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REPORT ON CONTAMINANT INVENTORY FOR THE GRAND FORKS AQUIFER for the GRAND FORKS AQUIFER PROTECTION COMMITTEE

Submitted to:

Grand Forks Aquifer Protection Committee
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EXECUTIVE SUMMARY

Golder Associates Ltd. (Golder) is pleased to present this Regional Contaminant Inventory for the Grand Forks Aquifer to the City of Grand Forks and the Grand Forks Aquifer Protection Committee (the Committee). The Committee was formed in the late 1990's in response to increasing concerns over the vulnerability of the aquifer underlying Grand Forks and the surrounding area (herein referred to as the Aquifer), and is made up of a number of water purveyors that obtain their groundwater supply from a total of 26 wells within the Aquifer, including the City of Grand Forks (CGF), Sion Improvement District (SION), Grand Forks Irrigation District (GFID), Covert Irrigation District (CID), and a number of mobile home parks.

As a proactive means of protecting the Aquifer, the Committee has undertaken the first two steps as outlined in the Well Protection Toolkit (the Toolkit) developed by the Groundwater Management Section of the BC Ministry of Water, Land and Air Protection (MWLAP), namely, Step #1 - forming a community planning team, and Step #2 - defining preliminary well protection areas. Given the dependence of the City and surrounding area on groundwater as a source of domestic and irrigation water, the intrinsic vulnerability of the local aquifer and the risk of groundwater contamination from agriculture, industry and other land uses, the Grand Forks Aquifer is ideally suited for groundwater protection planning. For the Grand Forks Aquifer, conducting a regional contaminant inventory was critical given that the major contaminant of concern is nitrate, which is known to result from regional land use activities that likely fall outside the community well capture zones.

This report presents the results of the following activities:

1. Review of existing data and reports.
2. Conduct a regional contaminant inventory.
3. Conduct a preliminary detailed contaminant inventory.

The unconfined Grand Forks Aquifer is comprised of gravel, sand, silt and clay up to 123 m depth which generally thins out to the east (approximately 40 m thick), generally become finer with depth. Based on available water levels, the local groundwater flow is described to be towards the Kettle River, while regional flow is generally from the west to the east. The Kettle River is reportedly recharging the Aquifer in the western part of the Aquifer, while the Kettle River is a discharge zone in the eastern part of the Aquifer. The east-flowing Kettle River and south-flowing Granby River converge in Grand Forks in the approximate centre of the Aquifer.

The Grand Forks Aquifer (Aquifer No. 158) is classed by MWLAP as a "IA" aquifer, considered heavily developed with high vulnerability to contamination. Existing impacts on the groundwater quality associated with nitrates and gasoline have been identified in some areas.

Preliminary capture zones were delineated by MWLAP using arbitrary and calculated fixed radius and analytical equations and analytical solutions. Collectively, capture zones defined by the AFR/CFR method appear to extend across approximately one-third of the total Aquifer area. The parabolic capture zones from the analytical solutions are generally smaller in aerial extent than those defined by the AFR/CFR method. The parabolic capture zones tend to provide further coverage along the length of the capture zone, but are narrower in width.

A numerical model was developed by Dr. Diana Allen of SFU (2000) to determine the capture zones and travel times zones for the main water supply wells. The study concluded that capture zones for the larger production wells are generally parabolic in shape, with the length orientated upgradient of the well. Based on the model simulations, it was concluded that a number of wells are recharged by water from the Kettle River. The capture zones estimated with the numerical model tend to be larger in aerial extent than the analytical solutions capture zones; however, the general shape of the numerical model and analytical solutions capture zones are similar.

A regional contaminant inventory was conducted by Golder to broadly identify existing and potential sources of groundwater contamination across the Aquifer. In response to a request from Golder, MWLAP conducted a search of its Contaminated Sites Registry (CSR), WASTE and spills databases for the Grand Forks region. A total of 17 sites within the City of Grand Forks and Regional District of Kootenay Boundary are registered with the MLWAP Sites Registry. A total of 69 sites from 30 businesses were listed in the MWLAP Waste Registry. A search of the MLWAP spills database identified 55 spill sites. Other potential sources of contamination identified by the regional inventory included underground storage tanks, septic systems, stormwater, abandoned water supply wells, transportation of dangerous goods, sand and gravel extraction, surface water influences, landfill and dumping, and application and use of fertilizers and pesticides (both agricultural and residential).

A preliminary detailed inventory of businesses and activities within the capture zones was conducted to identify threats to groundwater quality within the preliminary capture zones.

- The CID, Sion, Copper Ridge and Almond Garden MHP water supply wells are located in rural residential and agricultural areas of west and north Grand Forks, with few industrial sites noted nearby. No MWLAP spill or Site Registry sites were located within the preliminary capture zones for these wells, with the exception of the Copper Ridge and Almond Garden MHP wells.

- The Big Y and 87-2/5 wells are located in south Grand Forks, surrounded by a mix of industrial properties (Pacific Abrasives, railway tracks, junk yard), nurseries, other farms and rural residential. In addition, four MWLAP spill sites and one MWLAP effluent permit site were located within the preliminary capture zones for the Big Y and 87-2/5 wells.

- The Grand Forks wells are located in an area characterized by residential land use, with Highway 3 and associated commercial businesses (including service stations) nearby. Eight MWLAP CSR Site Registry sites and three MWLAP spill sites were located within the preliminary capture zones for the Grand Forks wells. Historical information also included airfields located at Hutton school and Dick Barlett Park, near the Grand Forks wells.

- The Nursery wells are located near the Kettle River in east Grand Forks, in a primarily agricultural area. One MWLAP CSR spill site was located within the preliminary capture zones for the Nursery wells.

- The Kettle River and Riviera MHP wells are located between Highway 3 and the Kettle River in east Grand Forks. The MHPs are surrounded by commercial and/or industrial properties (including a closed service station; car parts business; Aquila works yard; and, an auto body shop). One MWLAP effluent permit was associated with the MHP and a number of MWLAP spill and Contaminated Site Registry sites are located west of the Kettle River, within 500 m of the wells.

A number of water supply wells are located in areas not serviced by the City of Grand Forks water or sewer system, therefore it is assumed that each property contains a septic field and water supply well. Potential contamination associated with the residential and agricultural properties includes septic effluent and other chemicals entering the septic system, agriculture animal waste run-off, lawn care chemicals, other products associated with equipment and vehicle maintenance, and pesticides and herbicides used in agriculture. Potential contamination associated with the commercial properties is related to the chemicals handled by the respective business.

A relative risk rating was applied to the land use survey developed by MELP, based on the professional opinion of experience senior professionals practicing in the province of British Columbia, verified by discussions with other senior groundwater and agricultural professionals from the private and public sector. The other land use ranking was based on the potential volumes of chemicals commonly associated with the land use and the relative mobility of these chemicals in groundwater if a release were to occur. A ranking of hazards relative to land use indicates that generally, land occupied by commercial, industrial and certain types of agricultural land use poses the greatest threat to groundwater. Other agricultural land use poses a moderate threat, while residential land use poses a relatively low threat to groundwater.

Based on the results of this study, the following recommendations are made:

1. **Refine Numerical Model and Associated Capture Zones**: We understand that the numerical groundwater flow model for the Grand Forks Aquifer is currently being refined by SFU. We would recommend that the refinements include improvements to the water balance and numerical grid discretization of the model, and that a rigorous sensitivity analysis be carried out. Once these improvements are made, the model could presumably be used to determine more accurate capture zones and times of travel for the community groundwater supply wells.

2. **Conduct a Comprehensive Detailed Contaminant Inventory**: Once the capture zones of the key wells have been refined, a comprehensive contaminant inventory of the individual capture zones should be carried out. This inventory would expand upon the information collected as part of the regional contaminant inventory and the preliminary detailed inventory presented in this report. If required, the detailed inventory may include an analysis of the types and quantities of chemicals used within each capture zone (chemical inventory). The major contaminant risks associated with each capture zone should be evaluated through a subjective risk evaluation.

3. **Pesticide and Fertilizer Use**: Guidelines and restrictions for pesticide and fertilizer use in public use areas, and possibly residential properties, within capture zones should be implemented. These guidelines may include a designated no-spray zone around water supply wells. In addition, contingency plans should be prepared in the event of a pesticide or fertilizer spill or accident. Mixing of chemicals and refilling of containers, spray and applicators should be completed in contained areas away from wells, water sources, and areas characterized by permeable soil conditions.

In addition, we recommend that an educational brochure, pamphlet and/or workshop aimed at i) the residential land users and ii) agricultural land users be developed. The educational materials should outline the proper application of fertilizers and pesticides and the potential impact of these chemicals on the groundwater quality in Grand Forks.

4. **Water Quality Monitoring Program**: We understand that currently, each improvement and irrigation district, private water purveyor and the City of Grand Forks conducts individual monitoring of their respective groundwater quality. We recommend that the scope of the current groundwater monitoring programs for these purveyors be assessed, and that the historical water quality data be reviewed. The purpose of the review would be to identify any outstanding water quality issues and to identify additional monitoring that may be required to address risks identified by the contaminant inventory.

   In addition, it is recommended that the potential for groundwater to be influenced by microbial contamination from surface water sources be assessed.

5. **Designate Groundwater Protection Areas**: Once the capture zones for the wells have been refined, the CGF and RDKB should consider designating formal groundwater protection areas. Two different strategies can be employed when designating groundwater protection areas: i) a *wellhead protection approach*, whereby groundwater protection area is defined relative to a capture zone or part of a capture zone; and, ii) *aquifer protection approach*, whereby part or all of an aquifer is designated for protection.

   The CGF and RDKB may wish to defined groundwater protection areas based on the entire capture zone, or based on a corresponding travel time to a well. The advantage of defining groundwater protection in this manner is that a concerted effort can be made to manage activities near the wellhead, thereby protecting the water supply. In our experience, the greatest degree of groundwater protection is achieved by combining wellhead protection and aquifer protection. The CGF and RDKB may wish to consider designating part of the Grand Forks Aquifer that lies outside of the capture zones as some form of groundwater protection area. The advantage of defining protection areas in this manner is that it allows for the protection of groundwater recharge areas, regions serviced by private water wells and areas where future water supplies may be developed. Additional aquifer characterization and mapping may be required to assist with the designation of areas of the aquifer requiring protection, such as recharge zones.

6. **Develop Groundwater Protection Measures**: Once designated groundwater protection areas have been established and additional potential contaminant sources have been identified, the CGF and RDKB may wish to embark on the development of groundwater protection measures. Groundwater protection measures can be implemented at the municipal level through both regulatory and non-regulatory measures. In our opinion, while non-regulatory measures, such as public education and best management practices, can be highly effective, some degree of regulatory control may to required to ensure the protection of the groundwater resources. These regulatory strategies often involve the use of municipal land use planning and zoning bylaws to restrict certain high-risk land use activities within protection areas. As an alternative to land use restrictions, some communities, such as Fredericton, New Brunswick, have chosen to restrict the types and quantities of chemicals used within groundwater protection areas.

   Public participation and education represents one of the most important forms of non-regulatory groundwater protection. It is essential to the success of a groundwater protection plan and provides a means of securing political and financial support. A public education campaign would identify groundwater protection areas, threats to groundwater supplies in those areas, and measures individuals and businesses can take to protect the resource. Examples of public education tools include the use of the public information meetings, signs erected at strategic locations around groundwater protection areas, the use of media, distribution of information brochures on best management practices and school education programs.

7. **Develop Contingency Plans**: Contingency planning consists of developing a plan for the location and provision of alternative drinking water supplies in the event that the existing well field cannot be used. Disruptions to the existing well field may be related to either contamination or non-contamination effects. The contingency plan should identify short-term alternatives in the event of a minor disruption, and long-term alternatives in the event of a complete loss of water supply. It is recommended that if one is not already in existence, a contingency plan for the various water supplies be developed.

8. **Develop Emergency Response Plans**: The goal of groundwater protection is to prevent the contamination of underground drinking water supplies. Even under the best prevention plans, a scenario that threatens to contaminate the aquifer may occur. When this happens, an emergency response plan directing a coordinated and timely response is an effective tool for assuring a continued supply of potable water. Many

communities' emergency response plans do not include specific provisions for the protection of groundwater resources in the event of a spill or accident.

For example, it may be prudent for emergency response personnel to restrict the use of fire retardant chemicals in sensitive groundwater areas. We recommend that the irrigation district, MHP and CGF's existing emergency response plan be evaluated and revised, if necessary, to allow for the protection of sensitive groundwater resources.

9. **Other**:

- Conduct a door-to-door survey to determine which wells are abandoned but have not been properly decommissioned.
- Prepare an educational brochure or pamphlet aimed at all Grand Forks residents on the proper maintenance and use of domestic effluent disposal to septic fields. This could be completed in conjunction with the door-to-door water well survey.
- Conduct an annual survey of all transformers in the vicinity of the wells to confirm that no leakage is occurring.
- To ensure the security of the water distribution system, we recommend that access to all wellheads and water distribution systems be restricted.

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) is pleased to present this Regional Contaminant Inventory for the Grand Forks Aquifer to the City of Grand Forks and the Grand Forks Aquifer Protection Committee. The project was carried out in accordance with the Terms of Reference outlined in our proposal entitled "Grand Forks Aquifer Protection Committee, Contaminant Inventory, Request for Proposal No. 2002-001" (Golder Proposal Number P22-4140), dated September 4, 2002. The work consisted of identifying potential sources of contamination at a regional scale that may pose a threat to groundwater quality.

2.0 BACKGROUND

Grand Forks is located approximately at the confluence of the Kettle River and Granby River in the Boundary District of south central British Columbia, as shown in Figure 1. The population of Grand Forks is approximately 4,000, with approximately 3,500 people living in the surrounding Area D district of the Regional District of Kootenay Boundary (Area D of Regional District of Kootenay Boundary is herein referred to as RDKB). The economic base of the region is primarily agricultural and tourism, with some mining and forestry. Photographs of the Grand Forks area are provided in Appendix I (Photographs 1, 2 and 3) and aerial coverage is provided in Figure 2.

The Grand Forks Aquifer Protection Committee (the Committee) was formed in the late 1990's in response to increasing concerns over the vulnerability of the aquifer underlying Grand Forks and the surrounding area (herein referred to as the Aquifer). The Aquifer is generally described as unconfined in nature and hosted within glacio-fluvial deposits lain within the Kettle River Valley. The B.C. Ministry of Water, Land and Air Protection (MWLAP) has classified the Grand Forks Aquifer as "IA", meaning it is highly developed and highly vulnerable to surface contamination due to the absence of a protective, confining layer. The depth to water is generally within 15 m of ground surface and the Aquifer is considered highly vulnerable to contamination from surface sources.

The Committee is made up of a number of water purveyors that obtain their groundwater supply from a total of 26 wells within the Aquifer, including the City of Grand Forks (CGF), Sion Improvement District (SION), Grand Forks Irrigation District (GFID), Covert Irrigation District (CID), and a number of mobile home parks (Figure 3). These 26 wells extract approximately 320 billion litres of groundwater annually from the Grand Forks Aquifer for domestic and irrigation use. According to MWLAP, most of Grand

Forks and the surrounding area relies on groundwater for their water supply, with over 240 water wells registered on MWLAP water well registry (MELP, 1994) (Figure 4).

In recent years, water quality monitoring has indicated the Aquifer has come under increasing stress, mainly from nitrate loading as a result of fertilizer application associated with widespread agricultural activities in the valley and possibly from ground disposal via septic systems of domestic sewage effluent.

As a proactive means of protecting the Aquifer, the Committee has undertaken the first two steps as outlined in the Well Protection Toolkit (the Toolkit) developed by the Groundwater Management Section of the BC Ministry of Water, Land and Air Protection (MWLAP), namely, Step #1 - forming a community planning team, and Step #2 - defining preliminary well protection areas. Given the dependence of the City and surrounding area on groundwater as a source of domestic and irrigation water, the intrinsic vulnerability of the local aquifer and the risk of groundwater contamination from agriculture, industry and other land uses, the Grand Forks Aquifer is ideally suited for groundwater protection planning. While the development and implementation of a groundwater protection program requires some effort and expense, the relative cost of this proactive approach is minor compared with the economic and environmental costs that could be incurred if the groundwater resource were to be left unmanaged. This project initiates work on Step #3 of the Toolkit – identifying potential contaminants.

3.0 SCOPE OF WORK

Step #3 of the MWLAP Toolkit (MELP, 1999) focuses on determining the sources of potential contaminants, where they are located, and what type of contaminants they are. As a means of achieving this, the toolkit recommends the following be carried out:

- Obtain information about past, present and potential sources of contamination;
- Document current management practices for activities in the well protection area;
- Record this information in a format that can be easily viewed and used;
- Set priorities for implementing protection measures,
- Update the inventory of potential contaminants on a regular basis.

While the Toolkit serves as a valuable resource tool in assisting communities with the protection of their groundwater resource, the toolkit provides a prescriptive approach that should be tailored to meet the unique conditions in every community. It is important to note that while the Toolkit provides for ***"wellhead protection"*** of community wells, it does not make provisions for ***"aquifer protection"***, which allows for the protection of areas where private wells are located, and vulnerable areas of the Aquifer such as groundwater recharge zones.

In our experience, contaminant inventories are most effective when they are completed on three scales. Initially, a ***regional contaminant inventory*** is conducted of the entire aquifer to obtain a "snap-shot" of regional conditions and to identify concerns that may require additional investigation. Subsequent to the regional contaminant inventory, ***detailed contaminant inventories*** are carried out within capture zones of community wells and any other high risk areas identified by the regional inventory. In some cases, a third scale of investigation is required, whereby detailed ***chemical inventories*** of the types and quantities of chemicals used by "high risk" facilities located within capture zones are conducted.

For the Grand Forks Aquifer, conducting a regional contaminant inventory was critical given that the major contaminant of concern is nitrate, which is known to result from regional land use activities that likely fall outside the community well capture zones.

Capture zones for 24 community water supply wells were initially defined by the Ministry of Water, Lands and Parks (MWLAP) using simplified analyses (MWLAP, 1999). Subsequently, the capture zones were redefined by Dr. Diana Allen of Simon Fraser University (SFU) using a numerical groundwater model (Allen, 2000).

3.1 Data Compilation and Review

A regional contaminant inventory was conducted to broadly identify general environmental concerns across the area (aquifer extent determined by MWLAP and shown on Figure 3) and existing and potential sources of groundwater contamination within the Aquifer. In addition, a preliminary detailed inventory in the area of each well was conducted to identify specific concerns within each capture zone. The regional inventory was conducted by means of field reconnaissance and supplemented by data from a wide range of information sources, as outline below. The regional inventory did not include interviews with private property owners or site-specific inspections.

1. A search of the databases maintained by the BC Ministry of Water, Land and Air Protection (MWLAP) to identify: 1) sites contained within the Sites Registry; 2) sites contained within the WASTE database, used to manage information related to permits and approvals; and, 3) sites contained within the database for reporting spills to MWLAP.
2. A discussion with Lorraine Thompson, Environmental Health Officer, Interior Health Authority, regarding private water purveyors, domestic septic systems, overall water quality concerns and potential environmental concerns.
3. A discussion with Brian Porter, Superintendent CGF, regarding water quality concerns and potential environmental concerns.
4. A review of the CGF Zoning Bylaw No. 1606 and RDKB (Electoral Area 'D') Bylaw No. 620.
5. A review of the City of Grand Forks Official Community Plan (OCP), and the RDKB OCP.
6. A discussion with Blair MacGregor and Ramey Rooke, Fire Chiefs for the CGF and surrounding area, respectively, concerning the status of underground storage tanks (USTs).
7. Discussions with Carl Wiffler, BC Ministry of Agriculture, Food and Fisheries and Carol Chenery, Canadian Food Inspection Agency, regarding agricultural practices in the region.
8. Discussions with other local residents, including Dan Martin and Rose Gobeil, regarding potential environmental concerns to the Aquifer.
9. A discussion with the representatives of the main irrigation districts (Jim Watson, Steve Babikoff, and Peter Stoochnoff).
10. A review of the Telus "Grand Forks Area Superpages", Valid 2001/2002.

11. A review of available business licenses maintained by the CGF and RDKB.
12. A review of the sanitary sewer, drainage and water distribution systems for the City of Grand Forks.
13. A review of historical fire insurance maps for Grand Forks;
14. A review of other available TRIM, topographic and regional maps.
15. A review of aerial photographs.
16. A review of the City of Grand Forks museum archives and discussions with Judy Ronaghan, museum employee.
17. A review of information provided by MWLAP.

3.2 Field Reconnaissance

Following data compilation and review, a preliminary field reconnaissance was conducted by means of a windshield survey. The purpose of the field reconnaissance was to provide some preliminary information towards the detailed contaminant inventory of the capture zones, and to investigate any regional areas of concern identified during data compilation. A "windshield survey" was conducted within the CGF and surrounding area, which included visiting the municipal groundwater supply wells and driving most of the major industrial and agricultural areas within or adjacent to the wells. The locations of potential sources of contamination and properties where chemicals may be stored were noted.

3.3 Prioritization of Contaminant Risks

Once data from the information review and field reconnaissance was assembled, a subjective contaminant risk analysis was conducted to rank the potential contaminant risks to the Aquifer and prioritize areas requiring further analysis.

4.0 HYDROGEOLOGICAL CONDITIONS

4.1 Description of Grand Forks Aquifer

The Grand Forks Aquifer (herein referred to as the Aquifer) is described as late Pleistocene age and glaciofluvial origin, comprised of gravel, sand, silt and clay up to 123 m depth which generally thins out to the east (approximately 40 m thick). In addition, the Aquifer materials generally become finer with depth (MELP, 1994; MWLAP, 2002). The unconfined aquifer is bounded laterally by bedrock and vertically by lower permeability soils. A second sand and gravel aquifer is located in the northwest area of the study area, separated from the upper aquifer by fine sand, silt and clay. The bedrock geology of the Grand Forks region is generally described as highly metamorphosed igneous and sedimentary rocks, part of the Eastern Tectonic Belt, folded around an east-southeast and northerly trending axes. The Grand Forks group is bounded by faults on the east (along the Granby River) and the west (at Christina Lake).

The Aquifer is located in a broad, terraced valley at the confluence of the Granby and Kettle Rivers, covering an area approximately 8 km east-west direction and 5 km in a north-south direction. The east-flowing Kettle River and south-flowing Granby River converge in Grand Forks in the approximate centre of the Aquifer. The headwaters of the Kettle River is in the Monashee Mountains near Cherryville and flows 290 km, criss-crossing the Canadian-American border, to the Grand Coulee Dam.

The recharge to the Aquifer is described to be snow run-off, precipitation, infiltration from the Kettle and Granby Rivers, and possible irrigation return flow (MWLAP, 2002). Groundwater is observed at a depth between 1.5 to 47 m below ground surface. Based on available water levels, the local groundwater flow is described to be towards the Kettle River, while regional flow is generally from the west to the east (MELP, 1994b).

According to the Aquifer Classification System for Groundwater Management available on the MWLAP internet page, the Grand Forks Aquifer (Aquifer No. 158) is classed as a "IA" aquifer, considered heavily developed with high vulnerability to contamination. MWLAP developed a ranking scheme by which aquifers across the province could be compared, based on the productivity, size, vulnerability, demand, type of use, quality concerns, and quantity concerns of the Aquifer (MELP, 1994a). Based on the conditions of the Grand Forks Aquifer, the Aquifer scored a 17 out of a possible 21 on the ranking scheme, with increasing number associated with higher priority.

In 2002, Piteau Associates (Piteau) was retained by the Friends of the Grand Forks Aquifer to conduct a hydrological assessment to determine the potential impact on the Aquifer of the proposed "Cascade Heritage Park Project".

Piteau collected and reviewed information on the geology, water wells, well usage, groundwater levels and flow directions, and river water levels. The average monthly surface water flow were estimated to range from 14.3 m^3/s to 44.8 m^3/s in the Granby River (at Grand Forks) and from 32.4 m^3/s to 129.5 m^3/s in the Kettle River (at Cascade). The study found that the water levels in the Aquifer tend to mimic the water levels in the Kettle River, with highest water levels observed in May and June. In addition, based on water levels observed in the Kettle River and surrounding groundwater, the study concluded that the Kettle River recharges the Aquifer in the western part of the Aquifer, while the Kettle River is a discharge zone in the eastern part of the Aquifer.

4.2 Groundwater Supply Wells

As summarized in Section 2.0, the Grand Forks Aquifer Protection Committee is comprised of the CGF, SION, GFID, CID and a number of mobile home parks. Water for domestic, irrigation and industrial/commercial use is obtained from 26 groundwater supply wells (Figure 4). As shown in Table 1, total well depths range from 12.3 m to 103 m below ground surface (m bgs). The peak daily flow rates and/or annual flow rates are also provided in Table 1.

4.3 Preliminary Capture Zones Delineated by Others

To efficiently manage and protect a groundwater supply, an understanding of the well "capture" zone and "time to travel" zones is required. A "capture zone" is the land area, and underlying geologic media, that contributes water to the community water well. Any well within this volume eventually reaches the well. The capture zone can be divided into sub-areas based on "time of travel". The time of travel is the time it takes for water to flow from a given point to the well. Travel times provide an indication of the time frame for contaminants to travel to the well from different areas in the capture zone and they help to set priorities for groundwater management within the capture zone.

