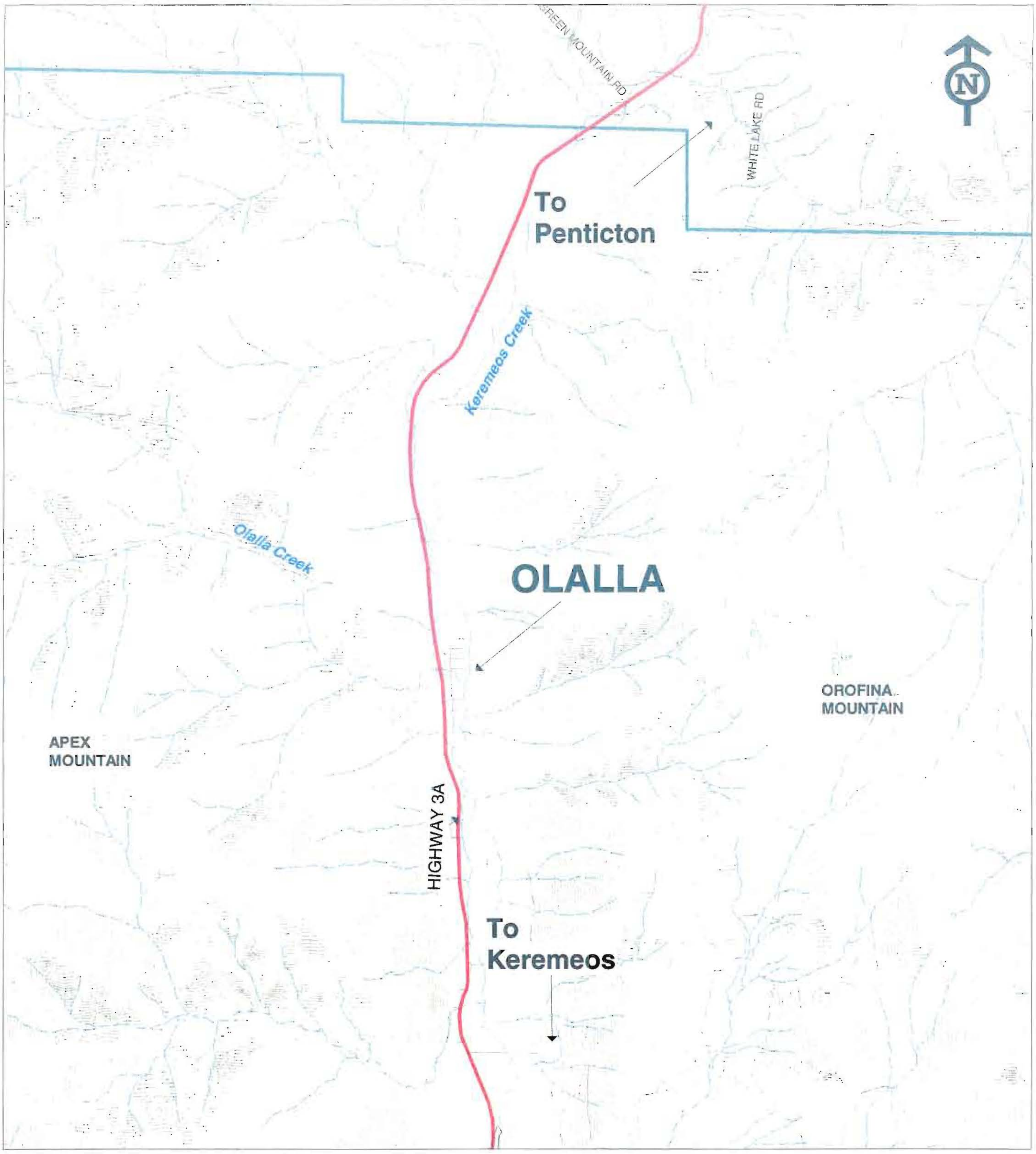
Well Tag Number	Well Owner	Legal Address	Approximate Location in Olalla[1]	Aquifer Type	Construction Date	Screen Top	Screen Bottom	Well Bottom	Static Level
					year	m[2]	m[2]	m[2]	m[2]
15750	G. Schopp	DL 176 Plan 85 Blk A (1st Street)	3rd Street	Unconfined (sand and gravel)	1959			18.0	9.5
46677	Stan Bobowski	DL 2061, PL 11007, Lot 1 (Cherry Wood Estates)	on Hwy 3A at 3rd Street	Unconfined (sand, gravel and pebbles)	1980	27.4	28.7	29.0	16.5
44690	E Johnson & T Smith	DL 2749, PL 28907, Lot A	Main Street at 4th Street	unconfined/semi confined (cemented sand and gravel - 12 m)	1980	26.5	29.9	29.9	16.2
36775	W. Hall	PL 85, Lot 14	between 6th and 7th Street	unconfined/semi confined (cemented sand, gravel and clay - 12 m)	1977	25.0	26.2	26.2	14.6
Abandoned Well (no well tag number)	Olalla Improvement District Well Site (Jack Adams)		7th Street	unconfined/semi confined (silty clay with gravel - 10 m layer)	1986	28.0	34.1	34.1	12.9
Community Well (no well tag number)	RDOS	D.L. 18s	Hwy3A at 11th Street	unconfined/semi confined (sand and gravel with clay - 6 m layer)	1998	40.1	47.2	47.2	18.0
44076	Garvin Nyen	DL 176	South of Olalla or 7th Street[3]	semi confined/confined (clay - 1 m layer)	1980	12.2	13.7	14.0	4.3
49646	Trevor Jolleys	DL 909	12th Street	unconfined/semi confined (cemented gravel with clay - 3 m layer)	1981	20.4	22.0	22.0	6.7
49973	Trevor Jolleys	DL 909	13th Street	unconfined/semi confined (silt and sand - 1 m layer)	1982	26.2	29.6	30.5	2.4
35655	Carpenter	DL2398 (Hwy 3A South of Olalla)	South of Olalla on Hwy3A	unconfined/semi confined (clayey gravel - 1.5 m layer)	1976			18.3	4.3
53183	Circle C Ranch	DL 393, PL 24262, Lot A	South of Olalla next to Keremeos Cr.	Confined (hardpan 12.5 m)	1984			16.5	7.6
37786	Wilson Clifton	DL 393 (south of Olalla)	South of Olalla next to Keremeos Cr.	Confined (till 22.2 m)	1977	37.5	40.5	46.6	1.8

Notes:

1. The well locations are the approximate locations provided by the MWLAP groundwater well database.

2. Meters below top of casing.

3. MWLAP indicates well tag number 44076 south of the Village boundaries, whereas the location is reported (Stanley, 1996) to be around 7th Street.



