2017

Non-Saline Groundwater in the Peace-Slave Watershed

Report to the MPWA IWMP Steering Committee

Non-Saline Groundwater Working Group
1/31/2017

EXECUTIVE SUMMARY

The Mighty Peace Watershed Alliance (MPWA) Integrated Watershed Management Plan (IWMP) Steering Committee struck a multi-sector *Non-Saline Groundwater Working Group* to investigate a number of non-saline groundwater-related topics and provide recommendations to the Steering Committee for consideration in their planning process. The Working Group met five times, sharing sector perspectives and information, before drafting its recommendations and report.

Overall, the Working Group found that while non-saline groundwater is present throughout the Peace-Slave watershed, it is difficult to assess the state of this resource given the current level of knowledge. Some areas within the watershed have groundwater information and others have none. Until we have a more complete understanding of non-saline groundwater aquifer volumes, as well as an understanding of current and future use, potential risks, cumulative effects, and how climate change will affect this resource, it is challenging to set groundwater management priorities. Hence the majority of recommendations made by the Working Group focus on building better baseline information, and communicating this information to decision-makers in the Peace-Slave watershed.

"We need to more pro-actively manage groundwater as an integrated part of the water cycle and the watershed." Working Group Member

ACRONYMS

AAF	Alberta Agriculture and Forestry
AAFC	Agriculture and Agri-Food Canada
AEMERA	Alberta Ecological Monitoring, Evaluation and Reporting Agency
AEP	Alberta Environment and Parks
AER	Alberta Energy Regulator
AGS	Alberta Geological Survey
AHS	Alberta Health Services
AWC	Alberta Water Council
BMP	Best or Beneficial Management Practices
CEP	Conservation, efficiency and productivity
cm or m^3	cubic meter
dam^3	cubic dam (1 dam^3 = 1000 m^3)
EIA	Environmental Impact Assessment
GGAMAA	Grimshaw Gravel Aquifer Management Advisory Association
GOA	Government of Alberta
GOC	Government of Canada
GOWN	Groundwater Observation Well Network
IWMP	Integrated Watershed Management Plan
MPWA	Mighty Peace Watershed Alliance
NRCB	Natural Resources Conservation Board
PFRA	Prairie Farm Rehabilitation Administration
TDS	Total Dissolved Solids
WG	Working Group
WPAC	Watershed Planning and Advisory Council
WURS	Water Use Reporting System

ACKNOWLEDGEMENTS

The Working Group (listed in Appendix 1) thanks their sectors and agencies for supporting their participation on the Working Group. The Group thanks all those who made sector presentations and provided additional information to inform our work. We also thank Mighty Peace Watershed Alliance (MPWA) staff for their administrative support of the Working Group as well as the staff of the Belle Petroleum Centre (Peace River) for their logistical assistance. Finally, we thank the IWMP Steering Committee and the MPWA Board for providing this opportunity to provide meaningful input into their Integrated Watershed Management Plan for the Peace-Slave watershed.

INTRODUCTION

BACKGROUND

After completing a '*state of the watershed report*' and in developing their terms of reference for an Integrated Watershed Management Plan (IWMP), the Mighty Peace Watershed Alliance (MPWA) identified a number of topics relevant to future areas of work, including *'non-saline groundwater'*.[1] Non-saline groundwater is an important source of water for individuals, communities, the environment and industry throughout the Peace-Slave watershed.

To investigate this topic further, the IWMP Steering Committee struck a multi-sector Non-Saline Groundwater Working Group (WG). Membership of this group is listed in Appendix 1. The Steering Committee also developed terms of reference (Appendix 2) which included a number of groundwater-related topics for the WG to investigate further.

Through this report, the WG will provide its findings to the IWMP Steering Committee and, ultimately, the MPWA Board of Directors, for their consideration in developing an IWMP. The purpose of the IWMP is to address effective and sustainable management and use of the water resources in the Peace-Slave watershed. Creation and implementation of the plan will also support the achievement of *Water for Life's* three main goals of: safe, secure drinking water; healthy aquatic ecosystems; and reliable, quality water supplies for a sustainable economy.

METHODOLOGY

The WG met five times from October 2016 through January 2017. After sharing sector perspectives and information on groundwater and groundwater management in the Peace-Slave watershed (see Resources in Appendix 3), the WG then developed recommendations for the Steering Committee. This includes a work plan (Appendix 4) with future groundwater-related activities for inclusion in the MPWA IWMP.

While they endeavored to work in a multi-sector, consensus-seeking manner, the WG was limited by the short amount of time provided to undertake their tasks. Thus, while this report provides a summary of what was learned and discussed, as well as a number of recommendations for consideration in further work, it by no means implies broad sector approval. Further sector engagement and consultation on non-saline groundwater and other related topics will be necessary as the IWMP process moves forward.

[1] Note that other topics identified by the MPWA and reported on elsewhere included water quality and availability away from the mainstem, wetlands and wetland loss, Peace River flow regime and consumptive use of fresh water.

WORKING GROUP FINDINGS

DEFINITIONS

Groundwater can be described as *"all of the water below the surface of the earth."* It originates from rainfall and snowmelt that penetrates the layer of soil just below the surface.

Groundwater can be found in practically every area of the province, but depths, yields, and water quality vary. To be a recoverable resource, it must exist in an **aquifer**. An aquifer is a water-bearing geologic unit below the groundwater table, fully saturated with water, with permeable enough materials (often sand and gravel rather than silt and clay) to allow water to flow at a significant rate.

What is Hydrogeology? The study of groundwater is closely linked to geology (the study of the Earth). Hence the term *hydrogeology* is used to describe the area of geology that deals with the distribution and movement of groundwater in the soil and rocks of the Earth's crust (commonly in aquifers).

Aquifers can be **Surficial** or **Bedrock** aquifers. Surficial aquifers are *generally* shallower with 'younger' *fresh* water (non-saline) suitable for domestic use and agriculture. However, they can also be quite variable in depth, extent and quality of water. Surficial aquifers are recharged by infiltrating surface waters. Residence time (the time between when the aquifer is recharged by inflows and when it discharges its water back to the surface) is usually short and groundwater flow fluctuates seasonally and annually, in response to surface conditions like drought or heavy precipitation. Shallow groundwater tends to retain surface water characteristics. In addition, shallow aquifers can be vulnerable to surface contaminants. Surficial aquifers include both **alluvial** and **buried channel** aquifers.

Surficial Aquifers

Surficial aquifers include both alluvial and buried valley aquifers. **Alluvial aquifers** are generally shallow sand and gravel deposits laid down over time in a river channel or floodplain, typically occurring between 10-30 m (33-100 ft.). The name "alluvial" refers to the loose, unlayered nature of the material – often silt, clay, sand, and gravel, deposited by running water in and around rivers.

In Alberta, there is a vast network of interconnected valleys located beneath the land surface. These **buried valleys** appear to have been carved into the upper portion of the underground rock formations and sometimes contain extensive deposits of sand and gravel. They range in depth from 15-90 m (50-300 ft.) and in width from under 0.4 km (1/4 mi.), to over 16 km (10 mi.). For more information on Alberta's groundwater aquifers, see Alberta Agriculture and Forestry's webpage *Understanding Groundwater* or the Alberta Waterportal groundwater webpage.

In contrast, bedrock aquifers are *generally* deeper, often with older water and potentially poorer quality. Deep aquifers are recharged as part of the regional groundwater flow regime which can be very slow (up to thousands of years). This water might be used for industrial use, depending on how 'brackish' or salty (saline) it is. Water that has Total Dissolved Solids (TDS) greater than 4000 mg/L is defined as **saline** in Alberta. Anything less than 4000 mg/L is defined as **non-saline**. Note however that not all non-saline water is potable, or even suitable for treatment. That is, even within the definition of non-saline water, there is a useable portion and a portion that may be too saline for certain uses.[2]

Finally, aquifers can be 'confined' or 'unconfined'. A confined aquifer is one that is not readily connected to the surface (i.e., it is confined by an upper layer of impermeable material also known as an aquitard). An unconfined aquifer only has a bottom aquitard with its top still exposed to the ground surface.