Several methods of capture zone analysis exist, including:

1. fixed radius method,
2. type curves and analytical solutions for capture zone extent,
3. analytical groundwater flow models, and
4. numerical groundwater flow models.

The methods vary in their accuracy and applicability. Method 1 assumes a circular area with an arbitrary radius, while the other three methods are based on the hydrogeological properties of the groundwater flow system.

Numerical groundwater flow models are capable of representing more complicated hydrostratigraphy, hydrogeological boundaries, and variable and multiple pumping rates.

For comparative purposes, 60 days is the approximate time required for microbial contaminants moving in groundwater to degrade, while 5 years is the average time necessary to implement groundwater remedial purposes in response to a contamination event according to the US Environmental Protection Plan.

4.3.1 Capture Zones Defined by MWLAP (1999)

In 1999, MWLAP delineated preliminary captures zones using Methods 1 and 2 – arbitrary and calculated fixed radius and analytical equations. The difference between arbitrary fixed radius (AFR) and calculated fixed radius (CFR) is that AFR is based on a fixed linear distance from the well, while CFR is based on a cylindrical volume around the well. The 1-year, 5-year and 20-year preliminary captures zones estimated from the AFR/CFR method are summarized in Table 1 and illustrated in Figure 5. As shown in Figure 5, a number of the AFR/CFR capture zones overlap one-another, as well as extending across the Kettle River. Collectively, capture zones defined by the AFR/CFR method appear to extend across approximately one-third of the total Aquifer area.

In addition to using the fixed radius method to delineate preliminary captures zones, MWLAP used analytical solutions developed by the United Stated Environmental Protection Agency (1993). The analytical solution uses the transmissivity, flow rate and hydraulic gradient to calculate the length and width of the parabolic capture zone. Due to limited information regarding the pumping rates and transmissivity, only nine capture zones were calculated for the main 26 water supply wells in the Aquifer. As shown on Figure 5, the parabolic capture zones are generally smaller in aerial extent than those defined by the AFR/CFR method. The parabolic capture zones tend to provide further coverage along the length of the capture zone, but are narrower in width.

Use of the AFR/CFR methods and analytical solutions for the capture zone analysis are subject to limitations, and require that the hydrogeological and pumping conditions be simplified. However, such methods method provide suitable preliminary estimates of capture zones for Grand Forks, where the aquifer is characterized by in unconfined sand and gravel aquifer, with a relatively flat, uniform water table.

4.3.2 Capture Zones Defined by SFU (2000)

A numerical model was developed by Dr. Diana Allen of Simon Fraser University (SFU) to determine the capture zones and travel times zones for the main water supply wells (Allen, 2000).

Numerical models are generally capable of accounting for complicated hydrostratigraphy, hydrogeological boundaries and variable pumping rates. The groundwater model and capture zone analysis was constructed using MODFLOW and MODPATH, capable of simulating three-dimensional groundwater flow and advective transport in complex geological settings under a variety of boundary conditions and hydrogeological settings. These packages are the most widely used numerical codes for hydrogeological modeling, and are recognized by regulators, the research community and professional hydrogeologists. Capture zones were estimated in MODPATH by placing imaginary particles through the groundwater flow fields modeled by MODFLOW and tracking the particles backwards towards the well. Particles that are captured by the well within a given time period (i.e., 1-year, 5-years, 10-years) define the capture zone.

The capture zones estimated by the SFU numerical model for the Grand Forks wells, Big Y wells, Almond Gardens wells and Nursery wells are presented on Figure 5, along with the capture zones developed by MWLAP. We understand that reverse particle tracking to estimate the capture zones for some wells was unsuccessful because the model boundaries were too close to the wells and/or the discretization of the numerical grid near some wells was insufficient.

The study concluded that capture zones for the larger production wells are generally parabolic in shape, with the length orientated upgradient of the well. However, around some of the smaller, low volume wells, the capture zones tend to be smaller and circular. Based on the model simulations, it was concluded that a number of wells are recharged by water from the Kettle River. Interference between the pumping wells was not modeled; however, as illustrated in Figure 5, the capture zones for most wells overlap one another.

Capture zones using both analytical solutions and the numerical model were available for Grand Forks #2, Grand Forks #3, Grand Forks #4/5 and Big Y#2/3. As shown in Figure 5, the capture zones estimated with the numerical model tend to be larger in aerial extent than the analytical solutions capture zones; however, the general shape of the numerical model and analytical solutions capture zones are similar. The "tails" (the portion of the capture zone upgradient of the well) of the capture zones extend as long as 3 km upgradient of the wells, and in some cases, underneath the Kettle River.

We understand that the numerical model is currently being revised by SFU. Therefore, the capture zones illustrated in Figure 5 are considered preliminary only. Presumably, once improvements to the water balance and numerical model discretization of the model is carried out, together with a rigorous sensitivity analysis, the model could be used to estimate more accurate capture zones and times of travel for all the major groundwater supply wells.

5.0 RESULTS OF CONTAMINANT INVENTORY

5.1 BC MWLAP Database

Mr. Don Vergamini, Contaminated Sites Technician for MWLAP (Thompson & Okanagan Regions) conducted a search of three BC MWLAP databases: 1) Site Registry, 2) Waste, and 3) Spills databases to identify sites within the Aquifer. Results of the database searches are presented in Tables 2, 3 and 4 and locations from the databases are shown on Figure 6.

5.1.1 Contaminated Sites Registry

Since 1989, MWLAP has maintained a Site Registry database that contains environmental information pertaining to non-contaminated, contaminated and previously contaminated (*i.e.*, subsequently remediated) sites. The existence of a site within the MWLAP Site Registry does not necessarily imply that the site is contaminated because under the existing Contaminated Sites Regulation, the site registration process can be triggered by a number of mechanisms, including property transactions and facility upgrades. Similarly, there may be a number of sites within the Grand Forks region that may be contaminated, but are not registered on the Site Registry.

In total, 17 sites are registered in the CSR database for the City of Grand Forks and surrounding area. Table 2 provides a summary of all sites within the Grand Forks area that are registered on the Site Registry, and these locations are shown on Figure 6. It should be noted that the latitude and longitude provided by MWLAP did not match the location of the site addresses. For these properties, the site addresses were assumed to be the most accurate description of the site location. Of the 17 sites registered, 16 are located with the City of Grand Forks, with one site located approximately 30 km north of Grand Forks.

In Figure 6, the locations of the sites registered on the Site Registry are superimposed over the preliminary capture zones estimated by M. Wei (MWLAP, 1999). Approximately three sites that are active and under assessment and/or remediated are

located within the 1 year capture for Grand Forks #4/5; and three sites are located within the 5-year capture zone for Grand Forks #4/5; and two sites are located within the 5 year capture zone for Grand Forks #3 and Grand Forks #4/5.

5.1.2 Waste Database

The WASTE database is used by MLWAP to manage information related to permits and approvals for effluent discharge, refuse or storage of special waste, and pollution abatement and pollution prevention orders.

A total of 69 entries from 30 businesses/sites were listed in the WASTE database, as shown in Table 3. Thirty-nine entries were associated with air permits, 19 entries were associated with effluent disposal, nine entries were associated with refuse permits and two were associated with special waste storage. Locations of the effluent, refuse and special waste sites are shown on Figure 6. Since the site locations were not provided on the Waste Database and were determined by searching the telephone directory, the locations shown are approximate and do not necessarily correspond to the point of contamination or waste disposal/discharge. In some situations, an address could not be determined.

As shown on Figure 6, an effluent permit for Pacific Abrasives on Carson Road is located within the 1-year capture zone of Big Y#1, 2 and 3; and an effluent permit for Bannert Readimix on Eagle Ridge is located within the 5-year capture zone of Copper Ridge Well.

5.1.3 Spills database

A limited database has been maintained by the Emergency Response Officer since approximately 1990 for spills reported to MWLAP. Mr. Vergamini stated that the spills are generally cleaned up according to the Spill Reporting Regulation and only a few sites are subsequently registered on the Sites Registry. Presumably, many other spills may have occurred that were not reported to MWLAP. A total of 55 sites within the Grand Forks area were listed on the Spills database (listed in Table 4), including twelve spills reported since 2001 (shown on Figure 6). Since site locations were not provided with all entries on the spill database, some locations were determined by searching the telephone directory and are therefore considered approximate. In some situations, an address associated with a spill site could not be determined. The material released was not provided.

The majority of the reported spills are located in the Industrial area of Grand Forks, immediately south of the confluence of the Granby and Kettle Rivers. However, reported spills were also located within the 1-year and 5-year capture zone for: Copper Ridge, Grand Forks #4/5, Big Y#4, and Nursery #2.

Ms. Thompson also recalled historic spills in the Grand Forks area including:

- Heating oil at 9th Ave. and Central Ave. approximately 2 years ago;
- Diaoxin (herbicide) approximately 5 km north on North Fork Road; and,
- Oil spill at 76th Ave. and 21st Street approximately 13 years ago.

5.2 Underground Storage Tanks

The major concern associate with fuelling centers is the potential for leakage from underground storage tanks (USTs), particularly those containing gasoline and diesel. Because of the immiscible nature of these products, the release of even small quantities of these chemicals could have serious consequences. The risk associated with USTs can be reduced by secondary containment provisions (berms or double walled tanks) and best management practices, such as monitoring and maintaining reconciliation records. USTs may be associated with commercial and industrial businesses, such as gas stations and gravel pit operations, and possibly with individual homeowners (for heating fuel).

The Fire Chief for the City of Grand Forks, Blair MacGregor, and the Fire Chief for rural Grand Forks, Ramy Rooke, were contacted regarding USTs in the area. According to the Fire Chief MacGregor, information regarding USTs in Grand Forks is contained within each individual property file and no database of sites possessing USTs is available. Similarly for the areas outside of the City Limits, no records exist regarding USTs. Fire Chief MacGregor was aware of historical (approximately 1983) leakage of fuel from USTs on Central Avenue and 19th Street that impacted a groundwater supply well (PW#1). Although Fire Chief MacGregor was not aware of any other leaking USTs, he did state that a number of old gas stations were being remediated. Fire Chief Rooke stated that he was not aware of any USTs outside of the Grand Forks City limits, with the exception of heating fuel (oil) USTs.

Lorraine Thompson stated that two former service stations have had environmental investigations – Texaco and Shell. In addition, a water supply well located at the corner of Central Avenue and 19th Street (PW#1) was impacted with fuel originating from the Texaco service station. Lorraine Thompson also stated that USTs may still be located at the former airport located at Dick Barlett Park near 72nd Avenue and 19th Street.

Tables 5 and 6 provide a list of current service stations and bulk fuel distributors in Grand Forks based on a search of business license and telephone directories, respectively.

Mr. Dan Martin, government agent in Grand Forks, recalled a Texaco station across the highway from the current Chevron station, and also believed that a former Shell station two blocks east of the Court House was remediated approximately 2 years ago.

5.3 Septic Systems

Private septic systems are located in areas not serviced by the City of Grand Forks sanitary system, the approximate extent of which is shown on Figure 7. Based on Golder's experience, private septic systems can be potential sources of groundwater contamination for bacteria, viruses, nitrates, detergents, oils and chemicals. Groundwater contamination in areas serviced by septic systems may result where systems are poorly sited, designed or constructed; where systems are poorly maintained; or where septic system densities are too high to allow sufficient groundwater renovation. Industrial or commercial properties that are using septic systems for effluent disposal may contribute to groundwater contamination because septic systems are not designed to renovate effluent containing industrial or commercial chemicals.

Lorraine Thompson indicated that the highly permeable soils in the Grand Forks area result in percolation tests often less than 10 seconds per 2.5 cm. Ms. Thompson estimated that 5% to 7% of the existing permits fail each year, and approximately 60% to 70% of the existing septic fields are likely not working correctly. Since 1996, all new septic tanks installed are required to be 12,000 gallon, rather than the typical 800 gallons. Ms. Thompson is requiring property owners applying for a septic permit in areas serviced by the municipal water supply to properly decommission the abandoned water wells prior to issuing the permit. Ms. Thompson was not aware of reported effluent daylighting along the Kettle River.

Further discussion of the potential impact of septic systems, and associated nitrates, is provided in Section 5.10.1

5.4 Stormwater

Within the CGF, stormwater is collected into stormwater sewers that ultimately discharge into rock pits and/or the Kettle River. The approximate extent of the City catch basin system is shown in Figure 7. No information was available regarding stormwater collection in areas outside of the CGF. Stormwater run-off is commonly characterized by contaminants such as metals, oils, grease, anti-freeze, gasoline and other petroleum and

biological constituents. Concentrations of these constituents are typically most elevated in areas where there are no provisions for source control or treatment.

5.5 Existing and Abandoned Water Supply Wells

Improperly abandoned wells can provide direct conduits for the migration of surface contamination to underlying aquifers. In other jurisdictions, abandoned wells have been used for the disposal of wastes such as motor oil (Golder, 1995) and interviews with some local citizens have indicated that this practice may have occurred in the area. Because improperly abandoned wells provide direct pathways to underlying aquifers, their presence represents a threat to groundwater.

A search of the MWLAP water well database identified over 240 wells located within the Aquifer (MELP, 1994b). Figure 7 shows the location of municipal and private wells in the study area, along with the approximate extent of the City of Grand Forks water distribution system. Presumably, most of the private water wells that are located in the areas currently serviced by municipal water supply are no longer in use. If these wells have not been properly decommissioned, they may serve as potential contamination sources. As stated in Section 5.3, Lorraine Thompson stated that when property owners apply for a septic permit in areas serviced by the municipal water supply, abandoned water wells on the property must be properly decommissioned prior to issuing the permit. In addition, local residents have reported cases in the past where abandoned water wells may have been used as waste disposal receptors, or where chemicals were directly placed into water wells prior to the application of pesticides/herbicides, rather than mixing the chemicals in a holding tank.

5.6 Transportation of Dangerous Goods

Truck routes, rail lines and pipelines are considered a potential source of groundwater contamination because of the risk of spills or accidents resulting in the release of hazardous materials and the possible introduction of higher levels of stormwater contaminants. Release can be sudden, such as from a highway accident, or incidental, resulting from common vehicle discharges of oil and other chemicals. Spills or accidents could also be associated with railway crossings, interchanges and transfer stations. The distribution of the major roads, rail lines and pipelines are shown on Figure 8.

The City of Grand Forks and RDKB's road transportation network services a number of industries and commercial businesses. Presumably, the highest risk of spills or accidents would be associated with routes characterized by the highest truck traffic, such a highways and arterial routes. Highway 3, the east-west highway for southern BC, is the

primarily road through Grand Forks, with Granby Road, Donaldson Road, Carson Road and US Highway 21 representing other major roads in the area.

At one time, four railways once serviced the area (Section 5.11). Only one line is currently in operation, reportedly providing transportation of smelter slag and/or wood chips between CanPar, Pacific Abrasives and the Burlington Railway.

According to the City of Grand Forks and RDKB planning files, a natural gas pipeline is located just north of the American border (Figure 4). No known crude oil pipelines are located in the region.

5.7 Sand and Gravel Extraction

Sand and gravel extraction, both active and historical, may represent a potential groundwater contamination concern. As part of active excavations, hazardous materials are generally stored on site, including gasoline, diesel, solvents and waste oils.

Surface excavations remove ground cover, which causes contaminant transport times to groundwater to be reduced. In the past, old and abandoned excavations have also been used as dumping or landfill areas.

Figure 8 shows the locations of known aggregate deposits in the area based on the available topography maps. There is no indication whether these sites are active or closed, and therefore the potential threat to groundwater could not be discerned. According to the City of Grand Forks Zoning Bylaw No. 1606 (1999), gravel extraction processing is permitted in I-2, General Industrial Zones, while all gravel extraction activities (i.e., storage, manufacturing, heavy equipment repair) is permitted in I-4, Gravel/Mineral Processing Zones. The OCP plan for Grand Forks states that the Council's policy is to utilize land outside of the ALR for gravel extraction prior to extracting gravel from within the ALR. In the RDKB Zoning Bylaw No. 620 (1989), gravel extraction is permitted in Rural Resource 2 Zones.

5.8 Surface Water Interactions

Surface water degradation or contamination of the Kettle or Granby Rivers may pose a risk to groundwater quality in the areas where the groundwater flow system is ultimately recharged by the rivers. Ambient surface water quality can be affected by many sources, including upstream effluent discharge from industries, urban and agricultural run-off and stormwater outfall locations. Specific contaminant events can also occur from transportation accidents, presumably with higher risk at transportation crossings.

Environment Canada has monitored the water quality on the Kettle River downstream of Grand Forks in Gilpin since 1980 (MELP, 1996). Parameters analyzed have included total metals, colour, conductivity, hardness, pH, nitrogen (nitrate/nitrite), total dissolved nitrogen, residues (filtered, fixed filtered, non-filterable, and fixed non-filterable), temperature, and turbidity. The report summarized that the water quality in the Kettle River was "excellent" between 1980 and 1994 for the parameters monitored. Water quality was concluded to be closely associated with seasonal patterns. During freshet, the water is highly turbid, and thus, select total metals (i.e., Al, Cr, Fe, Mn, Zn) and phosphorus tend to be elevated. Details for select parameters are provided below.

- Fluoride – Concentrations have exceeded the aquatic life standard, but met the drinking water criterion. It was inferred that the elevated fluoride concentrations were associated with the geologic conditions in the area.
- Cadmium – The method detection limit for cadmium was generally greater than the aquatic life criteria. This was believed to be associated with quality assurance/quality control issues, reportedly due to the failure of the re-usable Teflon liners in the bakelite preservative vial caps. However, the report did state that there are concerns associated with slag piles on the Kettle River downstream from Midway.
- Cyanide – Elevated cyanide concentrations measured prior to 1991 were inferred to be associated with sampling contamination (reportedly due to the failure of the re-usable Teflon liners in the bakelite preservative vial caps). MELP was reportedly not aware of confirmed cyanide contamination from gold mining in Canada or the US.
- Nitrogen (total dissolved) and nitrate/nitrite as nitrogen – Similar to other parameters, total dissolved nitrogen and nitrate/nitrite as nitrogen concentrations appeared to be elevated during freshet. However, all concentrations of total dissolved nitrogen generally remained less than 0.5 mg/L and nitrate/nitrite as nitrogen remained less than 0.4 mg/L, both below the drinking water criterion of 10 mg/L.
- In general, the peak turbidity measurements during freshet have been increasing since the mid 1980s.

The study did not provide any data on microbial characteristics of the Kettle River or any water quality data for the Granby River.

5.9 Landfills and Dumping

The Grand Forks Regional Landfill (GFRL) is located approximately 2 km north of Grand Forks on the northeast side of Granby River, across from the smelter slag piles, as

shown on Figure 8. Select photographs from the perimeter of the landfill are provided in Appendix I (Photographs 4 and 5). The GFRL, operated by RDKB, accepts materials from municipal and commercial collection services, the general public and area contractors. Mr. John Popikoff of the RDKB and Mr. Brian Porter of the CGF stated that the only landfill in the Grand Forks area is the GFRL, and they were not aware of another other historical landfills in the area. According to Mr. Porter, the GFRL has been in operation for approximately 20 years. The current landfill was labeled a "gravel pit" in the 1966 topography map.

Water quality in the vicinity of the landfill was reportedly tested as of 1996; however, the data was not available for review.

5.10 Fertilizers and Pesticides

Groundwater contamination from agricultural land use can results from the use and storage of animal manure and the application of chemical fertilizers and pesticides. The potential for groundwater contamination from agricultural properties can be low to high, depending on the degree of compliance with manure storage and handling guidelines. The risk will also depend on the nature and volume of chemicals used and stored, disposal practices and the presence and maintenance of storage tanks and septic systems. Similar chemical applications that are used on agricultural properties may also be used on playing fields, golf courses and general lawn areas.

Previous studies have investigated the potential impact of fertilizers (nitrates) on the groundwater in the Grand Forks area, but insufficient regional groundwater information is available to assess the magnitude of problem, if any, related to the use of pesticides. Reportedly, a pesticide survey was conducted by Ministry of Health approximately 12 years ago; however, this report was not available for review.

Agriculture has been a significant industry in the Grand Forks area since the early 1900s. The dominant agricultural crop has evolved throughout the years, changing from cattle, fruit tree nurseries, fruit and some vegetables and flowers to potatoes, seed growing (flowers and vegetables), nurseries and hay. According to Carol Chenery of the Canadian Food Inspection Agency, nurseries have been the dominant agricultural crop for the past 15 to 20 years, with some potatoes and onions. She also stated that nurseries tend to use less pesticides and fertilizers than other crops. However, Ms. Chenery also stated that the use of pesticides and fertilizers has also evolved with time with the pesticide/fertilizer technology and education. Significant pesticides that may have been used in the past includes Dinoseb, Aldrin, Temik and Toradon. She believes that most problems associated with pesticides and fertilizers tend to be associated with misuse and

improper irrigation with both the agricultural industry and homeowners. There are no local manufacturers or suppliers of pesticides in Grand Forks.

According to the book "*The Life and Times of Grand Forks, Where the Kettle River Flows*" by Jim and Alice Glanville (1997), the first signs of pesticides impacts on the agriculture in the area was noted in 1964. The book stated that Aldrin was applied on potato crops to prevent wire worms, however Dieldrin, a by-product of Aldrin, was found in elevated concentrations in milk and beef fat.

A large amount of effort and resources have been expended to investigate the impact of nitrates on the groundwater quality in Grand Forks. Sampling by MELP in 1989 and 1990 from wells in the CGF, SID and CID districts identified three areas of elevated nitrate-nitrogen concentrations (MELP, 1994b): 1.) south of airport, 2.) nursery area, and 3) near North Fork Road along western limits of Grand Forks. These high nitrate concentrations generally occurred in areas of vegetable farming, where inorganic fertilizers may be leaching into the Aquifer. These elevated nitrate concentrations also corresponded to high specific conductance, TDS, chloride, sulfate, hardness, magnesium and manganese concentrations in groundwater. The sampling also identified decreasing nitrate concentration with depth, suggesting surface sources.

Further nitrate sampling in the GFID identified a correlation between high nitrate concentrations and land use, in particular, the nature of agriculture. The region of Horkoff Road East to the Nursery area was historically characterized by more intense agricultural land use than the western CID area. This region has historically included a large potato field south of the airport along Kenmore Road and south of the railway between Kenmore Road and Seminoff Road, and a pickling onion field north of Carson Road between Como Road and International Road. Other areas identified with elevated nitrates include those around a strawberry field along Almond Garden Road, and a potato farm along North Fork Road north of the Kettle River. It was concluded that the sources of nitrate may be fertilizer use and/or septic fields.

In 2001, additional water sampling was conducted in wells and piezometers in select areas of Grand Forks (MWLAP 2002). In general, areas previously identified with high nitrates were also found to be elevated in 2001, including:

- Area I - North Fork Road, with a median nitrate concentration of 3.3 mg/L and 6.6% of the wells exceeding the drinking water standard of 10 mg/L;
- Area II - Big Y area along Carson Road east of the airport – west Carson Road – Almond Gardens, with a median nitrate concentration of 2.5 mg/L and 15% of the wells exceeding the drinking water standard; and,

- Area III - Darcy/Cameron Road area (from Como Road to east of Darcy Road) with a median nitrate concentration of 7.3 mg/L and 26% of the wells exceeding the drinking water standard.

In general, Area I is near the hospital, with a large lawn area, and potatoes farms to the west and southwest; Area II has ornamental nurseries, forage crops, residential, animal feeding, and former agricultural land use nearby; and, Area III is agricultural (hay and nursery, potato), grazing and residential. Areas II and III are generally areas of low septic field density in comparison to Area I, and Area II is primarily residential, with some forage crops. Since 1989, 24% of the wells were exhibiting increasing nitrate concentrations, while 76% of the wells were exhibiting steady or decreasing concentrations.

Similar to previous studies, elevated nitrates were generally found in the shallow wells, suggesting that the source is likely from the surface, septic systems or agricultural activities (over fertilization, over irrigation) (MWLAP, 2002). In the eastern portion of the Aquifer, the elevated nitrates were found through the entire extent of the Aquifer, while elevated nitrates were only found in the upper Aquifer in the western area.

Areas of low nitrate concentrations included:

- West end of Carson Road
- Almond Gardens Road
- Hughes and Copper Road
- Siminoff and Como Roads
- North end of Kenmore and Glenmore Roads.

An isotope investigation was conducted in 1991 and 1993 to determine whether the nitrogen isotope signature in groundwater was characteristic of manure and septic wastes, or inorganic fertilizer. The *draft* results indicated that the nitrate in the groundwater was from inorganic fertilizers from commercial nurseries, agricultural fields and/or residential and park land use rather than human or animal wastes (Wei, 2002). However, one residential well tested exhibited heavier nitrogen isotope, suggesting a septic influence.

Ms. Chenery and Mr. Wiffler stated that no large-scale cattle or swine operations currently exist in the Grand Forks region. One cattle operation (approximately less than 100 cattle) was noted near the Kettle River at the northeast corner of Spargett and Almond Gardens Road. It is reported that the cattle winter in this area and graze at higher elevations in the summer.