File Location: N:Active\2004\1440\04-1440-163\Figures\Figure 01.wor

NOTE: THIS DRAWING TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT

PROJECT
Olalla Groundwater Protection Plan

TITLE
KEY PLAN

Golder Associates

PROJECT NO.	04-1440-040		FILE	Figure 01.wor
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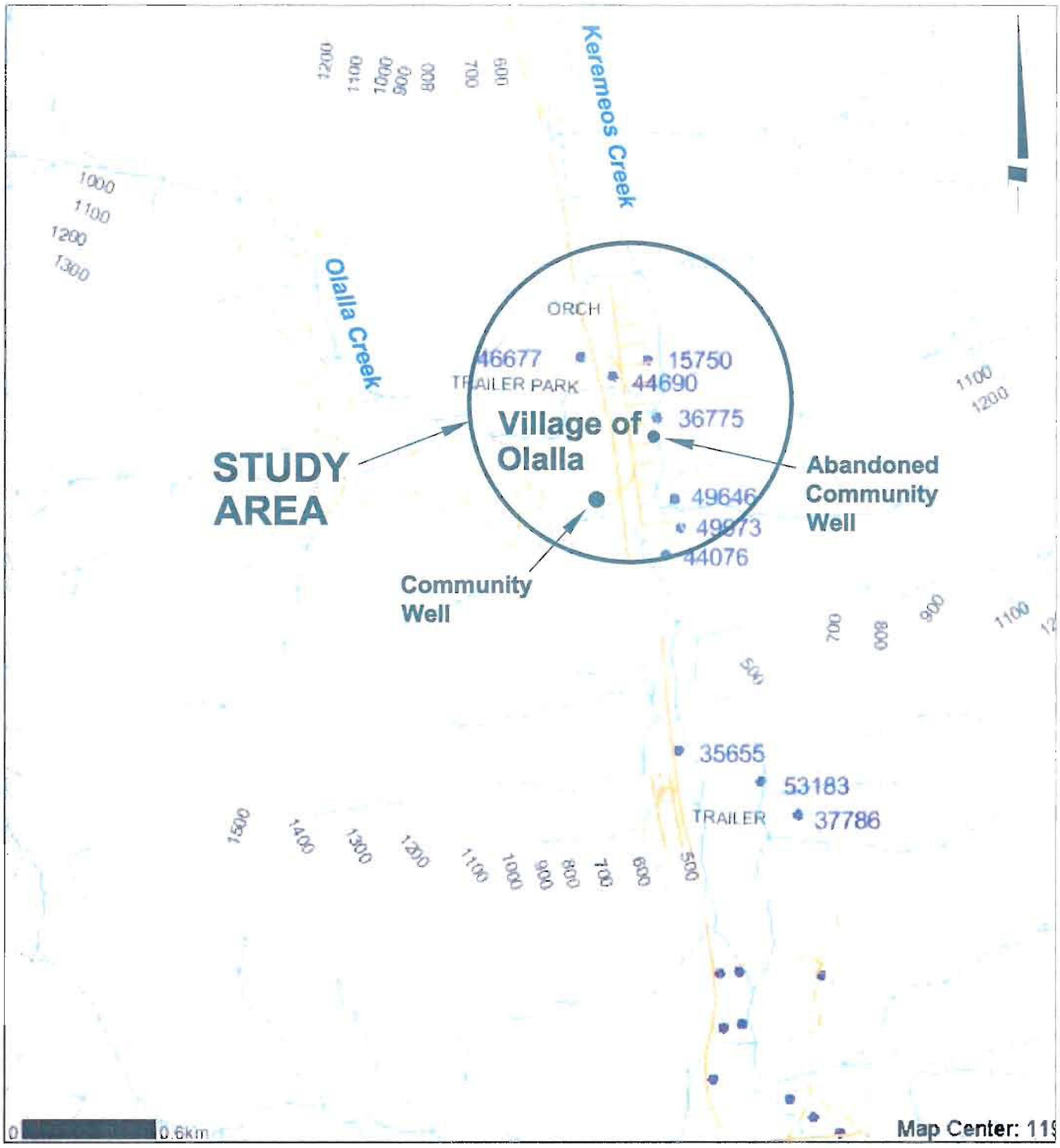
CHECK				
REVIEW				

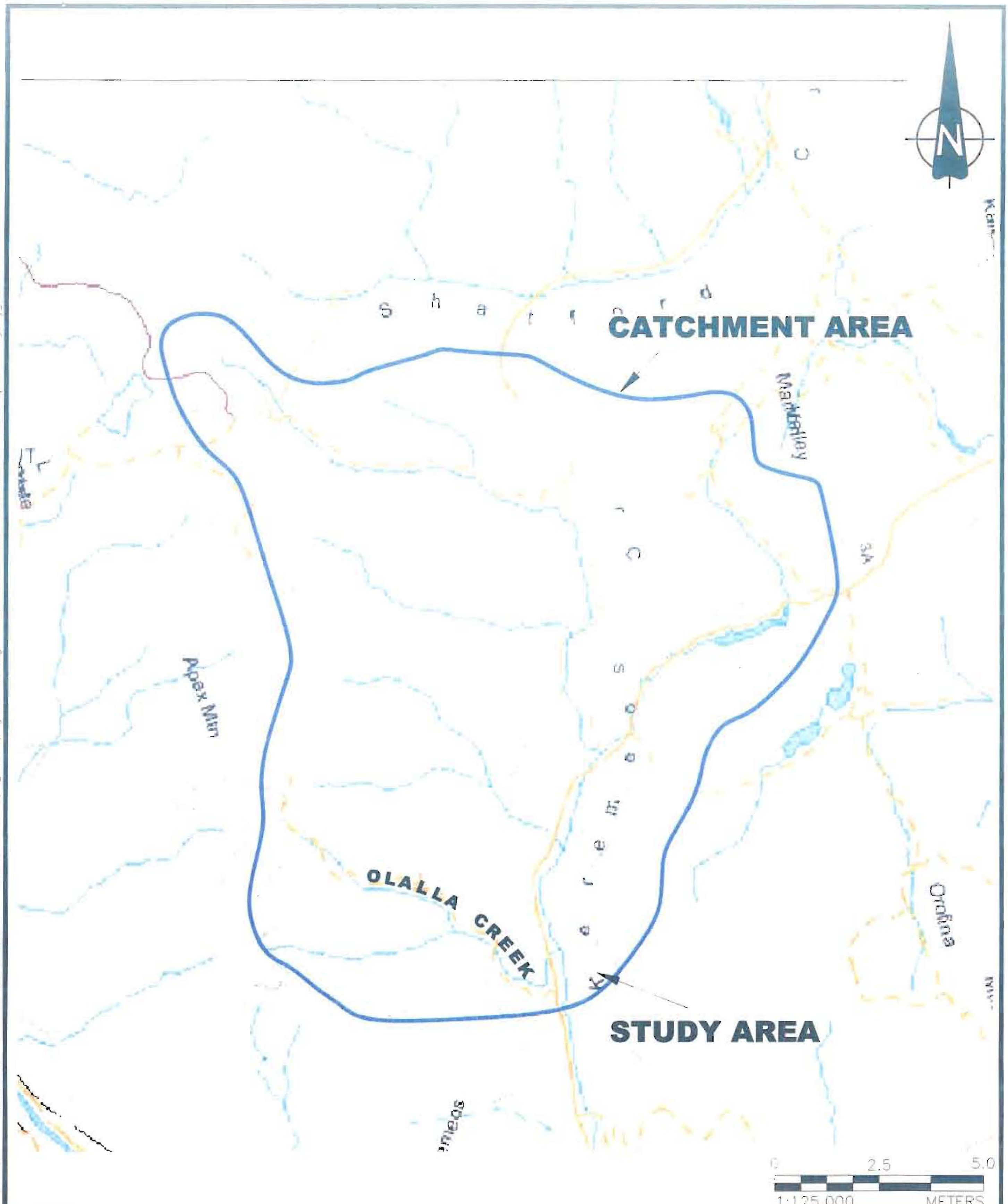


LEGEND:

• 35655 : Approximate Well Location and MWLAP Tag Number

Golder Associates, Kelowna, BC	SCALE: AS SHOWN DATE: 09/16/04 DESIGN: L.D. CADD: L.D. CHECK: REVIEW:	TITLE: **STUDY AREA AND WATER WELL LOCATIONS**
FILE No.: Figure 2.dwg		OLALLA GROUNDWATER PROTECTION PLAN
PROJECT No.: 04-1440-040 REV. 0		FIGURE: 2

Drawing file: Figure 2.dwg Mar 24, 2005 - 2:37pm



SCALE	1:125,000	TITLE
DATE	11/04/04	**CATCHMENT AREA CONTRIBUTING RECHARGE TO OLALLA**
DESIGN	ZM	
CADD	LD	
CHECK		
REVIEW	RA	Olalla Groundwater Protection Plan

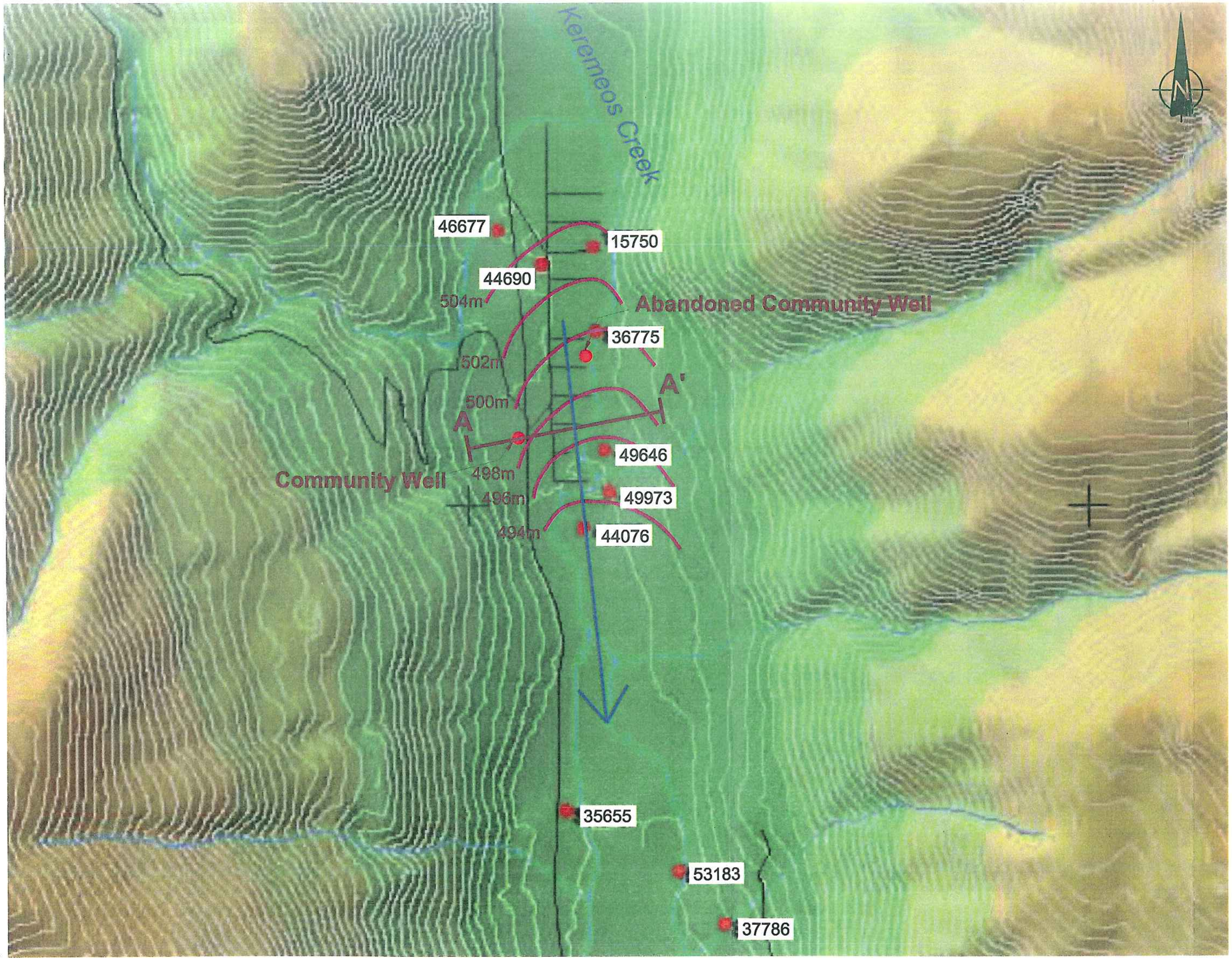
FIGURE 3

Golder Associates
KELOWNA, B.C.

FILE No. FIGURE_3.DWG

PROJECT No. 04-1440-040 REV.

Drawing: N:\Active\2004\1440 - Kelowna\04-1440-040 RDOS - Olalla GWPP\Figures\Figure 3.dwg Plotted: Mar 24, 2005 - 2:37pm By: jgoodier



LEGEND

- MWLAP Well
- Equipotential Line
- Road
- River/Stream
- Contour - 20 m Interval
- Waterbody
- Wetland

Digital Elevation Model (masl)

- 200 - 400
- 400 - 600
- 600 - 800
- 800 - 1000
- 1000 - 1200
- 1200 - 1400
- 1400 - 1600
- 1600 - 1800
- 1800 - 2000
- 2000 - 2200
- 2200 - 2400
- 2400 - 2600

