Grimshaw Gravels Aquifer
Source Water Protection Plan

December 14, 2018

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ACKNOWLEDGEMENTS

This source water protection plan is a collaboration between The Mighty Peace Watershed Alliance, the municipalities who are part of the Grimshaw Gravels Aquifer Management Advisory Association (Clear Hills County, MD of Peace, MD of Fairview, Town of Grimshaw, Village of Berwyn, and County of Northern Lights), as well as Alberta Environment and Parks. It builds upon work already completed by the Grimshaw Gravels Aquifer Management Advisory Association and will proactively maintain the quality and quantity of water within the aquifer for a range of uses at present, and into the future.

The Grimshaw Gravels Aquifer Source Water Protection Plan was completed through the work of the project team. We thank them for their hard work and dedicated efforts:

- Adam Norris – Watershed Coordinator, Mighty Peace Watershed Alliance
- Cheryl Anderson – Councillor, County of Northern Lights
- Chris Chalk – Regional Hydrogeologist, Alberta Environment and Parks
- Colleen Sklapsky – Councillor, Town of Grimshaw
- David Walty – Director, Mighty Peace Watershed Alliance
- Janice Reyda – Councillor, MD Peace
- Kim Steeves – Councillor, Village of Berwyn
- Peter Frixel – Councillor, Clear Hills County
- Ray Skrepnek – Councillor, MD of Fairview #136
- Rick Keillor – Director, Mighty Peace Watershed Alliance

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STATEMENT OF APPROVAL

By signing, I declare that I am familiar with and endorse the Grimshaw Gravels Aquifer Source Water Protection Plan produced by the Grimshaw Gravels Aquifer Management Advisory Association and the Mighty Peace Watershed Alliance. Furthermore, I believe that the perspectives of those I represent have been considered and addressed in the development of this plan.

Adam Norris _____

Cheryl Anderson _____

Chris Chalk _____

Colleen Sklapsky _____

David Walty _____

Janice Reyda _____

Kim Steeves _____

Peter Frixel _____

Ray Skrepnek _____

Rick Keillor _____

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1.0 INTRODUCTION

Source water protection is the first step in a multi-barrier approach to safe drinking water. The multi-barrier approach to safe drinking water puts measures and strategies into place throughout the drinking water cycle to protect and improve water quality from source-to-tap-to-source. The multi-barrier approach emphasizes source water protection as it recognizes that it is easier to prevent water contamination than it is to improve water quality once contamination has occurred. Source water protection identifies risks to source water and outlines management actions that can be put in place to protect drinking water from contamination.

The Grimshaw Gravels Aquifer is a glacio-fluvial deposit of coarse sand and gravel located in northwest Alberta within the Peace Watershed. It is west of the town of Peace River and adjacent to Cardinal Lake in the Upper/Central Peace Basin. It has excellent water quality and high yield, making it the most economically viable aquifer within the region. Numerous communities with a total population of approximately 7000 residents within the region rely on the aquifer as their drinking water source, including Berwyn, Brownvale, Grimshaw, Whitelaw, Weberville, and Duncan's First Nation. In addition to municipal water treatment systems, there are 7 water co-ops and 6 public wells that provide drinking water to residents within the region. There are 919 domestic wells, 83 stock wells, 1 irrigation well and 74 municipal wells.

The Grimshaw Gravels were deposited by rivers on top of the underlying sandstone and shale bedrock 5.3 to 2.5 million years ago. Ancestral rivers created channels and eroded the gravel deposit into smaller gravel bodies or lobes. The Grimshaw Gravels aquifer has four main gravel bodies or lobes: 1) southwestern lobe; 2) central lobe; 3) northeastern lobe; and 4) Whitelaw lobe, as well as numerous smaller, scattered deposits. Over time, these ancestral river channels became filled with drift deposits and are now "buried valleys" or "channels" that separate the lobes, such as the Berwyn Channel or Shaftesbury Channel.

The thickness of the Grimshaw Gravels differs throughout the region but ranges from minimal to 30 m thick. The Whitelaw and southwest lobe are both approximately 10 m thick and the central lobe is 25 m thick, while the northeast lobe is minimal with only small portions over 10 m thick. The aquifer is protected from contamination by overlying drift cover; however, the thickness of this drift cover varies throughout the region and is absent in some areas. This means that areas of low or no drift cover are at particularly high risk for contamination as the aquifer is in direct or almost direct contact with contaminants generated by surrounding land uses.

2.1 GOALS AND OBJECTIVES

This project follows up on the work already completed by the Grimshaw Gravels Aquifer Management Advisory Association (GGAMAA). Source water protection is a high priority of the GGAMAA. As such, this source water protection plan seeks to maintain the quality of water available in the Grimshaw Gravels Aquifer for a range of uses. This plan is limited in scope to only address potential risks that may degrade water quality. Additional reports will address other concerns, such as water quantity and climate change impacts. The intent is to be proactive and through risk assessment, mitigate risks and subsequently reduce the risk of losing this valuable resource.

The primary and overarching goal of the Grimshaw Gravels Aquifer Source Water Protection Plan (GGASWPP) is to identify potential contaminant hazards to the aquifer, assess the associated risk, and develop management actions to reduce these risks. This assessment will proceed with the understanding that water quality is inextricably linked to the land uses occurring above the aquifer and within its recharge zone. This source water protection plan constitutes a risk management system for the water resource found in the Grimshaw Gravels Aquifer. The plan development follows a 5-stage process (Figure 1) and the Source

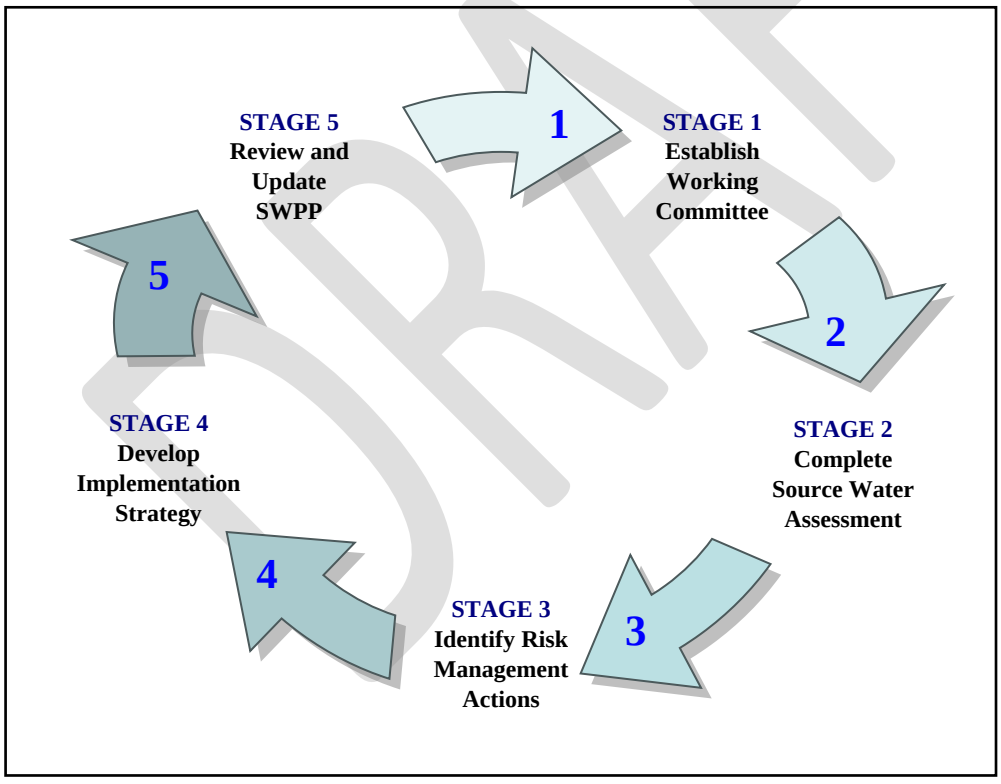

Figure 1: Plan development process

Water Protection Plan uses the following 5 steps:

1. Identify hazards to aquifer function (what could go wrong?)
2. Assess the risk (how likely or probable is it?)

3. Prioritize the risks to aquifer function
4. Inform the public and stakeholders of the risks to aquifer function
5. Develop a suite of recommended management actions

2.2 SCOPE

The geographical scope of the GGASWPP is the extent of the Grimshaw Gravels Aquifer and its proposed recharge zone. This includes the individual lobes of the Grimshaw Gravels Aquifer, overlying surficial aquifers, underlying sandstone aquifers, as well as the numerous buried valley and terrace deposits that make up the Grimshaw Gravels Aquifer system. The aquifer system also includes surface water bodies such as lakes, springs, and wetland areas located on or adjacent to the aquifer system.

The project team recognized that the vulnerability of the aquifer to contamination is dependent upon the thickness of the overlying drift cover, with areas of little to no cover being more vulnerable to contamination risk than areas with thicker drift cover. As such, the project team has completed work to classify areas of the aquifer as vulnerable where the drift cover is less than 4 meters. Source water management actions are prioritized in the high risk areas.

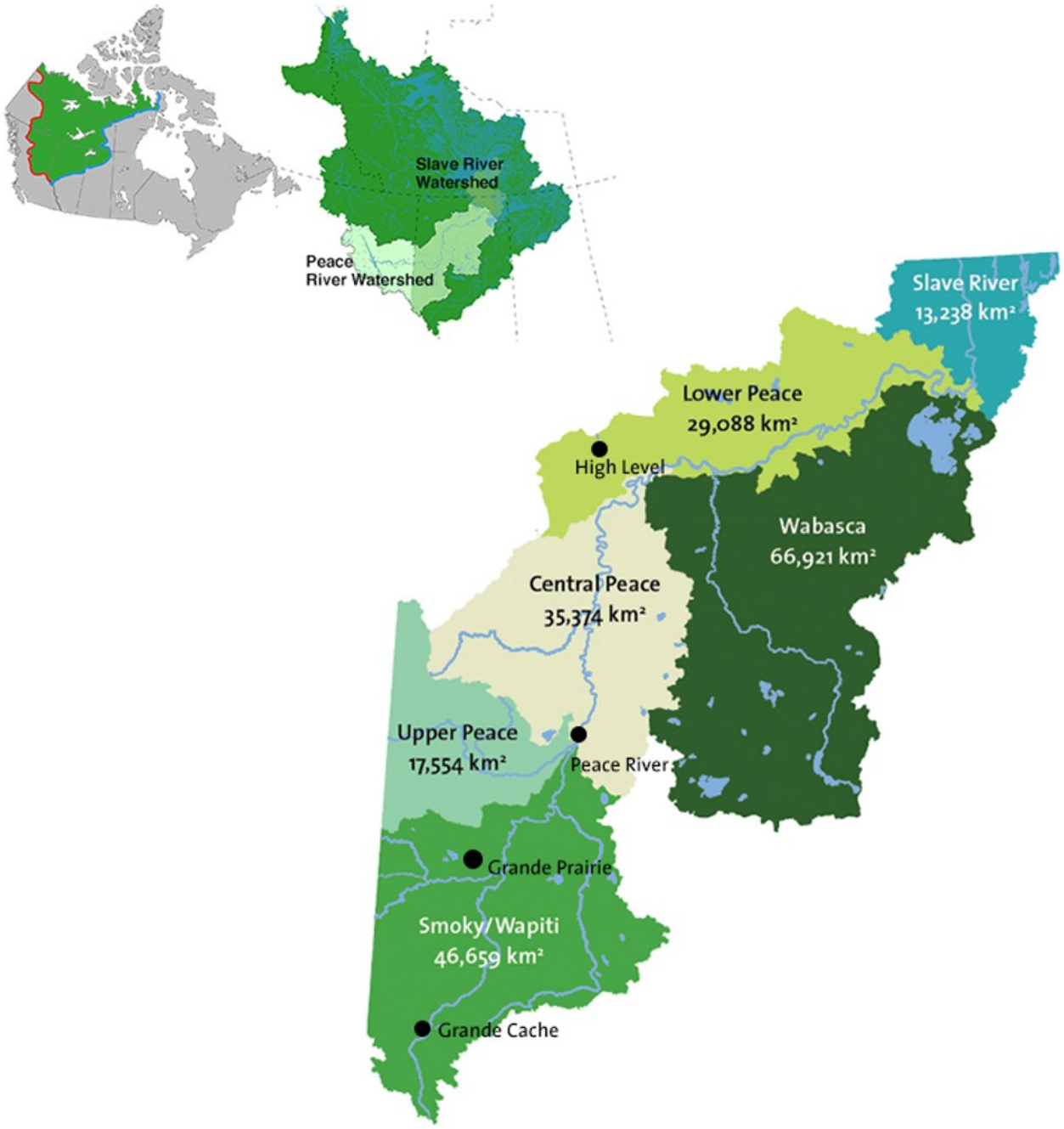

Figure 2: Location of the Mackenzie River Watershed within Canada; The Peace River Watershed and Slave River Watershed within the Mackenzie River Watershed (SWR 2015); the sub-watersheds that make up the Peace River Watershed within Alberta (ESRD, 2017)

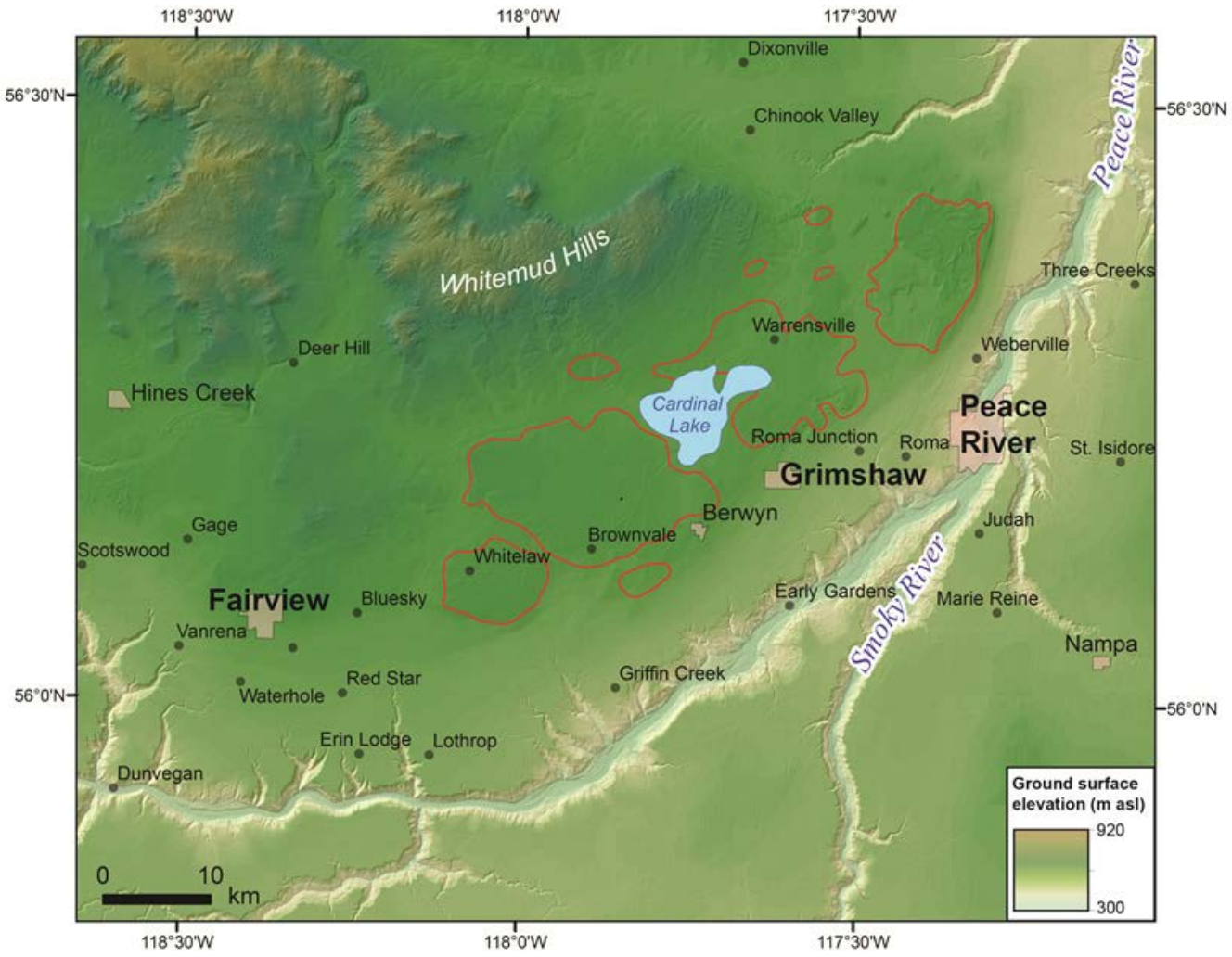

Figure 3: Geographical distribution of the Grimshaw Gravels Aquifer (Source: Architecture and Geometry of Basal Sand and Gravel Deposits, Including the 'Grimshaw Gravels', Northwestern Alberta (NTS 84C and 84D) produced by the Alberta Geological Survey)

2.3 RISK ASSESSMENT

Potential risks to source water quality were identified and ranked for the Grimshaw Gravels aquifer system. A risk matrix was used to rank identified potential risks according to the likelihood they would occur and the impact they would have on human or ecosystem health if they were to occur. Risk assessment scores were classified as low risk (yellow), medium risk (orange), or high risk (red). The results of the risk assessment are listed in Table 1 from highest to lowest. Priority for action will be decided based on level of risk and availability of resources (financial/time). See Appendix B for the risk matrix used and complete risk assessment.