5.11 Historical Business Activities

In addition to information obtained from the City of Grand Forks museum, information regarding historic business activity was collected from the following two books:

"*The Life and Times of Grand Forks, Where the Kettle River Flows*" by Jim and Alice Glanville (1997), and

"*Historical Businesses of Grand Forks*" by the Boundary Museum (2001).

The primary historical businesses in Grand Forks have been the copper smelter and agriculture. The Granby Consolidated Mining and Smelter Company (Granby Smelter) operated between 1889 and 1919, mixing ore and coke to process copper and slag (Boundary Museum, 2001). The Granby Smelter was located on the Granby River, approximately 1 km north of the confluence of the Granby and Kettle Rivers (as shown on Figure 8).

Smelter produced from the copper extracting process was deposited along the sides of the Granby River, and is still present today at this location (Photographs 6, 7 and 8). A large lake, Smelter Lake, was formed at the smelter to provide hydro-electric power and water supply for the Smelter. Smelter Lake, estimated to have been approximately 270 hectares (670 acres), was breached in approximately 1948, resulting in extensive flooding in the downtown of Grand Forks.

A summary of the businesses operating in Grand Forks is presented for different time periods in "*The Life and Times of Grand Forks, Where the Kettle River Flows*" (Glanville, 1997). From the 1970s to 1997, the following industrial businesses (along with environmental issues) were noted to be in operation in or near Grand Forks:

- Union Mine/Sumac Ventures, located approximately 25 km north of Grand Forks, was charge with releasing cyanide from the mine.
- Can-Par, fined $25,000 in 1992 for discharging urea formaldehyde into a marsh area.
- Enercon, converting solidified slag into insulation material, located in the Industrial Park of town, operating between 1980 – 1987, after which the business was renamed Bradford Enercon.
- Pacific Abrasives, formed in 1971 to process granulated slag, transported from the smelter site, for shipment to the US.

- Interior Mill Equipment (IME), formerly located in the former CPR roundhouse, now located in the Chilco building, formerly manufactured dry kilns and now produces gasifiers.
- Boundary Industries, parent company of Boundary Mechanical, Boundary Electric and IME.

Other significant changes in the Grand Forks Area included (Glanville, 1997):

- New airport opened in 1971 (former airports located at Hutton school and Dick Barlett Park).
- CPR removing railroad tracks in early 1990s.
- Sewer system installed to areas of Grand Forks in 1957.
- 65 year old irrigation system replaced with groundwater supply wells in 1990.

Other businesses of potential environmental concern noted in *Historical Businesses* include a former auto repair shop, located at the current location of the Grand Forks Gazette (7330 2nd Street) and a former dry cleaner, located across the street from the Grand Forks Gazette. No indication of the years these businesses operated was provided.

A number of businesses of potential environmental concern were shown on a 1966 topography map, including: i) airport at location of Dick Barlett Park, and ii) roundhouse and gasoline tanks at current location of the Station Pub. A Public Works Yard was also shown on a 1959 Insurance Advisory Organization (IAO) map near Victoria Street and 4th Avenue.

Four railway companies once operated in Grand Forks: Canadian Pacific Railway (CPR)/ Kettle Valley Railway (KVR), Great Northern Railway (GNR) and Grand Forks Railroad Company (GFRC). CPR operated the Columbia and Western Line through Grand Forks, with a railway divisional point and joint terminal with the KVR located at the current location of the Grand Forks Station Pub and Columbia Grill on Donaldson Drive near Coalshute Drive. Great Northern Railway was amalgamated with Burlington Northern Railroad (BNR) and connects with the GNR, which operates on former CPR tracks. According to a 1901 City Map, the GNR yards were formerly located near Hutton School at 27th Street and 75th Avenue and operated in Grand Forks until 1943. However, in *Life and Times*, the GNR shops are described to be located in Weston, at the location of the 2nd airport (Dick Barlett Park). In 1990, the CFRC formed to transport raw materials (wood chips and smelter slag) and products (particle board and abrasives) between the industries in Grand Forks and to the BNR.

5.12 Current Business Activities and Zoning

Information regarding current business activity was obtained from a search of the City of Grand Forks business license database, City of Grand Forks Telephone Directory, and "*The Life and Times of Grand Forks, Where the Kettle River Flows*" by Jim and Alice Glanville (1997). In addition, during the site reconnaissance on March 18, 2003, general businesses activities in Grand Forks and the RDKB were noted during the windshield survey.

We understand that information on historical business licenses from the City of Grand Forks is not available. According to the RDKB, no business licenses are required for businesses located in the RDKB, but home businesses must be in compliance with the zoning bylaws. The sites of concern identified from searches of the business licenses and Yellow Pages telephone directory are summarized in Tables 5 and 6.

On Figure 9, the current zoning for the City of Grand Forks and the RDKB is presented. In general, lands occupied by commercial and industrial properties pose the greatest threat to groundwater; agricultural land use poses moderate threat to groundwater; and, residential land use poses a relatively low risk to groundwater. Further discussion on the relative risk ranking of land use to groundwater is provided in Section 7.0.

The site reconnaissance to Grand Forks and the RDKB on March 18, 2003, a windshield survey of the current business activities in the area was observed. In general, the industrial businesses are located along 2nd street, south of 68th Avenue, downtown, Granby Road area and Donaldson Drive area. Photographs of select industrial businesses are provided in Appendix I, including:

- CanPar and sewage lagoons in Photograph 9
- Cantex, railway and Pope and Talbot in Photograph 10
- Roxul and CanPar in Photograph 11
- Pacific Abrasives Photograph 12

Service stations noted during the site reconnaissance included:

- Chevron on the northeast corner of 19th Street and Central Avenue
- Petro-Canada on the northwest corner of 16th Street and Central Avenue
- Shell on the southeast corner of Boundary Drive and Central Avenue
- Super Save on the northwest corner of 27th Street and Central Avenue

5.13 Other Potential Sites of Concern

During the process collecting information on specific topics, additional information regarding other areas of potential concern in the Grand Forks Area was gathered.

Fire Chief MacGregor reported that polychlorinated biphenyls were stored in an enclosed-drip plan at the sawmill (Pope and Talbot). He also stated that a site in the west end was undergoing reclamation associated with high copper concentrations in the former railway bed. According to Fire Chief MacGregor, five bulk fuel stations were formerly located on Donaldson Drive in the vicinity of the hospital: Texaco, Imperial Oil, Chevron, Petro-Canada and Shell. Imperial Oil and Chevron are reportedly the only sites remaining; both are currently closed and the tanks drained. Texaco and Petro-Canada sites are vacant, while the Shell site is now the recycling depot.

Fire Chief Rooke stated that there are likely a large volume of chemicals stored at the larger farms and nurseries. He was not aware of any large spills of chemicals. According to Fire Chief Rooke, a large fire of creosote-treated railway ties occurred on a property at the south end of town (700 block of Carson) approximately two years ago. He stated that the ties are normally stored along the railway tracks; however, approximately 200 ties were accumulated on this property.

De-icing chemicals were also reported to be used on occasion at the airport, including Absolute Ice Melter (NaCl, KCl, urea-based), which is reported to be stored at City Works Yard (Wei, 2002).

6.0 RESULTS OF PRELIMINARY DETAILED CONTAMINANT INVENTORY

A preliminary detailed inventory of businesses and activities within the capture zones was conducted by means of a limited field reconnaissance, supplemented by information from other data sources described in the regional contaminant inventory. The field reconnaissance consisted of a windshield survey of most of the publicly accessible areas of the capture zones. The site reconnaissance was conducted by D. Atkinson of Golder on March 18, 2003.

The capture zones considered were the CFR/AFR capture zones defined by MWLAP (1999), since these were the most conservative boundaries with the limited amount of information available. The inventory did not include interviews with private property owners or site-specific inspections. Other than the information outlined in the regional contaminant inventory, the preliminary detailed contaminant inventory did not include a review of historical site activities. Site photographs are provided in Appendix I.

6.1 CID#1, 2 and 3 and Sion#2 Wells

The CID wells and Sion#2 well are located in an area south of Highway 3, consisting primarily of small hobby farms and rural residential properties. With the exception of one greenhouse near Sion#2 (Photograph 13), no large scale nurseries, orchards or vegetable farms were noted during the site reconnaissance. Hay and grazing appeared to be the dominant agricultural activity, with a few horses and cattle observed on the hobby farms, as shown in Photograph 14.

Highway 3 is located within the preliminary capture zone of Sion#2. In addition, the roadway leading to the Carson border crossing, a potential truck route, is located within the capture zone of the CID wells and Sion#2. No industrial businesses were noted in the area of the CID wells; however, two areas with accumulated debris (metal and/or wood) were noted near Sion#2. Furthermore, the MELP land use survey noted a property with "treating/disposal of solid waste" located between CID#1/2 and Sion#2, east of the road to Carson. A natural gas line is located near CID#1/2. No MWLAP CSR sites were located within the preliminary capture zones for CID#1, 2 and 3 or Sion#2. Power transformers were noted in the vicinity of Sion#2 (Photograph 13).

The residential properties within this area are not serviced by the City of Grand Forks water or sewer system, therefore it is assumed that each property contains a septic field and water supply well. Potential contamination associated with the residential and agricultural properties includes septic effluent and other chemicals entering the septic system, agriculture animal waste run-off, lawn care chemicals, other products associated

with equipment and vehicle maintenance, and pesticides and herbicides used in agriculture.

According to Piteau (2002), CID#1/2 and Sion#2 wells are only used for irrigation purposes, while CID#3 is used for both irrigation and domestic purposes.

6.2 Sion#1

Sion#1 well is located north of Highway 3, on the southeast corner of Canning Road and Reservoir Road. The area surrounding Sion#1 well is similar to the area surrounding the CID wells and Sion#2, consisting primarily of rural residential properties and some hobby farming. Hay appeared to be the dominant agricultural crop in the area, with a few horses and cattle observed on the hobby farms.

Highway 3 is located within the preliminary capture zone of Sion#1. No industrial businesses were noted in the area of the Sion#1; however, the MELP land use survey noted a property with "former extraction activities" located northwest of Sion#1. No MWLAP CSR sites were located within the preliminary capture zones for Sion#1. Power transformers were noted in the vicinity of Sion#1 (Photograph 15).

The residential properties within this area are not serviced by the City of Grand Forks water or sewer system, therefore it is assumed that each property contains a septic field and water supply well. Potential contamination associated with the residential and agricultural properties includes septic effluent and other chemicals entering the septic system, agriculture animal waste run-off, lawn care chemicals, other products associated with equipment and vehicle maintenance, and pesticides and herbicides used in agriculture.

Sion#1 is reportedly used for both irrigation and domestic purposes.

6.3 Sion#3

Sion#3 well is west of the Hardy Mountain and North Fork Roads intersection. The area surrounding Sion#3 well is comprised primarily of rural residential properties with some hobby farming. Hay appeared to be the dominant agricultural crop in the area, with a few horses and cattle observed on the hobby farms. Some fruit production land use was noted in the MELP land use survey northwest of Sion#3.

Hardy Mountain and North Fork Roads are located within the preliminary capture zone of Sion#3, with some larger vehicles (i.e., agricultural, dump trucks) possibly utilizing these roads. No industrial businesses were noted in the area of the Sion#3; however, the

MELP land use survey noted a property with "extraction activities" located approximately 500 m northwest of Sion#3. No MWLAP CSR sites were located within the preliminary capture zones for Sion#3. Power transformers were noted in the vicinity of Sion#3 (Photograph 16).

The residential properties within this area are not serviced by the City of Grand Forks water or sewer system, therefore it is assumed that each property contains a septic field and water supply well. Potential contamination associated with the residential and agricultural properties includes septic effluent and other chemicals entering the septic system, agriculture animal waste run-off, lawn care chemicals, other products associated with equipment and vehicle maintenance, and pesticides and herbicides used in agriculture.

Sion#3 is reportedly used for both irrigation and domestic purposes.

6.4 Copper Ridge (GFID)

The Copper Ridge (GFID) well was not located during the site reconnaissance. However, the location of the Copper Ridge well was described as east of Hardy Mountain Road, approximately 1 km north of Ward Lake. According to the MLWAP land use survey, the area surrounding the Copper Ridge well is undeveloped with some residential dwellings and agricultural land use (cattle/horses, forage crops and/or grazing). In addition, a large power transformation subs-station was located immediately north of Ward Lake, inferred to be within the preliminary capture zone.

Hardy Mountain Road is located within the preliminary capture zone of the Copper Ridge well, with some larger vehicles (i.e., agricultural, dump trucks) possibly utilizing the road. No industrial businesses were noted in this area. Two MWLAP sites were located within the preliminary capture zone for Copper Ridge – one spill and one effluent disposal permit at the Bannert Ready-Mix property, inferred to be located on Eagle Ridge Road.

The residential properties within this area are not serviced by the City of Grand Forks water or sewer system, therefore it is assumed that each property contains a septic field and water supply well. Potential contamination associated with the residential and agricultural properties includes septic effluent and other chemicals entering the septic system, agriculture animal waste run-off, lawn care chemicals, other products associated with equipment and vehicle maintenance, and pesticides and herbicides used in agriculture.

Copper Ridge well is reportedly connected to the municipal water supply system for the GFID.

6.5 Big Y#1, 2, 3 and 4; 87-2 and 87-5

The Big Y wells are located in south Grand Forks, along Carson Road. Wells 87-2 and 87-5 are also inferred to be located along Carson Road near the Big Y wells; however the locations of 87-2 and 87-5 were not found during the site reconnaissance.

The area surrounding the wells consists of a mix of industrial properties, nurseries, other farms and rural residential properties. The industrial properties include Pacific Abrasives at the northeast corner of Carson Road and Copper Road (Photograph 12); a junkyard located immediately east of Pacific Abrasives; and railway tracks located south of the Big Y wells and between Big Y#1 and 2 (Photograph 17). A firehall was also located immediately southwest of Big Y#2. Other land use noted in the MELP survey included "storage activities" south of Big Y#2 and 3; and "treating/disposal of solid wastes" northeast of Big Y#1. Agricultural activities in the area included large scale nurseries, grazing and hay growing, and some root vegetable crops. During the site reconnaissance, the activities on Pacific Abrasive could not be observed due to fencing. Chemical storage in drums in a shed was noted along the railway tracks south of the Big Y wells (Photograph 17).

Four MWLAP spill sites and one MWLAP effluent permit site (Pacific Abrasives) were located within the preliminary capture zones for the Big Y wells and/or 87-2/5. The residential properties within this area are not serviced by the City of Grand Forks water or sewer system, therefore it is assumed that each property contains a septic field and a water supply well. Potential contamination associated with the residential and agricultural properties includes septic effluent and other chemicals entering the septic system, agriculture animal waste run-off, lawn care chemicals, other products associated with equipment and vehicle maintenance, and pesticides and herbicides used in agriculture.

The Big Y wells are reportedly used by the GFID (Big Y#1, 3 and 4 for irrigation purposes only; Big Y#2 for irrigation and domestic purposes; and 87-2 and 97-5 for domestic purposes only).

6.6 Grand Forks #2, 3 and 4/5

Given the close proximity of Grand Forks Wells #2, 3 and 5, the results of the preliminary detailed contaminant inventory for the wells is presented in the same section.

The Grand Forks wells are located in an area generally characterized by residential land use, with Highway 3 and associated commercial businesses separating Grand Forks #2 from Grand Forks #3 and 4/5.

Other activities in the area included a school, hotel, and agricultural field (Grand Forks #2) (Photograph 18); houses and vacant fields (Grand Forks #3) (Photograph 19); and school and arena (Grand Forks #4/5) (Photograph 20). The commercial businesses along Highway 3 included service stations (Super Save, Chevron, former Texaco). A total of eight MWLAP CSR Site Registry sites were located within the preliminary capture zones for the Grand Forks wells, including sites under assessment and/or remediation. In addition, three MWLAP spill sites were located within the preliminary capture zones for the Grand Forks wells. An airfield was formerly located at the park where Grand Forks #4/5 is located (Dick Barlett Park) and at the current location of Hutton school.

Most of the residential properties within this area are serviced by the City of Grand Forks water and sewer system. Potential contamination risks in the vicinity of these wells may be associated with the commercial properties along Highway 3, and possibly residential and agricultural properties. Potential contaminants of concern may include lawn care chemicals, and products associated with equipment and vehicle maintenance and fueling.

6.7 Nursery#1 and 2

The Nursery Wells (GFID) are located east of the Kettle River and south of Highway 3 in east Grand Forks. The area surrounding the Nursery wells primarily consists of large grazing, grain and forage crop farms and nurseries, with rural residential properties. Only one of the two Nursery wells was located during the site reconnaissance (Photograph 21).

Highway 3 is located within the preliminary capture zone of Nursery#2. In addition, the wells are located very close to the Kettle River. No industrial businesses were noted in the area of the Nursery wells. One MWLAP CSR spill site was located within the preliminary capture zones for Nursery#1. Power transformers were noted in the vicinity of one Nursery well located during the site reconnaissance (Photograph 21).

The residential properties within this area are not serviced by the City of Grand Forks water or sewer system, therefore it is assumed that each property contains a septic field and water supply well. Potential contamination associated with the residential and agricultural properties includes septic effluent and other chemicals entering the septic system, agriculture animal waste run-off, lawn care chemicals, other products associated with equipment and vehicle maintenance, and pesticides and herbicides used in agriculture.

The Nursery#1 well is reportedly used by the GFID for both irrigation and domestic purposes, while Nursery#2 is used only for irrigation purposes.

6.8 Almond Garden MHP Wells

Two water supply wells supplying groundwater for the Almond Gardens (AG) MHP are located at the northwest and northeast corners of the HMP property. The area surrounding the wells is primarily agricultural and rural residential. The Kettle River forms the west property boundary of the MHP.

The area surrounding AG East well was observed to be primarily grazing field, while storage of vehicles (Photograph 22), the river and horses (Photograph 23) were observed in the vicinity of the AG West well. Other land use noted in the MELP survey included berry production and root vegetables. No industrial businesses were noted in the area of the AG wells. One MWLAP effluent permit, associated with the MHP, was located within the preliminary capture zones for the AG wells. The MHP is not serviced by the City of Grand Forks sewer system, therefore it is assumed that effluent from the MHP is discharged to a septic field.

A discussion of potential contamination associated with the residential and agricultural properties is presented in Section 6.1.

6.9 Kettle River Place and Riviera MHP

The exact locations of the water supply wells at the Kettle River Place and Riviera MHP were not observed during the site reconnaissance. In general, the wells are inferred to be located on the respective MHP properties, located between Highway 3 and the Kettle River in east Grand Forks.

The Kettle River forms the southwest property boundary of both the MHPs. The MHPs are surrounded by commercial and/or industrial properties, including: a closed service station; car parts business; Aquila (power company) works yard; and, an auto body shop. No capture zones have been defined for these wells. However, one MWLAP effluent permit was associated with the MHP and a number of MWLAP spill and Contaminated Site Registry sites are located west of the Kettle River, within 500 m of the wells.

The MHPs are not serviced by the City of Grand Forks sewer system, therefore it is assumed that effluent from the MHPs is discharged to septic fields. Potential contaminant risks in the vicinity of these wells may be associated with the commercial properties along Highway 3, and possibly residential properties. Potential contaminants of concern may include lawn care chemicals, and products associated with equipment and vehicle maintenance and fueling.

7.0 SUBJECTIVE RISK ASSESSMENT

In 1993, a land use survey was conducted by MELP to document current land use, together with the locations of septic fields and groundwater supply wells. The survey was conducted by visiting all properties in the Grand Forks area, and recording the information on a GIS-based map (Figure 10).

Previous sections of this report provide a description of groundwater contamination sources identified during the regional contaminant inventory. While several areas posing an existing threat to groundwater have been identified, it should be recognized that any land use activities involving the storage, use or handling of hazardous materials represent a potential threat to groundwater quality. To provide a summary of the key potential risks to drinking water quality, a relative risk rating was applied to the land use survey developed by MELP, separated into agricultural land use and other land use (Table 8 and 9, respectively). The agricultural relative ranking of risks is based on the professional opinion of experience senior groundwater personnel practicing in the province of British Columbia, and with discussions with senior professionals at Agriculture Canada. The other land use ranking was based on the potential volumes of chemicals commonly associated with the land use and the relative mobility of these chemicals in groundwater if a release were to occur. The other land use relative ranking of risks is based on the professional opinion of experience senior groundwater personnel practicing in the province of British Columbia and has been verified by discussions with other senior groundwater and agricultural professionals from the private and public sector.

As shown on Figure 11, each property with the study area was assigned one of three hazard rankings, which are colour coded: red – high; yellow – moderate; green – low. Hazard rankings for each land use category are summarized in Tables 7 and 8, with a summarized Key Contaminant Risk provided in Table 9. The current zoning for the CGF and RDKB (Electoral Area 'D") is also presented for comparison in Figure 9.

In general, land use occupied by commercial and industrial properties pose the greatest threat to groundwater. Typical sources of groundwater contamination resulting from commercial facilities include gasoline and diesel from gas stations, solvents from dry-cleaning facilities, oils and solvents from auto repair shops and scrap yards, and countless others. Typical sources of groundwater contamination from industrial facilities include metals and solvents from machine and metal working shops, wood waste and solvents from sawmills and various other chemicals from manufacturing facilities. Generally, agricultural land use poses moderate threat to groundwater, except in the cases of inappropriate waste disposal and improper application of pesticides and fertilizers, where agriculture represents a greater threat. Generally, residential land use poses a relatively low risk to groundwater; however groundwater contamination can result from septic systems (nitrates), lawn chemicals (fertilizers and pesticides) and inappropriate handling of hazardous household products.

8.0 CONCLUSIONS

- The unconfined Grand Forks Aquifer is comprised of gravel, sand, silt and clay up to 123 m depth which generally thins out to the east (approximately 40 m thick), generally become finer with depth. Based on available water levels, the local groundwater flow is described to be towards the Kettle River, while regional flow is generally from the west to the east. The Kettle River is reportedly recharging the Aquifer in the western part of the Aquifer, while the Kettle River is a discharge zone in the eastern part of the Aquifer. The east-flowing Kettle River and south-flowing Granby River converge in Grand Forks in the approximate centre of the Aquifer.

- The Grand Forks Aquifer Protection Committee is comprised of the CGF, SION, GFID, CID and a number of mobile home parks. Water for domestic, irrigation and industrial/commercial use is obtained from 26 groundwater supply wells, with total well depths ranging from 12.3 m to 103 m bgs. The Grand Forks Aquifer (Aquifer No. 158) is classed by MWLAP as a "IA" aquifer, considered heavily developed with high vulnerability to contamination. Existing impacts on the groundwater quality associated with nitrates and gasoline have been identified in some areas.

- MWLAP (1999) delineated preliminary captures zones using arbitrary and calculated fixed radius and analytical equations and analytical solutions. Collectively, capture zones defined by the AFR/CFR method appear to extend across approximately one-third of the total Aquifer area. The parabolic capture zones from the analytical solutions are generally smaller in aerial extent than those defined by the AFR/CFR method. The parabolic capture zones tend to provide further coverage along the length of the capture zone, but are narrower in width.

- A numerical model was developed by Dr. Diana Allen of SFU (2000) to determine the capture zones and travel times zones for the main water supply wells. The study concluded that capture zones for the larger production wells are generally parabolic in shape, with the length orientated upgradient of the well. Based on the model simulations, it was concluded that a number of wells are recharged by water from the Kettle River. The capture zones estimated with the numerical model tend to be larger in aerial extent than the analytical solutions capture zones; however, the general shape of the numerical model and analytical solutions capture zones are similar.

- A regional contaminant inventory was conducted to broadly identify existing and potential sources of groundwater contamination across the Aquifer. In response to a request from Golder, MWLAP conducted a search of its Contaminated Sites Registry (CSR), WASTE and spills databases for the Grand Forks region.

A total of 17 sites within the City of Grand Forks and Regional District of Kootenay Boundary are registered with the MLWAP Sites Registry. A total of 69 sites from 30 businesses were listed in the MWLAP Waste Registry. A search of the MLWAP spills database identified 55 spill sites. Other potential sources of contamination identified by the regional inventory included underground storage tanks, septic systems, stormwater, abandoned water supply wells, transportation of dangerous goods, sand and gravel extraction, surface water influences, landfill and dumping, and application and use of fertilizers and pesticides (both agricultural and residential).

- A preliminary detailed inventory of businesses and activities within the capture zones was conducted to identify threats to groundwater quality within the preliminary capture zones.

  - The CID, Sion, Copper Ridge and Almond Garden MHP water supply wells are located in rural residential and agricultural areas of west and north Grand Forks, with few industrial sites noted nearby. No MWLAP spill or Site Registry sites were located within the preliminary capture zones for these wells, with the exception of the Copper Ridge and Almond Garden MHP wells.

  - The Big Y and 87-2/5 wells are located in south Grand Forks, surrounded by a mix of industrial properties (Pacific Abrasives, railway tracks, junk yard), nurseries, other farms and rural residential. In addition, four MWLAP spill sites and one MWLAP effluent permit site were located within the preliminary capture zones for the Big Y and 87-2/5 wells.