A — A' Cross Section

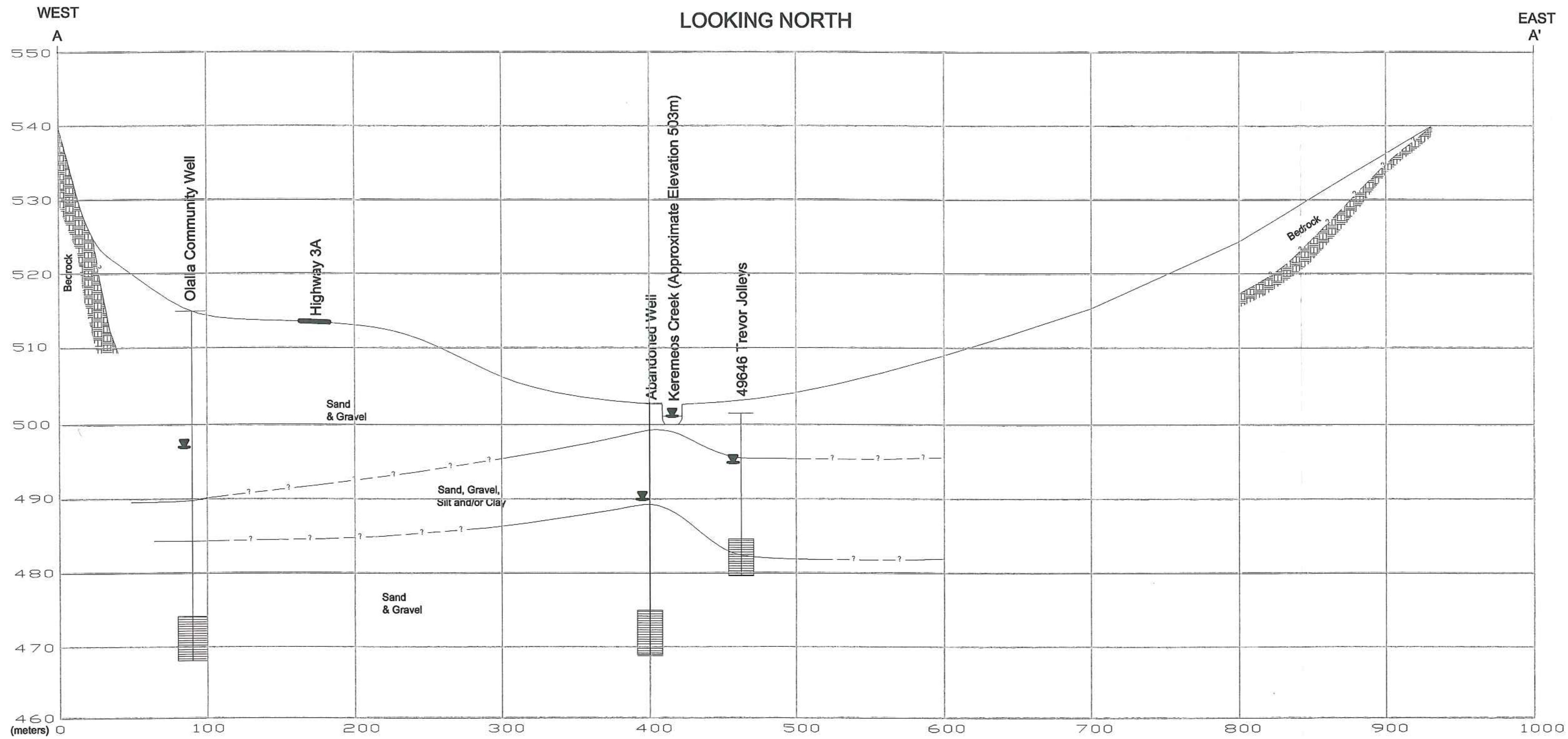
500m Equipotential Lines and Elevation

44076 Well Location and Well Tag Numbers

Groundwater Flow Direction

Golder Associates Kelowna, BC	SCALE 1:20,000	TITLE	
	DATE 11/04/04	**CROSS SECTION LOCATION AND PIEZOMETRIC SURFACE**	
	DESIGN ZM		
	CADD LD		
FILE No. Figure 4.dwg	CHECK		
PROJECT No. 04-1440-040 REV. 0	REVIEW	Olalla Groundwater Protection Plan	FIGURE 4

Drawing file: Figure 4.dwg Mar 24, 2005 - 2:39pm



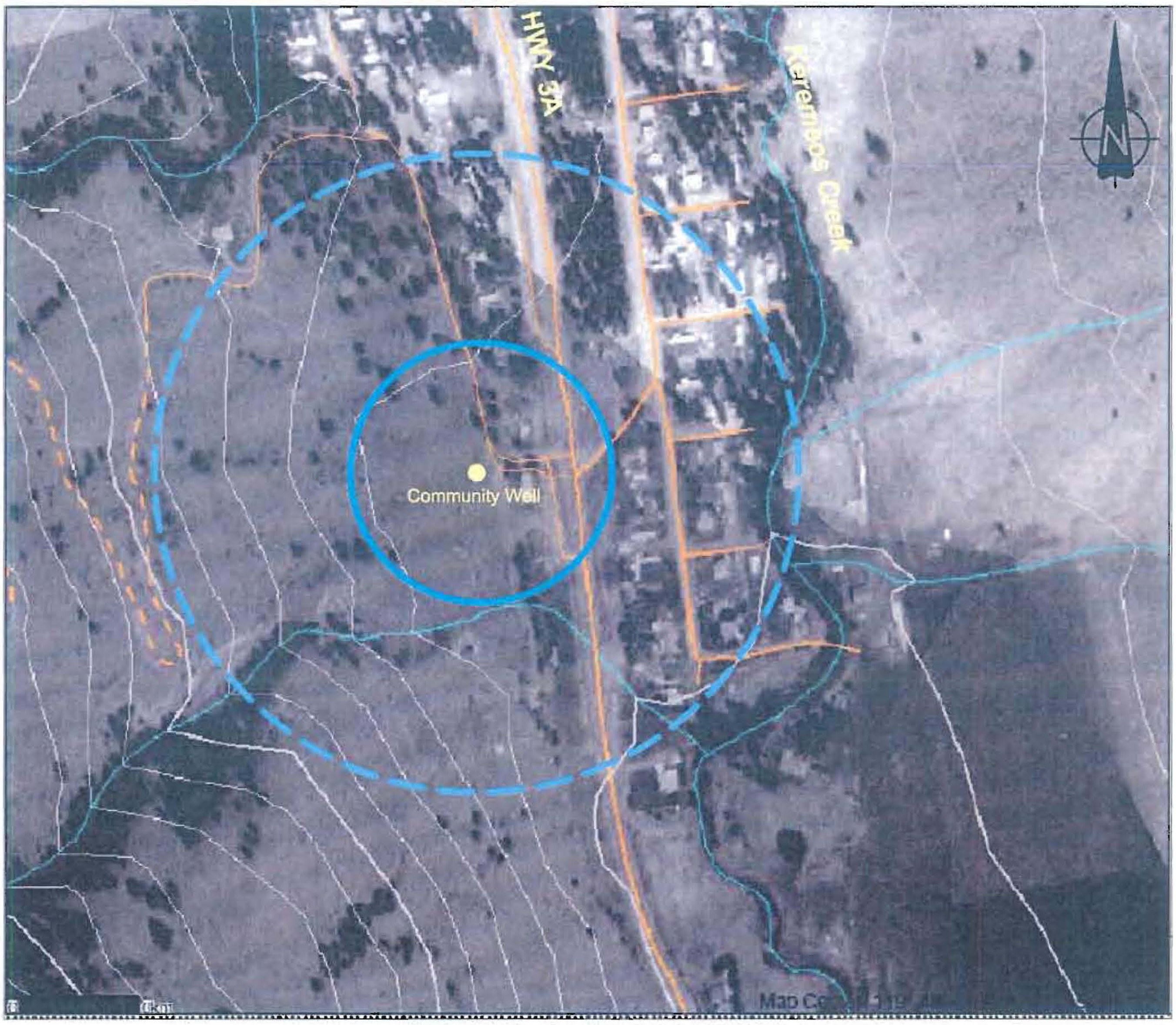
Legend:

- Screen Interval
- Observed Stratigraphy Change
- Inferred Stratigraphy Change
- Reported Static Water Level

Golder Associates
Kelowna, BC

SCALE	As Shown	TITLE	**CROSS SECTION A - A', LOOKING NORTH FROM COMMUNITY WELL**
DATE	09/21/04		
DESIGN	Z.M.		
CADD	L.D.		
FILE No.	04-1440-040	CHECK	
PROJECT No.	Figure 5.dwg	REV. 0	REVIEW
		Olalla Groundwater Protection Plan	FIGURE 5

Drawing file: Figure 5.dwg Mar 24, 2005 - 2:40pm



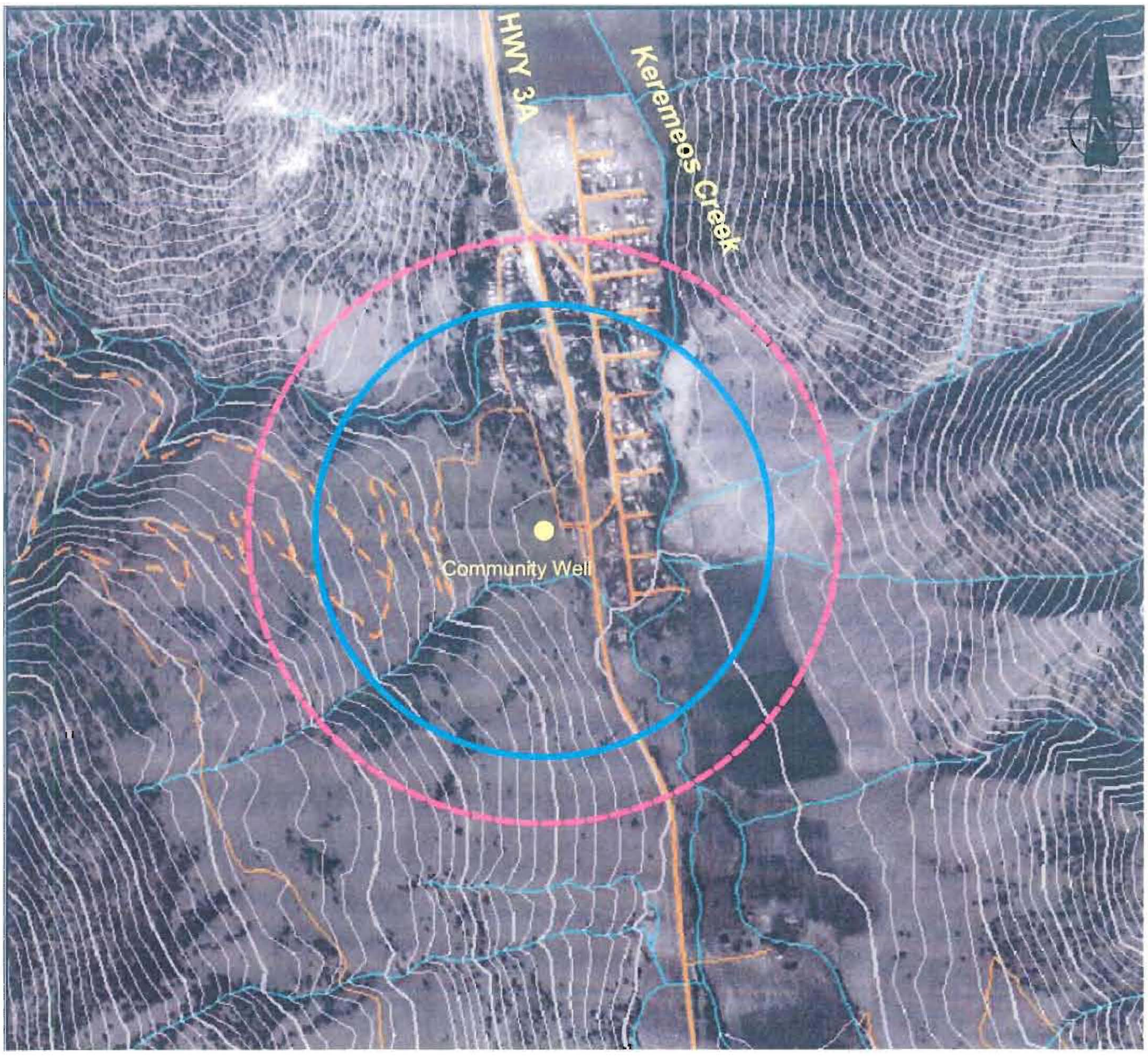
Legend:

- 60 Day Capture Zone
- 1 Year Capture Zone

0 50 100 150 200 250

Scale In Meters (Approximate)

Golder Associates KELOWNA, B.C.		SCALE 1:5000+/−	TITLE **60 DAY & 1 YEAR CAPTURE ZONES OF THE COMMUNITY WELL**
		DATE 11/10/04	
		DESIGN Z.M.	
		CADD L.D.	
FILE No. FIGURE_5.DWG		CHECK	
PROJECT No. 04−1440−040	REV.	REVIEW	Olalla Groundwater Protection Plan — FIGURE 6



Legend:
- 5 Year Capture Zone
- 10 Year Capture Zone

0 100 200 300 400 500
Scale in Meters (Approximate)

Golder Associates
KELOWNA, B.C.

SCALE	1:15000+/-
DATE	11/10/04
DESIGN	Z.M.
CADD	L.D.
CHECK	
REVIEW	
FILE No.	FIGURE_6.DWG
PROJECT No.	04-1440-040
REV.	

TITLE

5 AND 10 YEAR CAPTURE ZONES OF THE COMMUNITY WELL

Olalla Groundwater Protection Plan

FIGURE 7

Drawing file: 5-10yr_CaptureZones.dwg Nov 16, 2004 - 9:49pm

APPENDIX I

AVAILABLE WELL LOGS IN OLALLA AND SURROUNDING AREAS

BRITISH COLUMBIA

Well Tag Number 000000015750

Owner: GEORGE SCHOPP

Address: OLALLA

Area: OLALLA

WELL LOCATION:
SIMILKAMEEN Land District
District Lot 176 Plan Lot
Township Section Range
Indian Reserve Meridian Block
Quarter
Island
BCGS Number (NAD 27) 082E021423 Well 1

Well Use Unknown Well Use
Construction Method Drilled
Diameter 0.0 inches
Well Depth 59.0 feet
Elevation 0
Bedrock Depth UNK feet
Screen from 0 to 0 feet
Slot Size 1 Slot Size 2
Slot Size 3 Slot Size 4

Construction Date 19590101

Driller L.J. DESILETS
License Number

PRODUCTION DATA AT TIME OF DRILLING
Well Yield 0
Artesian Flow
Static Level 31 feet

Water Utility
Lithology Info Flag Y
Pump Test Info Flag
File Info Flag
Sieve Info Flag
Screen Info Flag
Water Chemistry Info Flag
Field Chemistry Info Flag
Site Info (SEAM)
Other Info Flag

GENERAL REMARKS:

From	0	To	30	Ft.	dug well
From	30	To	39	Ft.	sandy gravel
From	39	To	42	Ft.	compact silty sand
From	42	To	48	Ft.	sandy gravel
From	48	To	52	Ft.	compact silty sand
From	52	To	59	Ft.	fine gravel

6 rows selected.