A few features of the Grimshaw Gravels Aquifer deserve specific mention as defining characteristics of this area and subsequently risks to the aquifer.

i) Water wells are high risk as they are a direct conduit to the aquifer. Management and maintenance of water wells that are in use is the responsibility of the owner. Owners also manage land use for local well capture zones, which is the area that specifically contributes groundwater recharge to a pumping well.
ii) Abandoned (meaning those that are no longer maintained) water wells are even higher risk as management is often overlooked or there is none.
iii) The Grimshaw gravels are just that, a huge bed of gravels attractive to the gravel industry. As such, pressures to increase or sustain gravel mining over time will continue to erode the drift layer protecting the aquifer increasing the number and size of vulnerable areas.

2.3.1 Land use

The lobes of the aquifer, where most of the ground water is accessed have been grouped into 3 risk zones (RZ). Risk zones 1 and 3 comprise the lobe, the main groundwater recharge area for the aquifer, plus the surrounding areas that may be contributing run off and recharge to the aquifer lobes as well as the outlying water wells. Risk Zone 2 is outside the main aquifer but represents the upper watershed and contains the Whitemud Hills, an upland area that provides recharge to some extent to the aquifer located down slope (Figure 7: Map of Grimshaw Gravels (red outline, Prairie Farm Rehabilitation Administration 1998), Proposed Risk Zone boundary (blue outline), Approximate extent of Old Fort Gravel Terrace (spotted dark grey, Prairie Farm Rehabilitation Administration 1998), and population centers including towns, hamlet's and Locality's (black circle) overlaid on hillshade (Alberta Environment and Parks, Government of Alberta)). The risk zone therefore encompasses the lands where land use can potentially influence aquifer water quantity and quality.

Within the Risk Zones, we have identified vulnerable areas (VA), which are areas in the aquifer that have less than 4 meters of overburden. Overburden refers to the thickness of soil overlying the aquifer. These areas are deemed more vulnerable to surface influence because overlying soils have some ability to filter out contaminants or block their passage into the aquifer. Excavations like gravel pits can also reduce the thickness of overburden, and therefore increase the risk to contamination. The location and number of gravel pits have been identified to aid management.

When assessing risk, potential contamination sites in vulnerable areas are, therefore, higher risk locations.

Quantifying human activity on the land, this exercise is termed land use assessment, helps us gauge the magnitude of risk to the aquifer. The location and extent of area subject to a specific land use can help us to determine where the potential threat is and what its extent is. This concept has been termed footprint of human footprint. For example, agriculture has a footprint of 55,481 hectares in the Grimshaw Gravels Aquifer area; 43% of the entire aquifer area.

Land use has been grouped into 3 categories: 1) Linear features footprint (roads, rail lines, seismic and pipelines etc); 2) Industrial/urban footprint (urban, rural, mines, pits, waste facilities, sewage, reservoirs sumps and high density livestock); and 3) Agriculture and Forestry footprint (Table 3: Human Footprint Summary). The footprint of each land activity is quantified by area (hectare) and percent and the location is mapped (Table 4: Human footprint Overview andFigure 14: Human footprint Inventory, Figure 15: Human Footprint Inventory – Industrial and Rural Sites, Figure 16: Human Footprint Inventory – Linear Footprint, & Figure 17: Human Footprint Inventory – Agriculture and Forestry). Land use is quantified within each vulnerable area, outside the vulnerable areas, for each risk zone and for the aquifer as a whole.

Risk Zones 1 and 2 have similar footprints, with roughly 33% of the area subject to land use. Of that 33%, greater than 20 % of Risk Zone 1 is in agriculture while in Risk Zone 2, greater than 20% is in forest harvest or cut blocks. In both these zones, the industrial/urban footprint and the linear footprint are less than 5% of the total area. Risk Zone 3, the largest zone, has a substantially larger footprint with 67% of the area in land use. Of that percentage, 58% is in agriculture and with equal footprints of approximately 3 % each for cut blocks, industrial/urban and linear.

It is important to note, that surface water quality and quantity is often impacted in watersheds where the footprint exceeds 60% of the area.

Thirteen (13%) percent of the area (16,499 ha.) of the aquifer is comprised of wetlands. Wetlands include bogs, fens, marshes, open water and swamps. One third of this wetland area, 5,600 hectares, is in the open water category constituted by Lac Cardinal. Lac Cardinal is of primary importance to the aquifer.

Table 1: Grimshaw Gravels Aquifer: Risk Assessment Results

Potential Risk to Source Water	Risk Assessment Score
1. Gravel pits	High
2. Livestock operations	High

3. Active water wells	High
4. Abandoned water wells	High
5. Application of agricultural chemicals	High
6. Farming land use and water management practices	High
7. Orphaned oil & gas wells	High
8. Pipelines	High
9. Private septic systems	High
10. Abandoned below ground tanks (farms, former gas stations)	High
11. Road salt application	High
12. Dangerous good transport routes	Medium
13. Historical dumps and landfills	Medium
14. Improper disposal of household hazardous waste	Medium
15. Fracking activities	Medium
16. Abandoned rail line/stations/stock yards	Medium
17. Microplastics	Medium
18. Borrow pits/dug outs	Medium
19. Active fuel storage tanks on farms	Medium
20. Forestry	Medium

21. Storage of agricultural chemicals (private)	Low
22. Rail transport	Low
23. Improper disposal of hazardous waste at businesses, shops, etc.	Low
24. Active landfills, dumps and transfer stations	Low
25. Inactive bulk plants	Low
26. Maintenance yards and industrial sites	Low
27. Residential yard maintenance	Low
28. Municipal sewage	Low
29. Hydro-vac trucks	Low

2.4 RECOMMENDED MANAGEMENT ACTIONS

The project team identified existing management actions currently in place for each identified risk to the Grimshaw Gravels Aquifer in addition to identifying recommended management actions that could be implemented to reduce or eliminate the threat to the Grimshaw Gravels Aquifer for each identified risk. It should be noted that the recommended management actions are non-binding and seek to guide the implementation of source water protection measures by the Grimshaw Gravels Aquifer Management Advisory Association, Mighty Peace Watershed Alliance, and the counties, communities, and residents within the Grimshaw Gravels Aquifer. The current and proposed management actions are listed in the following table.

Table 2: Grimshaw Gravels Aquifer Risk Management Actions

Num.	Risk Ranking (High to Low)	Potential Risk to Source Water	Existing Management Actions	Proposed Management Actions
1.	High	Gravel pits	- Permitting process with conditions	a) Assess and review conditions b) Compare permitting conditions across municipalities to create consistency/standardize/improve on existing practices c) Improve review and approval process for pits below 5 hectares, including more in-depth hydrogeological review at the municipal level. Engage AEP policy on update regarding pits of this size located on top of the Grimshaw Gravels Aquifer. d) Conduct a study to determine the maximum surface area that should be exposed at any time over the aquifer that would result in an unacceptable impact to water quality. e) Create responsible development plan using a cumulative effects approach
2.	High	Livestock operations (including seasonally concentrated feeding areas)	- Existing Beneficial Management Practices - Courses delivered on manure management, drainage, etc. - Peace Country Beef and Forage Association do	a) Partner with Peace Country Beef and Forage Association and agriculture service boards to develop and deliver an aquifer-specific course and encourage adoption of best practices b) Create a local stewardship group c) Identify and flag seasonally concentrated feeding areas to potentially incorporate sites into groundwater monitoring study

			"discovery farm" tours - No confined feeding operations on aquifer bylaw	
3.	High	Active water wells	- Working Well workshops (every 2-3 years) - Well aware program - 5-6 wells tested in 2016 and 2017	a) Develop voluntary/citizen science private water well monitoring program (quality and level) b) Develop an on-going voluntary water well survey program to identify active wells, promote the well aware and working well programs c) Develop and deliver education on well head protection zones and collection of water samples for analytical testing d) Create a responsible development plan using a cumulative effects approach
4.	High	Abandoned water wells	- Provincial database of well records	a) Update existing list/map of active/inactive water wells; conduct ground truthing and locate water wells missing from list/map b) Education and outreach program around proper water well decommissioning c) Prioritize/risk rank water wells for decommissioning d) Discuss potential program to fund decommissioning of high risk abandoned water wells.
5.	High	Application of agricultural chemicals	- Existing Beneficial Management Practices and Material Safety Data Sheets	a) Establish baseline monitoring program for both soil and groundwater b) Conduct study to determine pathways of contamination (i.e. aquifer recharge through impacted soil). c) Develop long term cumulative effects monitoring program to examine where loading is occurring. d) Collect feedback on and modify Beneficial Management Practices, as appropriate
6.	High	Farming land use and water management practices	- Existing Beneficial Management Practices, water conservation policies, etc. - Environmental farm plans in place	a) Develop a communication and outreach strategy about wetland policy and other relevant policy in consultation with Alberta Environment and Parks wetland specialist. b) Prioritize focus areas based on wetland quality, sensitivity, etc. c) Develop a targeted drainage management education program; review and improve drainage management component of environmental farm plan d) Promote Environmental Farm Plan
7.	High	Orphaned oil and gas wells	- Orphan well program	a) Engage Alberta Energy Regulator and Orphan Well Association to inventory wells b) Inventory well condition and prioritize decommissioning based on risk c) Increase communication with Alberta Energy Regulator about orphan wells, orphan well program, decommissioning status, etc.

8.	High	Pipelines	- Regulations and Emergency Response Plan in place	a) Develop communication plan with input from industry and Alberta Energy Regulator to communicate identified high risk/sensitive areas and recommendations for those areas (increased frequency of inspections, installation of shut off valves, etc.) b) Review Emergency Response Plans
9.	High	Private septic systems	- Regulations (new systems)	a) Develop education and outreach program on private septic systems maintenance b) Develop an online training course on private septic systems in partnership with a post-secondary institution
10.	High	Abandoned below ground tanks (farms, former gas stations)	- Contaminated sites program	a) Inventory locations not already listed on the Environmental Site Assessment Repository and prioritize cleanup based on high risk/sensitive areas b) Conduct targeted phase I Environmental Site Assessments based on sensitive areas c) Develop an education and outreach program about what to do if a contamination is discovered (eg., below ground tank).
11.	High	Road salt application		a) Plan a communication meeting with LaPrairie Group to discuss Beneficial Management Practices, training, etc. b) Test private water wells near roads for salts to determine if there is an impact
12.	Medium	Dangerous goods transport routes	- Dangerous goods route regulations - Emergency Response Plan in place	a) Review and increase awareness around Emergency Response Plans regarding impacts to the aquifer b) Communicate high risk/sensitive areas c) Collect information at weigh stations to determine material and volume of dangerous goods being transported d) Recommend that Dangerous Goods routes bypass the aquifer where feasible (i.e. not short haul)
13.	Medium	Historical dumps and landfills	- Decommissioned and reclaimed to applicable standards	a) Increase communication around monitoring and reporting (as per reclamation and decommissioning requirements) b) Inventory locations, decommission and reclamation standards applied, determine if monitoring and reporting is occurring c) Engage Alberta Environment and Parks to potentially reclaim old sites to more stringent guidelines in sensitive areas
14.	Medium	Improper disposal of household hazardous waste	- Peace River eco-center - Spring clean-ups (check which municipalities) - Paper and plastic bins in Berwyn	a) Increase community education, outreach, and engagement (newsletters, newspapers, social media, radio) b) Build on community clean-up, increase engagement, education, hold during the same week/weekend every year c) Improve signage at transfer stations

			- Transfer station in Grimshaw - Appliance pick-up services	d) School education program
15.	Medium	Fracking and active oil and gas wells	- Alberta Energy Regulator approvals process - Conditional conductor pipe installed initially (directive 8) - MD of Peace has a policy and Northern Lights has a by-law - Within 1 km of a well, must monitor before and after fracking - Well inspections and maintenance	a) Have all municipalities within aquifer incorporate by-law b) Engage Alberta Energy Regulator in discussion around developing buffer zone around aquifer/recharge areas (using precautionary principle), what is required to establish, willingness to adopt (consider adding Grimshaw to Directive 8) c) Engage Alberta Energy Regulator in discussion around well inspections, maintenance, particularly for those wells constructed prior to development of by-law d) Request Alberta Energy Regulator develop communication materials with technical content around wells
16.	Medium	Abandoned rail line/stations/stock yards	- Locations of abandoned lines, stations, stock yards identified for Whitelaw	a) Engage Canadian Transportation Agency around decommissioning, monitoring, etc. b) Determine locations and generate map of all abandoned lines, stations, stock yards c) Engage agricultural services board (or applicable body) around application practices of herbicides for weed control on rail line
17.	Medium	Microplastics		a) Incorporate microplastics as parameter to assess in environmental baseline study b) Promote plastic reduction practices
18.	Medium	Borrow pits/dug outs	- Section under the Water Act, must apply to create	a) Reclaim existing borrow pits that are not currently in use b) Develop or reference dugout best practices documents, incorporate into public education and outreach plan c) Engage in reclamation (where needed/possible)
19.	Medium	Active fuel storage tanks on farms	- Federal above ground storage tank regulations	a) Incorporate information and mitigation information into farm plans (pertaining to risks to aquifer as well as Emergency Response Plan in worst case scenario) b) Incorporate fuel tank best management practices/regulations into farm plans