  - The Grand Forks wells are located in an area characterized by residential land use, with Highway 3 and associated commercial businesses (including service stations) nearby. Eight MWLAP CSR Site Registry sites and three MWLAP spill sites were located within the preliminary capture zones for the Grand Forks wells. Historical information also included airfields located at Hutton school and Dick Barlett Park, near the Grand Forks wells.

  - The Nursery wells are located near the Kettle River in east Grand Forks, in a primarily agricultural area. One MWLAP CSR spill site was located within the preliminary capture zones for the Nursery wells.

  - The Kettle River and Riveria MHP wells are located between Highway 3 and the Kettle River in east Grand Forks. The MHPs are surrounded by commercial and/or industrial properties (including a closed service station; car parts business; Aquila works yard; and, an auto body shop). One MWLAP effluent permit was associated with the MHP and a number of MWLAP spill and

Contaminated Site Registry sites are located west of the Kettle River, within 500 m of the wells.

- A number of water supply wells are located in areas not serviced by the City of Grand Forks water or sewer system, therefore it is assumed that each property contains a septic field and water supply well. Potential contamination associated with the residential and agricultural properties includes septic effluent and other chemicals entering the septic system, agriculture animal waste run-off, lawn care chemicals, other products associated with equipment and vehicle maintenance, and pesticides and herbicides used in agriculture. Potential contamination associated with the commercial properties is related to the chemicals handled by the respective business.

- A relative risk rating was applied to the land use survey developed by MELP, based on the professional opinion of experience senior professionals practicing in the province of British Columbia, verified by discussions with other senior groundwater and agricultural professionals from the private and public sector. The other land use ranking was based on the potential volumes of chemicals commonly associated with the land use and the relative mobility of these chemicals in groundwater if a release were to occur. A ranking of hazards relative to land use indicates that generally, land occupied by commercial, industrial and certain types of agricultural land use poses the greatest threat to groundwater. Other agricultural land use poses a moderate threat, while residential land use poses a relatively low threat to groundwater. The relative ranking for the land use survey conducted by MWLAP is presented in Figure 11.

9.0 RECOMMENDATIONS

9.1 Refine Numerical Model and Associated Capture Zones

We understand that the numerical groundwater flow model for the Grand Forks Aquifer is currently being refined by SFU. We would recommend that the refinements include improvements to the water balance and numerical grid discretization of the model, and that a rigorous sensitivity analysis be carried out. Once these improvements are made, the model could presumably be used to determine more accurate capture zones and times of travel for the community groundwater supply wells.

9.2 Conduct a Comprehensive Detailed Contaminant Inventory

Once the capture zones of the key wells have been refined, a comprehensive contaminant inventory of the individual capture zones should be carried out. This inventory would expand upon the information collected as part of the regional contaminant inventory and the preliminary detailed inventory presented in this report. If required, the detailed inventory may include an analysis of the types and quantities of chemicals used within each capture zone (chemical inventory). The major contaminant risks associated with each capture zone should be evaluated through a subjective risk evaluation.

9.3 Pesticide and Fertilizer Use

Guidelines and restrictions for pesticide and fertilizer use in public use areas, and possibly residential properties, within capture zones should be implemented. These guidelines may include a designated no-spray zone around water supply wells. In addition, contingency plans should be prepared in the event of a pesticide or fertilizer spill or accident. Mixing of chemicals and refilling of containers, spray and applicators should be completed in contained areas away from wells, water sources, and areas characterized by permeable soil conditions.

In addition, we recommend that an educational brochure, pamphlet and/or workshop aimed at i) the residential land users and ii) agricultural land users be developed. The educational materials should outline the proper application of fertilizers and pesticides and the potential impact of these chemicals on the groundwater quality in Grand Forks.

9.4 Water Quality Monitoring Program

We understand that currently, each improvement and irrigation district, private water purveyor and the City of Grand Forks conducts individual monitoring of their respective groundwater quality.

We recommend that the scope of the current groundwater monitoring programs for these purveyors be assessed, and that the historical water quality data be reviewed. The purpose of the review would be to identify any outstanding water quality issues and to identify additional monitoring that may be required to address risks identified by the contaminant inventory.

In addition, it is recommended that the potential for groundwater to be influenced by microbial contamination from surface water sources be assessed.

9.5 Designate Groundwater Protection Areas

Once the capture zones for the wells have been refined, the CGF and RDKB should consider designating formal groundwater protection areas. Two different strategies can be employed when designating groundwater protection areas: i) a *wellhead protection approach*, whereby groundwater protection area is defined relative to a capture zone or part of a capture zone; and, ii) *aquifer protection approach*, whereby part or all of an aquifer is designated for protection.

The CGF and RDKB may wish to defined groundwater protection areas based on the entire capture zone, or based on a corresponding travel time to a well. The advantage of defining groundwater protection in this manner is that a concerted effort can be made to manage activities near the wellhead, thereby protecting the water supply. In our experience, the greatest degree of groundwater protection is achieved by combining wellhead protection and aquifer protection. The CGF and RDKB may wish to consider designating part of the Grand Forks Aquifer that lies outside of the capture zones as some form of groundwater protection area. The advantage of defining protection areas in this manner is that it allows for the protection of groundwater recharge areas, regions serviced by private water wells and areas where future water supplies may be developed. Additional aquifer characterization and mapping may be required to assist with the designation of areas of the aquifer requiring protection, such as recharge zones.

9.6 Develop Groundwater Protection Measures

Once designated groundwater protection areas have been established and additional potential contaminant sources have been identified, the CGF and RDKB may wish to embark on the development of groundwater protection measures. Groundwater protection measures can be implemented at the municipal level through both regulatory and non-regulatory measures. In our opinion, while non-regulatory measures, such as public education and best management practices, can be highly effective, some degree of regulatory control may to required to ensure the protection of the groundwater resources.

These regulatory strategies often involve the use of municipal land use planning and zoning bylaws to restrict certain high-risk land use activities within protection areas. As an alternative to land use restrictions, some communities, such as Fredericton, New Brunswick, have chosen to restrict the types and quantities of chemicals used within groundwater protection areas.

Public participation and education represents one of the most important forms of non-regulatory groundwater protection. It is essential to the success of a groundwater protection plan and provides a means of securing political and financial support. A public education campaign would identify groundwater protection areas, threats to groundwater supplies in those areas, and measures individuals and businesses can take to protect the resource. Examples of public education tools include the use of the public information meetings, signs erected at strategic locations around groundwater protection areas, the use of media, distribution of information brochures on best management practices and school education programs.

Golder would be pleased to assist with the development of specific groundwater protection measures once some of the preceding work has been carried out. Some examples of groundwater protection measures that may be considered are presented below. These measures have been adapted from the Environment Canada/Fraser River Action Plan (FRAP) report entitled *"Groundwater Quality Protection Practices"* (Environment Canada, 1995), which was prepared by Golder on behalf of Environment Canada. The primary goal of the study was to review the applicability of groundwater protection practices developed within other jurisdictions to the Fraser River Basin.

Examples of Groundwater Protection Measures

1.	Hazardous Waste Collection	✓ Drop-off at central depot outside of capture zone ✓ Mobile units that travel to various locations ✓ Collection days once or twice per year
2.	Technical Assistance	✓ Best Management Practices pamphlets ✓ Training building and fire inspectors to recognize abandoned wells and USTs ✓ Agricultural consultants ✓ Septic system consultants ✓ Training for commercial and industrial facilities
3.	Land Acquisition	✓ Donation ✓ Land exchange ✓ Land purchase ✓ Purchase and lease back
4.	Cluster Development	✓ Encourage development in less sensitive areas ✓ Encourage development where sewer extension is planned
5.	Storm Water and Sewage Control	✓ Integrated Water Management Plan ✓ Design standards for drainage systems and catch basins ✓ Regular inspection and maintenance ✓ Upgrading and replacement ✓ Testing of stormwater and sewage discharges ✓ Permitting of stormwater and sewage discharges ✓ Containment and treatment of discharges ✓ Subdivision controls ✓ Prohibit dry wells and infiltration trenches
6.	Septic System Controls	✓ Educational programs ✓ Technical assistance ✓ Water conservation ✓ Siting control ✓ Prohibition in sensitive areas ✓ Minimum lot size requirements ✓ Design control ✓ Restrict use by industry ✓ Extend sewer system ✓ Use holding tanks ✓ Operational permits

		✓ Regular inspection program and maintenance program ✓ Inspection prior to property transfer ✓ Ban cleaners with organic solvents
7.	Agricultural Controls	✓ Educational programs (working groups) ✓ Technical Assistance ✓ Best Management Practices pamphlets ✓ Restrict amount and type of chemicals stored ✓ Pesticide/fertilizer application control ✓ Prohibit/restrict agricultural activities in sensitive areas ✓ Reporting requirements ✓ Research
8.	Transportation Controls	✓ Designated truck route ✓ Designated rail route ✓ Warning signs ✓ Speed limits ✓ Education of delivery personnel ✓ Training for emergency response personnel ✓ Road and maintenance repair
9.	Well Drilling and Abandonment	✓ Siting guidelines/regulations ✓ Construction guidelines/regulations ✓ Maintenance guidelines/regulations ✓ Guidelines/regulations for well abandonment ✓ Identification of abandoned wells as a condition of site plan approval/property transaction
10.	Geotechnical Controls	✓ Guidelines/regulations for grouting boreholes ✓ Limit depth of excavations in sensitive areas
11.	Forest Management	✓ Forest management plan ✓ Management to reduce the risk of fire ✓ Control of activities around streams ✓ Cutting restrictions ✓ Design controls for haul roads, skid trails and log landings ✓ Control of pesticides and herbicides ✓ Performance bonds

12.	Market Approaches	✓ Performance bonds ✓ Surcharge on water use ✓ Penalties/fines for non-compliance ✓ Financial incentives through tax credits ✓ Financial incentives through grants and loans
13.	Groundwater Quality Guidelines/Regulations	✓ Non-degradation policy ✓ Limited degradation policy
14.	Zoning	✓ Overlay zones ✓ Prohibition of hazardous materials ✓ Prohibition of land uses ✓ Aquifer-wide protection area ✓ Protection area around a well field ✓ Large-lot zoning
15.	Facility Siting, Design and Operation Controls	✓ Best management plan ✓ Siting Restrictions ✓ Design and construction standards (i.e., secondary containment) ✓ Operating standards ✓ Permitting and licensing ✓ Regular inspection and maintenance ✓ Contingency plan
16.	Hazardous Materials Restrictions	✓ Control type and quantity of hazardous materials ✓ Registration and tracking controls (i.e. business license renewal process) ✓ Storage and handling controls ✓ Disposal controls
17.	Underground Storage Tanks and Pipelines	✓ Operations standards ✓ Secondary containment ✓ Pressure testing ✓ Groundwater Monitoring ✓ Permitting ✓ Fees ✓ Prohibition in sensitive areas

18.	Above-ground Storage Tanks	✓ Operations standards ✓ Secondary containment ✓ Pressure testing ✓ Groundwater Monitoring ✓ Permitting ✓ Fees ✓ Prohibition in sensitive areas
19.	Sand and Gravel Mining	✓ Security requirements ✓ Drainage control ✓ Mining restrictions ✓ Prohibition in sensitive areas
20.	Inspection and Compliance	✓ Fire Inspectors

Adapted from (Environment Canada, 1995) Table 10: Detailed Summary of Groundwater Protection Measures

9.7 Develop Contingency Plans

Contingency planning consists of developing a plan for the location and provision of alternative drinking water supplies in the event that the existing well field cannot be used. Disruptions to the existing well field may be related to either contamination or non-contamination effects. The contingency plan should identify short-term alternatives in the event of a minor disruption, and long-term alternatives in the event of a complete loss of water supply. It is recommended that if one is not already in existence, a contingency plan for the various water supplies be developed.

9.8 Develop Emergency Response Plans

The goal of groundwater protection is to prevent the contamination of underground drinking water supplies. Even under the best prevention plans, a scenario that threatens to contaminate the aquifer may occur. When this happens, an emergency response plan directing a coordinated and timely response is an effective tool for assuring a continued supply of potable water. Many communities' emergency response plans do not include specific provisions for the protection of groundwater resources in the event of a spill or accident. For example, it may be prudent for emergency response personnel to restrict the use of fire retardant chemicals in sensitive groundwater areas. We recommend that the irrigation district, MHP and CGF's existing emergency response plan be evaluated and revised, if necessary, to allow for the protection of sensitive groundwater resources.

9.9 Other

Other recommendations include:

- Conduct a door-to-door survey to determine which wells are abandoned but have not been properly decommissioned.
- Prepare an educational brochure or pamphlet aimed at all Grand Forks residents on the proper maintenance and use of domestic effluent disposal to septic fields. This could be completed in conjunction with the door-to-door water well survey.
- Conduct an annual survey of all transformers in the vicinity of the wells to confirm that no leakage is occurring.
- To ensure the security of the water distribution system, we recommend that access to all wellheads and water distribution systems be restricted.

10.0 LIMITATIONS

This report was prepared for the exclusive use of the Grand Forks Aquifer Protection Committee and the City of Grand Forks. 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. The report is based on data and information collected during the investigation conducted by Golder Associate Ltd.'s personnel and is based solely on the data provided by other parties and conditions observed at the time of the site reconnaissance as described in this report.

The investigation program followed the standard of care expected of professionals undertaking similar work in British Columbia under similar conditions. No warranty expressed or implied is made. This report provides a professional opinion, and therefore no warranty is either expressed, implied or made as to the conclusions, advice and recommendations offered in this report. This report does not provide a legal opinion regarding compliance with applicable laws. With respect to regulatory compliance issues, it should be noted that regulatory statutes and the interpretation of regulatory statutes are subject to change.

The scope of work for this study was intended to provide an overview only and did not include such items as subsurface investigations, entry into buildings, contaminated sites assessment, geotechnical assessment, hydrogeological assessment or a detailed review of records.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in the future, Golder should be requested to re-evaluate the conclusions of this report and to provide amendments, as required, prior to any reliance upon the information presented herein. The report, which specifically includes all tables and figures, is based on data and information collected during the investigations by Golder Associates Ltd. The report must be read and understood collectively, and can only be relied upon in its totality.

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 accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

11.0 CLOSURE

It was our pleasure to assemble this report as a foundation for your groundwater protection planning. Should you have any questions or comments, please do not hesitate to contact us.

Yours very truly,

GOLDER ASSOCIATES LTD.

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DA/JS/at

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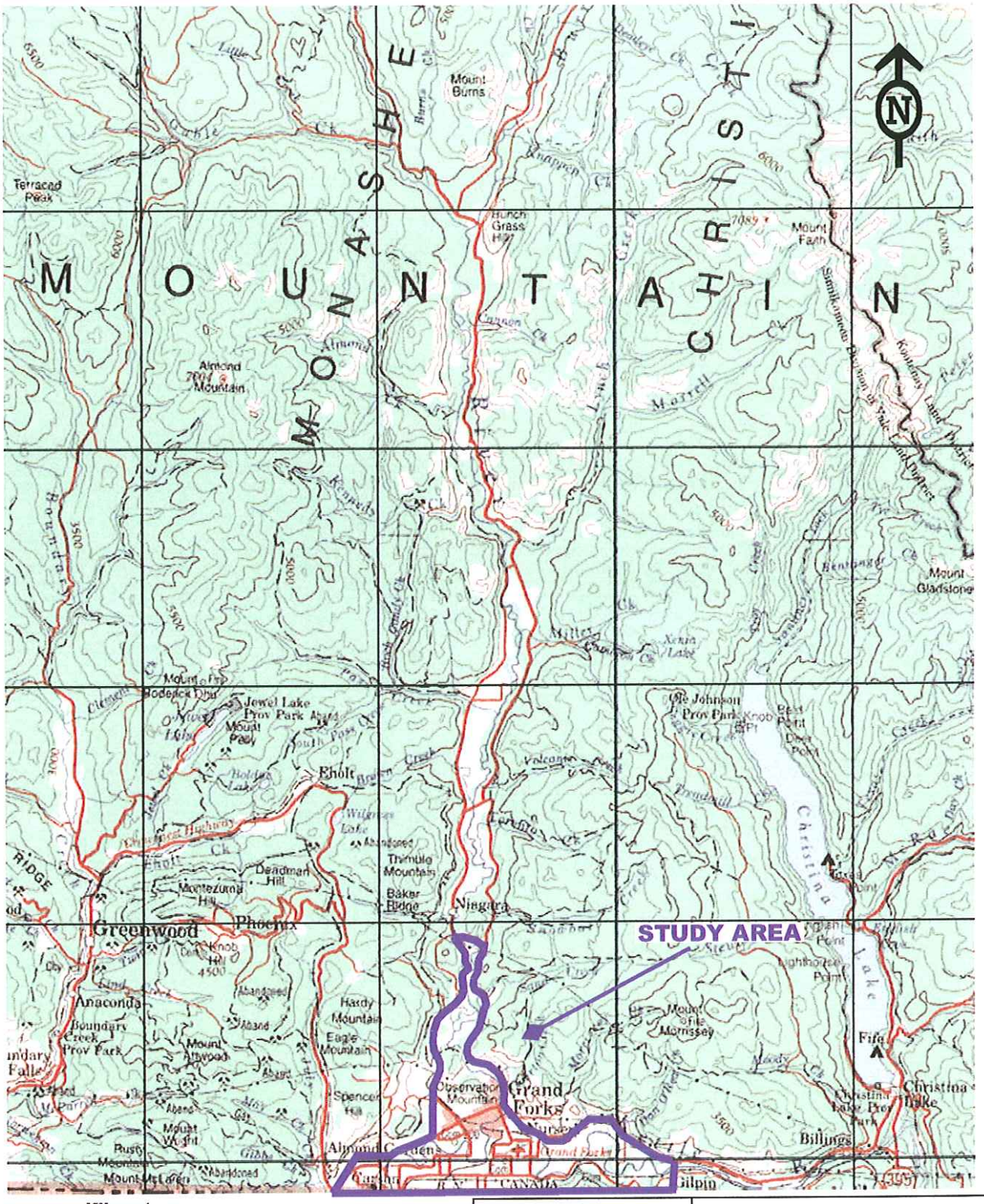


PROJECT NO. 022-4168 DRAWN BY: SN REVIEWED BY: DATE: Mar-12-03 FILE LOCATION: n:\active\4100\022-4168\Figures\Report Figures\Figure 01.cdr

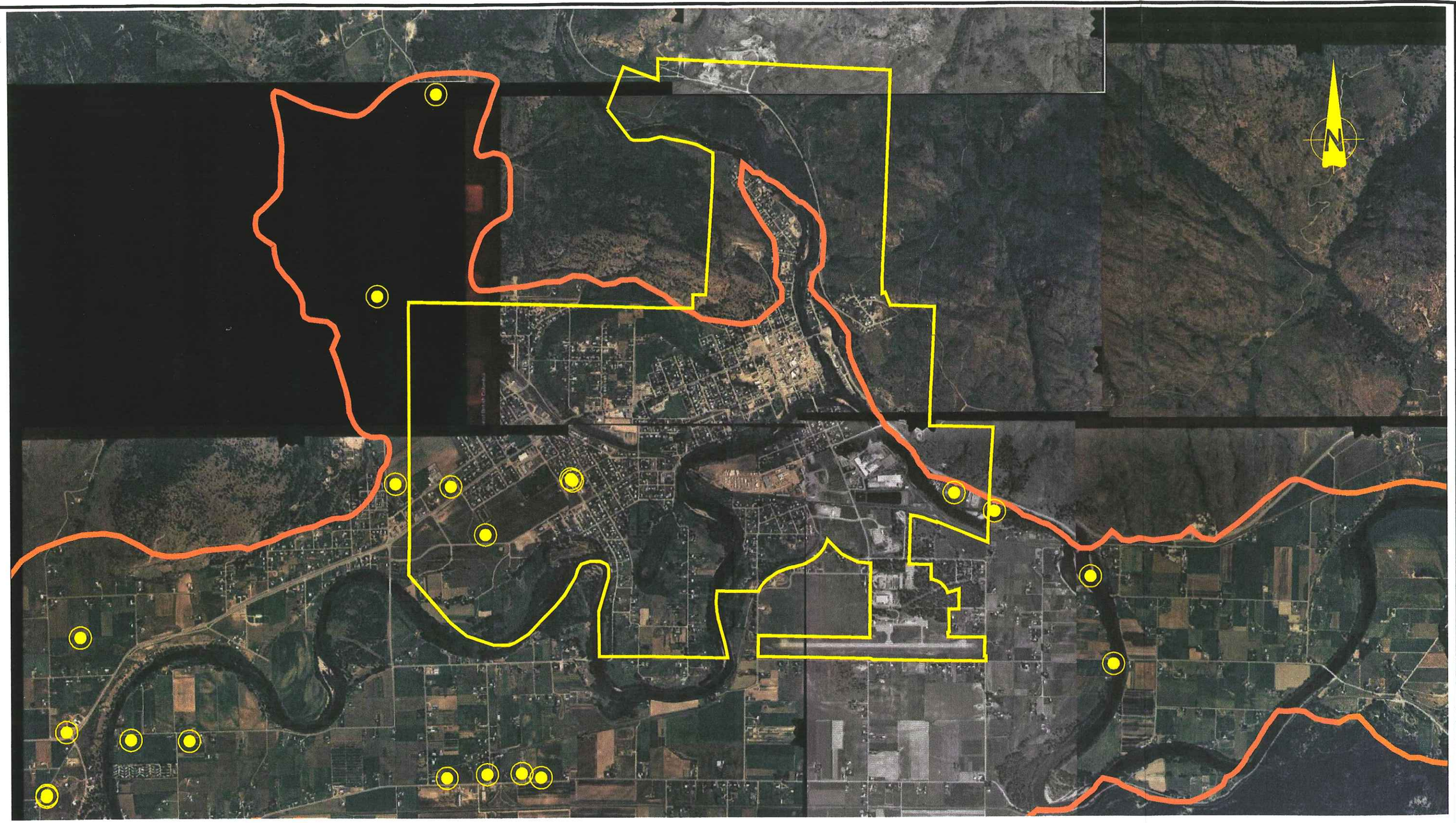
Golder Associates

KEY PLAN
Grand Forks and Regional District
Kootenay Boundary
Contaminant Inventory

Drawn: SN	App'd:	Date: Mar-12-03	Figure: 1

Project No.: 022-4168

Revision No.:



LEGEND

Approximate extent of aquifer

Grand Forks City Limits

Municipal water well location

REFERENCES

- AIR PHOTO COVERAGE BASED ON BC MWLAP (SURVEYS AND MAPPING BRANCH), 1993
- AQUIFER EXTENT PROVIDED BY M. WEI & K. RONNESETH (MINISTRY OF WATER, LAND, AND AIR PROTECTION)

0 200 400 600 800 1000

Scale in Meters

Golder Associates
Kelowna, BC

FILE No.	Figure 02.dwg
PROJECT No.	022-4168
REV.	0

SCALE	1:25,000
DATE	03/22/03
DESIGN	SN
CADD	SN
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REVIEW	