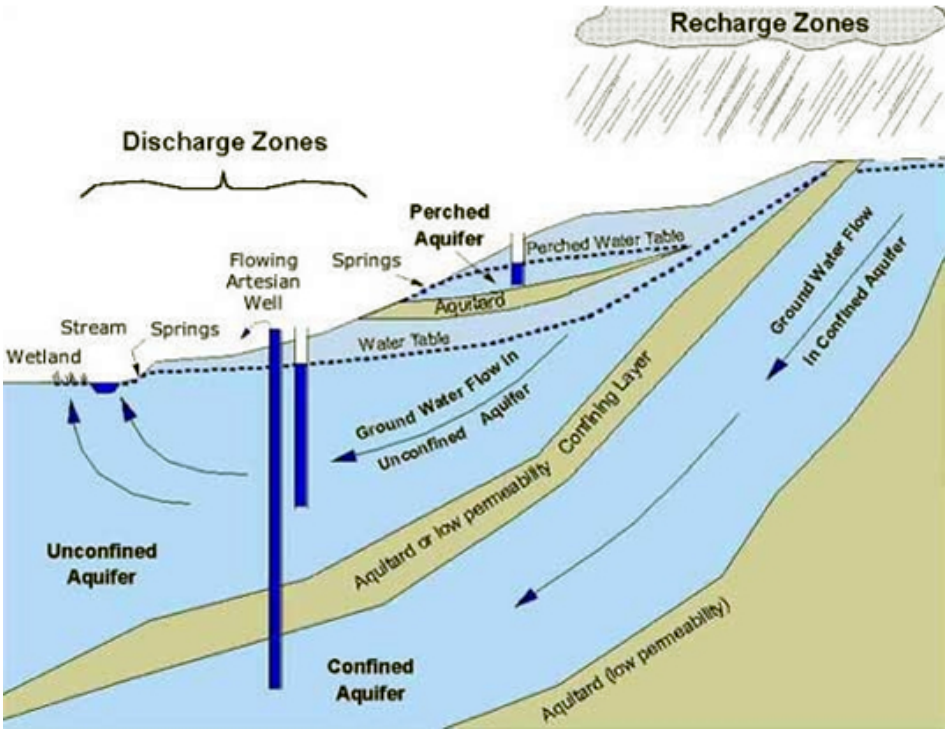


Figure 1. This graphic, from the Alberta Environment and Parks Groundwater webpage, provides a good overview of how surface water recharges groundwater aquifers, which in turn discharge to the surface.

[2] Note that the AER provides industry and others with the Base of Groundwater Protection Query Tool which gives information by legal land location on the elevation of the base of the formation in which non-saline groundwater occurs at that location.

Ground Water Reserves

The province of Alberta is thought to have about 40,000 cubic kilometres of groundwater — enough to cover the entire province in about 60 metres of water. But only 0.01% of this groundwater is thought to be recoverable.[3] While groundwater studies have been conducted throughout the province, generally speaking, more is known about the southern part of the province and less is known about the north.

To add to its complexity, groundwater doesn't follow surface sub-basins. Instead, for the Peace-Slave watershed, aquifers can be placed in western and eastern groupings.[4] The Western Grouping includes aquifers underlying the Smoky/Wapiti, Upper and Central Peace sub-basins. This includes several surficial aquifers such as the Grimshaw Gravel, Bezanson/Brazeau, Grande Prairie, Wembley, and Shaftsbury aquifers. The western grouping also includes several bedrock formations such as the Horseshoe Canyon, Oldman, Foremost, Dunvegan, Shaftsbury and Peace River.

More is known about western aquifers than those to the east. Information from well-logs, pumping tests, storage and long term yield data have been compiled. This information tells us that there are more bedrock aquifers in this area with a shortage of high-yielding non-saline water available.

The Eastern Grouping includes aquifers underlying the Lower Peace, Wabasca and Slave sub-basins. Although less is known about aquifers in this area, it is generally thought that groundwater is more abundant here. Surficial aquifers include several buried valleys such as Misaw and Atikameg aquifers. Bedrock aquifers also exist in this area but do not tend to provide water suitable for drinking water.

Although it is important to understand groundwater in the Peace-Slave watershed, it is challenging and costly to study and monitor this resource. Some baseline work was done to describe aquifers in the province between the late 1960s and early 1980s. Additionally, the Prairie Farm Rehabilitation Administration (PFRA) has conducted Regional Groundwater Assessments (yield, quality and depth) across the White (Settled) Area of the province. The 2004 report for the Peace White Area estimated total groundwater use within the Study Area as 66,756 m^3/day. Approximately 34% of the total estimated groundwater use is from licensed and registered water wells, the remainder from unlicensed wells for domestic and livestock use. This information from the PFRA assessment on groundwater potential can be queried for a specific legal land location using an online tool created by Hydro-geological Consultants Limited.

[3] As per the Government of Alberta's Focus on Groundwater: Groundwater Use.
[4] For more on this, see the MPWA Regional Hydrological Assessment of the Peace River Watershed Background Report.

For a good overview of what is known to date about the extent and nature of groundwater reserves in Alberta, including the northern watersheds, see the Alberta Geological Survey's Compilation of Alberta Groundwater Information from Existing Maps and Data Sets (2009) report.

Groundwater Monitoring

The Government of Alberta (GOA), through Alberta Environment and Parks (AEP), maintains a groundwater management framework that includes about 250 active monitoring wells throughout the province, making up the Groundwater Observation Well Network (GOWN).

In recent years, the province has looked at how to make this system more efficient in terms of well distribution, sampling period, etc. Today, a 'backbone' of 60 active wells across the province are sampled annually. Data is then enhanced via a system of rotational wells sampled at a minimum of every three years.

Groundwater Observation Wells are targeted to monitor surficial (alluvial and buried channel) aquifers, monitoring ambient conditions.[5] Data recorders at each station provide hourly, real-time data such as water level, temperature and pressure.

Today in the Peace-Slave watershed, there are four backbone wells (with depths varying from 12 to 105 m). There are five additional wells monitored on a rotational basis. All nine wells are non-saline water; however, TDS is variable from well to well.

Looking at the data collected through this monitoring framework over time, certain trends can be discerned. Aquifer water levels can show both a short term seasonal variation as well as a longer year-over-year trends.

[5]Note that this program is different from programs aimed at testing domestic drinking water wells. Data from drinking water well testing is managed by Alberta Health Services.

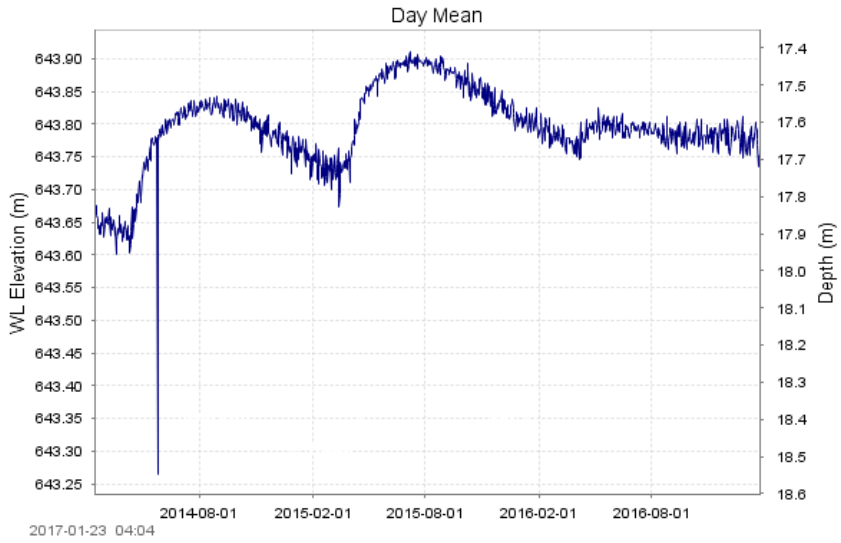


Figure 2. Grimshaw groundwater observation well data showing seasonal trends downloaded from AEP GOWN website Jan. 23-17.