20.	Medium	Forestry		a) Communicate with Alberta Agriculture and Forestry to reduce use of herbicides, manage run-off, flag special/sensitive areas
21.	Low	Storage of agricultural chemicals (private)	- Best management practices	a) Education and outreach around storage of agricultural chemicals, impact on aquifer, sensitive areas.
22.	Low	Rail transport	- Emergency Response Plans in place	a) Identify critical/sensitive areas and share information with rail companies b) Review Emergency Response Plans and improve (if needed), request additional spill response equipment on-site within aquifer (if needed)
23.	Low	Improper disposal of hazardous waste at businesses, shops, etc.	- Regulations in place, operating/business licence includes regulations	a) Review business licence agreements to incorporate mitigation measures identified in source water plan b) Develop education and outreach materials/program for business owners on aquifer risks, best practices, etc.
24.	Low	Active landfills, dumps, and transfer stations	- Regulations in place	a) Engage landfill and transfer station operators of facilities in sensitive areas of the aquifer to increase due diligence, compliance with regulations, increased signage, etc.
25.	Low	Inactive bulk plants	- Decommissioned to regulations and standards of the time	a) Identify locations, determine risk to source water, owner, and if site has been decommissioned or remediated
26.	Low	Maintenance yards and industrial sites	- Regulations, Beneficial Management Practices, Workplace Hazardous Materials System, Transportation of Dangerous Goods	a) Engage with Alberta Environment and Parks to focus inspections/increase frequency of inspections in sensitive areas of aquifer b) Identify sites and engage around following regulations/Beneficial Management Practices and disseminating information on aquifer risk and sensitivity
27.	Low	Residential yard maintenance	- Acreage weed control spraying program with associated by-law for MD Peace	a) Education and outreach around risk of pesticides and herbicides to aquifer, accessing existing literature (green acreages guide)

28.	Low	Municipal wastewater treatment facilities	- Compliance with federal or provincial regulations - Monitor effluent quality	a) Ensure continuing compliance with regulations b) Ensure facilities have communication plan with downstream communities, residents, landowners, etc. in the event of an emergency release
29.	Low	Hydro-vac trucks	- Best practices in place	a) Ensure hydro-vac operators are following best practices

3.0 PLAN IMPLEMENTATION

The Grimshaw Gravels Aquifer source water protection plan represents a joint effort and commitment to protect and maintain water quality of the Grimshaw Gravels Aquifer by The Mighty Peace Watershed Alliance, the municipalities who are part of the Grimshaw Gravels Aquifer Management Advisory Association (Clear Hills County, MD of Peace, MD of Fairview, Town of Grimshaw, Village of Berwyn, and County of Northern Lights), Alberta Environment and Parks, as well as the people who live within the aquifer and rely on it as their drinking water source.

The working committee will use the plan to engage municipalities in discussions and on the ground efforts to improve or maintain water quality of the Grimshaw Gravels Aquifer. In addition, the working committee will use the plan as a tool to engage the general public to increase awareness of and participation in water stewardship opportunities within the region. It is the hope of the working committee that implementation of the mitigation actions identified in the plan will lead to proactive people doing proactive things to protect the water quality of the Grimshaw Gravels Aquifer.

The working committee will also use the plan to engage with the provincial government to ensure policy and environmental monitoring efforts align with the water management goals and priorities outlined in the plan.

The working committee will meet on a quarterly basis to review progress, identify new mitigation actions to be implemented, and to add any newly identified risks to source water to the plan. The working committee will make updates on their progress available to the public on an annual basis.

The source water protection plan is voluntary and non-binding; however, it is the hope of the working committee that it will guide improved water management and protection within the region, increase water stewardship, and bring individuals together to tackle shared water issues.

APPENDIX A - Additional maps and figures

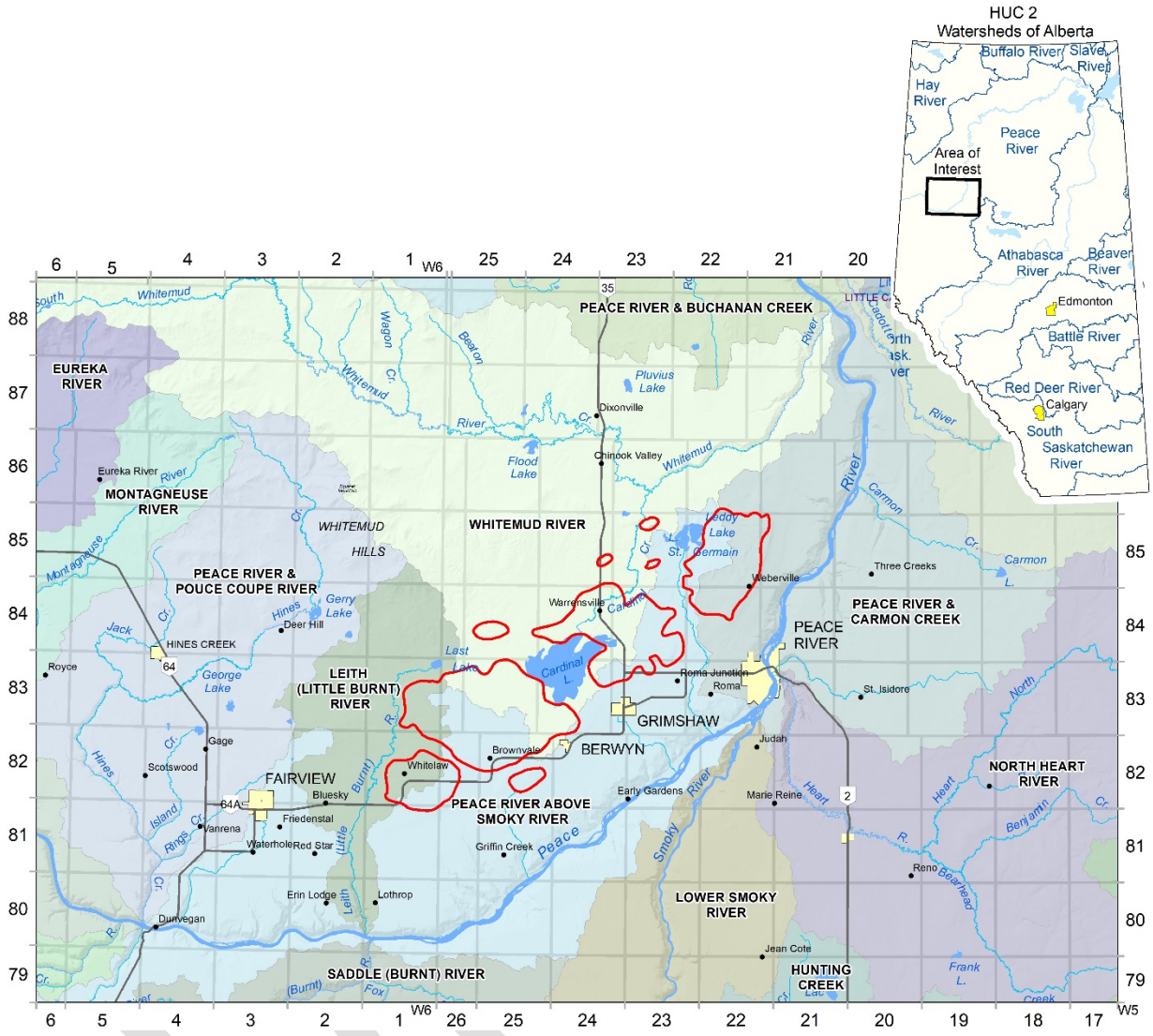

Figure 4: Inset map of Hydrologic Unit Code (HUC) Watersheds of Alberta (Source: Alberta Environment and Parks, Government of Alberta) and Grimshaw Gravels (red outline, Source: Prairie Farm Rehabilitation Administration 1998)

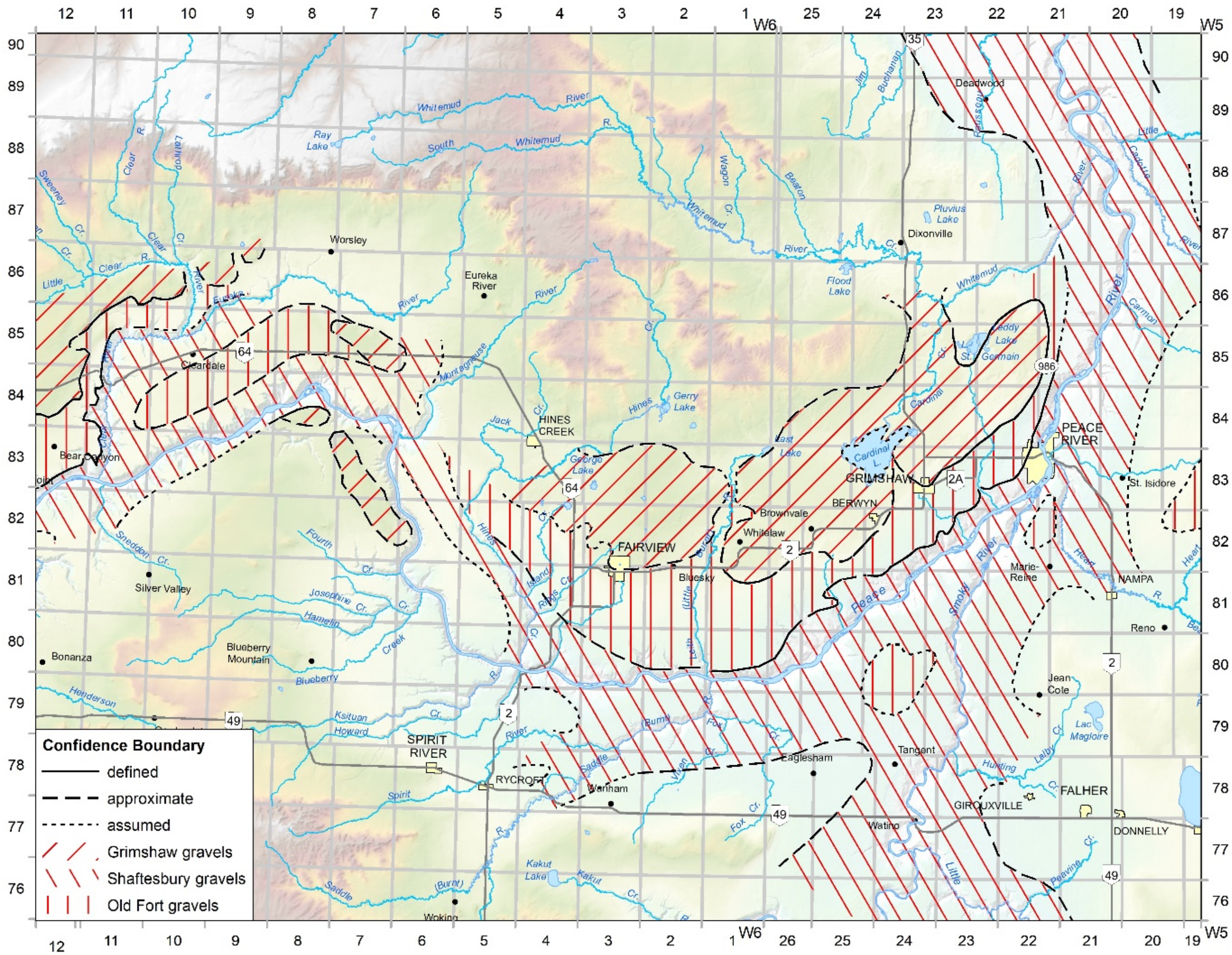

Figure 5: A reproduction of figure 17 from the AGS report. – Map of bedrock straths for Grimshaw, Old Fort and Shaftesbury (data from Alberta Geological Survey)

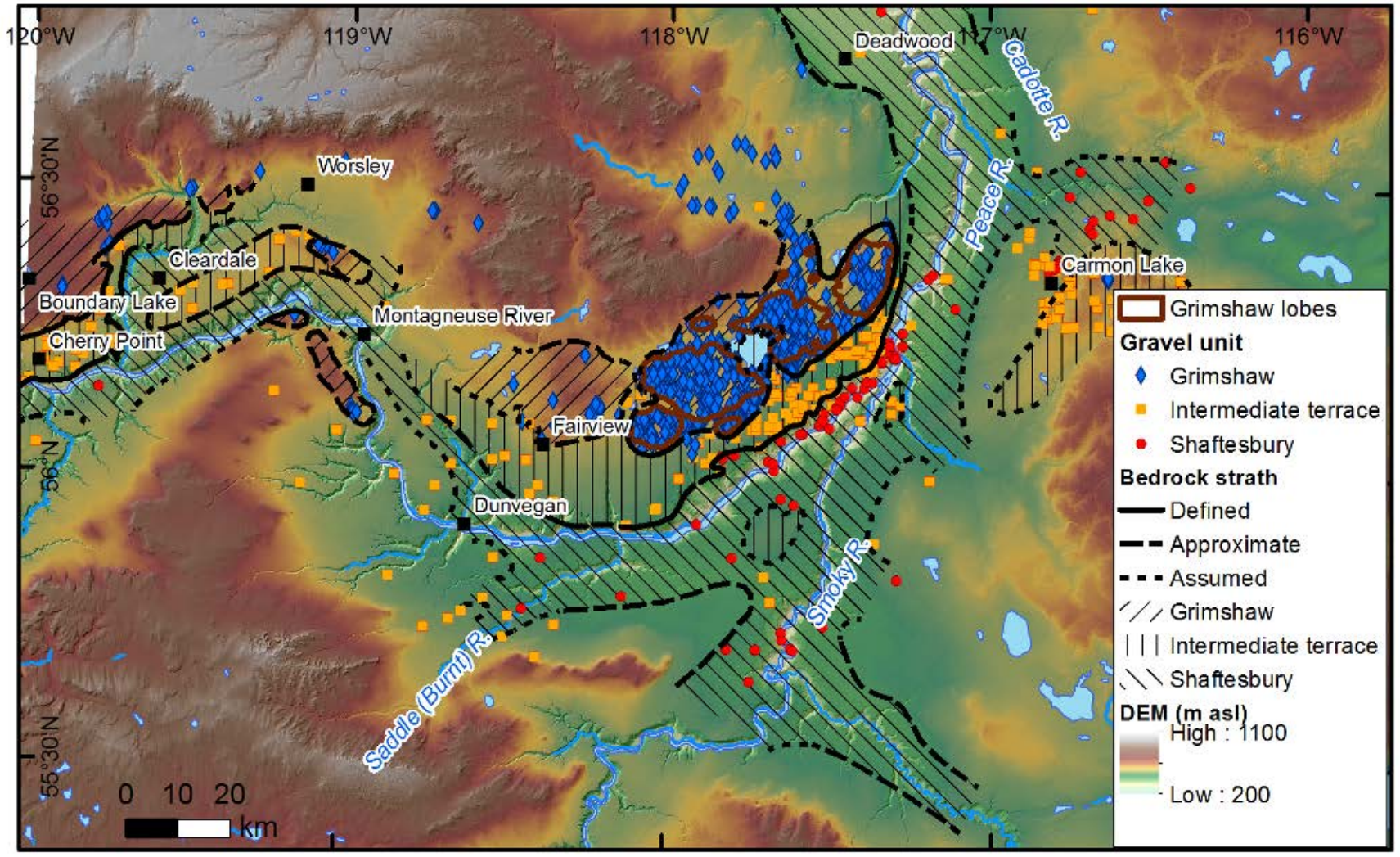

Figure 6: Underlying geology of the Grimshaw Gravel Aquifers (Source: Architecture and Geometry of Basal Sand and Gravel Deposits, Including the 'Grimshaw Gravels', Northwestern Alberta (NTS 84C and 84D) produced by the Alberta Geological Survey)