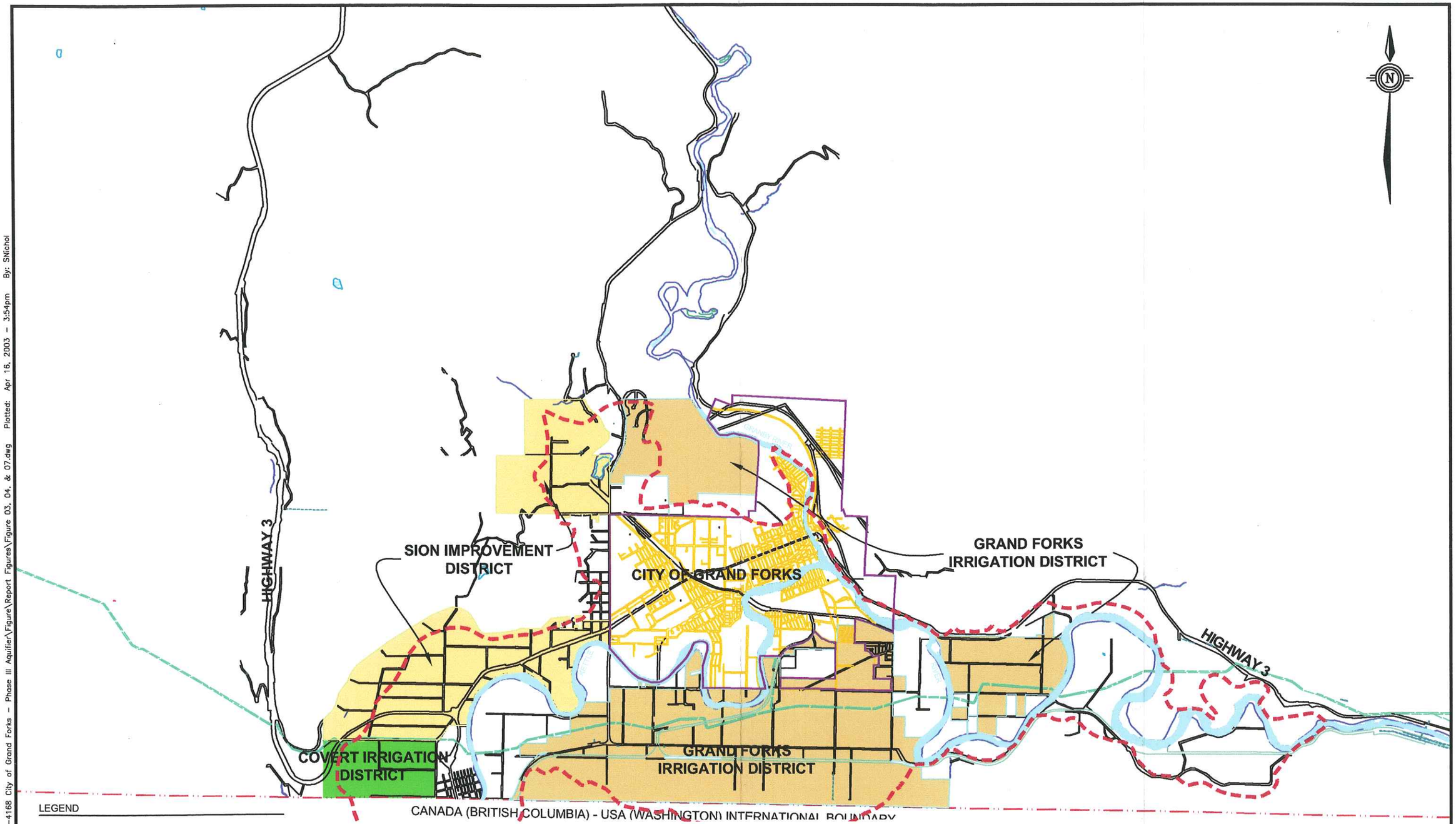
TITLE

AIR PHOTO COVERAGE FOR GRAND FORKS

GRAND FORKS

FIGURE 2

Drawing: N:\Active\4100\022-4168 City of Grand Forks - Phase III Aquifer\Figure\Report Figures\Figure 02.dwg Plotted: Apr 16, 2003 - 3:51pm By: SNichol



LEGEND

Approximate extent of aquifer

Natural Gas ROW

Grand Forks City Limits

REFERENCES

- BASED ON AUTOCAD DRAWING d_ocp_lu_map.dwg PROVIDED BY REGIONAL DISTRICT OF KOOTENAY BOUNDARY, NAD 83 UTM ZONE 11
- AQUIFER EXTENT PROVIDED BY M. WEI & K. RONNESETH (MINISTRY OF WATER, LAND, AND AIR PROTECTION)

0 1 2
SCALE KILOMETRES

Golder Associates
Kelowna, BC

SCALE	1:50,000
DATE	03/12/03
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FILE No. Figure 03.dwg
PROJECT No. 022-4168 REV. 0

TITLE

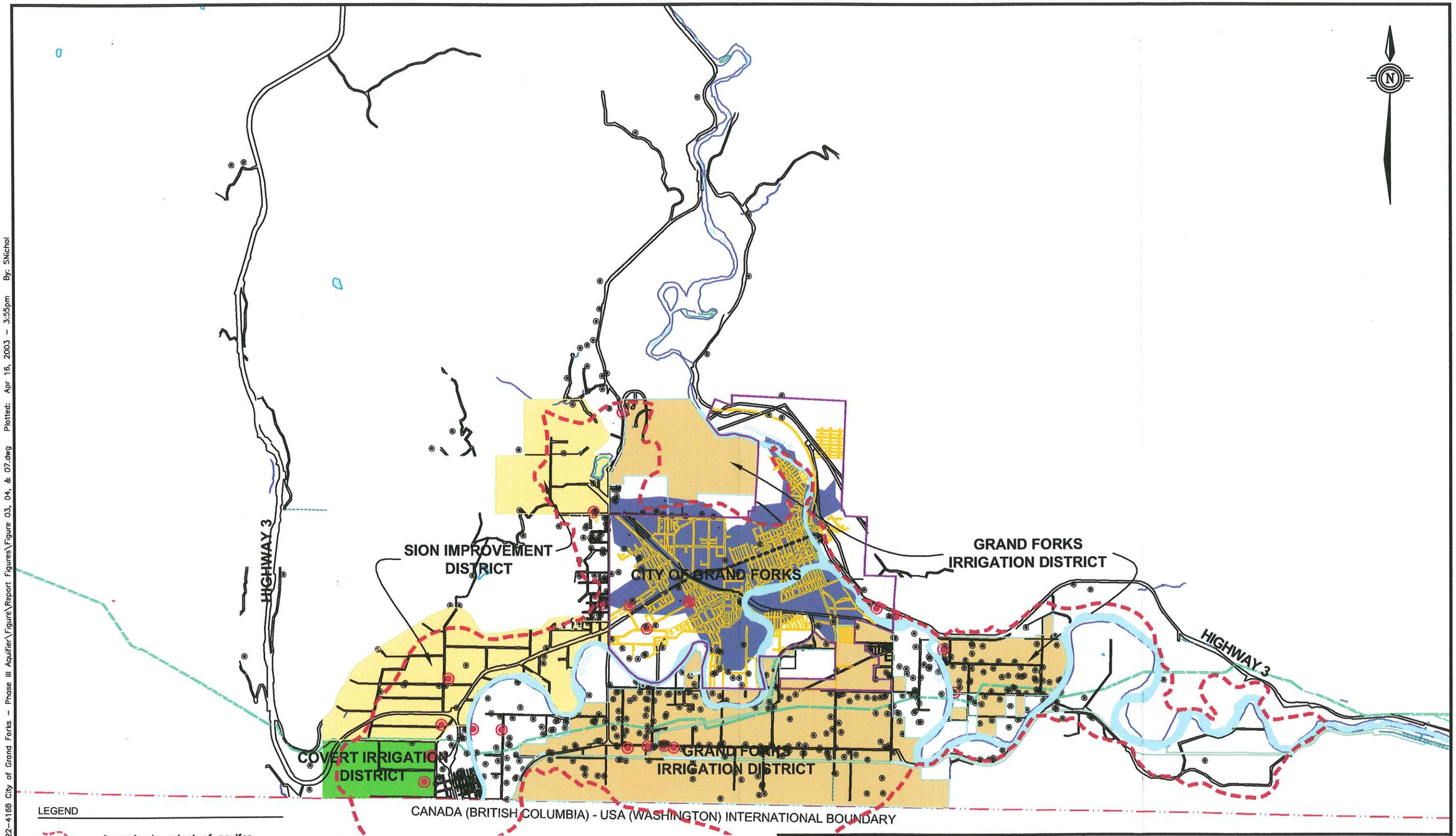
APPROXIMATE EXTENT OF GRAND FORKS AQUIFER

GRAND FORKS

FIGURE 3

Drawing: N:\Active\4100\022-4168 City of Grand Forks - Phase III Aquifer\Figure\Report Figures\Figure 03, 04, & 07.dwg Plotted: Apr 16, 2003 - 3:54pm By: SNichol

Drawing: N:\Active\4100\022-4168 City of Grand Forks - Phase III Aquifer\Figure\Report Figures\Figure 03, 04, & 07.dwg Plotted: Apr 16, 2003 - 3:55pm By: SNichol



LEGEND

- Approximate extent of aquifer
- Private water well location
- Municipal water well location
- Approximate Extent of City of Grand Forks Water Distribution

REFERENCES

- BASED ON AUTOCAD DRAWING d_ocp_lu_map.dwg PROVIDED BY REGIONAL DISTRICT OF KOOTENAY BOUNDARY, NAD 83 UTM ZONE 11
- BASED ON AUTOCAD DRAWING City.dwg PROVIDED BY CITY OF GRAND FORKS
- AQUIFER EXTENT AND WELL LOCATIONS PROVIDED BY M. WEI & K. RONNESETH (MINISTRY OF WATER, LAND, AND AIR PROTECTION)

0 1 2
SCALE KILOMETRES

Golder Associates
Kelowna, BC

FILE No.	Figure 04.dwg
PROJECT No.	022-4168
REV.	0
SCALE	1:50,000
DATE	03/12/03
DESIGN	RT
CADD	RT
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REVIEW	

TITLE
LOCATION OF PRIVATE AND MUNICIPAL WELLS AND CITY OF GRAND FORKS WATER DISTRIBUTION SYSTEM

GRAND FORKS

FIGURE 4

LEGEND

- Approximate extent of aquifer
- 1yr. Capture Zone, based on arbitrary and calculated fixed radius (M. Wei, 1999)
- 5yr. Capture Zone, based on arbitrary and calculated fixed radius (M. Wei, 1999)
- 10yr. Capture Zone, based on arbitrary and calculated fixed radius (M. Wei, 1999)
- Capture Zone from analytical solution (M. Wei, 1999)
- Capture Zones from Modflow Numerical model (Allen, 2000)
- Sion #2 — Municipal water wells

REFERENCES

- BASED ON AUTOCAD DRAWING d_ocp_lu_map.dwg PROVIDED BY REGIONAL DISTRICT OF KOOTENAY BOUNDARY,
- NAD 83 UTM ZONE 11, CAPTURE ZONES PROVIDED BY BC MWLAP (M.Wei), JULY 28, 1999

Copper Ridge
Sion #3
GRANBY RIVER
Grand Forks #4/5
West Grand Forks MHP
Grand Forks #2
Grand Forks #3
Kettle River Place MHP
Riviera RV Park and Campground
KETTLE RIVER
Nursery #2
Nursery #1
Sion #1
Sion #2
Almond Garden West
Almond Garden East
Big Y #4
Big Y #1
Big Y #3
Big Y #2
CID #1,#2
CID #3
CANADA (BRITISH COLUMBIA) - USA (WASHINGTON) INTERNATIONAL BOUNDARY

N

0 500 1000
SCALE METRES

Golder Associates
Kelowna, BC

FILE No.	Figure 05.dwg	SCALE	1:25,000
PROJECT No.	022-4168 REV. 0	DATE	03/17/03
		DESIGN	RT
		CADD	RT
		CHECK	
		REVIEW	

TITLE

ESTIMATED CAPTURE ZONES

GRAND FORKS

FIGURE 5

Drawing: N:\Active\4100\022-4168 City of Grand Forks - Phase III Aquifer\Figure\Report Figures\Figure 05.dwg Plotted: Apr 16, 2003 - 3:57pm By: SNichol

LEGEND

Approximate extent of aquifer

7773 Indicates contaminated site is registered on MWLAP Site Registry (with site ID) – active and under assessment or remediation.

2216 Indicates contaminated site is registered on MWLAP Site Registry (with site ID) – inactive and no further action required.

2601 Indicates contaminated site is registered on MWLAP Site Registry (with site ID) – inactive and no further action required.

X-e Indicates site registered on MWLAP Waste database (e–effluent, sw–special waste, r–refuse).

▲ Indicates site registered on MWLAP Spill database.

1yr. Capture Zone, based on arbitrary and calculated fixed radius (M. Wei, 1999)

5yr. Capture Zone, based on arbitrary and calculated fixed radius (M. Wei, 1999)

10yr. Capture Zone, based on arbitrary and calculated fixed radius (M. Wei, 1999)

Granby Road

GRANBY RIVER

X-r

X-e

Donaldson Drive

X-sw

2498

2642

2633

North Fork Road

2216

7158

7199

2218

5107

2219

2643

2487

2639

Central Avenue

Highway 3

2655

X-r

X-sw

X-e

X-e

2601

6227

7773

KETTLE

Highway 3

X-e

X-e

Carson Road

CANADA (BRITISH COLUMBIA) - USA (WASHINGTON) INTERNATIONAL BOUNDARY

REFERENCES

- BASED ON AUTOCAD DRAWING d_ocp_lu_map.dwg PROVIDED BY REGIONAL DISTRICT OF KOOTENAY BOUNDARY,
- NAD 83 UTM ZONE 11, CAPTURE ZONES PROVIDED BY BC MWAP (M.Wei), JULY 28, 1999

0 500 1000

SCALE METRES

Golder Associates
Kelowna, BC

SCALE	1:25,000
DATE	03/24/03
DESIGN	RT
CADD	RT
CHECK	
REVIEW	
FILE No.	Figure 06.dwg
PROJECT No.	022–4168
REV.	0

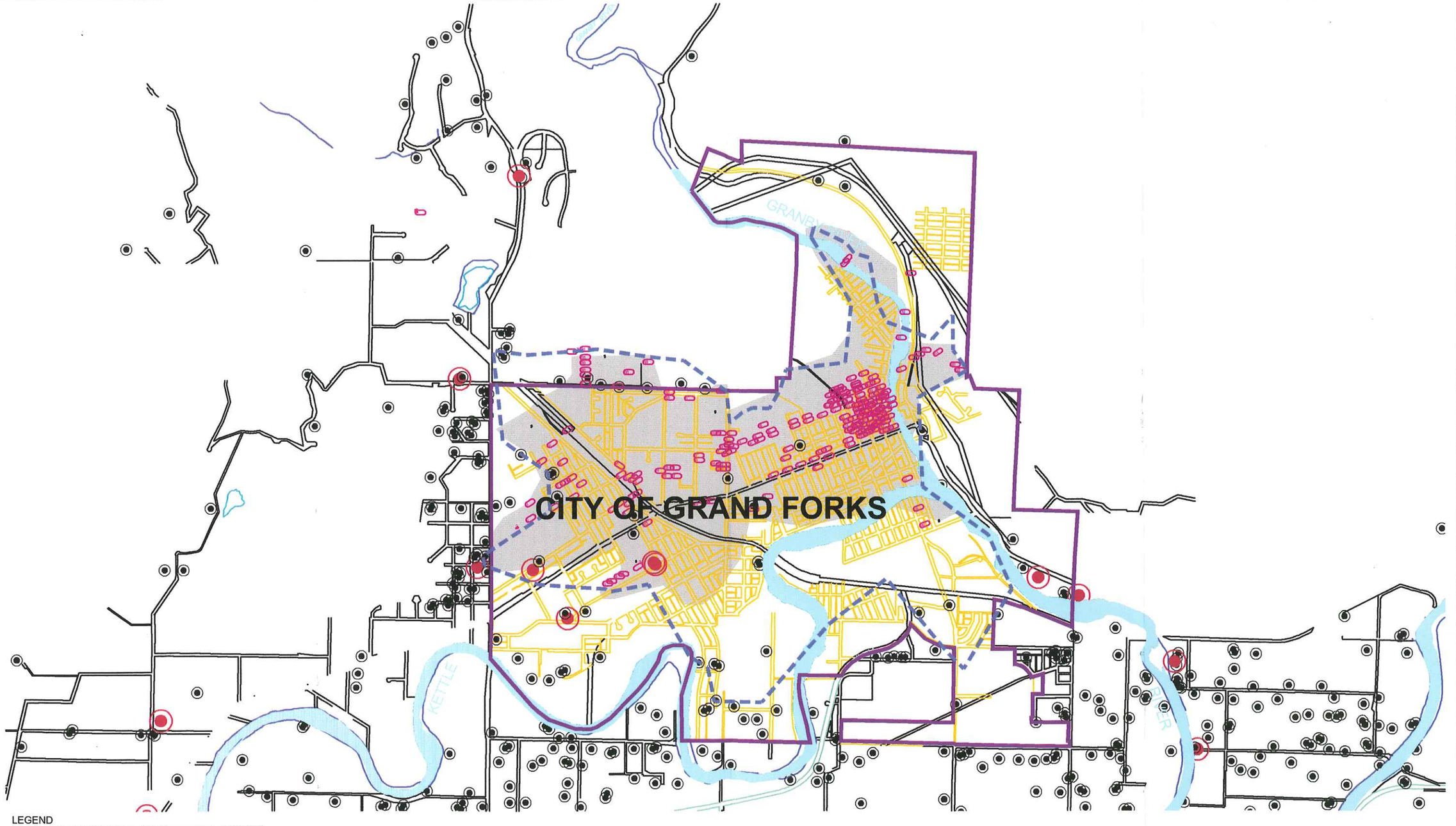
TITLE

SITES REGISTERED IN MWLAP DATABASES

GRAND FORKS

FIGURE 6

Drawing: N:\Active\4100\022-4168 City of Grand Forks – Phase III Aquifer\Figure\Report Figures\Figure 06.dwg Plotted: Apr 16, 2003 – 3:59pm By: SNichol



LEGEND

- Grand Forks City Limits
- Private water well location
- Municipal water well location
- Approximate Extent of City of Grand Forks Water Distribution
- Approximate Extent of City of Grand Forks Sewer Distribution
- City of Grand Forks Catch Basins

REFERENCES

- BASED ON AUTOCAD DRAWING d_ocp_lu_map.dwg PROVIDED BY REGIONAL DISTRICT OF KOOTENAY BOUNDARY, NAD 83 UTM ZONE 11
- BASED ON AUTOCAD DRAWING City.dwg PROVIDED BY CITY OF GRAND FORKS
- AQUIFER EXTENT AND WELL LOCATIONS PROVIDED BY M. WEI & K. RONNESETH (MINISTRY OF WATER, LAND, AND AIR PROTECTION)

0 500 1,000
1:25,000 METERS

Golder Associates
Kelowna, BC

FILE No.	Figure 07.dwg		
PROJECT No.	022-4168	REV.	0

SCALE	1:25,000
DATE	03/22/03
DESIGN	SN
CADD	SN
CHECK	
REVIEW	

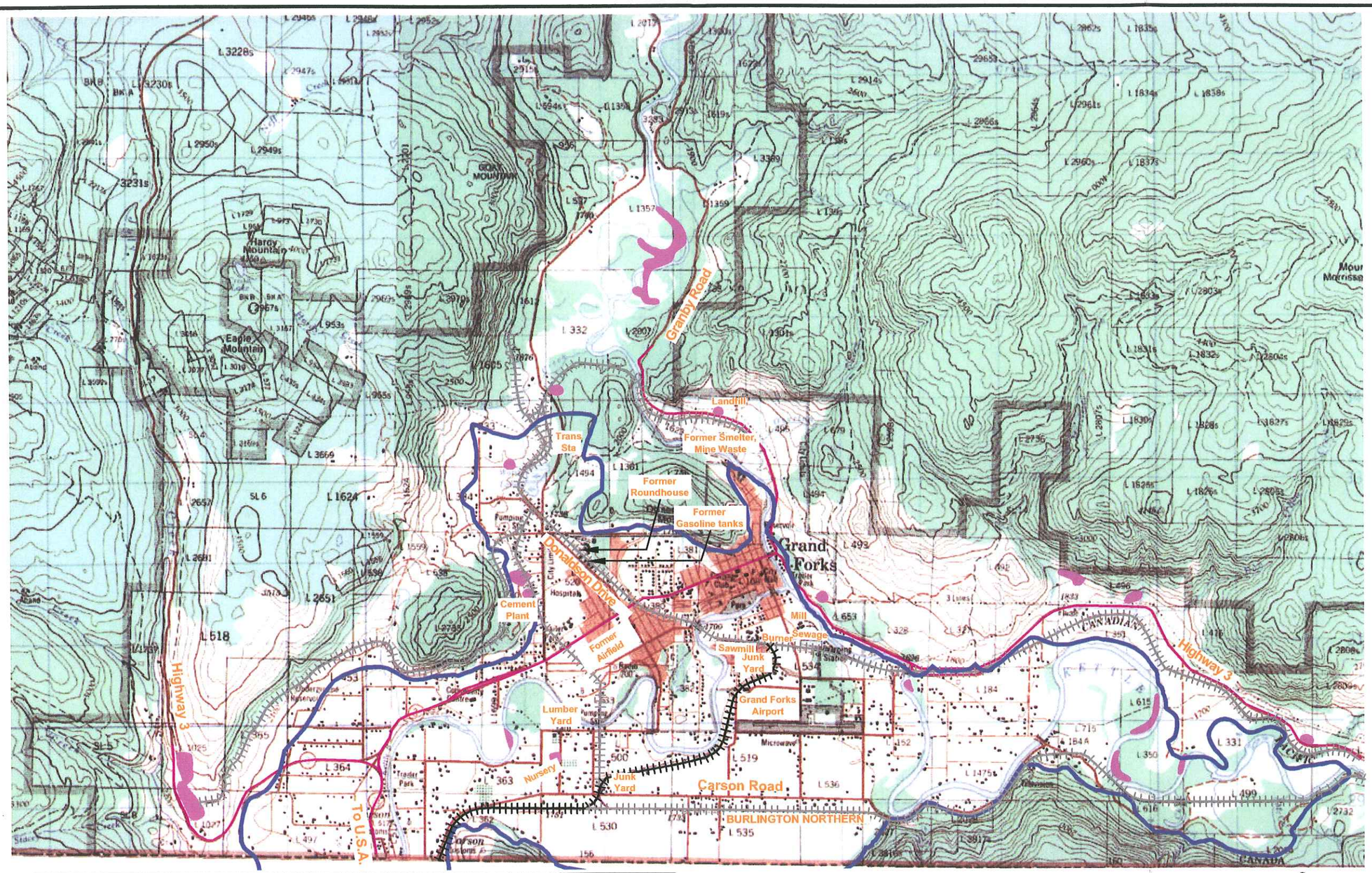
TITLE

CITY OF GRAND FORKS SEWER, CATCH BASINS, AND WATER DISTRIBUTION SYSTEM

GRAND FORKS

FIGURE 7

Drawing: N:\Active\4100\022-4168 City of Grand Forks - Phase III Aquifer\Figure\Report Figures\Figure 03, 04, & 07.dwg Plotted: Apr 16, 2003 - 3:56pm By: SNichol



0 1 2
1:50,000 KM

LEGEND

- Approximate aquifer boundary
- Roadway
- Former railway
- Approximate location of gravel pits or quarries
- Current railway

REFERENCE

Surveys and Mapping Branch, Dept. of Energy, Mines, and Resources.
Grand Forks 82 E/1 Ed. 2. 1978 and Grand Forks 82 E/1 W Ed. 1. 1966

Golder Associates
Kelowna, British Columbia

FILE No.	Figure 08.dwg
PROJECT No.	022-4168
REV.	0
SCALE	1 : 50,000
DATE	03/19/03
DESIGN	SN
CADD	SN
CHECK	
REVIEW	

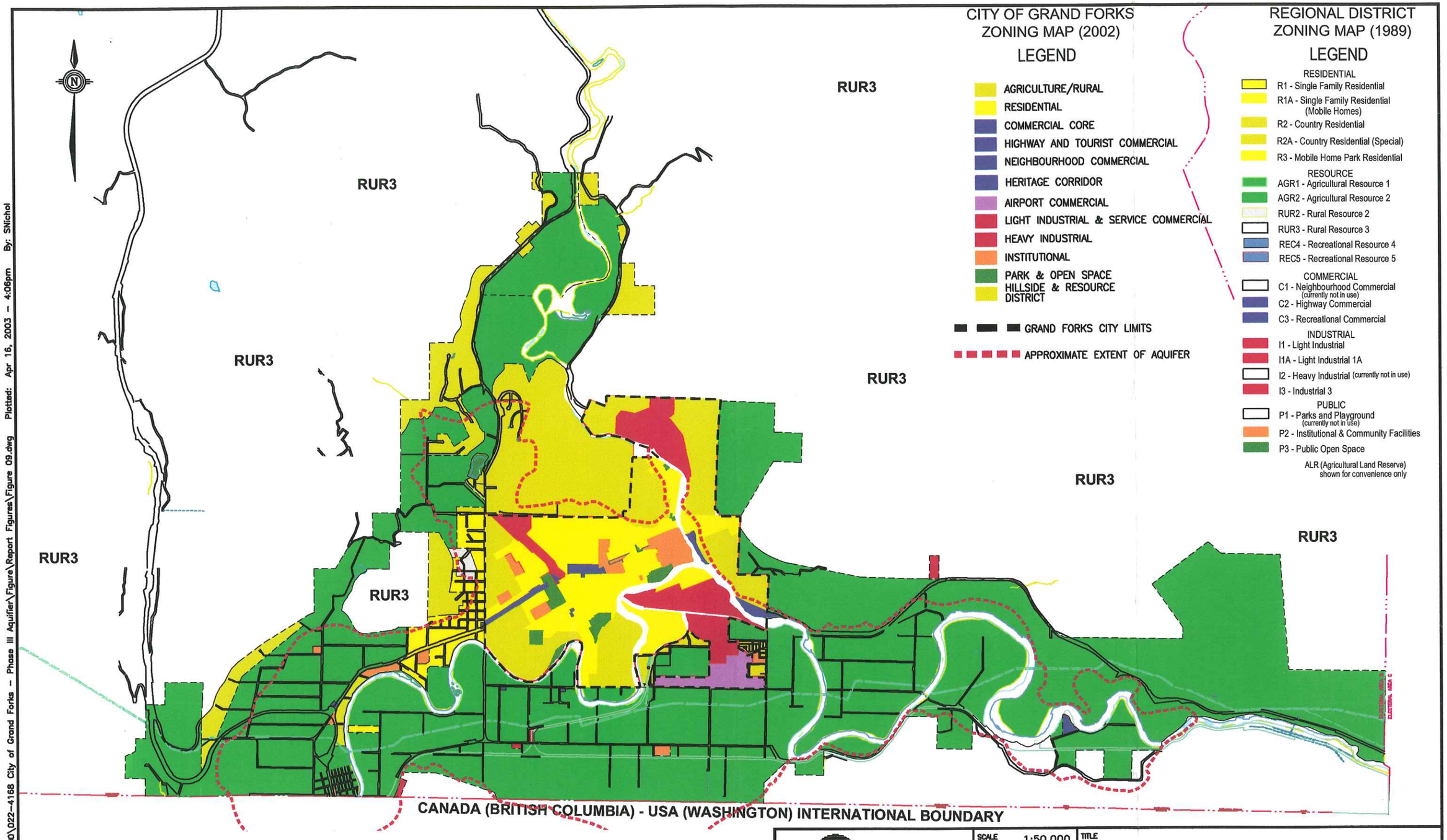
TITLE

TOPOGRAPHY MAP AND OTHER REGIONAL FEATURES

GRAND FORKS

FIGURE 8

Drawing: N:\Active\4100\022-4168 City of Grand Forks - Phase III Aquifer\Figure\Report Figures\Figure 08.dwg Plotted: Apr 16, 2003 - 4:03pm By: SNichol