Date entered to WELL

BRITISH COLUMBIA

Well Tag Number 000000046677

Owner: BOBOWSKI

Address:

Area:

WELL LOCATION:
SIMILKAMEEN Land District
District Lot 2061 Plan 11007 Lot 1
Township Section Range
Indian Reserve Meridian Block
Quarter
Island
BCGS Number (NAD 27) 082E021423 Well 4

Well Use Unknown Well Use
Construction Method Drilled
Diameter 6.0 inches
Well Depth 95.0 feet
Elevation 0
Bedrock Depth UNK feet
Screen from 90 to 94 feet
Slot Size 1 Slot Size 2
Slot Size 3 Slot Size 4

Construction Date 19801125

Driller Quality Well Drilling
License Number

PRODUCTION DATA AT TIME OF DRILLING
Well Yield 40 GPM
Artesian Flow
Static Level 54 feet

Water Utility
Lithology Info Flag Y
Pump Test Info Flag
File Info Flag
Sieve Info Flag
Screen Info Flag
Water Chemistry Info Flag
Field Chemistry Info Flag
Site Info (SEAM)
Other Info Flag

GENERAL REMARKS:

From	0	To	5	Ft.	soil and pebbles
From	5	To	8	Ft.	dry pebbles
From	8	To	18	Ft.	dirty brown sand and gravel, tight
From	18	To	21	Ft.	dry pebbles
From	21	To	30	Ft.	brown sand and pebbles
From	30	To	34	Ft.	clean pebbles
From	34	To	62	Ft.	brown sand, gravel, damp
From	62	To	75	Ft.	dirty sand (brown) and sharp gravel
From	75	To	95	Ft.	black sand and pebbles, clean

9 rows selected.

Date entered to WELL

BRITISH COLUMBIA

Well Tag Number 000000044690

Owner: E JOHNSON & T SMITH

Address: BOX 53 KEREMEOS TRAILER PK

Area: KEREMEOS

WELL LOCATION:
SIMILKAMEEN Land District
District Lot 2749 Plan 28907 Lot A
Township Section Range
Indian Reserve Meridian Block
Quarter
Island
BCGS Number (NAD 27) 082E021423 Well 3

Well Use Domestic
Construction Method Drilled
Diameter 8.0 inches
Well Depth 98.0 feet
Elevation 0
Bedrock Depth UNK feet
Screen from 87 to 98 feet
Slot Size 1 Slot Size 2
Slot Size 3 Slot Size 4

Construction Date 19800401

Driller Quality Well Drilling
License Number

PRODUCTION DATA AT TIME OF DRILLING
Well Yield 30 GPM
Artesian Flow
Static Level 53 feet

Water Utility
Lithology Info Flag Y
Pump Test Info Flag
File Info Flag
Sieve Info Flag
Screen Info Flag
Water Chemistry Info Flag
Field Chemistry Info Flag
Site Info (SEAM)
Other Info Flag

GENERAL REMARKS:
EXCELLENT WATER, SOFT AND CLEAR. LOTS OF WATER.

From	0	To	6	Ft.	tight sand and gravel and big rocks
From	6	To	20	Ft.	compact sand and gravel very sharp
From	20	To	43	Ft.	cemented sand, black gravel tight and
From	0	To	0	Ft.	sharp
From	43	To	55	Ft.	tight sand and gravel, sharp with brown
From	0	To	0	Ft.	clay
From	55	To	60	Ft.	cemented sand and gravel, tight
From	60	To	69	Ft.	sharp gravel with sand, black w.b.
From	69	To	75	Ft.	black sand and sharp gravel
From	75	To	85	Ft.	sharp rocks and black sand with brown
From	0	To	0	Ft.	clay on rocks, tight
From	85	To	98	Ft.	strips of w.b. material, gravel sharp
From	0	To	0	Ft.	with brown sand fine, brown clay on
From	0	To	0	Ft.	rocks, tight

14 rows selected.

Date entered to WELL

BRITISH COLUMBIA

Well Tag Number 000000036775

Owner: W HALL

Address: OLALLA

Area: OLALLA

WELL LOCATION:
SIMILKAMEEN Land District
District Lot Plan 85 Lot 14
Township Section Range
Indian Reserve Meridian Block 7
Quarter
Island
BCGS Number (NAD 27) 082E021423 Well 2

Well Use Unknown Well Use
Construction Method Drilled
Diameter 6.0 inches
Well Depth 86.0 feet
Elevation 0
Bedrock Depth UNK feet
Screen from 82 to 86 feet
Slot Size 1 Slot Size 2
Slot Size 3 Slot Size 4

Construction Date 19770303

Driller Quality Well Drilling
License Number

PRODUCTION DATA AT TIME OF DRILLING
Well Yield 50 GPM
Artesian Flow
Static Level 48 feet

Water Utility
Lithology Info Flag Y
Pump Test Info Flag
File Info Flag
Sieve Info Flag
Screen Info Flag
Water Chemistry Info Flag
Field Chemistry Info Flag
Site Info (SEAM)
Other Info Flag

GENERAL REMARKS:

From	0	To	3	Ft.	soil and gravel
From	3	To	8	Ft.	sand and gravel
From	8	To	12	Ft.	cemented sand and gravel and clay
From	12	To	48	Ft.	sand, gravel and rocks and clay -dirty
From	48	To	86	Ft.	same, clean

Date entered to WELL

OLALLA IMPROVEMENT DISTRICT
10-INCH WATER WELL
DRILLER'S LITHOLOG
(ABANDONED WELL)