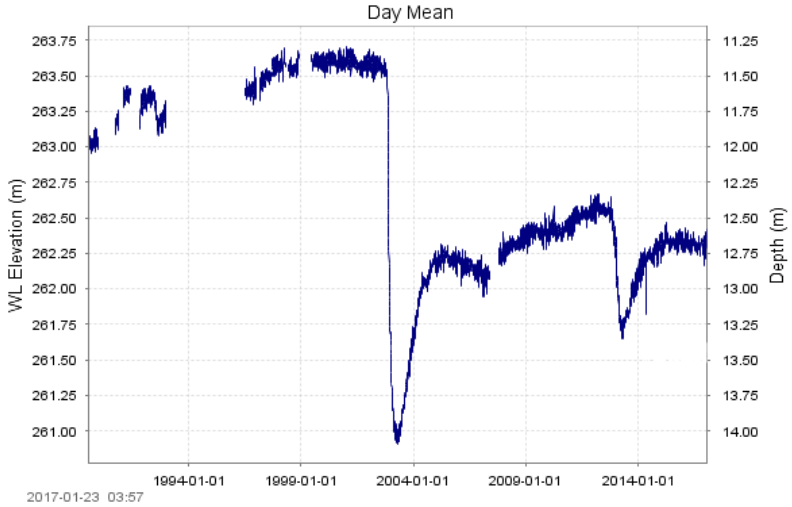


Figure 3. LaCrete groundwater observation well data showing a decline and slow recovery downloaded from AEP GOWN website Jan. 23-17.

The Groundwater Observation Well Network (GOWN) also monitors groundwater quality periodically at some locations. Ten wells are used to sample water quality (pH, dissolved oxygen, etc.) in the Peace-Slave watershed. Alberta Health and Wellness also promotes drinking water well-testing by all domestic well owners.[6] From AHS testing results collected from 1,258 domestic wells collected over the past decade, only a few domestic wells have exceeded Canadian Drinking Water Quality (CDWQ) guidelines (maximum acceptable concentration) for nitrate (6), arsenic (4), lead (4) and antimony (2). A larger number of wells (249) showed an exceedance for fluoride. Note that AEP asks groundwater licence-holders for a chemical analysis annually (a list of parameters is provided). Information is submitted

[6] For information about the Working Well Program, see http://aep.alberta.ca/water/education-guidelines/working-well/default.aspx.

through the water use reporting system (WURS). The University of Calgary has done some work on consolidating this information. Also, the Grimshaw Gravel Aquifers Management Advisory Association has a citizen science program involving local well-owners who submit regular test samples for analysis. To date, this program has shown that there is a fair amount of chemical variation between wells.

Groundwater under the direct influence of surface water (GWUDI) refers to groundwater sources that are vulnerable to contamination by pathogens from nearby surface water or infiltrating precipitation. Groundwater sources that are determined to be GWUDI[7] require treatment equivalent to that required for surface water sources if used as potable water.

Although there is no other systematic groundwater quality testing program in the Peace-Slave watershed, there is likely other information available from the literature. Unfortunately, it is beyond the scope of this project to conduct a comprehensive literature search to find such information. Note that although studies on topics such as selenium toxicity in fish and fish consumption warnings for mercury do exist, they generally tend to focus on surface waters, rather than groundwater.
Finally, AEP and AGS have partnered since 2008 to improve the inventory and mapping of Alberta's groundwater resources, establishing quantity and quality at a regional scale. This information is needed to help government make informed decisions about groundwater including assessing and understanding the cumulative effects of development.

Most of this work has been done in the Edmonton-Calgary corridor (see the Edmonton-Calgary Corridor Groundwater Atlas) and Calgary-Lethbridge Corridor but recently, there has been a focus by government and industry on provincial 'hotspots' such as Fox Creek and Grande Cache in order to support regional planning and regulatory initiatives. In the north, these hotspot areas are experiencing increased activities such as hydraulic fracturing and coal mining. Hence improved knowledge of the groundwater resource is required to ensure this resource is being managed sustainably, both for industry and communities, now and in the future.

Groundwater and the Town of Fox Creek

In the past, the Town of Fox Creek, population about 2500, relied on four or five wells to provide the town's domestic water supply. Flow rates were never great in these existing wells. In fact, levels have been declining over time and about three years ago became insufficient to meet town needs.

Requiring more water, the Town applied for and received permits to drill 13 new wells. All new and existing wells sit over two aquifers in the Paskapoo formation (drillers are not allowed to drill multi-aquifer wells). Although sufficient for the time being, these new wells also lack a good flow and may not meet future needs. Although the Town's source water quality is fairly good, some water quality concerns in the area including high iron, fluoride, arsenic, permanganate and chlorinate.

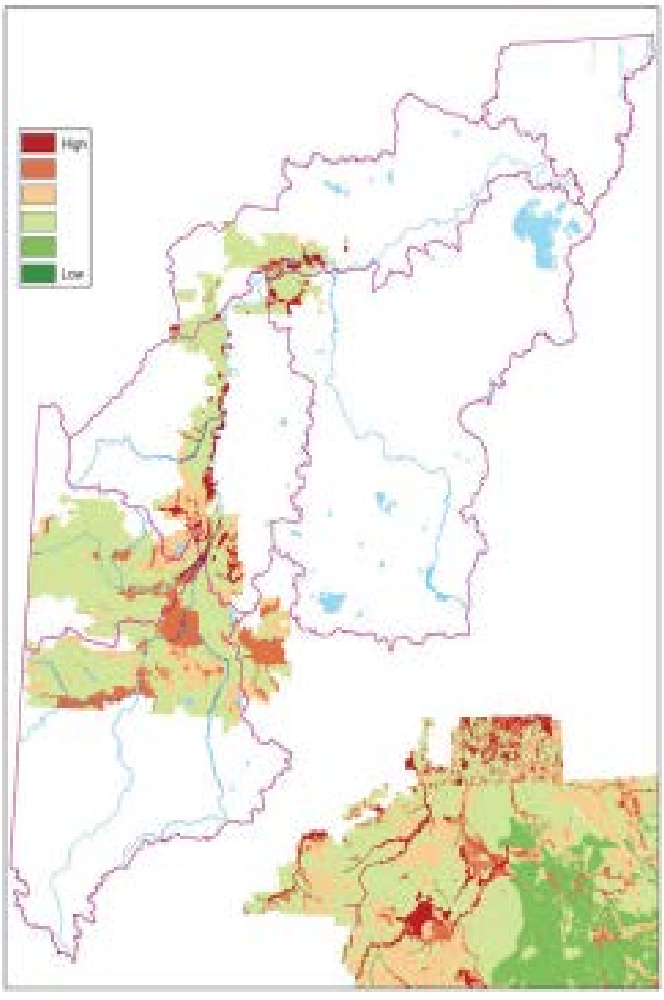
The Oil and Gas industry is also very active in this area, using hydraulic fracturing to recover local oil reserves. This sector uses both surface and ground water sources to meet its needs. Surface water withdrawals out of the Little Smoky river system has led to some concern, particularly during low flow periods in the fall and winter when local fish species, like the endangered Bull Trout, may be at risk. Interactions between surface and groundwater, via groundwater discharge to the Little Smoky River, also make managing this system complex. The AGS has released a report that illustrates the interaction between the Little Smoky River and groundwater.