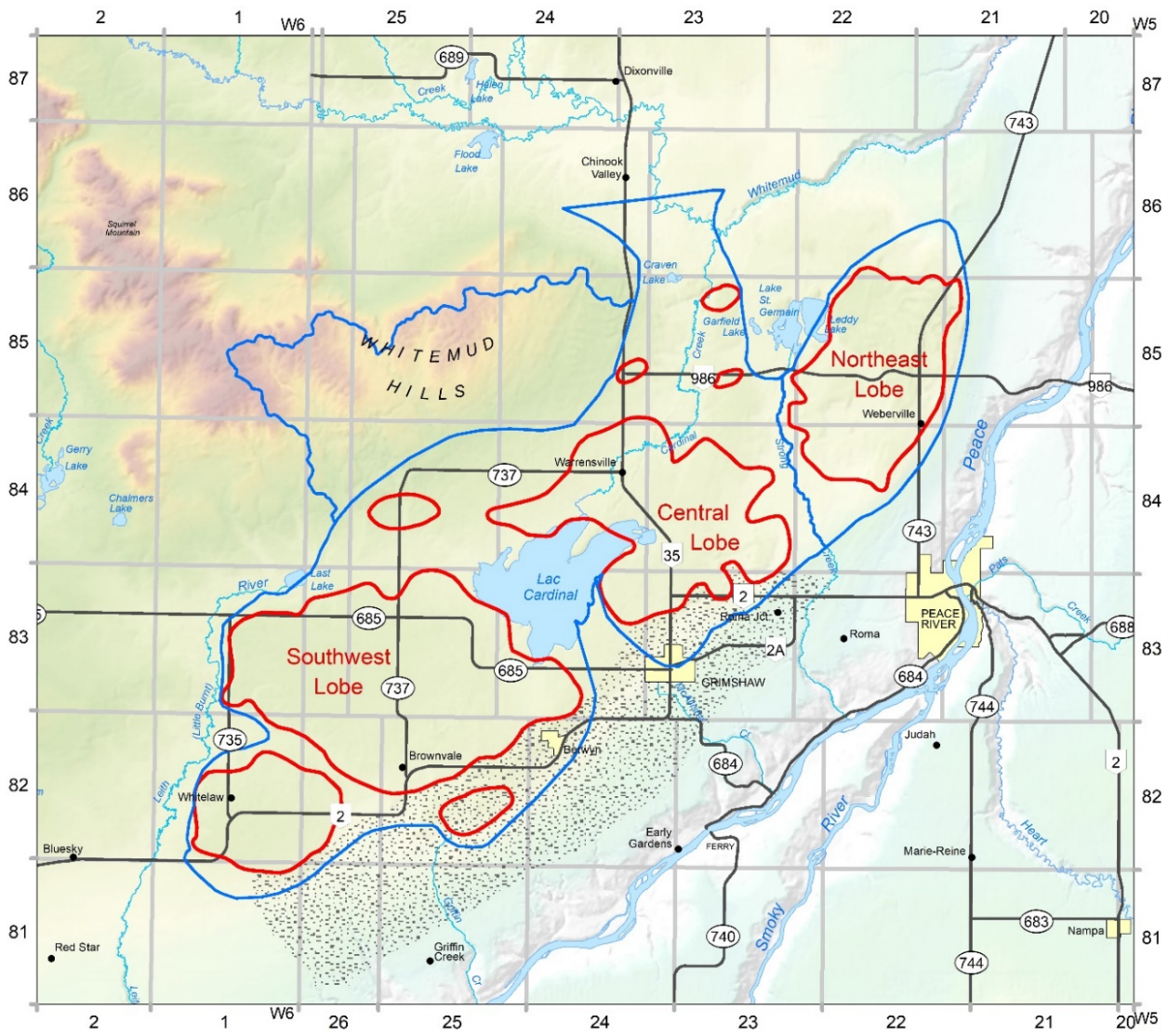

Figure 7: Map of Grimshaw Gravels (red outline, Prairie Farm Rehabilitation Administration 1998), Proposed Risk Zone boundary (blue outline), Approximate extent of Old Fort Gravel Terrace (spotted dark grey, Prairie Farm Rehabilitation Administration 1998), and population centers including towns, hamlet's and Locality's (black circle) overlaid on hillshade (Alberta Environment and Parks, Government of Alberta)

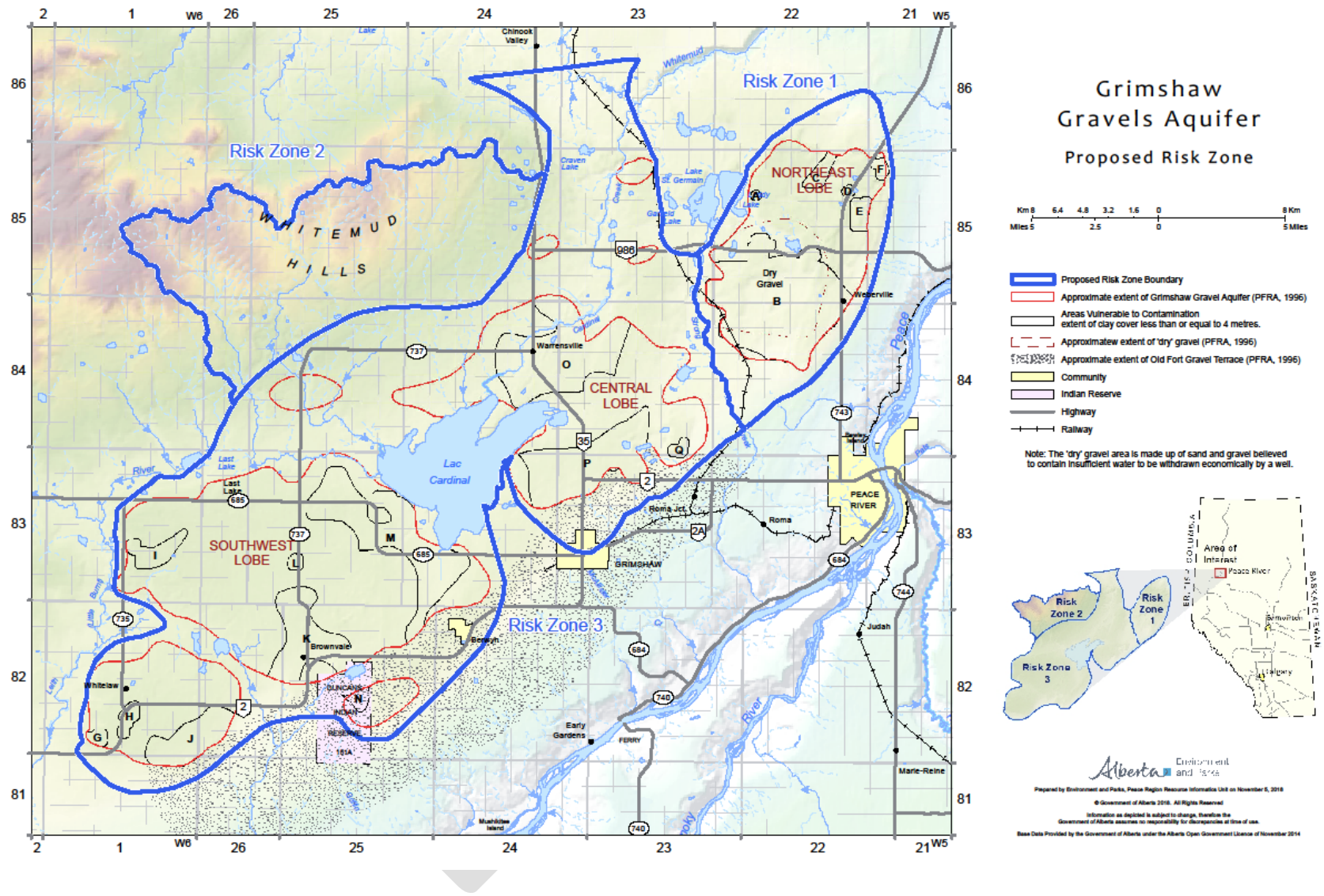

Figure 8: Map of Proposed Risk Zones, Grimshaw Gravels, population centers, and Areas Vulnerable to Contamination

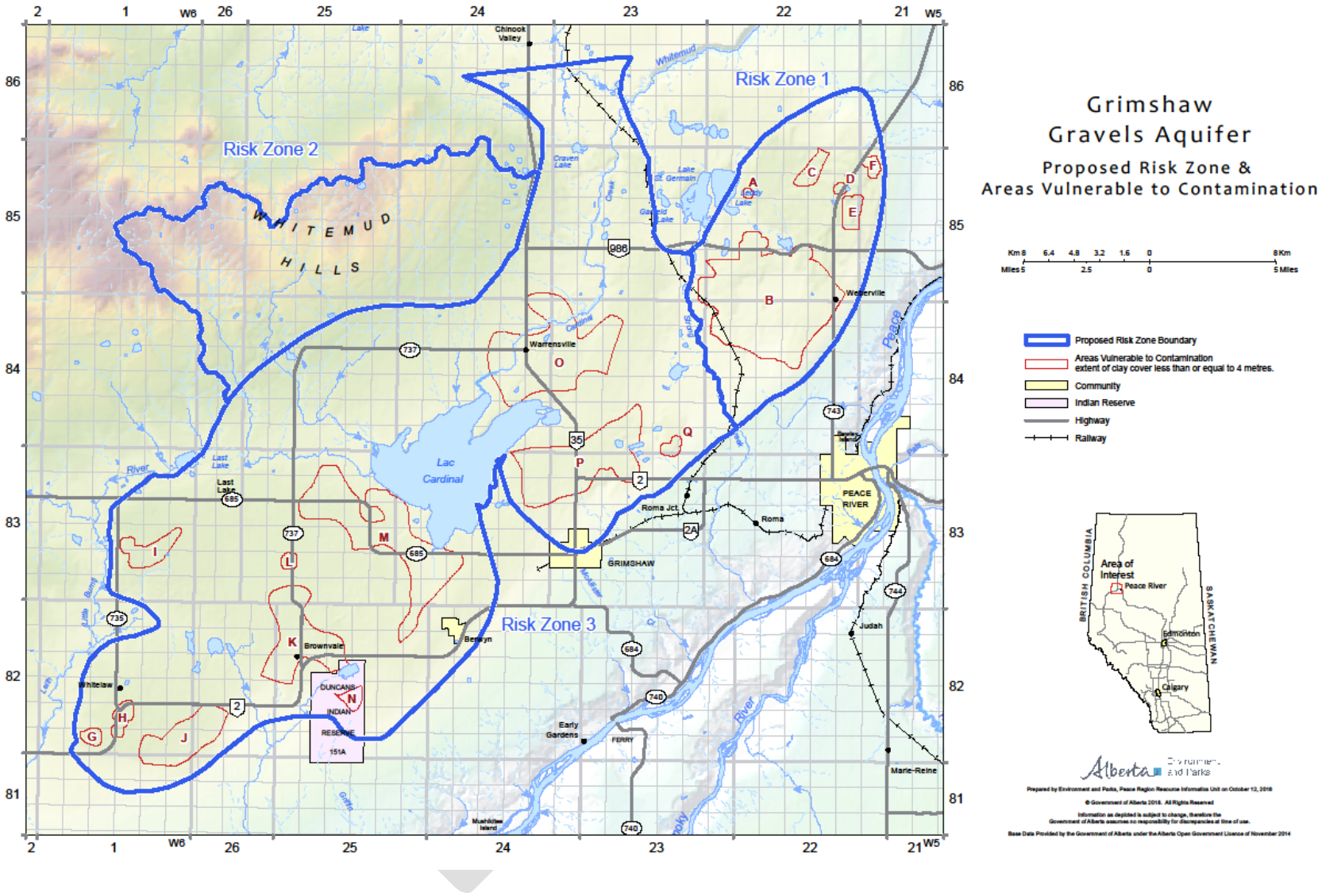

Figure 9: Map of Proposed Risk Zone with Areas Vulnerable to Contamination: extent of clay cover less than or equal to 4 metres