CITY OF GRAND FORKS ZONING MAP (2002)

LEGEND

- AGRICULTURE/RURAL
- RESIDENTIAL
- COMMERCIAL CORE
- HIGHWAY AND TOURIST COMMERCIAL
- NEIGHBOURHOOD COMMERCIAL
- HERITAGE CORRIDOR
- AIRPORT COMMERCIAL
- LIGHT INDUSTRIAL & SERVICE COMMERCIAL
- HEAVY INDUSTRIAL
- INSTITUTIONAL
- PARK & OPEN SPACE
- HILLSIDE & RESOURCE DISTRICT
- GRAND FORKS CITY LIMITS
- APPROXIMATE EXTENT OF AQUIFER

REGIONAL DISTRICT ZONING MAP (1989)

LEGEND

RESIDENTIAL
- R1 - Single Family Residential
- R1A - Single Family Residential (Mobile Homes)
- R2 - Country Residential
- R2A - Country Residential (Special)
- R3 - Mobile Home Park Residential

RESOURCE
- AGR1 - Agricultural Resource 1
- AGR2 - Agricultural Resource 2
- RUR2 - Rural Resource 2
- RUR3 - Rural Resource 3
- REC4 - Recreational Resource 4
- REC5 - Recreational Resource 5

COMMERCIAL
- C1 - Neighbourhood Commercial (currently not in use)
- C2 - Highway Commercial
- C3 - Recreational Commercial

INDUSTRIAL
- I1 - Light Industrial
- I1A - Light Industrial 1A
- I2 - Heavy Industrial (currently not in use)
- I3 - Industrial 3

PUBLIC
- P1 - Parks and Playground (currently not in use)
- P2 - Institutional & Community Facilities
- P3 - Public Open Space

ALR (Agricultural Land Reserve) shown for convenience only

REFERENCES

BASED ON AUTOCAD DRAWING d_zoning.dwg PROVIDED BY REGIONAL DISTRICT OF KOOTENAY BOUNDARY, NAD 83 UTM ZONE 11,
BASED ON AUTOCAD DRAWING 11x17LND.dwg PROVIDED BY URBAN SYSTEMS

1 0 1
SCALE KILOMETRES

Golder Associates
Kelowna, BC

FILE No.	Figure 09.dwg
PROJECT No.	022-4168 REV. 0
SCALE	1:50,000
DATE	03/17/03
DESIGN	RT
CADD	RT
CHECK	
REVIEW	

TITLE

CURRENT ZONING

GRAND FORKS

FIGURE 9

Drawing: N:\Active\4100\022-4168 City of Grand Forks - Phase III Aquifer\Figure\Report Figures\Figure 09.dwg Plotted: Apr 16, 2003 - 4:06pm By: SNichol

388000 389000 390000 391000 392000 393000 394000 395000 396000 397000 398000 399000

5434000 5433000 5432000 5431000 5430000 5429000

N

388000 389000 390000 391000 392000 393000 394000 395000 396000 397000 398000 399000

500 0 500 Meters

Scale - 1:30,000

LEGEND

- Study Area
- Water Supply Well
- Municipal Water Well

Landuse

- A-111 Growing Grain
- A-112 Growing Vegetables
- A-113 Growing Root Crops
- A-116 Growing Flowers & Bulbs
- A-121 Growing Forage Crops
- A-122 Grazing
- A-131 Tree Fruit Production
- A-133 Berry Production
- A-140 Growing Ornamental Shrubs/Trees
- A-150 Sod Production
- A-180 Specialty Perennial Crop
- A-190 Other
- A-220 Outside Animal Feeding Areas
- A-250 Storing Crops & Agricultural Machinery
- A-280 Beekeeping & Honey Making
- B-000 Unused Land
- B-100 Former Agriculture Activities
- B-200 Former Forestry Activities
- B-300 Former Extraction Activities
- B-500 Former Dwelling Activities
- C-100 Wholesaling
- C-200 Retailing
- C-300 Providing Commericial Services
- D-111 Single Family Dwelling
- D-112 Multiple Dwellings
- D-113 Mobile Homes
- D-220 Hotels & Motels
- E-120 Extraction Of Sand, Gravel & Clay
- H-000 Transportation & Communication Activities
- H-130 Transporting By Air
- H-160 Transporting By Electricity
- H-200 Communicating Activity
- J-000 Providing Institutional Services
- J-100 Legislative, Judicial & Legal Services
- J-200 Protective/Custodial
- J-300 Educational Services
- J-400 Health, Medical Care Facilities
- J-610 Worshipping
- J-620 Burying
- J-700 Assembly Activities
- L-000 Land in Transition
- M-000 Manufacturing/Storage Activities
- M-200 Raw Material Processing
- M-280 Processing Wood
- M-400 Assembly Products
- M-500 Storage Activities
- M-520 Storing Vehicles, Equipment
- M-530 Warehousing
- M-550 Open Air Storage
- M-610 Treating/Disposal of Liquid Waste
- M-630 Treating/Disposal of Solid Waste
- N-000 No Perceived Activity
- R-140 Viewing of Nature & Historical Areas
- R-170 Recreational Open Space
- R-200 Indoor & Outdoor Recreation Activities
- R-220 Indoor Recreation/Cultural Activities
- W-300 Vines
- Z-300 Ponds, Lakes, & Reservoirs

REFERENCE

Land Use Survey provided by MWALP, M. Wei and K. Ronneseth 1995
Datum: NAD 83 Projection: UTM Zone 11

PROJECT
GRAND FORKS AQUIFER PROTECTION COMMITTEE
CONTAMINANT INVENTORY
GRAND FORKS, B.C.

TITLE
MWALP LAND USE MAP

Golder Associates
Burnaby, B.C.

PROJECT No. 022-4168			SCALE AS SHOWN	REV. 0
DESIGN	CDB	15 Apr. 2003	**FIGURE 10**
GIS	CDB	15 Apr. 2003	
CHECK	DA	15 Apr. 2003	
REVIEW			

N:\Bur-Graphics\Projects\4000\2002\022-4168\GIS\aprs\land-use.apr (Layout: 11x17 Landscape Standard bottom legend) April 15, 2003

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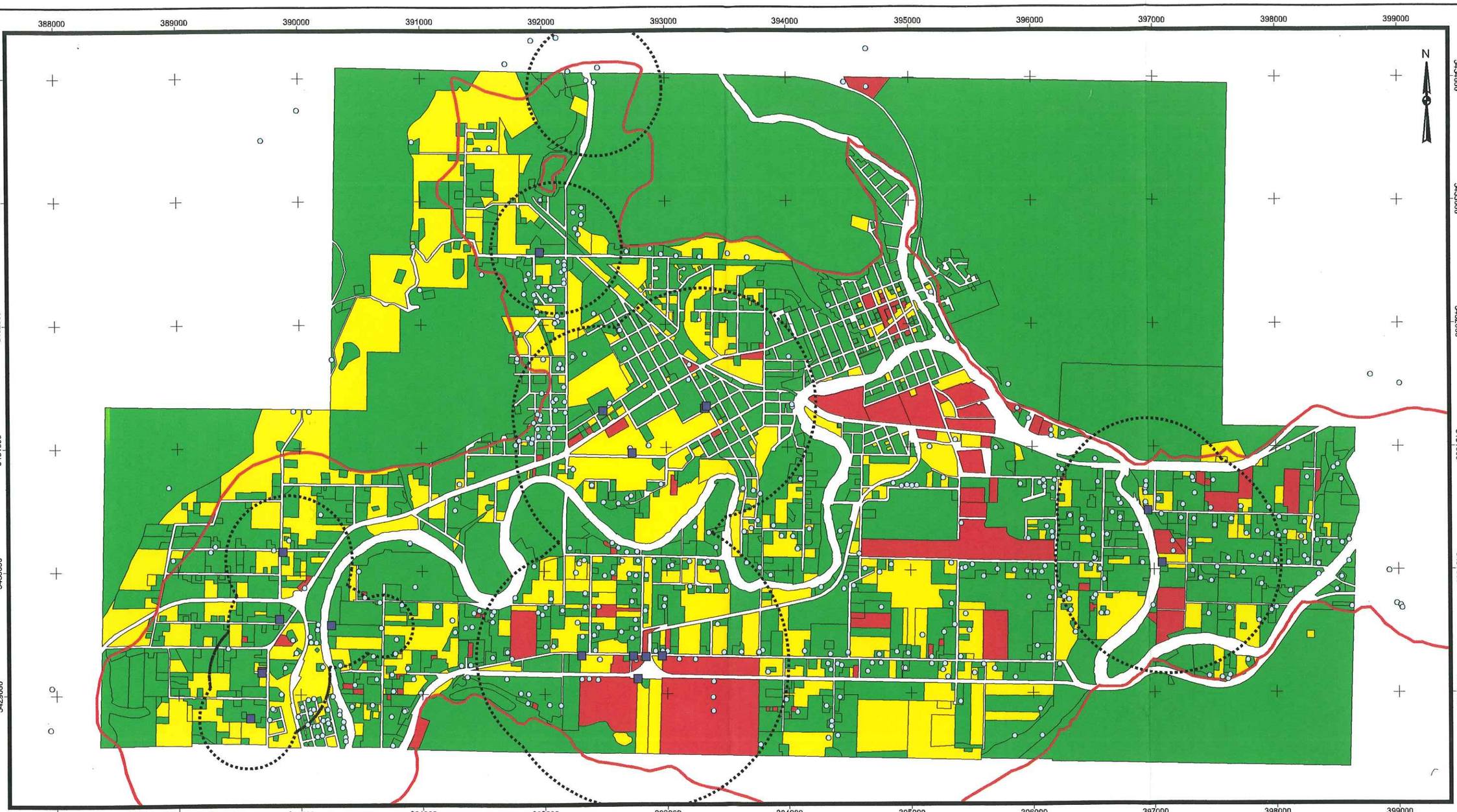
5434000 5433000 5432000 5431000 5430000 5429000

N



388000 389000 390000 391000 392000 393000 394000 395000 396000 397000 398000 399000

500 0 500 Meters

Scale - 1:30,000

LEGEND

- Study Area
- Water Supply Well
- Municipal Water Well
- 10yr. Capture Zone

Relative Risk
- High
- Moderate
- Low

REFERENCE

Relative risk based on Land Use Survey provided by MWALP, M. Wei and K. Ronneseth 1995
Relative risk ratings for land use categories summarized in Tables 7 and 8.
Datum: NAD 83 Projection: UTM Zone 11

PROJECT
GRAND FORKS AQUIFER PROTECTION COMMITTEE
CONTAMINANT INVENTORY
GRAND FORKS, B.C.

TITLE
RANKING OF RELATIVE RISKS OF REGIONAL LAND USE ACTIVITIES

Golder Associates
Burnaby, B.C.

PROJECT No. 022-4158			SCALE AS SHOWN	REV. 0
DESIGN	CDB	15 Apr. 2003	**FIGURE 11**	
GIS	CDB	15 Apr. 2003		
CHECK	DA	15 Apr. 2003		
REVIEW				

N:\Bur-Graphics\Projects\4000\2002\022-4168\GIS\aprs\land-use-ranking.apr (Layout: 11x17 Landscape Standard bottom legend) April 15, 2003

Table 1
Summary of Groundwater Supply Wells and Capture Zones Estimated by MWLAP
Grand Forks, B.C.

	Well	Location	UTM		Use[3]	Depth (m)	Annual Q	Q (peak day)	Area of Fixed Radius Capture Zone		
			E	N			10^6 m^3	m3/s	1yr	5yr	10yr
City of Grand Forks	GF#2	SE side of 75th Ave near 27th St.	392484	5431297	M	13.1		0.0379	228	509	720
	GF#3	NW side of 68th Ave, bw 25 & 27th St.	392720	5430952	M	30.3		0.0757	298	667	943
	GF#4	east corner of above lot (playing field) near corner of 70th Ave	393316	5431312	M	35.4		0.1211	290	648	916
	GF#5	and 19th St.	393329	5431332	M	70.1					
	Total						2.46				
Grand Forks Irrigation District	Big Y#1	along Carson Road, east, west, west and south of the Big Y, respectively	392957	5429302	I	51.7	0.36	0.171	382	853	1207
	Big Y#2		392824	5429300	I,D	54.2	0.47				
	Big Y#3		392721	5429302	I	42.8	0.24				
	87-2,5		392758	5429120	D	55.8	0.03				
	Big Y#4	along Carson Road, west of the Big Y	392299	5429308	I	23.8	0.81	0.0789	279	624	882
	Nursery#1	west end of Heaven Road	396951	5430476	I, D	17.6	0.36	0.0315	280	625	884
	Nursery#2	west end of Vatkin Road	397065	5430052	I	12.3	0.12	0.0112	238	532	752
	Copper Ridge3	East side of North Fork Rd, < 1 km north of Ward Lake	-	-	M	103	0.01	0.0066	173	388	549
	Total						2.4				
SION	Sion#1	NW corner of Lot 50, corner of Canning & Reservoir Rd	389860	5430156	I,D	105.4		0.0505	165	368	520
	Sion#2	SE corner Lot 29, near E end of Centre Rd near Coryell Rd	389827	5429610	I	114.6		0.0394	138	308	436
	Sion#3	North side of Hardy Mnt Rd, just W of N. Fork Rd	391972	5432588	I,D	90.5		0.0325	165	369	522
	Total						5.24				
CID	CID#1	SW corner of Lot1, off of Coryell Rd	389682	5429188	I	97.5		0.328	142	317	448
	CID#2		389681	5429176	I	69.5					
	CID#3	SW corner of Lot1, off of Coryell Rd	389586	5428807	I, D	96.6		0.0252	125	280	397
	Total						1.69				
Other	Almond W	NW end of mobile home park by Kettle R.	390254	5429558	I, D	15.5	0.01	0.0041	<108	<242	<342
	Almond E	NE end of mobile home park by Kettle R.	-	-	I, D	16.8		0.0022	<79	<178	<251
	Stewart Bros Nursery	Carson Road			I						
	West GF MHP	Close to North Fork Rd and 3rd Rd			D		0.01	0.066	51	113	160
	Kettle River Place MHP	on south 1/2 of property, 30 feet from the river			D		0	0.24	62	138	195
	Riveria RVP&C	under carport in main office back of house						0.033			
TOTAL							322.4				

Notes:
1. Table should be read in conjunction with accompanying report.
2. Information from table obtained from MWLAP, 1999 and Piteau, 2002.
3. Use - M=Municipal, D=Domestic, I=Irrigation

Table 2 - List of Sites Registered in the Contaminated Sites Registry (MWLAP)
Grand Forks, B.C.

Site ID	Site Name	Site Address	Longitude			Latitude			UTM N	UTM E	Status
2655	Canpar Industries	6590 Industrial Park Way	118	25	48	49	1	37	5431436.101	395464.129	AUA
6227	6050 2nd Street	6050 2nd St.	118	25	48	49	1	7	5430509.761	395446.671	AUA
2219	Downtown Shell - Food Corner	272 Central Ave.	118	26	19	49	2	1	5432189.074	394848.711	AUR
2487	Former Texaco (Central)	1866 Central Ave.	118	27	39	49	1	41	5431602.553	393212.596	AUR
2633	Chevron Cardlock	7766 Donaldson Dr.	118	28	1	49	1	57	5432105.220	392775.438	AUR
2639	Grand Forks Well Contamination - PW1	2020 Central Ave.	118	27	38	49	1	39	5431540.406	393231.712	AUR
2643	Chevron Station (Central)	1863 Central Ave.	118	27	39	49	1	41	5431602.553	393212.596	AUR
7158	Wally's World Shell Service Station	1512 Central Ave.	118	27	12	49	1	47	5431777.292	393764.381	AUR
7199	7348 10th Street	7348 10th Ave.	118	26	44	49	1	44	5431673.796	394331.139	AUR
7773	City of Grand Forks Property	Unknown	118	28	15	49	1	20	5430968.239	392469.045	AUR
126	Sumac Ventures Heap Leach Site	Union Mine Road	118	21	17	49	33	10	5489790.041	402014.812	INFA
2642	Chevron Bulk Plant	7778 Donaldson Dr.	118	28	2	49	1	58	5432136.491	392755.732	INFA
2216	Former RBT Enterprise	7436 Donaldson Dr.	118	27	37	49	1	44	5431694.405	393254.989	INFA
5107	Former Petro-Can	179 Central Ave.	118	26	15	49	2	2	5432218.413	394930.507	INFA
2498	Petro Canada Bulk Plant	7864 Donaldson Dr.	118	28	8	49	2	2	5432262.360	392636.305	INFA
2601	Grand Forks Gate Station - BC Gas	6149 Como St.	118	26	31	49	1	8	5430557.165	394573.974	IRC
2218	Former Marten's Petro-Can	331 Central Ave.	118	26	21	49	2	1	5432189.844	394808.105	IRC

Notes:
1. Data provided by MWLAP, Thompson & Okanagan Regions, January 2003
2. Status Definition:
   - INFA Inactive - No Further Action
   - AUR Active - Under Remediation
   - IRC Inactive - Remediation Complete
   - AUA Active - Under Assessment

Table 3 - List of Sites Registered in the WASTE Database (MWLAP)
Grand Forks, B.C.

Company	Address	Type		Status
Almond Gardens Mobile Home Park	5455 Almond Garden	Effluent	Pre application	Active
Almond Gardens Mobile Home Park		Effluent	Pre application	Active
Bannert Readimix Limited	3225 Eagle Ridge	Effluent	Permit	Active
Bannert Readimix Limited	3225 Eagle Ridge	Effluent	Permit	Amended
Bradford Enercon Inc.	?	Effluent	Permit	Cancelled
Bradford Enercon Inc.	?	Effluent	Permit	Withdrawn
Kootenay Boundary Regional District	?	Effluent	Permit	Active
Kootenay Boundary Regional District	?	Effluent	Permit	Active
Pacific Abrasives and Supply Inc.	2465 Carson	Effluent	Permit	Application
Riviera RV Park and Campground	6331 Highway 3	Effluent	Pre application	Active
Shell Canada Products Ltd.	?	Effluent	Approval	Expired
Shell Canada Products Ltd.	?	Effluent	Permit	Withdrawn
Sumac Ventures Ltd.	?	Effluent	Permit	Cancelled
The Corporation of the City of Grand Forks	Sewer	Effluent	Permit	Active
The Corporation of the City of Grand Forks	?	Effluent	Permit	Amended
The Corporation of the City of Grand Forks	?	Effluent	Permit	Amended
The Corporation of the City of Grand Forks	?	Effluent	Permit	Amended
Welco Management Services Ltd.	Landfill	Effluent	Permit	Amend in Progress
Welco Management Services Ltd.	Landfill	Effluent	Permit	Extern. amend. appl
Coatsworth, Elizabeth		Refuse	Order	Cancelled
Kootenay Boundary Regional District	?	Refuse	Municipal(Oper.Cert)	Active
Kootenay Boundary Regional District	?	Refuse	Permit	Amended
Kootenay Boundary Regional District	?	Refuse	Permit	Amended
Kootenay Boundary Regional District	?	Refuse	Permit	Cancelled
Pope and Talbot Ltd.	570 68th Ave	Refuse	Permit	Active
Pope and Talbot Ltd.	570 68th Ave	Refuse	Permit	Active
Pope and Talbot Ltd.	570 68th Ave	Refuse	Permit	Active
Welco Management Services Ltd.	Landfill	Refuse	Permit	Cancelled
Boundary Electric (1985) Ltd.	7990 Columbia	SW (Storage)	Permit	Withdrawn
Pope and Talbot Ltd.	570 68th Ave	SW (Storage)	Permit	Withdrawn

Notes:
1. Data provided by MWLAP, Thompson & Okanagan Regions, January 2003
2. Addresses from Grand Forks Telephone Directory

Table 4 - List of Sites Registered in the Spills Database (MWLAP)
Grand Forks, B.C.

Date	Spill	Location
24-Jul-90		CanPar
09-May-92		Old Carson Townsite
15-May-92		Boothman's Oxbow - 1 km east of Grand Forks
20-May-92		2nd and Market St.
28-Sep-92		Can Par sub station
02-Feb-93		5 km east of Grand Forks
07-Jul-93		CP Transport - Hwy 3 from Keremeos to Grand Forks
08-Jul-93		West Kootenay Power - 25 Km up east side Granby Rd
08-Jul-93		Kettle River at Almond Garden Road
28-Sep-94		Pope & Talbot
30-Jan-95		Canpar Industries, Industrial Parkway
14-Jun-95		Hagland Road off Fife Road near Christina Lake
08-Jul-95		July Creek 12 miles W of Grand Forks
12-Jul-95		Chevron - Donaldson Drive
23-Aug-95		1910 West Lake Drive - Christina Lake
26-Jan-96		McCallum View Drive
04-Jun-96	#58 Sandner Road , Christina Lake	#58 Sandner Road , Christina Lake
23-Jul-96	Canpar	Grand Forks Particle Board
08-Oct-96	Cobra Transport Inc - Attwood Ont. Lic#PJ7 933	E end of Yale Bridge
22-Nov-96	Trimac Freight	Shell Station 1512 Central Avenue
30-Nov-96	unknown	Forester Rd, off North Fork Rd, near West Koot. Sub Stn.
01-Jan-97	West Kootenay Power	Christina Lake
15-Jan-97	Pope and Talbot	Near Deadeye Ck north of Grand Forks
22-Sep-97	Louise McNamara, resident	2065 Carson Road
23-Sep-97	Unknown	Kettle River, Stevens County, Washington
29-Nov-97	Pope and Talbot Ltd	Km 6 off Burrell Cr Rd at 20 km North of Grand Forks
14-Oct-97	J. Watts Trucking Ltd.	Riverside Motel Parking Lot
06-Jan-98	Pope and Talbot Ltd	T- Bone intersection 50 km north of Grand Forks
28-Apr-98	Unknown - Suspect Atwood Gold Corp.	Athelstone-Hartford Rd 10 km west of Grand Forks
08-Aug-98	unknown - material from boathouse owned by Lincoln Sandner	between Christina Lk and Hwy 3 - 20 km east of Grand Forks
18-Dec-98	Unknown	Snowball Creek, 3 km east of Granby Rd, 5 km north of Grand Forks
29-Dec-98	Pope & Talbot	Boundary Creek Forest Road North of Grand Forks
08-Feb-99	Unknown - Suspect Canpar	behind plant at Industrial Parkway
31-May-99	KAT Transport, Brian Hay (Driver)	Enertek Products
24-Jun-99	Unknown	6205 Lawrence Road
16-Aug-99	Suspect Bannert Ready Mix	West site area and North Fork Road
14-Oct-99	Previous owner of 7346 10th Ave.	7346 10th Ave.
24-Feb-00	True Value Hardware	22- 72nd Avenue
22-Mar-00	Cantex Engineering, Grand Forks Asphalt Plant	Grand Forks
25-Jun-00	Unknown	Highway 97 and Berry Road
17-Jul-00	Industrial Plants	Kettle River by old train bridge 6060 Darcy Rd.
10-Aug-00	Homeowner	Gilpin, Between Grand Forks and Christina Lake.
23-Oct-00	Unknown	Santa Rosa Road off side road near Sutherland Crk.
13-Mar-01	Roxul or Canpar	6526 Industrial Park Way
25-May-01	Emcon Highway Maintenance	7776 GN Road,
31-May-01	Regional District of Kootenay Boundary	Rock Creek
16-Jul-01	Yamaha Dealer	2nd Street
22-Aug-01	Pope and Talbot Logging	Deadeye Forest Service Road, CP 263, block 1
27-Aug-01	Canpar Industries	2nd Street, Canpar Mill site
06-Nov-01	unknown	Esso Cardlock on Industrial Ave. at Canpar
28-Mar-01	Unknown	4250 Vancouver Ave.
19-Jul-01	Pope and Talbot Logging, Midway	14.4 kms on the Deadeye Forest Service Road, north of Grand Forks
08-Mar-02	Former Shell fuel station	Hwy 3 and 3rd Street
02-May-02	unknown	Bron & Sons Nursery, 3315 Carson Rd.
15-May-02	unknown	Carson Rd., off Horkoff Rd.