There is also some concern about surface water withdrawals out of local lakes. Town councillors have been working more closely with the Alberta Energy Regulator (AER) in recent years to ensure such withdrawals are licenced. AER, working with stakeholders, has trial run an 'Area Based Regulation' initiative to try and manage

Potential Risks to Non-saline Groundwater

Contamination

As mentioned previously, shallow aquifers are influenced by surface water quality and can be vulnerable to surface contamination. Factors such as soil, slope, drainage, aquifer depth, etc. can affect potential risk.



Contamination can occur via drinking water wells that are not properly abandoned. This can increase the risk of potential contamination from surface run-off from agriculture (pesticides, fertilizers, manure, viruses and bacteria) or other industrial and commercial activity (e.g., spills). Part 7 of the Water Ministerial Regulations specifies both the construction and reclamation required for a drinking water well in order to minimize the risk of contamination. Areas with shallow overburden, or other areas of

recharge or discharge, can also be entry points for contaminates.

Looking at depth, slope and soil, PFRA has done some groundwater vulnerability mapping in the White (settled) Area of the watershed. More could be done throughout the basin. Mapping other land cover and land uses can also inform the risk of potential contamination. PFRA has produced a number of maps looking at risks such as livestock density, wastewater discharge, well density, industrial operations, surface water quality, etc.

Figure 4. For better resolution of this groundwater vulnerability map, follow the link to the PFRA report.

OVER ALLOCATION

According to AGS, there were about 5,000 drinking water wells in the Peace-Slave watershed in 2009.[8] Just under half of these are domestic wells. The remainder are a mix of industry, agricultural (stock watering and irrigation) and municipal wells.

Overall, the total (surface and ground) water allocated for use (less than 1% of annual yield) is relatively minor compared to the water available in this watershed. And groundwater allocations are only a small (less than 10%) portion of the total amount allocated. However, groundwater allocations increased a fair amount from 2011 – 2013 in the Peace-Slave watershed as growth and development also increased. This has led to some concern in some local areas where landowners and municipalities are reliant on groundwater and growth and development is expected to increase again in the near future.

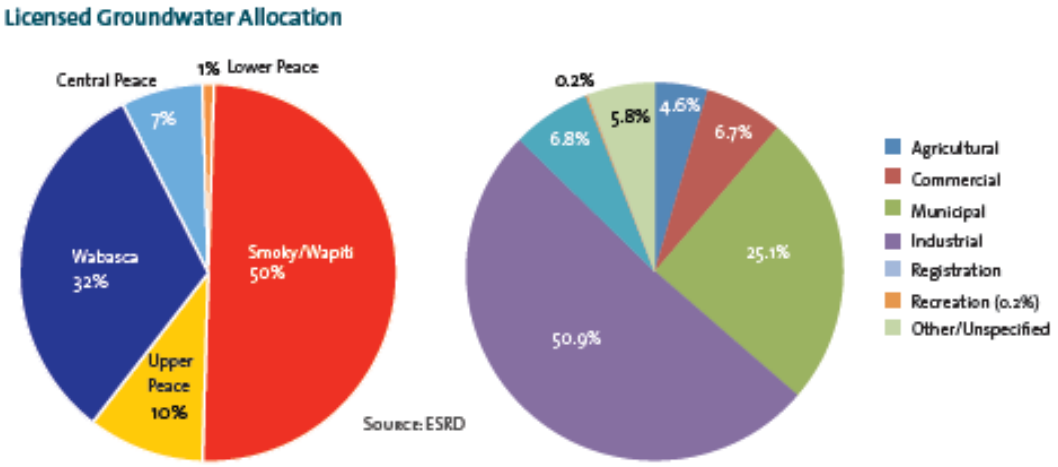
Today, most of these groundwater allocations occur in the Smoky-Wapiti and Wabasca sub-basins. There are no groundwater allocations in the Slave sub-basin. About half of the groundwater allocated is for industrial use, in particular, for oil and gas activities (i.e., in situ and hydraulic fracturing). Groundwater quantity can also be affected by changes on the landscape (such as the loss of wetlands; the drawdown of a lake or river) and by climatic events such as drought, floods, etc.

[8] From the AGS Compilation of Groundwater Information report.

Peace River Basin: Current Allocation

Industrial Activity	SW	GW	Total
Total (dam^3)	**175,213**	**18,708**	**193,921**
Agricultural	7,720	2,378	10,098
Commercial	96,280	593	96,873
Industrial	9,924	9,568	19,492
Municipal	28,740	4,783	33,523
Water Management and Other Use	32,550	1,385	33,935

Figure 5. Total surface and groundwater allocation in the Peace-Slave watershed.



Agriculture and Groundwater in the Peace-Slave watershed

About 5% of groundwater allocations in the Peace-Slave watershed are traditional registrations which allow an agricultural landowner to divert and use groundwater for the purpose of raising animals or applying pesticides to crops, as part of a farm unit. A registration of a diversion of water may not exceed 6250 cubic metres (cm) of water per year or the maximum amount specified in an applicable approved water management plan. A landowner had to prove first diversion of such water occurred prior to January 1, 1999 and the registration had to be made before December 31, 2001 (they are no longer available).

Another 6.4% of allocations in this basin were made by the agricultural sector via *Water Act* approvals. These are generally made for larger operations requiring more than 6250 cm allowed through registrations and are used for livestock watering and a small amount of irrigation.

Commercial Sector and Groundwater Use in the Peace-Slave Watershed

About 7% of groundwater allocations in the Peace-Slave watershed are allocated to commercial operations. These can include sand and gravel operations, construction (road dust control) and business parks.

Sand and gravel operations are a bit different from a typical licence to divert in that gravel extraction creates an end pit lake which becomes a sink due to evaporation. Surface water run-off adds volume to the lake but usually a water deficit is created at the end of operation. There may also be some loss during washing but overall the loss is small. Management of the lake can also affect water in downstream springs and rivers.

Hydraulic Fracturing and Groundwater Use

Hydraulic fracturing is a process whereby water is pumped down a well at high pressure to fracture the rock so gas (or oil) can flow. Sometimes the water is mixed with sand and chemical additives. Water use at a hydraulic fracturing site, though intensive, is short-term, often only a few days or weeks. Wells then produce oil or gas for 20-40 years, with no additional water requirements.

Wells for hydraulic fracturing are drilled 2-3 km deep - far below the water table. Hence impacts to much shallower domestic water wells due to interactions with the well where hydraulic fracturing is occurring are rare. To ensure this, Canadian Association of Petroleum Producers (CAPP) member companies meet or exceed a number of requirements for domestic water well testing pre- and post-drilling.

Additionally, the wellbore is designed and constructed to protect groundwater from the migration of gas and fracturing fluids into the aquifer. Multiple steel casings are cemented in place. Shale rock is also a natural barrier to migration. Groundwater protection is regulated by the AER at all stages of oil and gas activity.

DATA GAPS

Although there has been some work to understand the groundwater resource in the Peace-Slave watershed, efforts have typically been focused on study areas much smaller than the watershed and

there are still major gaps in our understanding. These gaps are discussed more under the sub-headings below.

GROUNDWATER QUANTITY

Currently, a provincial inventory of groundwater does not exist so it is not entirely clear when and where non-saline ground water can be used, in what amounts, in order to still be managed sustainably. However, there are tools (e.g., licensing, pump recovery tests/recharge rates, threshold / closed aquifers, etc.) to manage for sustainability on a local basis.

Without knowing how much of a groundwater resource we have, its difficult to know how much we can safely allocate, while still ensuring groundwater will continue to be sustainable in the future. Few aquifers in the Peace-Slave watershed have been accurately delineated (mapped). Without knowing the extent and other characteristics (e.g. porosity, etc.) of an aquifer, it is difficult to know the volume of water it holds at any given time, or the amount that can be sustainably withdrawn.