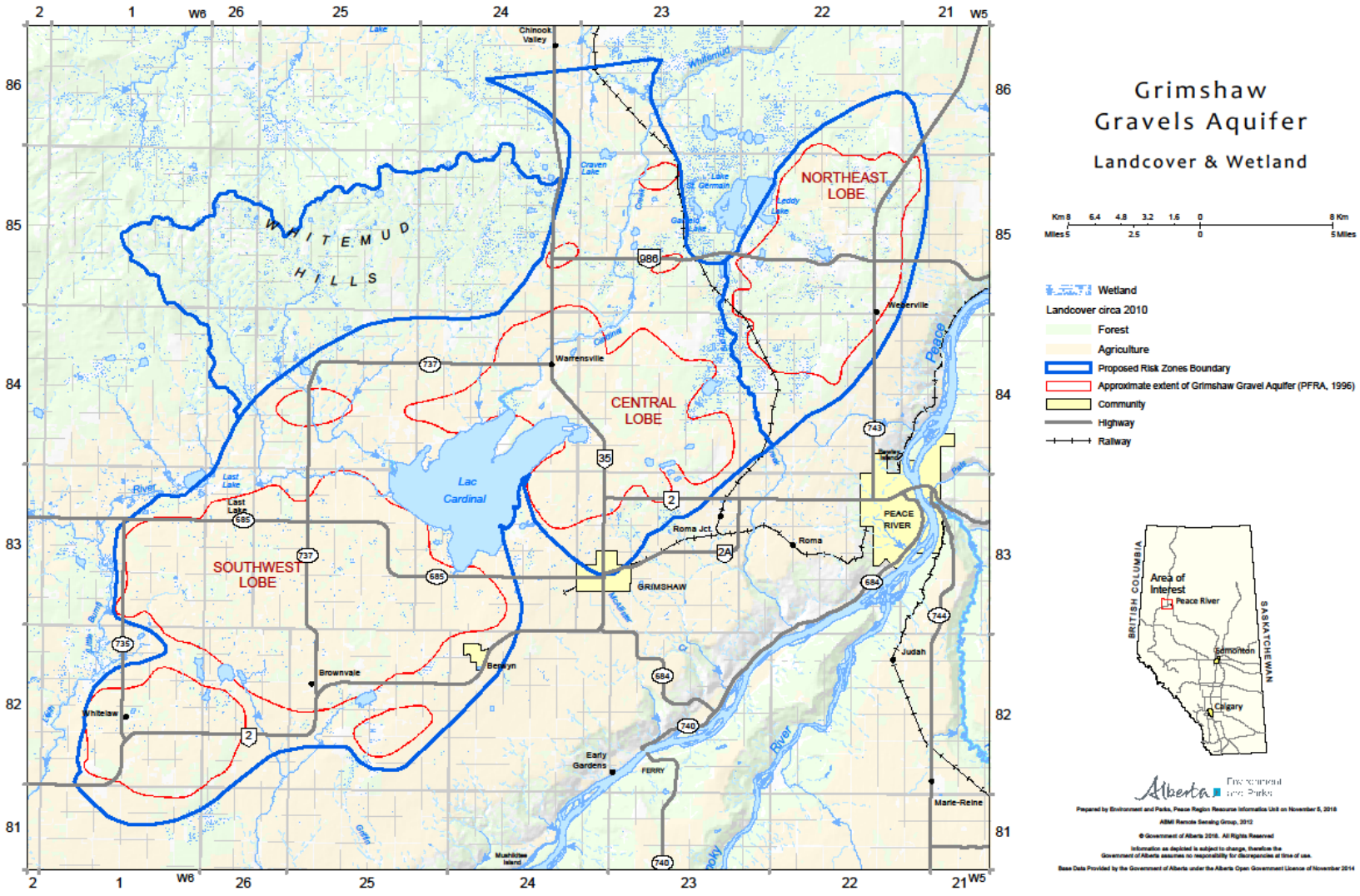

Figure 10: Map of Wetlands and Forest & Agriculture Landcover

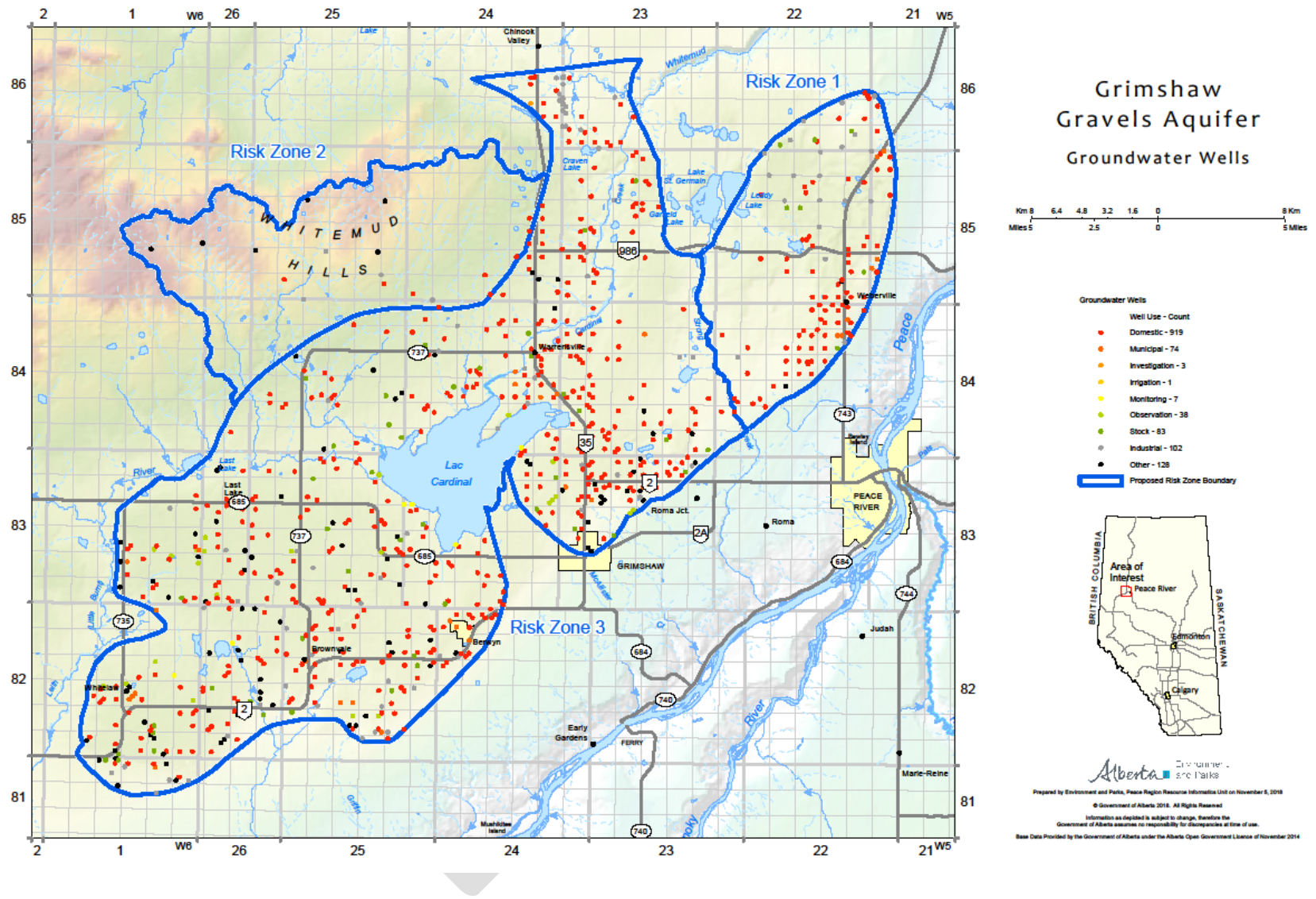

Figure 11: Domestic, irrigation and municipal wells

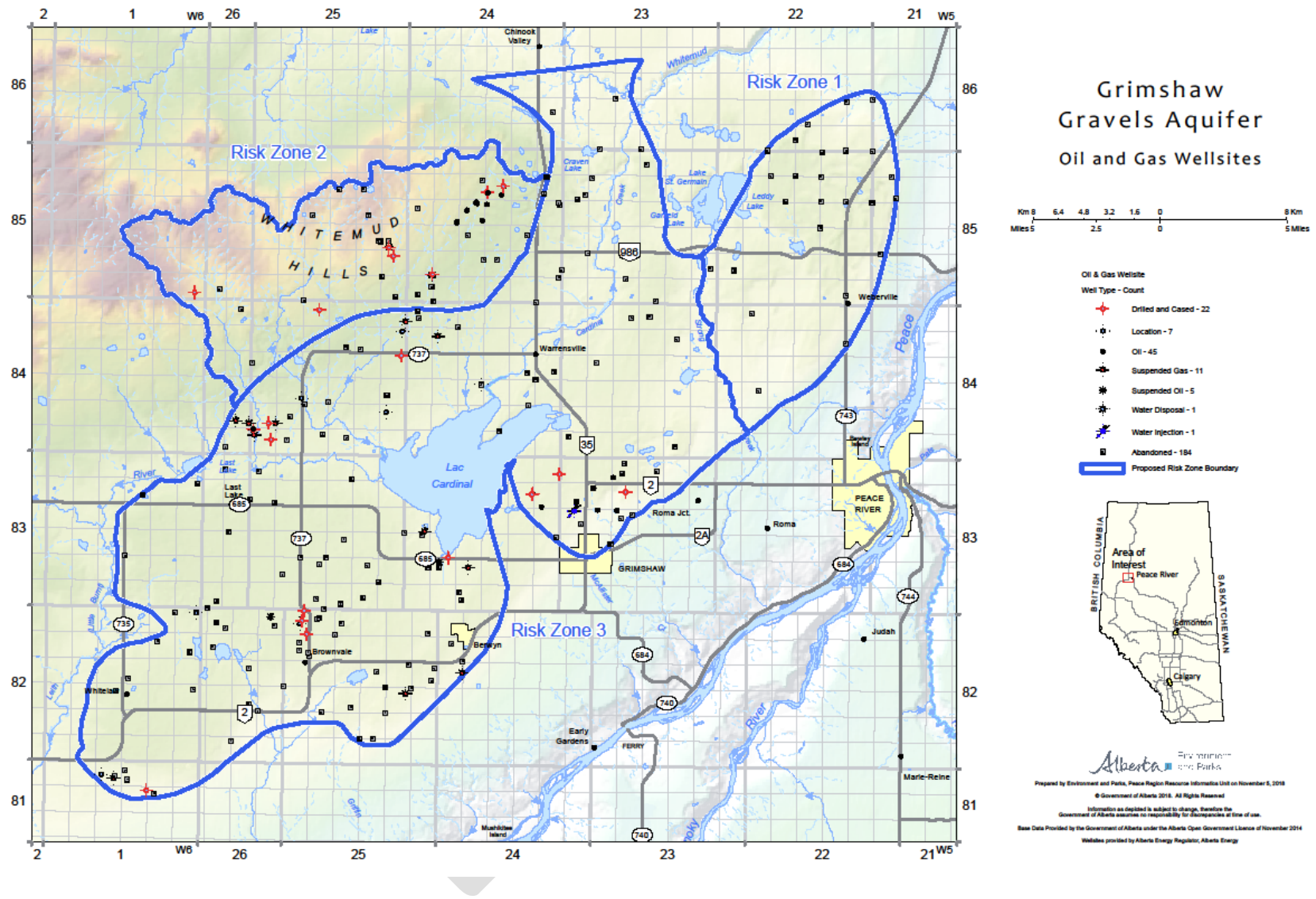

Figure 12: Oil and gas wells by type

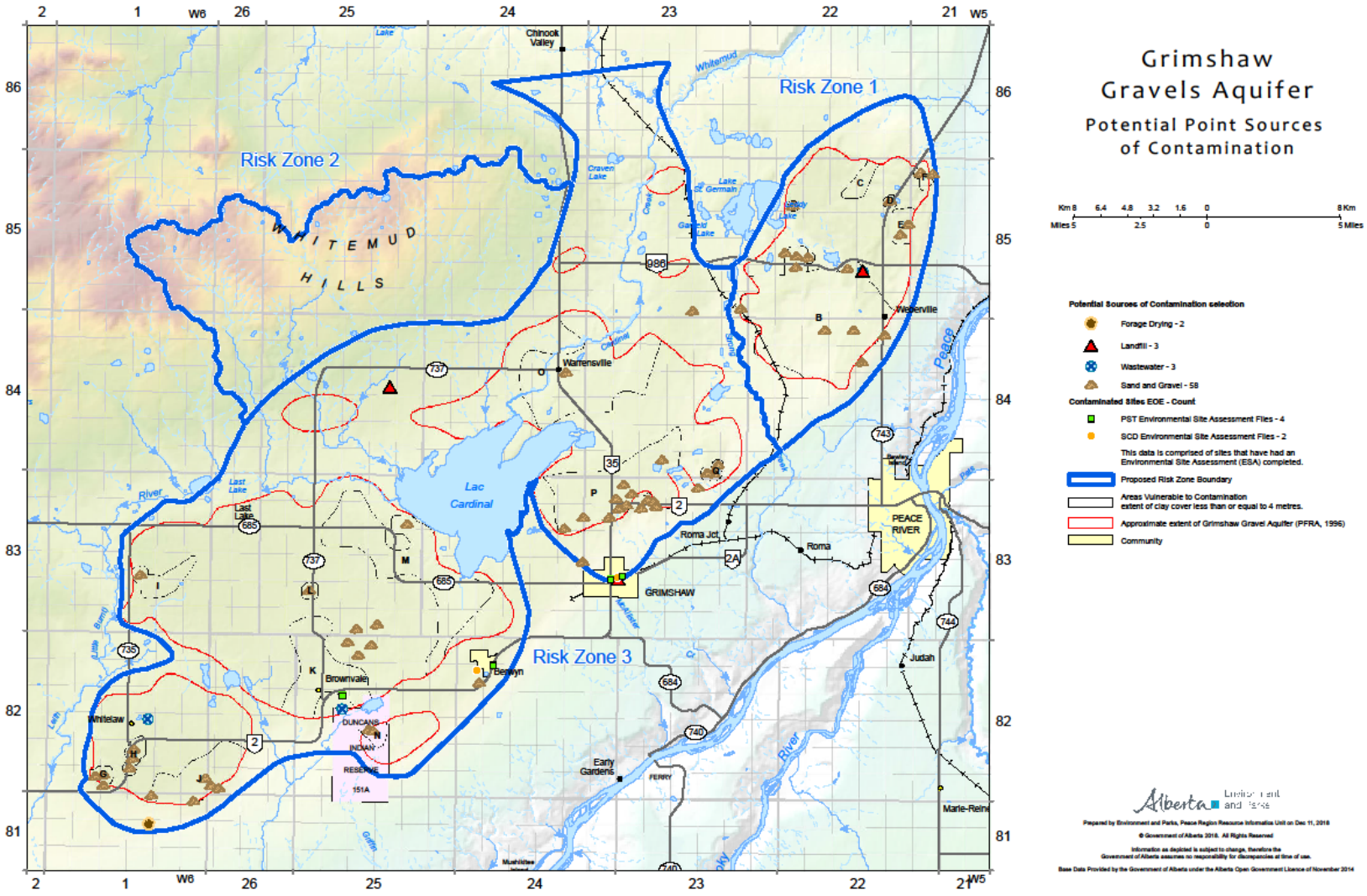

Figure 13: Potential Point Sources of Contamination

Table 3: Human Footprint Summary

GRIMSHAW GRAVEL AQUIFER HUMAN FOOTPRINT SUMMARY

		RISK ZONE 1		RISK ZONE 2		RISK ZONE 3		GRAND TOTAL	
		TOTAL		TOTAL		TOTAL			
		ha		ha		ha		ha	
Industrial and Rural Site Footprint	Urban and Rural Features								
	Rural (Residential/Industrial)	418.7	2.4%	29.3	0.1%	1,501.8	1.7%	1,949.8	1.5%
	Urban	1.0	0.0%			127.0	0.1%	128.0	0.1%
	Industrial Features								
	Industrial Site Rural	67.5	0.4%	3.4	0.0%	72.7	0.1%	143.6	0.1%
	Well Site	5.3	0.0%	38.1	0.2%	158.2	0.2%	201.6	0.2%
	High Density Livestock Operation					18.5	0.0%	18.5	0.0%
	Resource Extraction Features								
	Mine Site	177.2	1.0%			289.4	0.3%	466.7	0.4%
	Human created Waterbodies								
	Borrow-Pits/Dugouts/Sumps	17.9	0.1%	7.8	0.0%	98.6	0.1%	124.3	0.1%
	Municipal (Water and Sewage)					10.7	0.0%	10.7	0.0%
	Reservoirs					7.7	0.0%	7.7	0.0%
	SUB TOTAL	[illegible]	4.0%	[illegible]	0.4%	2,284.6	2.6%	3,050.8	2.4%
Linear Footprint	Hard Surface Features								
	Road - Hard Surface	117.4	0.7%	46.2	0.2%	849.0	1.0%	1,012.6	0.8%
	Rail - Hard Surface	9.7	0.1%			18.5	0.0%	28.2	0.0%
	Vegetated Roads, Verges and								
	Road/Trail (Vegetated)	54.7	0.3%	9.3	4.3%	192.6	0.2%	256.6	0.2%
	Road - Vegetated Verge	222.3	1.3%	78.7	0.4%	1,129.4	1.3%	1,430.4	1.1%
	Rail - Vegetated Verge	19.8	0.1%			39.7	0.0%	59.5	0.0%
	Soft Linear Features								
	Transmission Line			4.8	0.0%	75.3	0.1%	80.1	0.1%
	Pipeline	37.6	0.2%	61.0	0.3%	91.0	0.1%	189.6	0.2%
	Seismic line	271.2	1.6%	240.1	1.1%	461.6	0.5%	972.9	0.8%
	SUB TOTAL	732.6	4.3%	440.1	2.1%	2,857.2	3.3%	4,029.9	3.2%
Agriculture & Forestry Footprint	Cultivation Features								
	Cultivation (Crop/Pasture/Bare Ground)	3,564.2	20.8%	1,141.3	5.3%	50,775.9	57.9%	55,481.3	44.0%
	Managed Forest Features								
	Cut Blocks	684.8	4.0%	5,650.9	26.4%	2,334.4	2.7%	8,670.1	6.9%
	Misc. Features								
	Other Disturbed Vegetation	1.2	0.0%			70.8	0.1%	72.0	0.1%
	SUB TOTAL	4,250.2	25%	6,792.2	31.8%	53,181.0	60.7%	64,223.4	50.9%
	TOTAL HUMAN FOOTPRINT	5,670.5	33%	7,310.8	34%	58,322.8	67%	71,304.1	57%
	Area with NO Human Footprint	11,428.3	67%	14,076.2	66%	29,305.6	33%	54,810.1	43%
	TOTAL	17,098.8	100%	21,387.0	100%	87,628.4	100%	126,114.2	100%