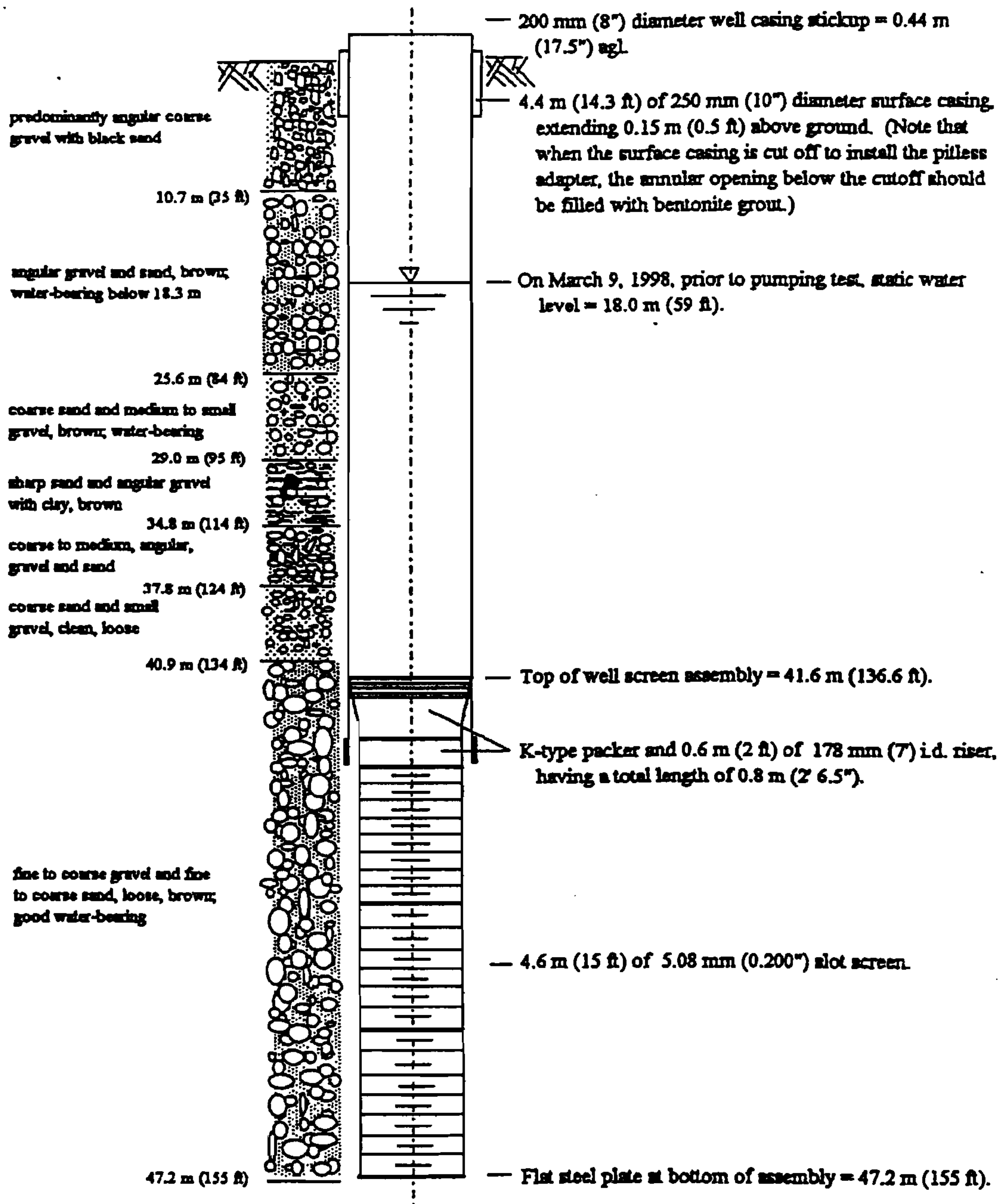
Depth Interval in feet	Lithologic description
0 - 2	Silty, sandy alluvial slide gravels
2 - 11	Silty, sandy broken alluvial gravels
11 - 26	Silty clay, sandy broken gravels
26 - 43	Silty clayey, sandy broken gravels, getting more gravelly and tighter with occasional layers of reddish brown clayey silt
43 - 53	Grey brown silty broken alluvial gravels, water started at 46 feet
53 - 63	Dark grey coarse cobbly silty gravel
63 - 76	Coarse cobbly broken gravels, occasional small boulders
76 - 80	Coarse cobbly broken gravels
80 - 81	Gravel is getting tighter, siltier and sandier water can be bailed down
81 - 88	Coarse cobbly broken gravels
88 - 89	Gravel is tight again
89 - 91	Gravel is looser
91 - 100	Gravel is looser and color is changing
100 - 102	Loose coarse silty broken gravels
102 - 102.5	Layer of firm silty clay

(Kala, 1986)

Driller's Litholog (continued)

Depth Interval in feet	Lithologic Description
102.5 - 110	Coarse loose sandy gravel, tight at the bottom. Layer of silt at 104 feet
110 - 112	Formation is getting tighter and casing driving hard (Till?)

(Kala, 1986)



Notes:

1. The sketch is not to scale.
2. The well screen is 200 mm (8") nominal diameter Johnson stainless steel, with an i.d. of 168 mm (6.6").
3. All measurements are below ground unless otherwise indicated.

PROJECT NO.: O707101	**PACIFIC HYDROLOGY CONSULTANTS LTD.** *CONSULTING HYDROGEOLOGISTS*		
PROJECT: **GROUNDWATER SOURCE DEVELOPMENT AT OLALLA FOR RDOS**	**OLALLA WELL 1-98 CONSTRUCTION DETAILS**		
LOCATION: Olalla, north of Keremeos, B.C.	DATE: 04/06/98	DRAWN BY: ab	FIGURE: 3

BRITISH COLUMBIA

Well Tag Number 000000044076 Owner: GARVIN NYEN Address: OLALLA Area: OLALLA WELL LOCATION: SIMILKAMEEN Land District District Lot 176 Plan Lot Township Section Range Indian Reserve Meridian Block Quarter Island BCGS Number (NAD 27) 082E021421 Well 1 Well Use Unknown Well Use Construction Method Drilled Diameter 6.0 inches Well Depth 46.0 feet Elevation 0 Bedrock Depth UNK feet Screen from 40 to 45 feet Slot Size 1 Slot Size 2 Slot Size 3 Slot Size 4	Construction Date 19800101 Driller Quality Well Drilling License Number PRODUCTION DATA AT TIME OF DRILLING Well Yield 25 GPM Artesian Flow Static Level 14 feet Water Utility Lithology Info Flag Y Pump Test Info Flag File Info Flag Sieve Info Flag Screen Info Flag Water Chemistry Info Flag Field Chemistry Info Flag Site Info (SEAM) Other Info Flag

GENERAL REMARKS:
WATER IS EXCELLENT, PLENTY OF WATER.

From	0	To	7	Ft.	black sand, gravel and rocks, tight
From	7	To	14	Ft.	cemented gravel and clay tight
From	14	To	17	Ft.	strip of brown clay hard
From	17	To	24	Ft.	sharp rocks with black sand dirty
From	24	To	30	Ft.	small gravel and sand -looser
From	30	To	36	Ft.	dark brown sand and gravel with fines,
From	0	To	0	Ft.	dirty
From	36	To	46	Ft.	lrg. and sm. gravel, br. sand, loose and
From	0	To	0	Ft.	clean

9 rows selected.