While groundwater mapping, using a combination of existing and new information (such as aerial surveys and core samples) has been done in the south (see the Edmonton-Calgary Corridor Groundwater Atlas), it is an expensive and time-consuming process. In the absence of any major issues, the likelihood of doing this type of work for the entire Peace-Slave watershed is very small. However, smaller projects to delineate the groundwater resource in 'hotspot' areas like the AGS Fox Creek project, might be considered if the benefits of this information out weigh the costs and/or the information is required to manage groundwater sustainably in such areas. One outcome of mapping in 'hotspot' areas is an assessment of the groundwater inventory.

In the absence of known volume data for a given target aquifer, groundwater managers focus on not withdrawing more than is being recharged to the aquifer in the vicinity of the pumping well. Pumping rates are tested at each individual well and this information is required by the applicant before diversion is permitted. In order to evaluate whether a pumping rate is sustainable pumping tests are evaluated by qualified professionals to determine the long term sustainable yield of the targeted aquifer unit in the vicinity of the pumping well. The challenge in using this approach is understanding the cumulative effects of multiple wells/withdrawals on an individual aquifer.

INTERACTIONS BETWEEN GROUND WATER AND SURFACE WATER

Groundwater movement is dynamic and dependent on recharge and discharge rates. In particular, groundwater recharge can be influenced by both short-term climate events such as droughts, floods, and precipitation events, as well as long term climate change.

In turn, discharge can be affected by withdrawals. That is, water taken out of the groundwater system via a well, even at or below the recharge rate, might otherwise have been discharged to a river, lake or wetland that in turn supports fish and other aquatic species. Hence, surface water and groundwater are integrally tied, and should be managed together. However, we have very little information on recharge and discharge areas and other interactions between surface and groundwater, even for our better-known aquifers such as the Grimshaw Gravel Aquifer.

> ***Did you know?***
>
> The AGS Springs inventory program is working to map all of the known springs in the province. A spring occurs where an aquifer is filled to the point where groundwater overflows onto the land surface and creates visible flow. In the Peace-Slave watershed, important springs occur at Whitelaw Springs, Deadwood Springs, near Grande Cache and south of Grimshaw.

Surface water also affects the quality of groundwater, at least in shallow surficial aquifers. Hence, what we do on the land, and how we manage risks like contamination, point and non-point source pollution, soil erosion, wetlands, etc., can impact the quality of groundwater. To date, however, we have limited information about the risk of potential pollution to our aquifers from land cover changes. This may warrant further studies in areas that are still undergoing clearing, wetland drainage and other land use changes (e.g., Mackenzie County) or areas that are believed to be closely associated to recharge and discharge areas (e.g., Lac Cardinal and the Grimshaw Gravel Aquifer). Areas important for groundwater protection should be noted as such in regional and municipal land use plans. Like surface water sources, aquifers could also undergo risk assessment and source protection planning to ensure their protection.

Synthesizing Existing Information

While there are obvious gaps in our knowledge about non-saline groundwater, there is a fair amount of data in different databases including well driller logs, industry records, government departments (AEP, AHS) and regulating/licensing agencies (AER). Unfortunately, much of this data has not been shared, analyzed and put together to provide a more comprehensive picture of the groundwater resource for the province, as well as for the Peace-Slave watershed.

Fortunately, to begin to address this issue, the Canadian Association of Petroleum Producers (CAPP) has partnered with AGS, AEP and others to begin to identify all such pockets of data and to enter them into a shared database (building on the AGS Coalbed Methane database). This initial work will hopefully lead to further efforts to synthesize information and identify knowledge gaps. While it is too early to tell how far this project will get, the MPWA can stay informed of its progress through its Oil and Gas board member.

Groundwater Management

Non-saline groundwater is an important resource as source drinking water for many rural and municipal basin residents. It is also important for agriculture, oil and gas and other sectors. Groundwater also has its own intrinsic value, as a component of the water cycle, the watershed, and the natural environment. As discussed previously, groundwater is integrally tied to surface water, and can be affected by what we do on the landscape.

Water in Alberta belongs to the Crown and is managed by the GOA. The Province is guided by the *Water Act*. Under the act, Albertans living on property under which groundwater exists have the statutory right to use up to 1,250 cubic meters (m^3) of water per year for household purposes. Beyond this amount, water cannot be diverted without a licence. Typically, a well is drilled and tested, application is then made to the appropriate licensing body (AEP or AER), before water is diverted for use.

There are several resources available to assist private domestic well owners with drilling, maintaining and de-commissioning water wells.[9] Additionally, regulatory frameworks guide industry groundwater use, as well as industry activities that may affect groundwater. The AER manages this framework for the oil and gas sector, providing a number of directives, notices and other best management information to guide this sector. All other *Water Act* applications are directed to AEP.

Groundwater Licensing Application Review

Alberta Environment and Parks uses a six-step process to review groundwater licence applications as follows:

Step 1 – Proponent submits an application for a diversion.

Step 2 – Application is reviewed for administrative completeness.

Step 3 – Public Notice is completed and Statements of Concerns are received and reviewed.

Step 4 – Review of application for technical completeness (responsibility of the Regional Hydrogeologist using the Alberta Environment Guide to Groundwater Authorizations, education and experience, water well database, google and other maps, hydrogeological reports and aquifer analysis software) checking for the following:

- Was the application prepared by a qualified groundwater specialist (if > 3,650 m^3/year)?
- Does the application contain an adequate description of regional and local hydrogeology?
- Is the well constructed properly?
- Is groundwater under the direct influence of surface water?
- Was an adequate field-verified water well survey conducted?
- Was a pumping test conducted?
- Was the aquifer test data interpreted properly?
- Will the well be able to sustain the pumping rate being applied for?
- What are potential short and long term impacts on the aquifer, environment and other users in the area?

Step 5 – Director Decision (based on technical review decision)

Step 6 – Approval Appeal (if decision not accepted by applicant)

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Similar to the AER, the Natural Resources Conservation Board (NRCB) provides a regulatory framework and guidance for other natural resource projects and confined feeding operations. The NRCB provides a number of resources detailing regulations under the *Agricultural Operational Practices Act* and best management practices for such projects.

In theory, the GOA, through AEP, sets policy direction for groundwater management. Bodies such as AER and NRCB then regulate industry to achieve such policies. In practice, departments and agencies often work together to find solutions to issues as they arise. In addition, groundwater managers must also take a broad view, understanding how other provincial initiatives, such as the Wetland Policy, Land Use Framework, etc., can affect the groundwater resource.

Whether or not current policies, legislation and regulatory frameworks, with their associated directives, industry best management practices, etc. are effective at managing non-saline groundwater in the Peace-Slave watershed, is a difficult question to answer. When Alberta's *Water for Life* strategy was developed in 2003, it was driven by events that had occurred in Walkerton, Ontario, where several individuals died after agricultural run-off containing *E.coli* contaminated the local drinking water via an older groundwater well. Fortunately, Alberta has never had such an experience. We do, however, have issues arise from time to time. Adaptive management and continuous improvement are key to ensuring our groundwater resource continues to be protected.

Water conservation, efficiency and productivity (CEP) initiatives are also important for managing both surface and groundwater resources. In recent years, the AER has encouraged industry to move away from using high quality non-saline groundwater. Additionally, under *Water for Life*, water-using sectors have committed to improving CEP statistics. Initiatives to reuse, recycle and reduce water use have been undertaken. This includes using treated wastewaters from municipalities or other industries; utilizing produced (water that flows to the surface as a by-product of oil and gas production) or flowback (water that returns to the surface after being injected for hydraulic fracturing) waters. Note however, that there are financial and environmental trade-offs to using alternative water sources or less water-intensive technologies that may increase other environmental impacts (e.g., GHG emissions, waste, land disturbance, etc.) and they may not be appropriate in all cases. Environmental net effects of an activity must be considered in its full context and in consideration of cumulative effects on the landscape.