Notes:
1. Data provided by MWLAP, database maintained by Emergency Response Officer.

Table 5
Grand Forks Business Licenses, 2002
Grand Forks, BC

Business	Description	Location
O.K. Tire Store (Grand Forks)	Retail	2923 Central Ave
Action Supersave Gas Stn Ltd	Gas Station	2773 Central Ave
Alf's Excavating	Backhoe Service	190 79th Ave
Alpine Disposal Ltd.	Waste Management - Garbage Collection	8058 Donaldson Dr
Al-Va Turf Ltd.	Irrigation Contractor	7633 20th St
A-Ok Construction	Construction	3556 Mill Rd
Argosy Construction	Construction	2240 Selkirk Pl
Bannert Ready Mix Ltd.	Ready Mix Sales	6975 18th St
B & F Sales & Service Ltd.	Motorcycles, etc.	7460 2nd St
Big Eds Car Cleaning Service	Auto Detailing	8008 Donaldson Dr
Boots Enterprise and Civil Process Serve	General Contracting	3325 Sion Frontage Rd
Boundary Transport	Trucking	7444 19th St
Bryans Performance Shop	Automotive Computer Enhancements & Rel	1548 Donaldson Dr
Buds Carline Muffler	Muffler/Exhaust Repair	256 72nd Ave
Cantex Engineering & Construction Co. Ltd	Paving Contractors/Hotmix Asphalt/Gravel	390 64A Ave
Chevron Canada Limited Tax & Treasury De	Bulk Fuel Dealer	Donaldson Dr
Christina Lake Gravel & Ready Mix Ltd	Construction & Gravel & Ready Mix	1411 Swanson Rd
Contact Photo Arts Inc.	Photo Finishing/Framing	275 Market Ave
Craig R.V.Refrigeration & Repair	R.V. Refrigeration & Repair, R.V.Parts & Se	6471 Hwy 3
Danco Transport Ltd.	Express Company, Vehicle Inspect. & Rep. G	6544 2nd St
D. Onions Holdings Ltd.	Equipment Owner/Operator - Grader, Cat	1547 Donaldson Dr
Electro Mechanical Service	Heating Pumps, Ventilation Repairs & Inst	6548 10th St
Emcon Services Inc.	Business - Rd, Bridge & Mechanical Maint	6150 2nd St
Eva Anthony Photography	Portrait Photography	47 83rd Ave
Fibre Tech Carpet Cleaners	Carpet Cleaning Upholstry, Insurance	650 69th Ave
Finning (Canada)	Itinerant Business - Equip. Sales, Lease Pu	Itinerant
Five Star Construction	Contractor	6240 Vine Rd
Grand Forks Autobody Ltd.	Auto Body & Painting	6391 #3 Hwy East
Grand Forks Brake & Muffler Ltd.	Automotive Repair	7460 Donaldson Dr
Grand Forks Petro Canada	Gas Bar, Convenience Store	1611 Central Ave
Grand Forks Construction Services Ltd.	Ready-Mix, Sand & Gravel & Construction	7816 Donaldson Dr
Harmony Homes	Contractor, New Home Construction	201 833 Finns Rd, Kelowna
Hardy Mountain Homes Ltd	Building Construction	3415 Hardy Mountain Rd
Larry's Office & Equipment Repair Service	Repair Service	7435 21st St
Jan's Painting & Home Repair	Painting, Renovations, Gardening	7242 6th St
J.D. Towing Inc.	Towing Serv. & Snow Removal	6585 Industrial Park Way
Jokat Enterprises Ltd.	Taxi	7679 Boundary Dr
Kal Tire Ltd.	Tire Sales & Service	283 Central Ave
Kettle Transport Ltd	Trucking (Dispatching)	8098 Donldson Dr
Kettle Valley Cleaning	Bldg. Maint. & Janitorial	6800 Danshin Village Rd
Kevins Kustom Woodcraft	General Contracting	100 #10 Kalamalka Lake Rd, Vernon
Koolers Appliance Service	Appliance Service & Repair	6190 19th St
Lornes Pit Stop	Automotive Service & Repair	246 72nd Ave
Mid Nytes Towing	Towing /Storage/Auto Wreck	Hwy #3 East
Mike Maurice & Associates Inc	Contractor Construction	Giant Foods Location
MSC Enterprises Ltd	Construction	1823 78th Ave
Natural Reflections Photography	Photography	3481 Panorama Dr
Norson Construction Ltd	Contractor	Overwaitea (Grand Forks)
N/P Trucking	Trucking	2185 Brycen Pl
Otto & Jun Holdings Ltd	Pinegrove Auto & Small Engine Repair	2091 Central Ave
Petco Installations Ltd	Construction	807 4th Ave, Prince George
Puma Autobody	Autobody	8038C Donaldson Dr
Q.C. Contracting	Painting, Renovations	100 Bighorn Rd
R & R Fuel Management	Fuel Tank Maintenance	7225 Boundary Dr
Sam Dutoff Auto Service Ltd.	Auto Repair	6785 19th St
Imperial Oil	Bulk Fuel Dealer	7870 Donaldson Dr
Smuland Construction	Contracting	8290 Ward Lake Rd
Stark Sales Ltd.	Service Station	1512 Central Ave
Suds Laundromat & Dry Cleaning	Laundromat	1420 Central Ave
Summit Gradall Service Ltd	Excavating	7915 McCallum View Dr
Sunshine Valley Appliance	Appliance/Refrigeration - Repair & Recove	7362 2nd St

Table 5
Grand Forks Business Licenses, 2002
Grand Forks, BC

Business	Description	Location
Sunshine Valley Laundromat	Coin Operated Laundromat	7344 3rd St
Ted Goulahs Home Repair Service	Home Repair Service	221 75th Ave
Three Phase Rebuilders	Auto/Elect. Services	7212 Riverside Dr
Three Rivers Rentals	Construction	Lundbreck, Alberta
Tonnis Welding & Radiator Service	Welding, Radiator & Mechanical	7436 Donaldson Dr
Tool Time Rental & Supplies Ltd.	Rental and Retail	7466 Donaldson Dr
Unifab Industries Ltd	Steel Fabrication & Machine Shop	6050 2nd St
V.K. Auto Ltd.	Car Sales & Auto Body Repair	7980 Donaldson Dr
Walt's Fab & Weld	Fabricating & Welding Metal Products	6883 16th St
West Arm Trucking Ltd.	Transportation	6585 Industrial Parkway
Western Aviation Services Ltd.	Aircraft Maint. & Repair	Grand Forks Airport
Westside Chevron 524388 B.C. Ltd	Service Station/Convenience Store	1863 Central Ave

Table 6
Commercial/Industrial Businesses from Yellow Pages
Grand Forks, BC

Automotive Repair	
Al's Auto Repair	446 Starchuk
Carline Muffler	256 72nd Ave
Kootenay Chrysler	2691 Highway 3
Grand Forks Brake & Muffler	7462 Donaldson
Jim's Auto Repair	6585 Industrial
Kal Tire	283 Central
Lorne's Pit Stop	246 72nd Ave
North Fork Mechanical	2965 Coalshute
Pinegrove Auto & Small Engine Repair	2091 Central Ave
Sam's Auto Sales and Service	6785 19th St.
Three Phase Rebuilders	7212 Riverside Dr.
Automotive Parts & Supplies - Used and Rebuilt	
Big Y Auto Recycling	2375 Carson
Automotive Washing and Polishing	
Big Ed's Car Cleaning Services	8098 Donaldson
Grime Busters Automotive Detailing Services	5495 Horkoff
Automotive Wrecking and Recycling	
Big Y Auto Recycling	2375 Carson
Cleaners	
Bud Laundromat & Drycleaning	8325 North Fork Rd
Suds Laundromat & Darycleaning	1460 Central
Dairies	
Boundary Country Dairy Ltd	7418 Valley Heights
Engines	
B&F Sales and Service Ltd	7466 2nd St.
Pinegrove Auto & Small Engine Repair	2091 Central Ave
Kastco Rentals	2240 E. Almond Gardens
Sam's Auto Sales & Service	6785 19th St.
Three Phase Rebuilders	7212 Riverside Dr.
Farm Equipment	
None	
Fertilizers	
Gaia Green Products	9130 Granby
Garden Centre	
Galena Perennials	2445 Carson Rd
Nurseries	
Galena Perennials	2445 Carson Rd
Rilkoff's General Store	4415 Hwy 3
Russian Roses for the North	5680 Hughes
Valley View Garden Centre	5855 Spencer
Oil Companies	
none listed in Grand Forks	
Paving Contractors	
Cantex Engineering & Construction	390 Industrial
Recreational Vehicles - Services and Repair	
Craig RV Refrigeration Repair	6471 Highway 3
Hardy Mnt Automotive	345 Industrial
Service Stations	
Chevron	Hwy 3 at West Central?
Petro-Canada	1611 Central
Kettle River Place	6491 Highway 3
Shell	1512 Central
Super-Save	2773 Central
Westside Chevron	1863 Central
Scrap Metal	
none	

Table 7
Relative Risk that Agricultural Land Uses Pose to Groundwater
Grand Forks, B.C.

Activity	Risk to groundwater from:			
	nitrates	pesticides	other (please specify)	OVERALL RANKING
growing grain	L	L		L
growing vegetables	M	M		M
growing root crops	M	M		M
growing flowers and bulbs	M	H		M
growing forage crops	L	L		L
grazing	L	L		L
tree fruit production	L	M		M
berry production	M	M		M
growing ornamental shrubs/trees	H	H		H
sod production	H	M		M
specialty perennial crop	M	M	will be a function of crop and management	M
other				L
outside animal feeding areas	M/H		pathogens	H
storage of manure and compost	H		pathogens	H
storing crops and agricultural machinery	H if leachate		M/H petroleum products	H
storage of pesticides and fertilizers (improper storage)	H	H		H
beekeeping and honey making		L		L
discharge of food processing wastes (cheese whey)	H		M (salts)	H
former agricultural activities				M
vines				M

H = high
M = medium
L = low

Table 8
Relative Risk that Other Land Uses Pose to Groundwater
Grand Forks, B.C.

Activity	Risk to groundwater:
unused land	L
former forestry activities	M
former extraction activities	M
former dwelling activities	L
wholesaling	M
retailing	H
providing commercial services	M
single family dwelling	L
multiple family dwelling	L
mobile homes	L
hotels and motels	L
extraction of sand, gravel and clay	M
transportation and communiciation activities	M
transportation by air	H
transportation by electricity	M
communicating activities	M
providing institutional services	L
legislative, judicial and legal services	L
protective/custodial	L
educational services	L
health, medical care facilities	L
worshipping	L
burying	M
assembly activities	L
land in transititon	M
manufacturing/storage activities	H
raw material processing	H
processing wood	H
assembling products	H
storage activities	H
storing vehicles, equipment	H
warehousing	H
open air storage	H
treating/disposal of liquid waste	H
treating/disposal of solid waste	H
no perceived activity	L
viewing of nature and historical areas	L
recreational open space	L
indoor and outdoor recreation activities	L
indoor recreation /cultural activities	L
ponds, lakes and reservoirs	L

H = high
M = medium
L = low

Table 9:
Key Contaminant Risk to the Grand Forks Aquifer
Grand Forks, B.C.

Potential Contaminant Source	Risk to Groundwater
Existing Contamination (CSR Sites)	Based on the locations of the CSR sites (Site Registry, Spill and Waste), risk ranges from **Low** at the CID, SION wells; to **Medium** at the Nursery wells, Grand Forks#2 and 3 and Big Y#4; to **High** at Copper Ridge, Grand Forks#4/5 and Big Y#1, 2 and 3.
Underground Storage Tanks (USTs)	**Low** to **Medium** from USTs on residential properties (likely associated with heating fuel) to **Medium** to **High** from USTs on agricultural or industrial properties. Applies to entire aquifer.
Septic Systems	**Low** to **High** associated with septic disposal, dependent on geological material and septic tank/field maintenance and proper operation. Applies to entire aquifer.
Stormwater	**Medium** from stormwater disposal in Grand Forks. At potential risk includes Grand Forks#2, 3 and 4/5.
Abandoned Water Supply Wells	**Medium** from incidental release to **High** from short-circuiting to groundwater and possible use as waste disposal. Applies to entire aquifer.
Transportation of Dangerous Goods	**Low** to **Medium** from incidental releases to **High** from spills or leaks. Wells at particular risk include Big Y wells (along railway); SION and CID wells (near roadway to Carson border crossing); and, Grand Forks and Kettle River/Riviera MHP wells (along Highway 3).
Sand Gravel Extraction	**Low** to **medium** from incidental releases to **Medium** from spills or leaks within extraction area. At potential risk includes Big Y#4, Grand Forks#2 and Sion#3.
Surface Water Interactions	**Low** to **Medium** from Kettle River and Granby River ambient water quality to **Medium** to **High** from spills or accidents. At potential risk includes Sion#1 and 2 wells (Kettle River near roadway to Carson border crossing); Grand Forks#2, 3 and 4/5 (Kettle River near Highway 3); and Kettle River/Riviera MHP and Nursery#1 and 2 (Kettle River near Highway 3). Further investigation is recommended to assess the risk.
Landfill and Dumping	**Medium** to **High** from Regional District Landfill (no wells nearby) and **Medium** to **High** associated with illegal and/or on-site disposal (applies to all wells except Grand Forks#2, 3 and 4/5).
Fertilizers and Pesticides	**Low** to **High** for agricultural, depending on type of agricultural activity, and incidental releases or spills (see Table 8). At particular risk includes SION wells, CID wells, Big Y wells and Nursery Wells. In addition, a **Low** to **High** risk associated with fertilizer and pesticide use on residential properties.
Historical Business Activities	**Low** to **High** from historical incidental releases or spills, depending on type of contaminant used and proximity to the well. At particular risk includes Grand Forks #2, 3 and 4/5.
Current Business Activities and Zoning	**Low** to **High** from current incidental releases or spills, depending on type of contaminant used and proximity to the well. At particular risk includes Grand Forks #2, 3 and 4/5, and Big Y wells.

Notes:
Table should be read in conjunction with report.
Refer to Table 7 and 8 for detailed ranking of each particular land use.

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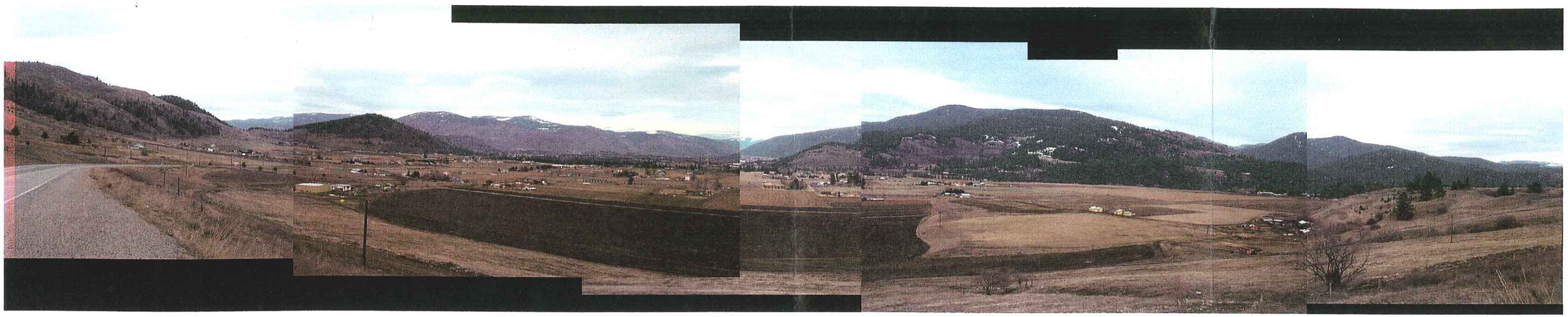
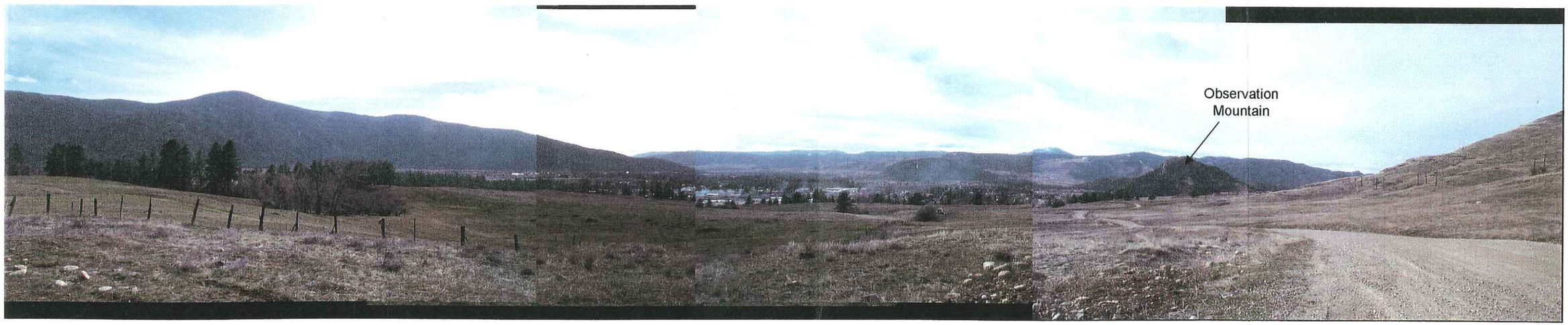


Photograph 1: Grand Forks, looking east from Highway 3. March 2003.

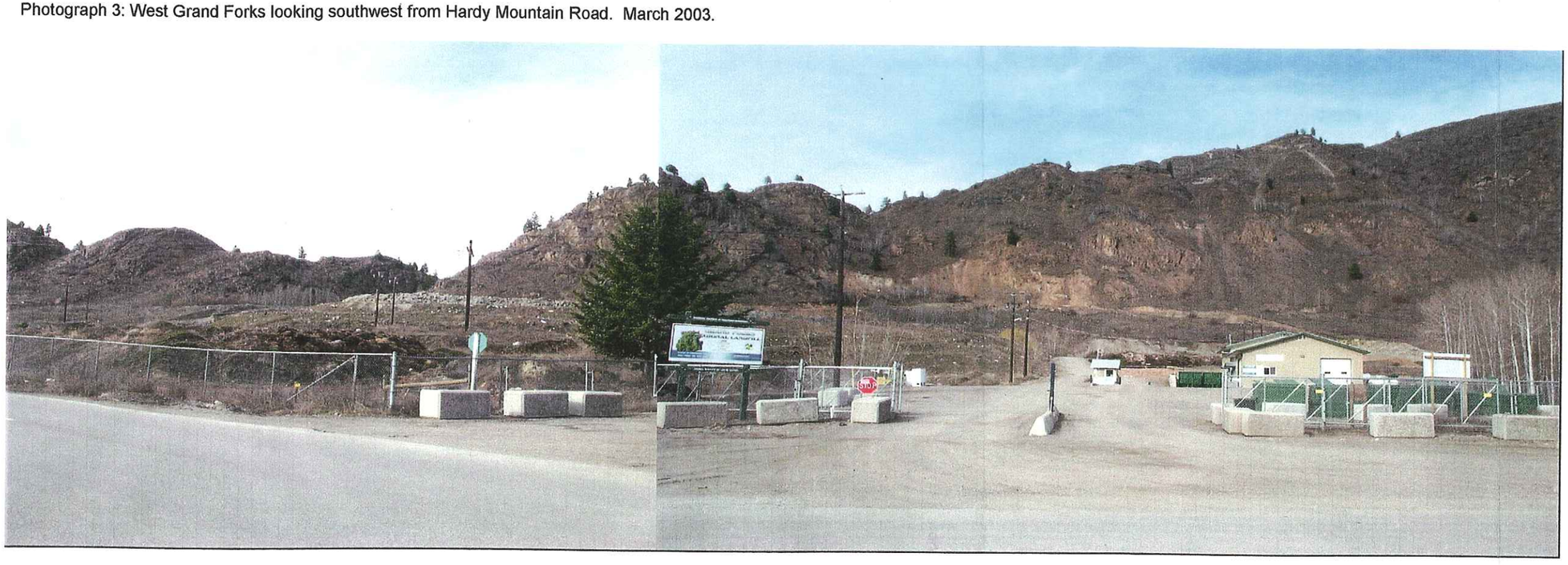


Photograph 2: East Grand Forks looking southwest from Sand Creek Road. March 2003.

Golder Associates

Photographs 1 and 2
Contaminant Inventory of the Grand Forks Aquifer, Grand Forks, B.C.

Photograph 3: West Grand Forks looking southwest from Hardy Mountain Road. March 2003.



Photograph 4: Grand Forks Landfill. Looking north from Granby Road. March 2003.

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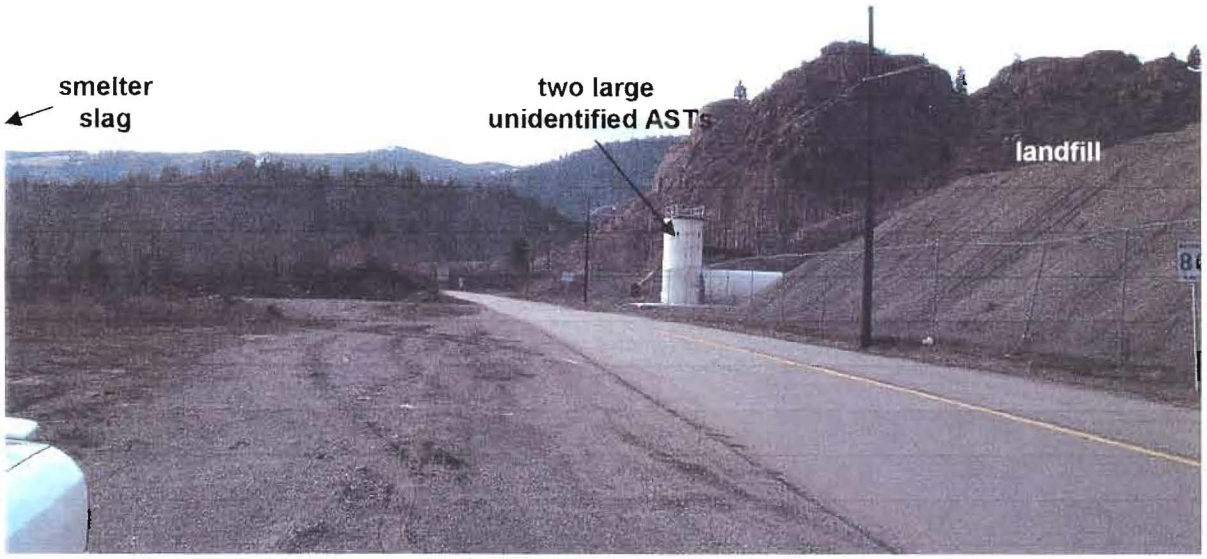
Photographs 3 and 4
Contaminant Inventory of the Grand Forks Aquifer, Grand Forks, B.C.



Photograph 5: Two large ASTs (with unknown contents) at northwest corner of landfill. Looking northwest along Granby Road. March 2003

Photograph 6: "Slag Mountain" slag piles on former smelter site. Looking south from Granby Rd. March 2003

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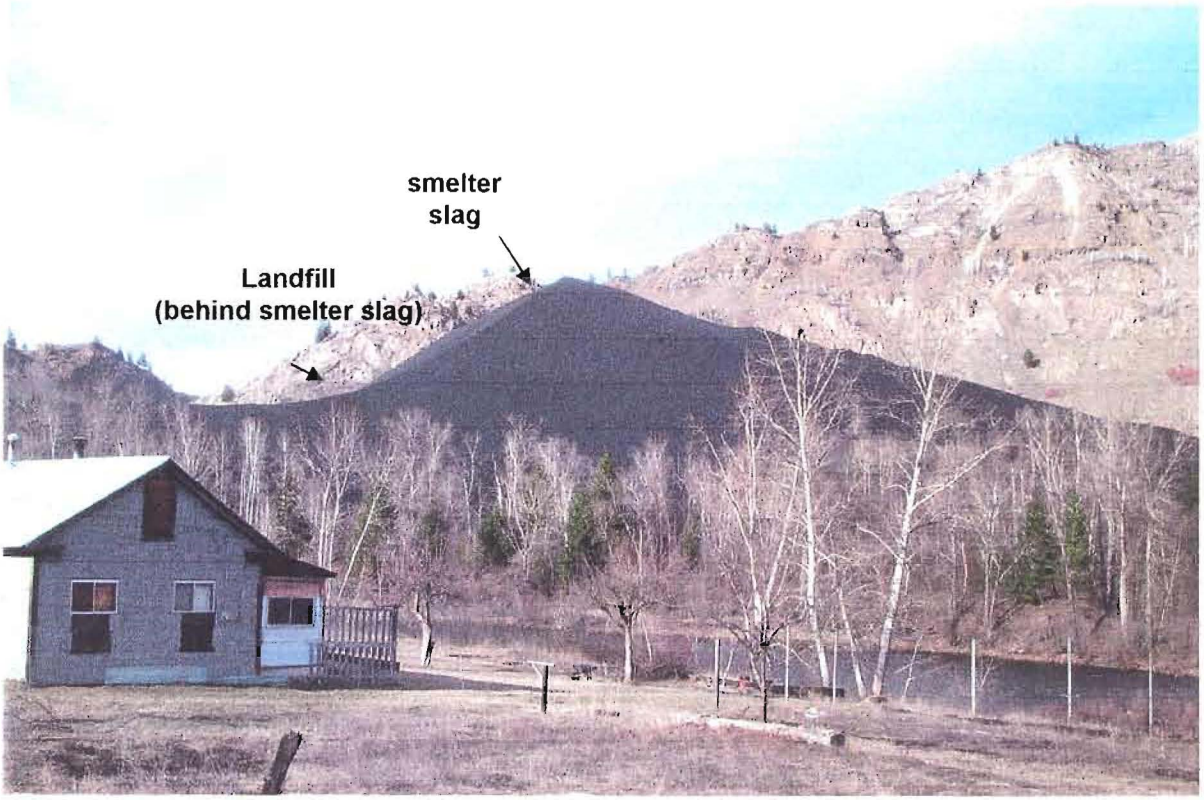
Photographs 5 and 6

Contaminant Inventory of the Grand Forks Aquifer, Grand Forks, B.C.