Date entered to WELL

BRITISH COLUMBIA

Well Tag Number 000000049646

Owner: TREVOR JOLLEYS

Address: RR 1 KEREMEOS

Area: KEREMEOS

WELL LOCATION:
SIMILKAMEEN Land District
District Lot 176 Plan Lot
Township Section Range
Indian Reserve Meridian Block
Quarter
Island
BCGS Number (NAD 27) 082E021422 Well 2

Well Use Unknown Well Use
Construction Method Drilled
Diameter 6.0 inches
Well Depth 72.0 feet
Elevation 0
Bedrock Depth UNK feet
Screen from 67 to 72 feet
Slot Size 1 Slot Size 2
Slot Size 3 Slot Size 4

Construction Date 19811201

Driller Quality Well Drilling
License Number

PRODUCTION DATA AT TIME OF DRILLING
Well Yield 10 GPM
Artesian Flow
Static Level 22 feet

Water Utility
Lithology Info Flag Y
Pump Test Info Flag
File Info Flag
Sieve Info Flag
Screen Info Flag
Water Chemistry Info Flag
Field Chemistry Info Flag
Site Info (SEAM)
Other Info Flag

GENERAL REMARKS:

From	0	To	7	Ft.	black sandy soil, very tight with broken
From	0	To	0	Ft.	rocks
From	7	To	16	Ft.	cemented black sand and rocks -tight
From	16	To	20	Ft.	clean black sand with polished gravel
From	0	To	0	Ft.	-little looser
From	20	To	26	Ft.	cemented gravel, very tight with br.clay
From	26	To	40	Ft.	cemented sand and gravel, tight with
From	0	To	0	Ft.	br. clay
From	40	To	63	Ft.	broken rocks cemented with br. clay
From	0	To	0	Ft.	-little water and black sand
From	63	To	72	Ft.	broken gravel, some sharp with black
From	0	To	0	Ft.	sand -w.b., active

12 rows selected.

Date entered to WELL

BRITISH COLUMBIA

Well Tag Number 000000049973

Owner: TREVOR JOLLEYS

Address: RR 1 KEREMEOS

Area: KEREMEOS

WELL LOCATION:
SIMILKAMEEN Land District
District Lot 176 Plan Lot
Township Section Range
Indian Reserve Meridian Block
Quarter
Island
BCGS Number (NAD 27) 082E021422 Well 1

Well Use Unknown Well Use
Construction Method Drilled
Diameter 8.0 inches
Well Depth 100.0 feet
Elevation 0
Bedrock Depth UNK feet
Screen from 86 to 97 feet
Slot Size 1 Slot Size 2
Slot Size 3 Slot Size 4

Construction Date 19820301

Driller Quality Well Drilling
License Number

PRODUCTION DATA AT TIME OF DRILLING
Well Yield 800 GPM
Artesian Flow
Static Level 8 feet

Water Utility
Lithology Info Flag Y
Pump Test Info Flag
File Info Flag
Sieve Info Flag
Screen Info Flag
Water Chemistry Info Flag
Field Chemistry Info Flag
Site Info (SEAM)
Other Info Flag

GENERAL REMARKS:

From	0	To	2	Ft.	rocky soil
From	2	To	3	Ft.	dark brown soil
From	3	To	9	Ft.	pebbles and large and small gravel with
From	0	To	0	Ft.	sharp rocks
From	9	To	35	Ft.	same - w.b.
From	35	To	38	Ft.	br. silt and sand
From	38	To	46	Ft.	br. sand and gravel
From	46	To	52	Ft.	br. silty sand and pebbles
From	52	To	66	Ft.	lrg. gravel
From	66	To	78	Ft.	lrg. and sm. gravel dirty -some clay
From	78	To	80	Ft.	lrg. and sm. gravel, some sand -cleaner
From	80	To	100	Ft.	lrg. gravel

12 rows selected.

Date entered to WELL

BRITISH COLUMBIA

Well Tag Number 000000035655 Owner: CARPENTER Address: HWY 3 OLLALA Area: OLLALA WELL LOCATION: SIMILKAMEEN Land District District Lot 2398 Plan Lot Township Section Range Indian Reserve Meridian Block Quarter Island BCGS Number (NAD 27) 082E021243 Well 1 Well Use Unknown Well Use Construction Method Unknown Constru Diameter 6.0 inches Well Depth 60.0 feet Elevation 0 Bedrock Depth UNK feet Screen from 0 to 0 feet Slot Size 1 Slot Size 2 Slot Size 3 Slot Size 4	Construction Date 19760904 Driller A.C. DRILLERS License Number PRODUCTION DATA AT TIME OF DRILLING Well Yield 0 Artesian Flow Static Level 14 feet Water Utility Lithology Info Flag Y Pump Test Info Flag File Info Flag Sieve Info Flag Screen Info Flag Water Chemistry Info Flag Field Chemistry Info Flag Site Info (SEAM) Other Info Flag

GENERAL REMARKS:

From	0	To	37	Ft.	soil rock and sand (alluvial slide mat-
From	0	To	0	Ft.	erials)
From	37	To	42	Ft.	brown clayey gravel
From	42	To	60	Ft.	sandy gravel

Date entered to WELL

BRITISH COLUMBIA

Well Tag Number 000000053183 Owner: CIRCLE "C" RANCH Address: OLLALLA Area: OLLALLA WELL LOCATION: SIMILKAMEEN Land District District Lot 393 Plan 24262 Lot A Township Section Range Indian Reserve Meridian Block Quarter Island BCGS Number (NAD 27) 082E021244 Well 2 Well Use Unknown Well Use Construction Method Unknown Constru Diameter 6.0 inches Well Depth 54.0 feet Elevation 0 Bedrock Depth UNK feet Screen from 0 to 0 feet Slot Size 1 Slot Size 2 Slot Size 3 Slot Size 4	Construction Date 19840101 Driller RURAL WELL DRILLERS License Number PRODUCTION DATA AT TIME OF DRILLING Well Yield 0 Artesian Flow Static Level 25 feet Water Utility Lithology Info Flag Y Pump Test Info Flag File Info Flag Sieve Info Flag Screen Info Flag Water Chemistry Info Flag Field Chemistry Info Flag Site Info (SEAM) Other Info Flag

GENERAL REMARKS:

From 0 To 41 Ft. hardpan
From 41 To 54 Ft. sand and gravel

Date entered to WELL

BRITISH COLUMBIA

Well Tag Number 000000037786

Owner: WILSON CLIFTON

Address: KEREMEOS

Area: KEREMEOS

WELL LOCATION:
SIMILKAMEEN Land District
District Lot 393 Plan Lot
Township Section Range
Indian Reserve Meridian Block
Quarter
Island
BCGS Number (NAD 27) 082E021244 Well 1

Well Use Unknown Well Use
Construction Method Drilled
Diameter 10.0 inches
Well Depth 153.0 feet
Elevation 0
Bedrock Depth UNK feet
Screen from 123 to 133 feet
Slot Size 1 Slot Size 2
Slot Size 3 Slot Size 4

Construction Date 19770730

Driller A.C. DRILLERS
License Number

PRODUCTION DATA AT TIME OF DRILLING
Well Yield 350 GPM
Artesian Flow
Static Level 6 feet

Water Utility
Lithology Info Flag Y
Pump Test Info Flag
File Info Flag
Sieve Info Flag
Screen Info Flag
Water Chemistry Info Flag
Field Chemistry Info Flag
Site Info (SEAM)
Other Info Flag

GENERAL REMARKS:

From	0	To	5	Ft.	tight silty gravel
From	5	To	17	Ft.	loose " "
From	17	To	80	Ft.	grey silt
From	80	To	119	Ft.	medium coarse tan colored till
From	119	To	153	Ft.	interbedded loose and tight silty gra-
From	0	To	0	Ft.	vels

6 rows selected.

Date entered to WELL