In general, the WG believes that groundwater is being managed well and the overall system is adaptive and responsive. As we learn, we implement the policies, legislation, and regulations needed to deal with specific issues as they arise. However, improvements could be made in making the public more aware of how the groundwater resource is being managed. This includes building and sharing a true understanding of baseline today (current quality and quantity) so that we are able to see and understand changes in the future.

Upstream Oil and Gas Water Conservation, Efficiency and Productivity Plan

The Upstream Oil and Gas Water Conservation, Efficiency and Productivity Plan scope includes water used for oil sands mining and in situ production (not including Peace River), conventional oil production, well drilling and completions and gas plants. It excludes shale gas production (due to lack of available data) and midstream or downstream oil and gas activities.

The plan provides actual production and water use statistics from 2000 to 2009, and projections to 2015. It uses two performance measures:

1. Non-saline water use productivity; i.e., the volume of non-saline water used per volume of hydrocarbon produced
2. Projected improvements compared to baseline (average of 2002 to 2004)

Between the baseline period and 2014, Alberta saw a 269% increase in bitumen production with a corresponding 56% increase in non-saline water use (from 12.5 million m^3 to 19.5 million m^3). Between the baseline period and 2014, Alberta saw a 7% decrease in conventional production with a corresponding 50% decrease in non-saline water (25.7 million m^3 to 12.9 million m^3). Overall, the proportion of non-saline water decreased from 75% to 62%. More information about this and other sector CEP plans is available on the Alberta Water Council website.

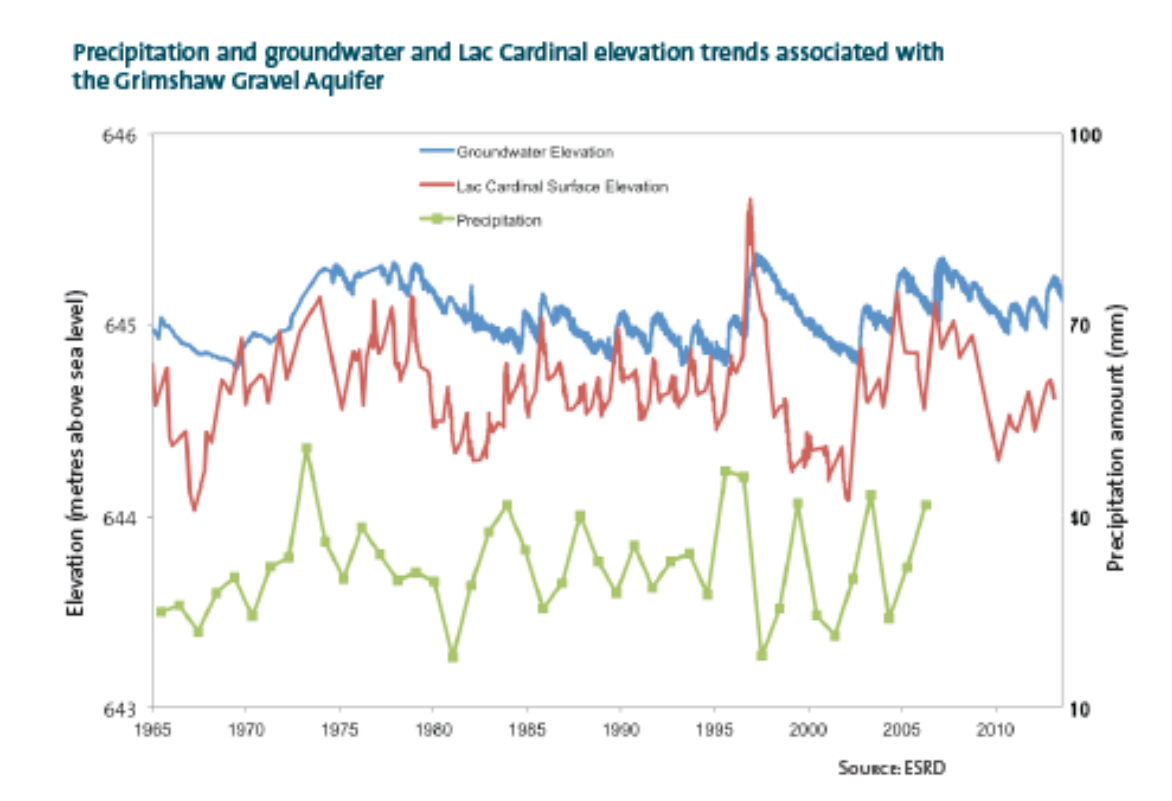
The Grimshaw Gravel Aquifer

To date, there is no particular framework for managing an individual aquifer. However, work on the Grimshaw Gravel Aquifer may lead to this.

West of Peace River, the Grimshaw Gravel Aquifer is a large, shallow sand and gravel aquifer, with high yields from 10 to 1000 cubic meters per day and excellent quality provided to approximately 7,500 users. With three lobes, it covers an area of 600 km^2, supplying source drinking water to Berwyn, Grimshaw, Whitelaw and Brownvale. It also supplies many landowners and industry.

The Grimshaw Gravel Aquifer is recharged by precipitation and possibly water from Lac Cardinal. Although levels have been known to fluctuate by as much as a meter the current supply is good, with no long term decline apparent.

The Grimshaw Gravel Aquifer Management Advisory Association (GGAMAA) was formed to develop a management plan for this aquifer and to promote best management practices to those active on and around the aquifer. For a review of the association's activities see the M.D. of Peace webpage. Though limited by capacity, this initiative could be used to showcase source protection planning and aquifer management in Alberta.



GROUNDWATER EDUCATION

In general, while there are some excellent resources available about groundwater, public knowledge about this resource may be limited in the Peace-Slave watershed.

Currently, public education about groundwater largely occurs through AEP's Working Well Program, that focuses on best management practices for individual domestic well owners. To date, a number of workshops have been held through the Peace-Slave watershed. AEP also provides fact sheets and web pages with more general information on groundwater. Agriculture and Forestry also has a webpage with several resources on water well management, particularly from a producer's viewpoint.

The MPWA also has a role in educating the public about groundwater. To date, this has occurred through its State of the Watershed report. In the future, the MPWA will continue to publicly report on the state of groundwater quantity and quality, as these are two indicators that will be used to measure IWMP progress over time. The MPWA might also consider doing more between state of reports to make basin residents more knowledgeable about this important resource.

RECOMMENDATIONS

After learning about non-saline groundwater, the WG was asked *"What should non-saline groundwater management look like in the Peace-Slave watershed in the future?"* The WG answered that non-saline groundwater should be:

- Sustainable (healthy, functional and resilient to change over time);
- Available (to landowners, communities, agriculture and industry);
- Managed adaptively (using benchmarks to measure progress in achieving clearly-defined objectives);
- Balanced with other social, economic and environmental values; and
- Monitored (i.e. both quantity and quality) in order to understand the current state of the resource as well as future status and trends.

From this discussion, the WG came up with a non-saline groundwater goal for the Steering Committee to consider guiding future work in this area as follows:

"Abundant, uncontaminated groundwater in the Peace-Slave watershed is managed with integrity so that the resource is publicly understood, predictable, sustainable and protected to benefit and meet the needs of basin inhabitants."

The WG then discussed at length what they would do to improve current non-saline groundwater management in the Peace-Slave watershed. Suggested actions were many but can be grouped into a number of outcomes that a watershed management plan would work to achieve including:

1. Groundwater information required for decision-making is available to all.
2. The groundwater resource is better understood with time.
3. Groundwater users, decision-makers and the public are better educated about sector groundwater use and how allocation decisions are made.
4. The Groundwater Allocation system is efficient and effective.
5. Groundwater management is integrated and adaptive such that it addresses cumulative effects and climate change.
6. A gold standard /template for aquifer management is known and utilized.