Table 4: Human footprint Overview

GRIMSHAW GRAVEL AQUIFER HUMAN FOOTPRINT OVERVIEW

RISK ZONE 1 — Areas Vulnerable to Contamination (VA)

Footprint	Feature	A ha	A %	B ha	B %	C ha	C %	D ha	D %	E ha	E %	F ha	F %	TOTAL ha	TOTAL %	outside of VA ha	outside of VA %
Industrial and Rural Site Footprint	**Urban and Rural Features**																
	Rural (Residential/Industrial)	2	6	190	4									192	3	227	2
	Urban			1	0									1	0		
	Industrial Features																
	Industrial Site Rural			10	0									10	0	57	0
	Well Site			2	0									2	0	3	0
	High Density Livestock Operation																
	Resource Extraction Features																
	Mine Site			111	2			2	4	22	9	2	2	137	2	40	0
	Human created Waterbodies																
	Borrow-Pits/Dugouts/Sumps			5	0									5	0	12	0
	Municipal (Water and Sewage)																
	Reservoirs																
	SUB TOTAL	2	6	319	7			2	4	22	9	2	2	348	6	339	3
Linear Footprint	**Hard Surface Features**																
	Road - Hard Surface			35	1			1	2	1	0	1	1	38	1	79	1
	Rail - Hard Surface			3	0									3	0	6	0
	Vegetated Roads, Verges and																
	Road/Trail (Vegetated)	1	2	21	0									22	0	32	0
	Road - Vegetated Verge	1	2	57	1			3	5	1	1	2	2	64	1	159	1
	Rail - Vegetated Verge			6	0									6	0	13	0
	Soft Linear Features																
	Transmission Line																
	Pipeline			17	0									17	0	21	0
	Seismic line	1	2	95	2	1	1	1	1	4	2	2	2	104	2	168	1
	SUB TOTAL	2	6	235	5	1	1	4	8	6	3	5	5	254	5	478	4
Agriculture & Forestry Footprint	**Cultivation Features**																
	Cultivation (Crop/Pasture/Bare Ground)	17	51	568	12	102	43	15	29	21	9	64	56	787	14	2,777	24
	Managed Forest Features																
	Cut Blocks			375	8					84	34			459	8	226	2
	Misc. Features																
	Other Disturbed Vegetation															1	0
	SUB TOTAL	17	51	943	19	102	43	15	29	106	43	64	56	1,247	22	3,003	26
	TOTAL HUMAN FOOTPRINT	21	62	1,497	31	103	44	22	42	134	54	71	62	1,848	33	3,821	33
	Area with NO Human Footprint	13	38	3,404	69	134	56	30	58	112	46	43	38	3,736	67	7,694	67
	TOTAL	34	100	4,901	100	237	100	52	100	246	100	114	100	5,584	100	11,515	100

RISK ZONE 2

Feature	outside of VA ha	outside of VA %
Rural (Residential/Industrial)	29	0
Urban		
Industrial Site Rural	3	0
Well Site	38	0
High Density Livestock Operation		
Mine Site		
Borrow-Pits/Dugouts/Sumps	8	0
Municipal (Water and Sewage)		
Reservoirs		
SUB TOTAL	79	0
Road - Hard Surface	46	0
Rail - Hard Surface		
Road/Trail (Vegetated)	9	0
Road - Vegetated Verge	79	0
Rail - Vegetated Verge		
Transmission Line	5	0
Pipeline	61	0
Seismic line	240	1
SUB TOTAL	440	2
Cultivation (Crop/Pasture/Bare Ground)	1,141	5
Cut Blocks	5,651	26
Other Disturbed Vegetation		
SUB TOTAL	6,792	32
TOTAL HUMAN FOOTPRINT	7,311	34
Area with NO Human Footprint	14,076	66
TOTAL	21,387	100

RISK ZONE 3 — Areas Vulnerable to Contamination (VA)

Feature	G ha	G %	H ha	H %	I ha	I %	J ha	J %	K ha	K %	L ha	L %	M ha	M %	N ha	N %	O ha	O %	P ha	P %	Q ha	Q %	TOTAL ha	TOTAL %	outside of VA ha	outside of VA %
Rural (Residential/Industrial)			2	1	5	1	6	1	43	2			39	1	1	1	138	4	97	4	6	5	337	3	1,165	2
Urban																									127	0
Industrial Site Rural							1	0									1	0	22	1	3	2	28	0	45	0
Well Site									11	1			7	0			3	0	6	0			27	0	131	0
High Density Livestock Operation																									19	0
Mine Site	35	29	13	6	11	2	56	5			6	7	11	0	2	2	18	1	40	2	11	9	204	2	85	0
Borrow-Pits/Dugouts/Sumps									2	0	0	1	3	0			1	0	2	0			9	0	89	0
Municipal (Water and Sewage)																									11	0
Reservoirs																									8	0
SUB TOTAL																							605	5	1,678	2
Road - Hard Surface	1	1	6	3	3	1	11	1	28	2	2	2	39	1	3	2	41	1	37	1	2	1	173	1	676	1
Rail - Hard Surface																									19	0
Road/Trail (Vegetated)			1	0	3	1	3	0	7	0			3	0	0	0	13	0	12	0	3	2	44	0	148	0
Road - Vegetated Verge	1	1	12	6	6	1	17	2	33	2	2	2	40	1	4	3	58	2	58	2	4	3	236	2	893	1
Rail - Vegetated Verge																									40	0
Transmission Line							6	1									12	0	8	0	2	1	28	0	48	0
Pipeline									4	0			1	0			1	0	1	0			7	0	84	0
Seismic line	1	0			1	0	15	1	5	0			3	0	2	1	22	1	8	0	6	5	62	0	400	1
SUB TOTAL																							551	4	2,306	3
Cultivation (Crop/Pasture/Bare Ground)	4	3	119	55	341	72	503	44	1,275	74	66	73	2,659	83	64	44	1,997	60	1,633	63	9	8	8,670	66	42,106	57
Cut Blocks	54	45	14	6	25	5	51	4					73	2			11	0	79	3			306	2	2,028	3
Other Disturbed Vegetation									6	0							27	1	2	0			35	0	35	0
SUB TOTAL	57	48	133	62	367	77	554	48	1,281	74	66	73	2,731	85	64	44	2,036	61	1,714	66	9	8	9,011	68	44,170	59
TOTAL HUMAN FOOTPRINT	95	80	166	77	396	84	669	58	1,414	82	76	84	2,878	90	76	52	2,344	70	2,008	78	45	37	10,167	77	48,154	65
Area with NO Human Footprint	24	20	49	23	78	16	480	42	319	18	14	16	320	10	71	48	983	30	579	22	77	63	2,994	23	26,314	35
TOTAL	119	100	215	100	473	100	1,149	100	1,733	100	91	100	3,198	100	146	100	3,327	100	2,587	100	122	100	13,161	100	74,468	100