Photograph 7: "Slag Mountain" on former smelter site. Looking north across Granby River on 85th Ave. March 2003

Photograph 8: Large, old, rusted, unidentified ASTs on west side of Granby Road (on inferred former smelter site). Looking east. March 2003

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Photographs 7 and 8

Contaminant Inventory of the Grand Forks Aquifer, Grand Forks, B.C.

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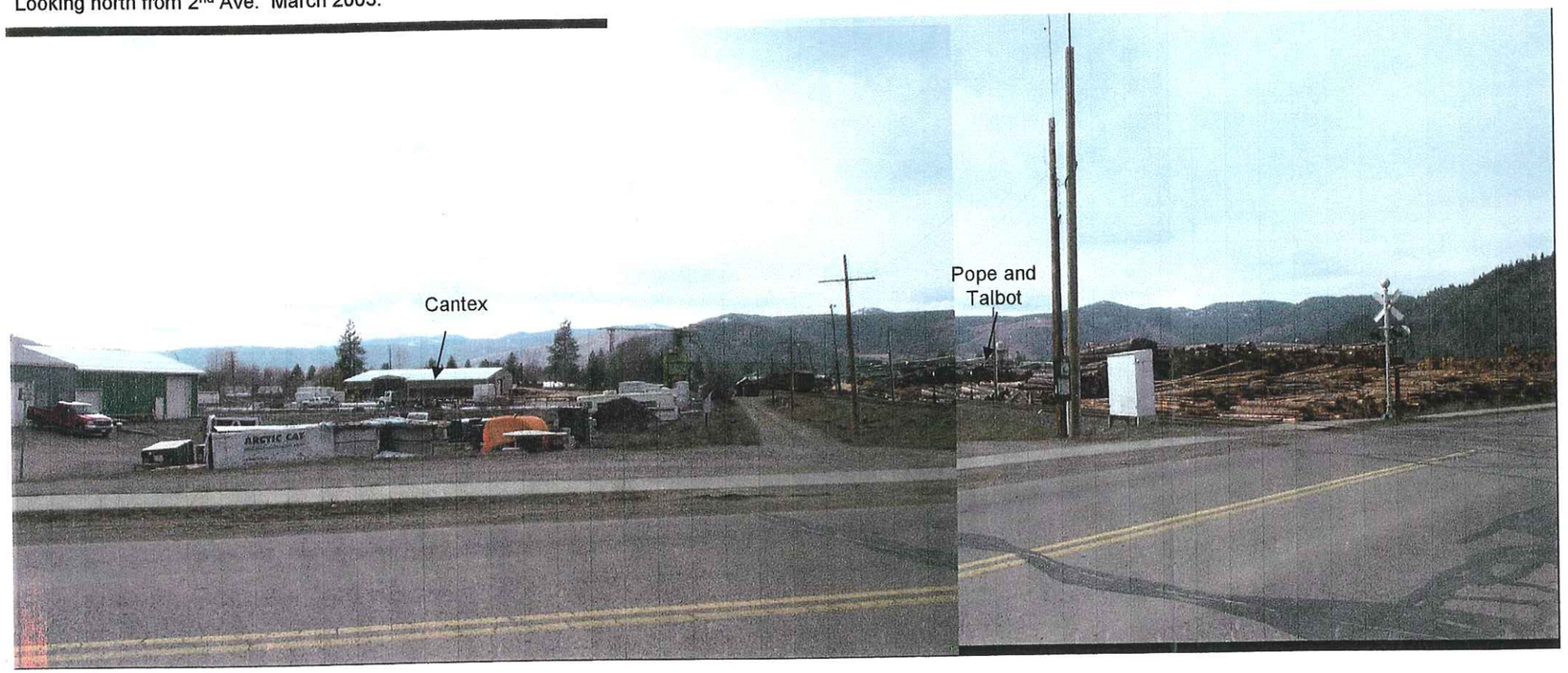
Photograph 9: CanPar, sewage lagoons and railway tracks in Industrial area of Grand Forks, north of the airport.
Looking north from 2nd Ave. March 2003.



Photograph 10: Cantex, railway and Pope and Talbot in Industrial area of Grand Forks, north of the airport.
Looking west from 2nd Ave. March 2003.

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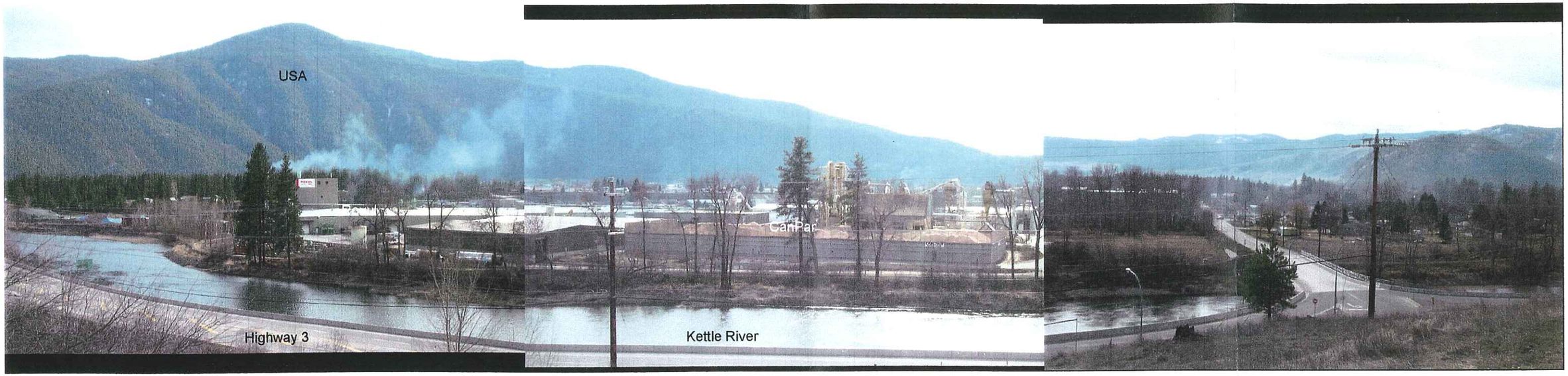
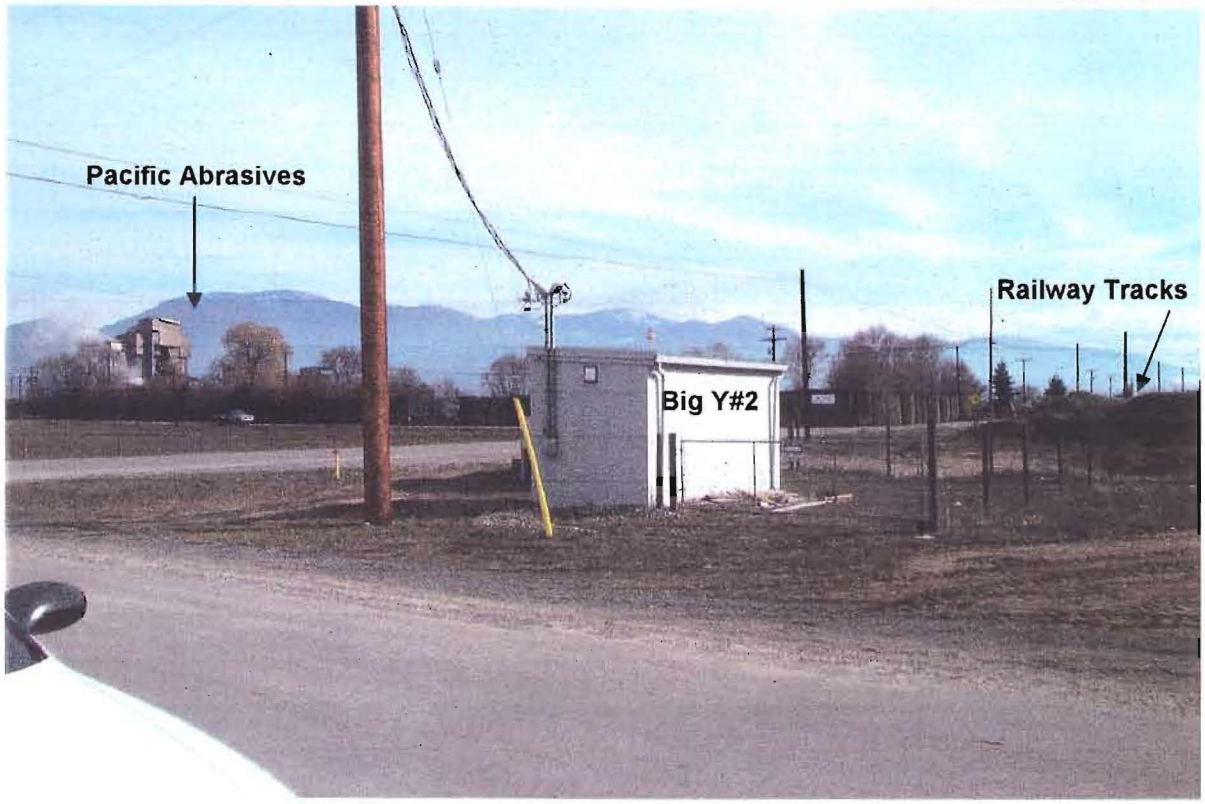
Photographs 9 and 10
Contaminant Inventory of the Grand Forks Aquifer, Grand Forks, B.C.



Photograph 11: Roxul and CanPar in Industrial area of Grand Forks, and Kettle River. Looking southwest from Sand Creek Road. March 2003.

Golder Associates

Photograph 11
Contaminant Inventory of the Grand Forks Aquifer, Grand Forks, B.C.



Photograph 12: Big Y#2 in south Grand Forks. Looking northeast. March 2003

Photograph 13: Sion#2, near commercial greenhouses in west Grand Forks. Looking west from corner of Hillview and Centre Roads. March 2003

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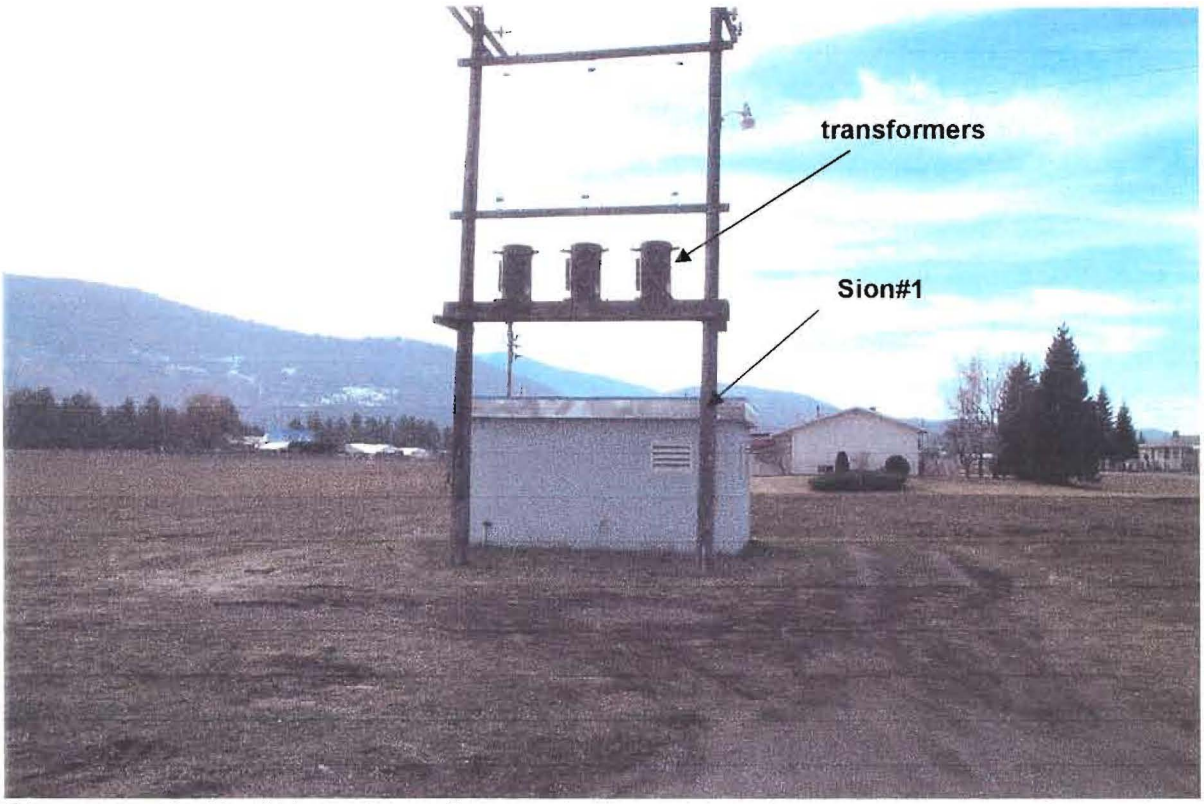
Photographs 12 and 13
Contaminant Inventory of the Grand Forks Aquifer, Grand Forks, B.C.

Photograph 14: CID#1,2 in rural agricultural area of west Grand Forks. Looking northwest from Coryell Road. March 2003



Photograph 15: Sion#1 in northwest Grand Forks, south of Canning Road. Looking south. March 2003

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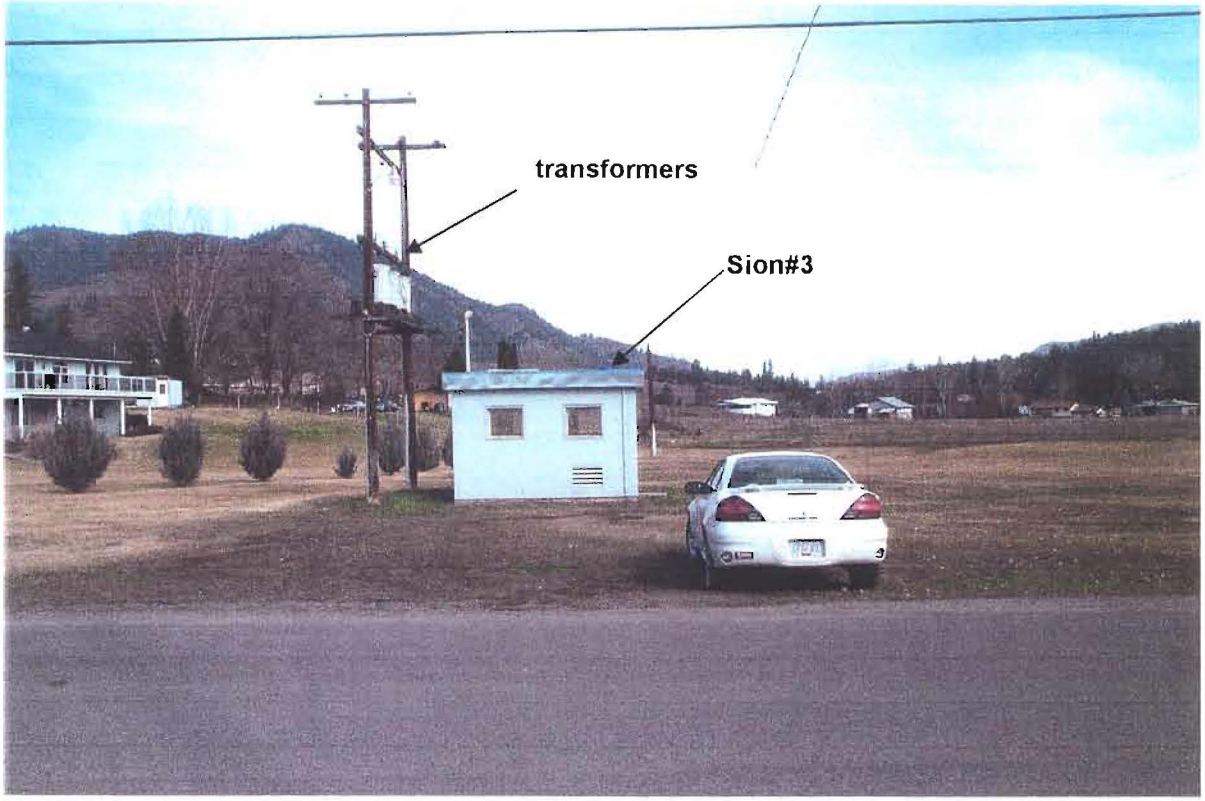
Golder Associates

Photographs 14 and 15

Contaminant Inventory of the Grand Forks Aquifer, Grand Forks, B.C.



Photograph 16: Sion#3 in northwest Grand Forks. Looking north from Hardy Mountain Rd. March 2003

Photograph 17: Big Y#2 in south Grand Forks. Looking south. March 2003

Golder Associates

Photographs 16 and 17
Contaminant Inventory of the Grand Forks Aquifer, Grand Forks, B.C.

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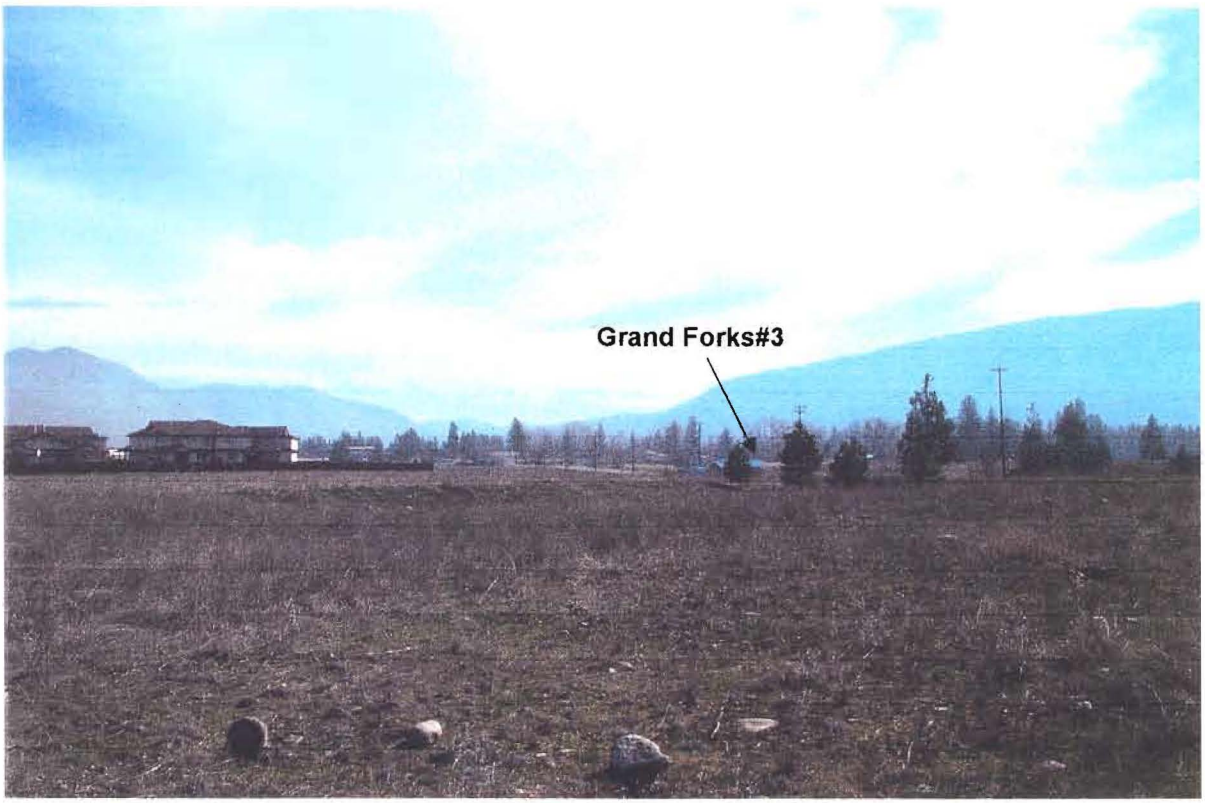
Photograph 18: Grand Forks#2. Looking southwest towards Ramada Inn, with Super-Save further to right. March 2003



Photograph 19: Grand Forks#3 in primarily undeveloped area. Looking southeast. March 2003

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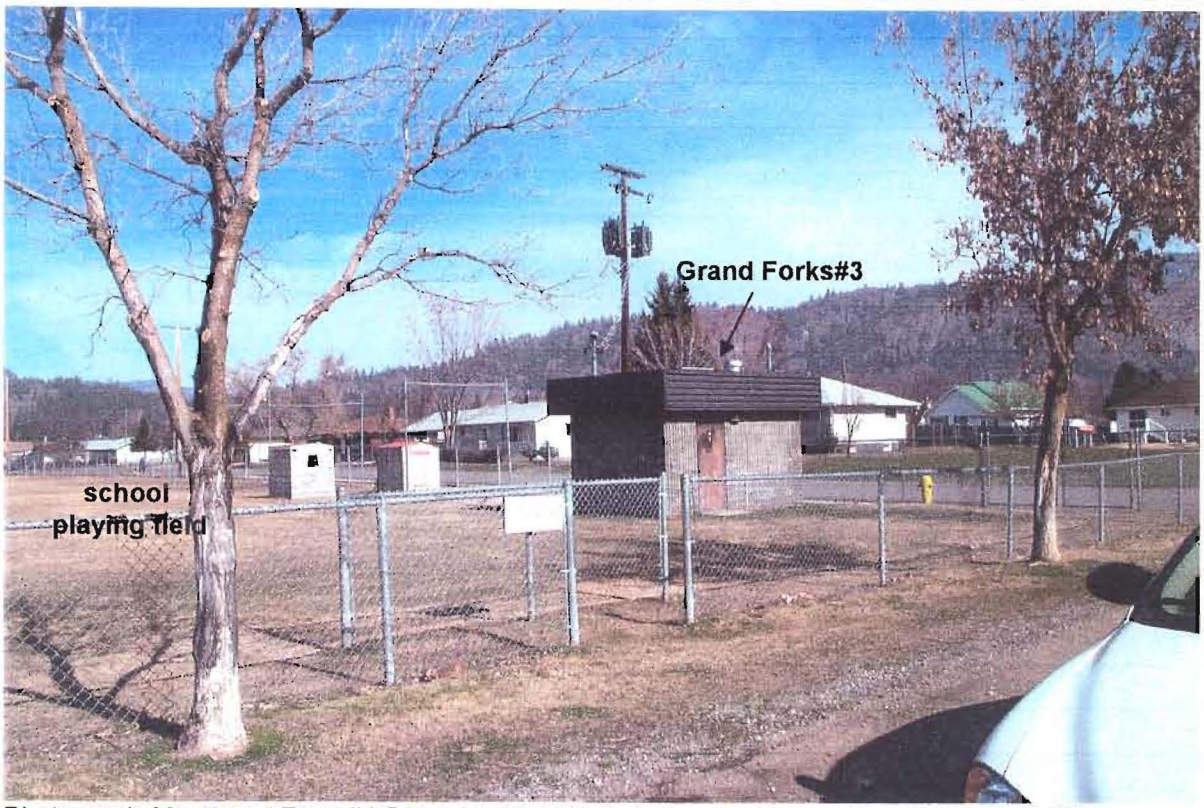
Photographs 18 and 19

Contaminant Inventory of the Grand Forks Aquifer, Grand Forks, B.C.



Photograph 20: Grand Forks#4/5 in school/residential area. Looking northeast. March 2003

Photograph 21: Nursery well in east Grand Forks. Looking west from corner of Nursery and Heaven Rds. March 2003

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Photographs 20 and 21

Contaminant Inventory of the Grand Forks Aquifer, Grand Forks, B.C.

Photograph 22: Almond Gardens west well, in storage compound. Looking west, with Kettle River on other side of compound. March 2003

Photograph 23: Horses and agricultural area north of Almond Gardens west well. Looking north. March 2003

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Photographs 22 and 23
Contaminant Inventory of the Grand Forks Aquifer, Grand Forks, B.C.