Further strategies, actions, leads, partners and timelines, required to achieve the objectives above is detailed in a proposed workplan (Appendix 4).

In addition to the workplan, the WG also made a number of recommendations to the Steering Committee as they move forward with the IWMP as follows:

- Groundwater is an important component of watersheds and is closely tied to other IWMP topics such as tributary flow (recharge), fisheries and aquatic health, wetland management, etc. Ensure these important connection points are made in the work of future groups and in the compilation/collation of the IWMP.
- Recognize the challenge of managing cumulative impacts / footprint and be prepared for these impacts to magnify. Make the IWMP flexible and able to adjust as we learn.
- Be prepared for climate change and variability by being adaptive and timely including:
    - Monitoring, assessing and reporting annually
    - Adapting if necessary (be nimble and responsive to new knowledge as it is collected)
    - Being clear on the process for plan implementation
    - Being creative in resourcing (e.g., consider a levy)
- Continue to seek sector input and feedback into the IWMP process (including agriculture, forestry, regulators, peat harvest and mining, First Nations, Métis, governments, etc.).
- Continue to participate in other planning processes. Work with AEP to ensure there is a clear process for IWMP and other MPWA information to be fed into the LUF Upper and Lower Peace planning processes and the upcoming review of the Lower Athabasca Plan. Support municipalities and industry in their planning processes, to the extent that capacity allows ensuring non-saline groundwater objectives are shared by all authorities and consistently implemented on the landscape.

GLOSSARY

Aquifer	An underground water-bearing formation that is capable of yielding water. Aquifers have specific rates of discharge and recharge. As a result, if groundwater is withdrawn faster than it can be recharged, the underground aquifer cannot sustain itself. Alberta has surficial (alluvial and buried channel) and bedrock aquifers.
Contaminant	A substance that, in a sufficient concentration, will render water, land, fish, or other things unusable or harmful.
Cumulative effects	The combined effects on the aquatic environment or human developments arising from the combined environmental impacts of several individual projects.
Discharge	Refers to the outflow, and is used as a measure of the rate at which a volume of water passes a given point. Therefore, the use of this term is not restricted as to course or location, and it can be used to describe the flow of water from a pipe or a drainage basin.
Groundwater	All water under the surface of the ground whether in liquid or solid state. It originates from rainfall or snowmelt that penetrates the layer of soil just below the surface. For groundwater to be a recoverable resource, it must exist in an aquifer. Groundwater can be found in practically every area of the province, but aquifer depths, yields, and water quality vary.
Groundwater recharge	Inflow of water to a groundwater reservoir (zone of saturation) from the surface. Infiltration of precipitation and its movement to the water table is one form of natural recharge. Also, the volume of water added by this process.
Hydrogeology	The area of geology that deals with the distribution and movement of groundwater in the soil and rocks of the Earth's crust (commonly in aquifers).
Non-saline groundwater	Groundwater that has less than 4,000 mg/L of total dissolved solids. Also known as ‘fresh’ although this is a relative term and water near 4,000 mg/L would not be suitable for domestic consumption.
Saline groundwater	Groundwater that has more than 4,000 mg/L of total dissolved solids. Also known as salty or brackish groundwater.
Total dissolved solids	1. A measure of the concentration of dissolved matter in water. Total Dissolved Solids measurements are often used to estimate a water body's salinity, which may affect the distribution of aquatic organisms. 2. Calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, and silica are typical dissolved solids.
Water table	The top of the saturated zone in the ground, where water fills the spaces in the soil and rock.
Water well	An opening in the ground, whether drilled or altered from its natural state, that is used for the production of groundwater, obtaining data on groundwater, or recharging an underground formation from which groundwater can be recovered. By definition in the provincial Water Act, a water well also includes any related equipment, buildings, and structures.

APPENDIX 1 – WORKING GROUP MEMBERSHIP

Name	Surname	Job Title or Perspective	Affiliation
Cheryl	Anderson	Grimshaw Gravels Aquifer Management Advisory Association	County of Northern Lights
Dan	Benson	Agriculture Water Specialist	Farm Water Supply Section, Alberta Agriculture & Forestry
Deanna	Cottrell	Oil and Gas	Shell/CAPP
Cory	Gillis*	Public at large	
Scott	Klasens	Water Approvals Engineer	Regional Integrated Approvals Alberta Environment and Parks
Bill	Kostiw*	Rural Municipality	Mackenzie County
Brian	Smerdon	Hydrogeologist	Alberta Geological Survey
			Grimshaw Gravels Aquifer Management Advisory Association
Roy	Dell	CAO	Town of Fox Creek
Joe	Hustler	Aggregate Resource Manager	Knelsen Sand and Gravel
Tom	Greene*	Chief Economic Officer	Duncan's First Nation
Rick	Keillor	IWMP SC	MPWA
Petra	Rowell	Project Manager	Consultant
Adam	Norris	Watershed Coordinator	MPWA
Megan	Graham	Education & Outreach Coordinator	MPWA

*Participant received and reviewed materials but was unable to participate in meetings.

APPENDIX 2 – TERMS OF REFERENCE

Integrated Watershed Management Plan Working Group
Non-saline Ground Water Terms of Reference

The following document describes the purpose and structure of the working groups including what they should achieve, who will participate, how work will be done and when it will be completed. The Board of Directors approved these Terms of Reference on

Context

The Mighty Peace Watershed Alliance Society (MPWA) is a multi-stakeholder not-for-profit organization registered under Alberta's Society Act. The MPWA is one of several *Watershed Planning and Advisory Councils* created under Alberta's *Water for Life* strategy. The MPWA is committed to achieving and implementing the three goals of the strategy:

- Safe, secure drinking water supply
- Healthy aquatic ecosystems
- Reliable, quality water supplies for a sustainable economy.

The implementation of these goals is guided by the vision, mission and shared values of the MPWA:

Vision – The Peace is a healthy, sustainable watershed that supports our social environmental and economic objectives.

Mission – To promote watershed excellence, the Mighty Peace Watershed Alliance will monitor cumulative effects from land use practices, industry and other activities in the watershed and work to address issues through science, education, communication policy and by supporting watershed stewardship.

Objectives

The working groups will work through the Issues of Concern as directed by the Integrated Watershed Management Plan Steering Committee (IWMP SC) in a consensus process. The end goal for each Issue of Concern is a set of concrete recommendations to the IWMP SC on how to improve water quality and quantity in pursuit of the 3 goals of the *Water for Life* strategy. This includes statements about the Issue of Concern and potential options for addressing this, which are ranked.

Working Group Task

1. To review the information presented by the Integrated Watershed Management Plan Steering Committee (IWMP SC), review and assess for completeness and data gaps.

2. The working group will ensure that Issue of Concern is properly framed through discussion and brainstorming.

3. The working group will develop statements for their assigned Issues of Concern to clarify and frame the issue. Subsequent to this, the working group will identify and evaluate potential management options of how to address the issues.

4. Finally, recommendations will be made by the Working Group to the IWMP SC on how best to move forward on their designated Issue of Concern. This recommendation will include ranked management options and indications of the consensus achieved within the Working Group.

What is in scope?

The IWMP SC will indicate to each working group what the Issue(s) of Concern they are to deal with is/are. Each issue is to be considered, diagnosed and potential management options for addressing are to be sought out, collected and evaluated. Please see Appendix I for more detail on each Issue of Concern.

What is out of scope?

Issues of Concern not assigned to a particular Working Group are out of scope, as is engaging consultants without the approval of the IMWP SC or implementation activities. The Working Groups will not engage is lobbying or promotion of a particular management option.