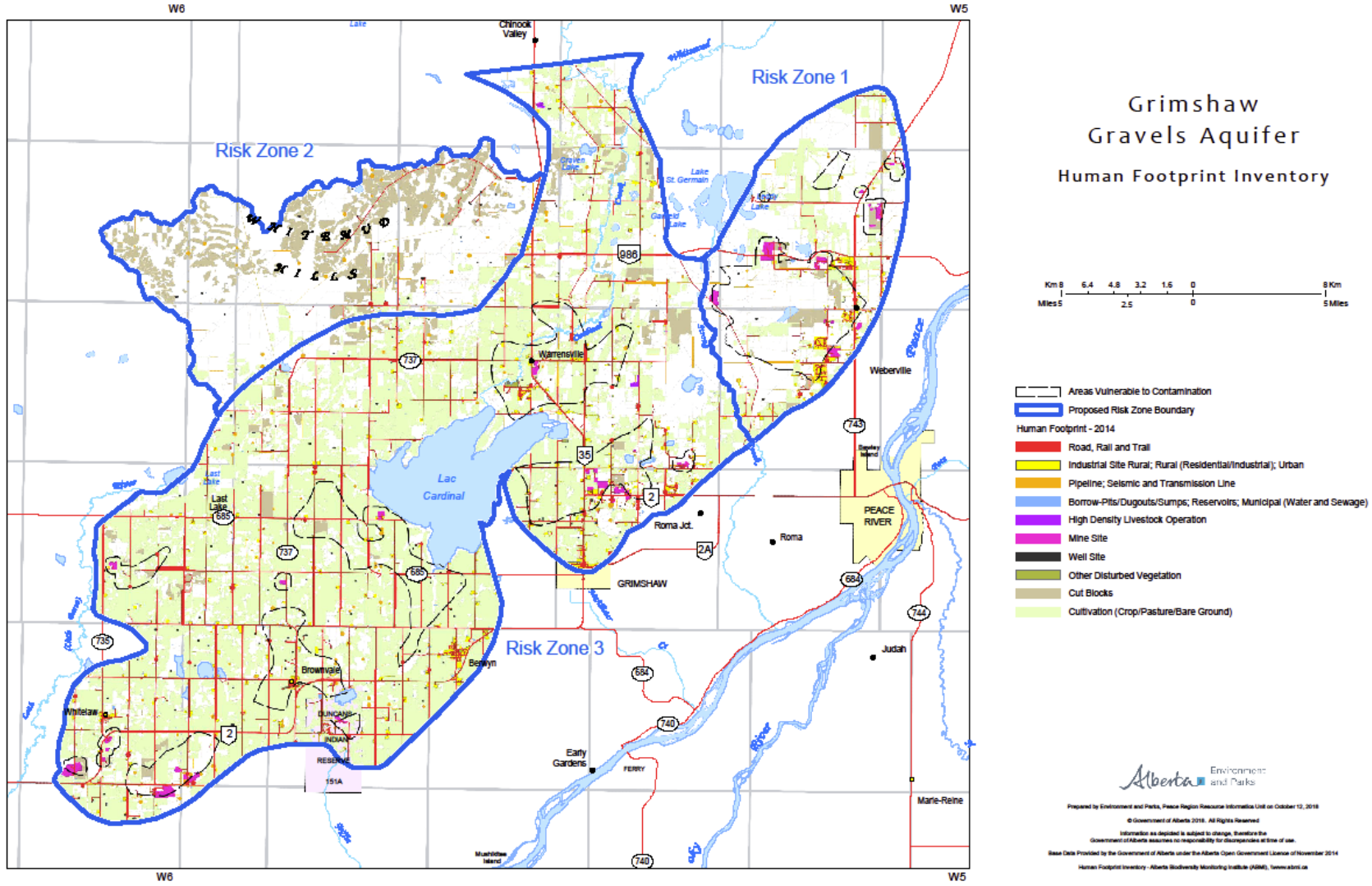

Figure 14: Human footprint Inventory

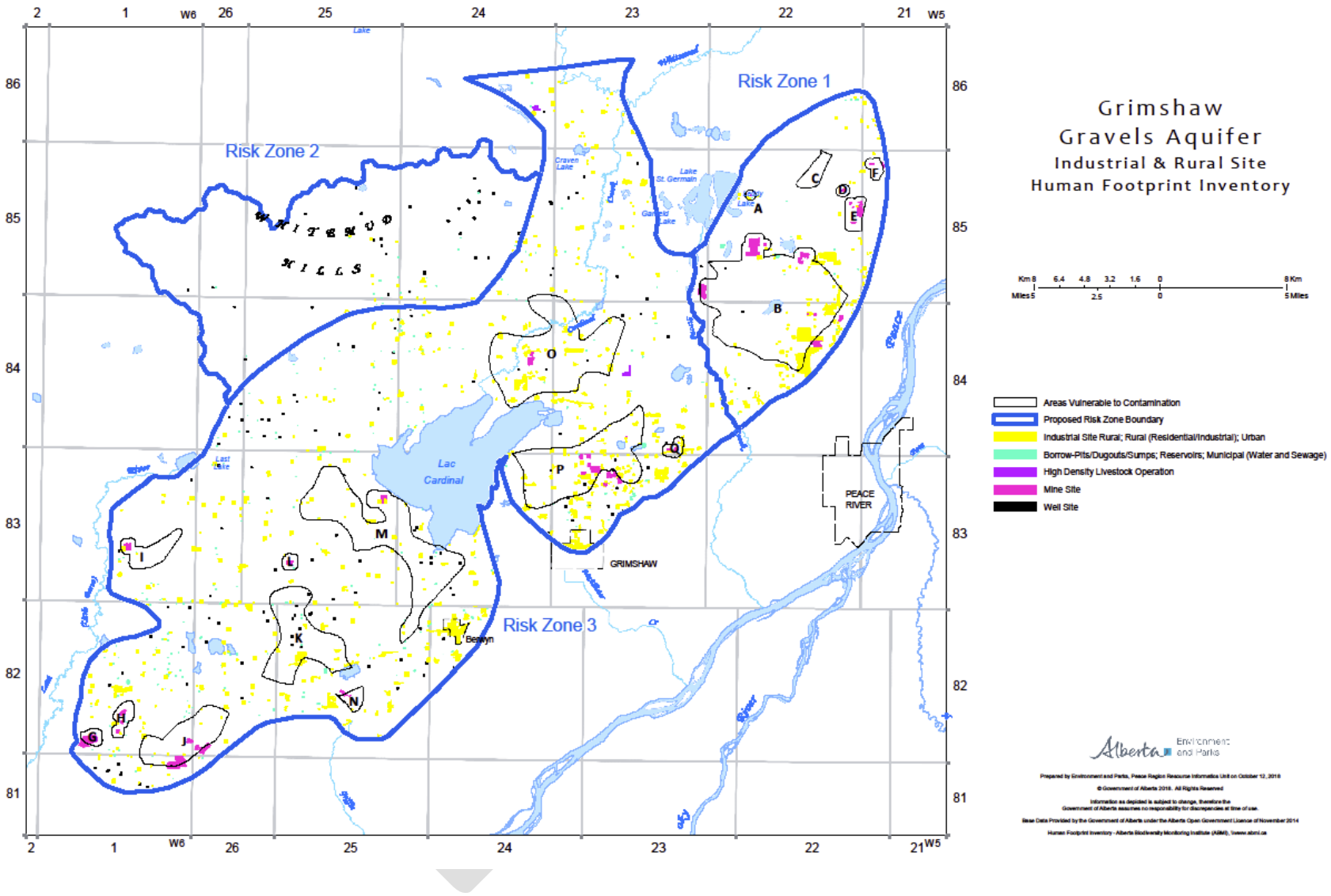

Figure 15: Human Footprint Inventory – Industrial and Rural Sites

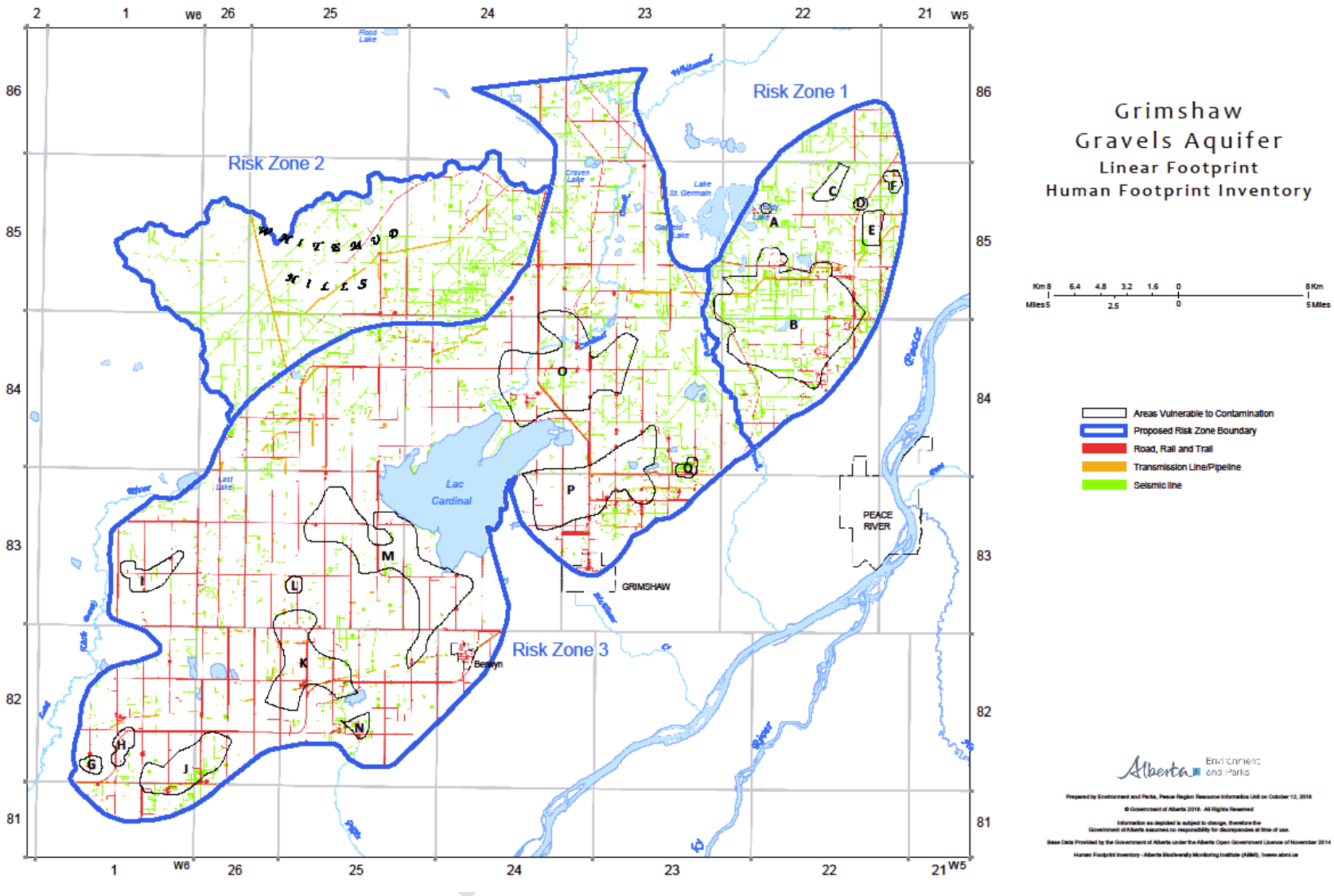

Figure 16: Human Footprint Inventory – Linear Footprint

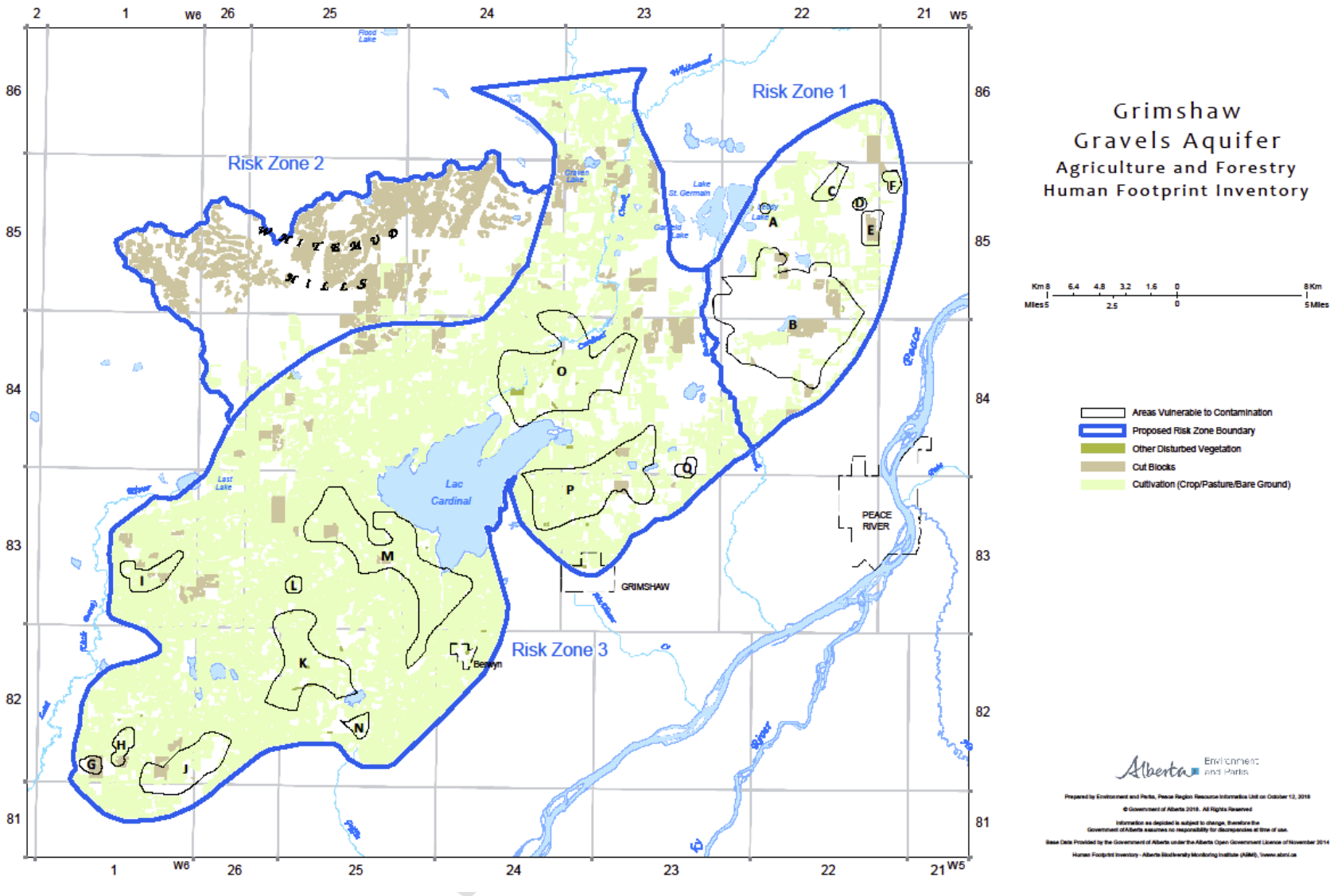

Figure 17: Human Footprint Inventory – Agriculture and Forestry

APPENDIX B

Source Water Risk Assessment

The potential risk associated with each contamination source in Table 6 was determined by multiplying the **Likelihood of Occurrence** by the **Impact of Occurrence**. Three steps were followed by the Working Committee to complete the risk assessment.

Step 1 Likelihood: The Working Committee used Table 5 showing the Likelihood of Occurrence and associated value (1-5).

Table 5: Likelihood of Occurrence

Likelihood	Value
Rare Extremely small chance of happening in the next 4 to 5 years	1
Unlikely Is possible but unlikely to occur in the next 4 to 5 years	2
Moderate 50/50 chance of happening in the next 4 to 5 years	3
Likely Is possible and likely to occur in the next 4 to 5 years	4
Almost certain Is expected to happen at least once in the next 4 to 5 years	5

Step 2 Impact: The Working committee used Table 6 showing the Impact of Occurrence and associated value (1-5).

Table 6: Impact of Occurrence

Impact	Value
Insignificant No significant impact to human or environmental health	1
Minor Localized short term impact, no significant impact on human or ecosystem health	2
Moderate Widespread long term aesthetic issues, no significant impact on human or ecosystem health	3
Severe Short to medium term effect on human or ecosystem health (e.g. actual illness)	4
Catastrophic Long term effects on human or environmental health	5

Step 3 Risk Assessment Score: The Working Committee combined the Likelihood of Occurrence (Table 5) and the Impact of Occurrence (Table 6) to produce a Risk Assessment Score Analysis Matrix as shown in Table 7.

Table 7: Risk Assessment Score Analysis Matrix

Likelihood of Occurrence	Impact of Occurrence				
	Insignificant	**Minor**	**Moderate**	**Severe**	**Catastrophic**
Rare (in next 4 -5 years)	1	2	3	4	5
Unlikely (in next 4 -5 years)	2	4	6	8	10
Moderate (in next 4 -5 years)	3	6	9	12	15
Likely (in next 4 -5 years)	4	8	12	16	20
Almost Certain (in next 4 -5 years)	5	10	15	20	25

The Working Committee used the 25-point ranking system in Table 8 to determine the numerical value above which the risk scores should be interpreted as “high risk” (red), “medium risk” (orange), and “low risk” (yellow). As the working committee did not assign a risk ranking value higher than 20, the designations of high, medium, and low risk were obtained by dividing the highest risk ranking score (20) by three. These designations assist with identifying the highest priority risks and determining which risk mitigation actions should be prioritized.

Table 8: Grimshaw Gravels Aquifer Risk Assessment Results

Potential Risk to Source Water	Likelihood of Occurrence	Impact of Occurrence	Risk Assessment Score
1. Gravel pits	5	4	20
2. Livestock operations	5	4	20
3. Active water wells	5	4	20
4. Abandoned water wells	5	4	20
5. Application of agricultural chemicals	4	4	16

6. Farming land use and water management practices	5	3	15
7. Orphaned oil & gas wells	5	3	15
8. Pipelines	3	5	15
9. Private septic systems	5	3	15
10. Abandoned below ground tanks (farms, former gas stations)	5	3	15
11. Road salt application	5	3	15
12. Dangerous good transport routes	4	3	12
13. Historical dumps and landfills	4	3	12
14. Improper disposal of household Hazardous Waste	4	2	12
15. Fracking	2	5	10
16. Abandoned rail line/stations/stock yards	5	2	10
17. Microplastics	5	2	10
18. Borrow pits/dug outs	3	3	9
19. Active fuel storage tanks on farms	4	2	8
20. Forestry	5	1.5	7.5
21. Storage of agricultural chemicals (private)	3	2	6
22. Rail transport	3	2	6
23. Improper disposal of hazardous waste at businesses, shops, etc.	3	2	6

24. Active landfills, dumps and transfer stations	3	2	6
25. Inactive bulk plants	3	2	6
26. Maintenance yards and industrial sites	3	2	6
27. Residential yard maintenance	5	1	5
28. Municipal sewage	2	2	4
29. Hydro-vac trucks	2	2	4

APPENDIX C

Additional tables used in the development of the source water protection plan

Table 9: Grimshaw Gravels Aquifer: Potential risks affecting source water, location, approximate distance to source (where applicable), contaminants of concern associated with risk, and transport mechanism of the identified contaminants of concern

Potential Risk to Source Water	Owner/ Contact	Location	Distance to Source (m)	Contaminants of Concern	Transport Mechanism
1. Gravel Pits	• Municipal Governments • Private • Government of Alberta • Alberta Transportation	• 51 gravel pits; list with associated LSD's available upon request	• Various	• Fuel • Hydrocarbons • Surface contaminant inflow, run-off • Pesticides/herbicides • Salt • Heavy metals	• Run-off • Direct deposition
2. Livestock operations (including seasonally concentrated feeding areas)	• Private	• Various	• Various	• Bacteria • Nutrients • Pharmaceuticals • Organics	• Leaching • Run-off • Direct deposition
3. Active water wells	• Private owners • Municipal governments • Water co-ops	• Various	• Various	• Hydrocarbons • Nutrients • Heavy metals • Chemicals • Salt	• Run-off • Infiltration • Direct deposition
4. Abandoned water wells	• Current land owners • Industry • Corporate	• Various	• Various	• Hydrocarbons • Nutrients • Heavy Metals • Chemicals • Salt	• Run-off • Infiltration • Direct deposition
5. Application of agricultural chemicals	• Private owners • Corporate farms	• Various	• Various • 0 m	• Heavy metals • Pesticides • Herbicides • Fungicides	• Infiltration • Run-off • Direct Deposition

6. Farming land use & water management practices	• Private farmers • Corporate farmers	• Various	• Various • 0 m	• Heavy metals • Pesticides • Herbicides • Fungicides	• Infiltration • Run-off • Direct Deposition
7. Orphaned oil & gas wells	• Alberta Energy Regulator • Government of Alberta	• Known, mapping (Alberta Energy Regulator shape files)	• Various	• Hydrocarbons • Heavy metals • Salts	• Run-off • Direct deposition • Infiltration
8. Pipelines	• Corporate • Alberta Energy Regulator	• Various (mapping)	• Various	• Oil & Gas • Condensate • Salts	• Infiltration • Direct deposition
9. Private septic systems	• Land owner	• Various	• 0 m	• Hydrocarbons • Pharmaceuticals • Bacteria • Nutrients • Garbage • Pathogens • Heavy metals	• Infiltration • Direct deposition • Run-off
10. Abandoned below ground tanks (farms, former gas stations)	• Industry • Private	• Whitelaw • Brownvale	• 0 m	• Gas & diesel • Used oil	• Infiltration • Direct deposition • Run-off
11. Road salt storage and application	• LaPrairie Group • Government of Alberta • Alberta Transportation	• Local area highways on all numbered highways • Grimshaw Highway Maintenance Yard	• 0 m	• Salts	• Run-off • Infiltration • Direct deposit

12. Dangerous goods transport routes	• Alberta Transportation • Companies • Municipalities • Alberta Serious Incident Response Team	• Various (maps)	• Various	• Hydrocarbons • Produced water • Various other chemicals	• Infiltration • Direct deposit • Run-off • Leaching
13. Historical dumps and landfills	• Municipalities	• Mapped (DW)	• Various	• Household hazardous waste • Garbage • Pharmaceuticals • Appliances • Hydrocarbons • Volatile organic compounds • Heavy metals • Salts • Methane gas	• Leaching/infiltration • Direct deposition • Run-off
14. Improper disposal of household hazardous waste	• Land owners	• Various	• 0 m	• Household hazardous waste • Garbage • Pharmaceuticals • Appliances	• Infiltration/leaching • Direct deposition • Run-off
15. Fracking and active oil and gas wells	• Oil and Gas Industry • Alberta Energy Regulator	• Various (mapping appendix)	• Various • 0m 1000m	• Fracking chemicals • Drilling chemicals • Salts • Hydrocarbons • Heavy metals	• Direct deposition • Run-off • Leaching
16. Abandoned rail line/stations/ stock yards	• Canadian National Railway	• Grimshaw to Hines Creek	• 0 m	• Hydrocarbons • PAH's • Heavy metals • Creosote • Herbicides and pesticides	• Run-off • Leaching • Direct deposit
17. Microplastics	• Alberta Environment and Parks • Municipalities • Private • Residents	• Various	• Various	• Polyaromatic hydrocarbons • Nitrogen • Sulphur • Phenols	• Suspended solids in runoff • Suspended solids in effluent

18. Borrow pits/dug outs	• Private land owners • Government of Alberta • Alberta Transportation • Municipal Government	• Various (on cumulative mapping)	• Various	• Hydrocarbons • Fuel • Surface contaminant inflow, run-off • Pesticides/herbicides • Salt • Heavy metals • Various other agricultural chemcicals	• Run-off • Leaching • Direct deposition
19. Active fuel storage tanks on farms	• Private land owners	• Various (inventory of active?)	• Various	• Hydrocarbons • Heavy metals • Fuel	• Leaching • Run-off • Direct deposition
20. Forestry	• Industry • Private companies • DMI Ltd.	• Various (map showing forestry leases, cut blocks)	• 0 m	• Pesticides • Herbicides • Water quality degradation due to sedimentation	• Run-off • Direct deposition • Leaching/infiltration
21. Storage of agricultural chemicals (private)	• Private owners • Corporate farms	• Various	• Various • 0 m	• Heavy metals • Pesticides • Herbicides • Fungicides	• Leaching • Ground Water Transport • Run-Off • Direct Deposition
22. Rail transport	• Canadian National Railway • Federal • Corporate • Emergency response • Alberta Serious Incident Response Team	• Various (east of Grimshaw)	• 0 m	• Creosotes • Preservatives • Hydrocarbons • Pesticides and herbicides	• Infiltration – Leaching • Run-off • Direct deposition
23. Improper disposal of hazardous waste at shops, businesses, etc.	• Private • Corporate • Retail	• Various (public works yards, businesses, mechanics,	• 0 m	• Household hazardous waste • Pharmaceuticals • Hydrocarbons • Garbage • Appliances	• Leaching • Direct deposition • Run-off

24. Active landfills, dumps, and transfer stations	• Municipalities • Private	• Weberville • Fairview • Brownvale • Whitelaw	• Various	• Household hazardous waste • Pharmaceuticals • Hydrocarbons • Garbage • Appliances • Volatile organic compounds • Heavy metals • Salts • Methane gas	• Leaching/infiltration • Direct deposition • Run-off
25. Inactive bulk plants	•	•	•	•	•
26. Maintenance yards and industrial sites	• Goldstar • Pinetree logging • Industry • Municipalities • Private	• Various	• 0 m	• Hydrocarbons • Transport materials • Fuel • Diesel	• Leaching • Direct deposition • Run-off
27. Residential yard maintenance	• Private landowners	• Various	• 0 m	• Nutrients • Pesticides • Herbicides	• Leaching • Direct deposition • Run-off
28. Municipal wastewater treatment facilities	• Municipalities	• Whitelaw • Weberville • Mapped	• 0 m	• Nutrients • Pharmaceuticals • Bacteria	• Infiltration/leaching • Direct deposition • Run-off
29. Hydro-vac trucks	• Municipalities • Private • Government of Alberta	• Various	• 0 m	• Hydrocarbons • Pharmaceuticals • Bacteria • Nutrients • Garbage • Heavy metals • Oil • Fuel	• Infiltration/leaching • Direct deposition • Run-off

Table 10: Grimshaw Gravels Aquifer: Timelines and Partnerships. Note that the timelines assigned to each risk mitigation action are used for the purposes of prioritization; the ability of mitigation actions to be implemented may be limited by money and resources

Num.	Risk Ranking High - Low	Potential Risks to Source Water	Proposed Management Actions	Timeline (When to start?) 1= within 1-2 yrs. 2= within 3 yrs. 3= within 5 yrs.	Stakeholders/ Partnerships
1.	20	Gravel pits	a) Access and review conditions for approvals b) Compare permitting conditions across municipalities to create consistency/standardize/improve c) Improve review and approval process for pits below 5 hectares, including more in-depth hydrogeological review d) Conduct a study to determine the maximum surface area that should be exposed at any time e) Create responsible development plan and guide that incorporates best management practices, results of study, etc.	a) 1 b) 1 c) 2 d) 2 e) 2	a) Gravel pit operators, municipalities, AEP, or MPWA b) GGAMAA, municipal development officers, MMSA c) AEP, gravel pit operators, development officers, MMSA d) AEP, AB sand and gravel association (local chapter) e) Municipalities, AEP, gravel pit operators, ASGA, MPWA
2.	20	Livestock operations	a) Partner with PCBFA and agriculture service boards to develop and deliver an aquifer-specific course and encourage adoption of best practices b) Identify and flag seasonally concentrated feeding areas to potentially incorporate sites into groundwater monitoring study	a) 1 b) 2	a) PCBFA, agriculture service boards, MPWA, AAF (Alberta agriculture and forestry), Alberta Beef Producers (ABP) b) Agriculture fieldmen (ASB), GGAMAA, MPWA
3.	20	Active water wells	a) Develop private water well monitoring program b) Develop an on-going strategy to identify active wells c) Promote the well aware and working well programs d) Develop citizen science program for water well monitoring (quality and level) e) Develop and deliver education on well head protection zones	a) 2 b) 1 c) 1 d) 1 e) 1	a) AEP, GGAMAA, MPWA, AGS b) GGAMAA, working well program, MPWA, ASB c) Agriculture societies, working well program, GGAMAA, municipalities d) GGAMAA, health unit, MPWA, PCBFA, post-secondary institutions, schools (junior and high) e) GGAMAA, MPWA, municipalities, PCBFA
4.	20	Abandoned water wells	a) Update existing list/map of active/inactive water wells; conduct ground truthing and locate water wells missing from list/map b) Education and outreach program around proper water	a) 1 b) 1 c) 3	a) GGAMAA, MPWA, ASB, historical societies, museum boards b) GGAMAA, MPWA, working well program, agriculture societies,

			well decommission c) Prioritize/risk rank water wells and decommission		municipalities c) GGAMAA, Alberta Environment and Parks
5.	16	Application of agricultural chemicals	a) Establish baseline monitoring program b) Conduct study to determine pathways of contamination via aquifer recharge c) Collect feedback on, review and modify BMP's, as appropriate	a) 2 b) 3 c) 2	a) PCBFA, GGAMAA, MPWA, Post secondary institutions, ASB b) AEP, post secondary institutions, GGAMAA, MPWA, agriculture and forestry c) PCBFA, ASB, NPARA, AAF
6.	15	Farming land use and water management practices	a) Develop a communication and outreach strategy about wetland policy and other relevant policy b) Prioritize focus areas based on wetland quality, sensitivity, etc. c) Develop a targeted drainage management education program; review and improve drainage management component of environmental farm plan d) Promote Environmental Farm Plan (those without an EFP or if saturation 100%)	a) 1 b) 2 c) 2 d) 1	a) MPWA, PCBFA, AEP, NPARA, ASB b) AEP, DU, ASB, municipalities, MPWA, Boreal Research Institute, ABMI c) AEP, ASB, PCBFA, NPARA d) PCBFA, NPARA, AAF, ASB
7.	15	Orphaned oil and gas wells	a) Engage AER and Orphan Well Association to inventory wells b) Inventory well condition and prioritize decommissioning based on risk c) Increase communication with AER about orphan wells, orphan well program, decommissionings, etc.	a) 1 b) 2 c) 1	a) AER, orphan well association, petroleum association b) Orphan well program, summer students, consultant c) AER, orphan well program, GGAMAA, MPWA
8.	15	Pipelines	a) Develop communication plan with industry to communicate identified high risk/sensitive areas and recommendations for those areas (increased frequency of inspections, installation of shut off valves, etc.) b) Review Emergency Response Plans	a) 1 b) 1	a) AER, GGAMAA, MPWA b) AER, GGAMAA, MPWA, municipalities
9.	15	Private septic systems	a) Develop/deliver education and outreach program on PSDS maintenance b) Develop an online training course on PSDS in partnership with a post-secondary institution	a) 1 b) 1	a) AWWOA, Water North Coalition, agriculture societies, municipalities, GGAMAA b) Water North Coalition, TSAG, Northern Lakes College
10.	15	Abandoned below ground tanks	a) Inventory locations and prioritize cleanup based on high risk/sensitive areas on a case by case basis b) Develop an education and outreach program about what to do if a below ground tank is discovered	a) 1 b) 1	a) AEP, ASIRT b) GGAMAA, MPWA, AEP

11.	15	Road salt application	a) Plan a communication meeting with La Prairie Group to discuss Beneficial Management Practices, training, etc. b) Test wells and surface water near roads for salts to determine if there is an impact	a) 1 b) 1	a) La Prairie, Group, GGAMAA, municipalities, operators b) GGAMAA, MPWA, post secondary institutions, PCBFA, NPARA, Schools
12.	12	Dangerous goods transport routes	a) Review and increase awareness around Emergency Response Plans regarding impacts to the aquifer, high risk/sensitive areas, spill response. Recommend that Dangerous Goods routes bypass the aquifer where feasible (ie. not shore haul)	a) 1	a) Transportation, ASIRT, GGAMAA
13.	12	Historical dumps/landfills	a) Inventory locations, determine which decommission and reclamation standards apply, determine if monitoring and reporting is occurring. Increase communication around monitoring and reporting (as per approval/registration requirements) b) Engage AEP to potentially reclaim old sites to more stringent guidelines in sensitive areas	a) 1 b) 2	a) GGAMAA, municipalities, AEP b) GGAMAA, AEP
14.	12	Improper disposal of household hazardous waste	a) Increase community education, outreach, and engagement (newsletters, newspapers, social media, radio) on proper disposal of HHW b) Build on community clean-up, increase engagement, education, hold during the same week/weekend every year c) Improve signage at transfer stations (maybe) d) School education program	a) 1 b) 1 c) 2 d) 2	a) GGAMAA, MPWA, municipalities, AEP, Alberta Recycling, eco centers, transfer stations, landfills b) Municipalities, contractors, eco centers, transfer stations, landfills c) GGAMAA, municipalities, transfer stations d) Schools, GGAMAA
15.	10	Fracking and active oil and gas wells	a) Have all municipalities within aquifer incorporate by-law b) Engage AER in discussion around developing buffer zone around aquifer boundary/recharge areas (using precautionary principle), what is required to establish, willingness to adopt (consider adding Grimshaw to Directive 8) c) Engage AER in discussion around well inspections, maintenance, particularly for those wells constructed prior to development of by-law d) Request AER develop communication materials with technical content around wells	a) 1 b) 2 c) 2 d) 2	a) Municipalities, GGAMAA, industry, AER b) GGAMAA, AER, MPWA, AEP c) GGAMAA, AER, MPWA, AEP d) GGAMAA, AER, Frac Focus, CAPP, AEP

16.	10	Abandoned rail lines/stations/stock yards	a) Engage Canadian Transportation Agency around decommissioning, monitoring, etc. b) Determine locations and generate map of all abandoned lines, stations, stock yards c) Engage agricultural services board (or applicable body) around application practices of herbicides for weed control on rail line	a) 3 b) 2 c) 3	a) Canadian Transportation Agency, GGAMAA b) AEP, CTA, GGAMAA c) ASB, GGAMAA, CTA
17.	10	Microplastics	a) Incorporate microplastics as parameter to assess in environmental baseline study b) Promote plastic reduction practices	a) 3 a) 1	b) Post secondary institutions, GGAMAA, MPWASchools, ASB, GGAMAA, MPWA, local businesses, Alberta Recycling
18.	9	Borrow pits/dug outs	a) Decommission existing borrow pits that are not currently in use b) Develop or reference dugout best practices documents, incorporate into public education and outreach plan c) Engage in reclamation or improvement (where needed/possible) of high risk dug outs	c) 3 d) 2 e) 3	a) AB Transportation, AEP, municipalities, landowners b) GGAMAA, MPWA, PCBFA, NPARA, ASB c) Landowners, GGAMAA, PCBFA, NPARA, ASB
19.	8	Active fuel storage tanks	a) Incorporate information and mitigation information into farm plans (pertaining to risks to aquifer as well as Emergency Response Plan in worst case scenario) b) Incorporate fuel tank best management practices/regulations into farm plans	a) 2 b) 2	a) Landowners, NPARA, GGAMAA, PCBFA, ASB b) PCBFA, GGAMAA, NPARA
20.	7.5	Forestry	a) Communicate with AAF to reduce use of herbicides, manage run-off, flag special/sensitive areas	a) 1	a) AAF, GGAMAA, MPWA, Forestry companies (Canfor, DMI)
21.	6	Storage of agricultural chemicals (private)	a) Education and outreach around storage of agricultural chemicals, impact on aquifer, sensitive areas.	a) 2	a) NPARA, MPWA, GGAMAA, ASB, PCBFA
22.	6	Rail transport	a) Identify critical/sensitive areas and share information with rail companies b) Review Emergency Response Plans and improve (if needed), request additional spill response equipment on-site within aquifer (if needed)	a) 1 b) 1	a) GGAMAA, CN, ASIRT, MPWA b) GGAMA, CN, ASIRT, MPWA

23.	6	Improper disposal of hazardous waste by local businesses	a) Review business licence agreements to incorporate mitigation measures identified in source water plan b) Develop education and outreach materials/program for business owners on aquifer risks, best practices, etc.	a) 3 b) 3	a) Municipalities, business owners, GGAMAA, MPWA b) Municipalities, business owners, GGAMAA, MPWA
24.	6	Active landfills, dumps, and transfer stations	a) Engage landfill and transfer station operators of facilities in sensitive areas of the aquifer to increase due diligence, compliance with regulations, increased signage, etc.	a) 2	a) Municipalities, operators, GGAMAA, MPWA
25.	6	Inactive bulk plants	a) Identify locations, determine risk to source water, owner, and if site has been decommissioned or remediated	a) 3	a) AEP, GGAMAA, MPWA
26.	4	Maintenance yards and industrial sites	a) Engage with AEP to focus inspections/increase frequency of inspections in sensitive areas of aquifer b) Identify sites and engage around following regulations/BMPs and disseminating information on aquifer risk and sensitivity	a) 2 b) 3	a) AEP, GGAMAA, MPWA b) Business owners, GGAMAA, watershed group (future, if established), AEP
27.	4	Municipal wastewater facilities	a) Ensure continuing compliance with regulations b) Ensure facilities have communication plan with downstream communities, residents, landowners, etc. in the event of an emergency release	a) 3 b) 3	a) Municipalities, GGAMAA, operators b) Municipalities, GGAMAA, operators, landowners/residents, water coalition north
28.	5	Residential yard maintenance	a) Education and outreach around risk of pesticides and herbicides to aquifer, accessing existing literature (green acreages guide)	b) 3	f) Landowners, GGAMAA, MPWA, Land Stewardship Center, municipalities, ASB
29.	4	Hydro-vac trucks	a) Ensure hydro-vac operators are following best practices for spreading	c) 3	g) GGAMAA, companies, landowners

Table 11: List of Abbreviations

Abbreviation	Explanation
AAF	Alberta Agriculture and Forestry
AB	Alberta
ABMI	Alberta Biodiversity Monitoring Institute
AEP	Alberta Environment and Parks
ASB	Agriculture Service Board
ASGA	Alberta Sand and Gravel Association
ASIRT	Alberta Serious Incident Response Team
AWWOA	Alberta Water and Wastewater Operators Association
CAPP	Canadian Association of Petroleum Producers
CN	Canadian National Railway
CTA	Canadian Transportation Agency
DU	Ducks Unlimited
GGAMAA	Grimshaw Gravels Aquifer Management Advisory Association
MMSA	Mackenzie Municipal Services Agency
MPWA	Mighty Peace Watershed Alliance
NPARA	North Peace Applied Research Association
PCBFA	Peace Country Beef and Forage Association
TSAG	Technical Services Advisory Group

APPENDIX D

Public engagement process/summary/report

- An online survey was released March 22, 2019 and closed (1 week after open house)
- An open house event was held in Grimshaw from 4 pm until 9 pm at the Grimshaw Legion
    - Maps, the draft plan and other materials were available to the public.
    - Project Team members were also available to explain the plan