Membership

1. Membership of the Integrated Watershed Management Plan Working Groups must be approved by the IWMP SC and shall consist of the following classifications:

Non-saline Ground Water

- Agriculture and Forestry member
- Alberta Environment and Parks member
- Alberta Geological Survey member
- Alberta Energy Regulator member
- First Nation member
- Grimshaw Gravels Aquifer Management Advisory Association member
- Integrated Watershed Management Plan Steering Committee member
- Mining Industry member
- Municipality using ground water member
- North Peace Tribal Council Land and Water Table member
- Oil and Gas Industry member
- Public at Large member
- Rural Municipality member

2. The Working Group can, with approval from the IWMP SC, call upon the expertise of people outside the Working Group and outside the MPWA.

Meetings

Meetings will be set as required and notification will be provided electronically.

Reporting

1. The Working Groups is responsible to and reports to the Integrated Watershed Management Plan Steering Committee, which in turn is responsible to and reports to the MPWA board (MPWA Process Guide section 6.1).
2. The Working Group will report to the IMWP SC after every meeting and the IWMP SC will report to the Board at minimum at every regular Board meeting.

Quorum

A simple majority of committee members shall constitute quorum.

Delegation

The Working Group may, with permission from the IWMP SC, delegate tasks to other qualified individuals or groups.

Timelines

The Working Group will convene in September 2016 and complete their work by January 2017.

Scope

The following is a list of components and questions to help start the work of the Non-Saline Ground Water working group.

1. Conflicts between industrial and residential use of ground water
a. Fox creek/Valleyview area availability
b. Hot spots - wherever there is currently a lot of Oil and Gas activity
c. West County of Grande Prairie/ Wembley
d. West of Saddle Hills - natural gas contamination of drinking wells
e. La Crete area
f. What interaction is there between hydraulic fracturing and non-saline ground water?
2. Lack of background information
a. Capacity and recharge rates of aquifers
b. Linkages between ground water and surface water
c. What are the exact problems with the lack of information (examples)?
d. What is the viability of aerial surveys for the Peace and Slave watersheds and ground water mapping
3. Sharing of information
a. What information does Alberta Energy Regulator receive about water discoveries?
b. What is the feasibility of bringing together all the known information on ground water including driller's logs?
c. Who becomes responsible for integrating ground water information?
d. Where is there uncollated data?
e. Is there a well drillers association?
f. Well testing/water quality in ground water? What are the current reporting requirements?
4. Who will do the gap filling work?
5. Availability of ground water reserves and their sustainability
a. What risks are there to our non-saline ground water?

6. Public Education about ground water
7. Grimshaw Gravels Aquifer - could this be an example/model/template for management?
a. What are the risks to future sustainability? How do we set thresholds?
8. Identify resources for ground water management (ground water mapping)
a. What are the BMPs? Are they being used? Are they effective? Who is doing these?
9. Potability
a. Assess the risk of selenium in ground water in the upper watershed?
b. Are there are any other particular contaminants that are a risk locally? Arsenic, mercury
c. Access to drinking water
10. Is there an appropriate regulatory framework in place surrounding Non-saline Ground Water?
a. Is there an appropriate metric to determine when and where non-saline ground water will be used so that it is sustainable?
b. How do Alberta Energy Regulator and Alberta Environment and Parks interact on ground water?

APPENDIX 3 – GROUNDWATER RESOURCES

Alberta Geological Survey	http://ags.aer.ca/activities/groundwater-inventory-and-basin-analysis.htm
Alberta Groundwater Resources / Groundwater in Alberta (Alberta Water Portal webpages)	http://albertawater.com/groundwater/alberta-groundwater-resources; http://albertawater.com/groundwater-in-alberta
Is Fracking Behind This Town's Dry Water Well? (Alberta Venture magazine)	Http://Albertaventure.Com/Water/Towns-In-Albertas-Industrial-Heartland-Ran-Out-Of-Water-Last-Summer-Is-Fracking-To-Blame/
Alberta Water Well Drilling Association	http://www.awwda.ca/
Alberta Water Well Information Database	http://aep.alberta.ca/water/reports-data/alberta-water-well-information-database/default.aspx
Authorization Viewer: Water Act and EPEA Approvals	http://aep.alberta.ca/lands-forests/land-industrial/programs-and-services/authorization-viewer.aspx
Compilation of Alberta Groundwater Information from Existing Maps and Data Sets (AGS report)	http://ags.aer.ca/document/OFR/OFR_2009_02.PDF
Drilling Water Wells in Alberta	http://www.lica.ca/attachments/077_WaterAct_Drilling_Water_Well_FS.pdf
Edmonton-Calgary Corridor Groundwater Atlas	http://ags.aer.ca/publications/INF_140.html
Focus on Groundwater (series of AEP factsheets)	http://aep.alberta.ca/water/programs-and-services/groundwater/education.aspx
Groundwater (Alberta Environment and Parks webpage)	http://aep.alberta.ca/water/programs-and-services/groundwater/default.aspx
Hidden Water (Inside Education video)	https://vimeo.com/111761927
Groundwater Observation Well Network (AEP website)	http://aep.alberta.ca/water/programs-and-services/groundwater/groundwater-observation-well-network/default.aspx
Groundwater Vulnerability Mapping	http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex10339/$file/pg_44_groundwater_quality.pdf?OpenElement
MPWA *State of the Watershed* Report	http://mightypeacesow.org/
MPWA Technical report: Regional Hydrological Assessment	http://mightypeacesow.org/
Natural Resources Conservation Board	https://www.nrcb.ca/
Provincial Groundwater Inventory Program (Edmonton – Calgary Corridor)	
Understanding Groundwater, Groundwater Management, Contracts for information about water wells (Alberta Agriculture and Forestry webpages)	http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/wwg406; http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/wwg417; http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/wwg418
Working Well Program	http://aep.alberta.ca/water/education-guidelines/working-well/default.aspx.

APPENDIX 4. MPWA INTEGRATED WATERSHED MANAGEMENT PLAN – NON-SALINE GROUNDWATER

Vision: Abundant, uncontaminated groundwater in the Peace/Slave watershed is managed with integrity so that the resource is publicly understood, predictable, sustainable and protected to benefit and meet the needs of the basin's inhabitants.				Short = 3 years, Medium = 5 years, Long = 10 years		
ISSUE	**Outcome**	**STRATEGIES**	**ACTIONS**	**Lead**	**Other partners**	**Time-frame**
Lack of easily accessible, consolidated information.	1. Groundwater information required for decision-making is available to all.	1.1 Build on the existing Coal Bed Methane database to develop a single, centrally located, accessible shared groundwater database.	1.1.1 Form a partnership/working group.	CAPP	AER, AGS, AHS, PFRA (AAFC), MPWA	Short-medium
			1.1.2Determine what kinds of data should be included in the database (e.g. data on water use, water levels, water quality, etc.).			
			1.1.3 Work with each partner agency to locate and review existing data, reports, etc. and analyze for relevance, digitize it and enter existing data (e.g. AHS well data, PFRA inventories, licensing, AGS, GOWN, municipal, etc.) into the database. (MPWA can promote this project in the north).			
		1.2 Identify data gaps on subsurface structure and groundwater inventory and develop a plan to fill gaps with new data and information.	1.2.1 Consider citizen science as a means for groundwater flow and well water quality data collection (See Rocky View Well Watch program)	MPWA	AGS, AEP	Medium
		1.3 Ensure processes (e.g. licensing, water use, etc.) are designed such that new data is automatically entered into the central shared database (onus is one the applicant to enter data into the designated system that all users can access.	1.3.1 Improve mandatory licensee WURS reporting and make it a subset of the new prosed database).	AEP	AER	Short-medium
			1.3.2 To support AEPs integrated application system, at the application stage, require info like transmissivity, etc. to populate the database.	AEP	AER, licensee	Short
			1.3.3 Undertake work to better understand household use, agricultural	AHS	AEP, AGS, MPWA	Short-medium

Vision: Abundant, uncontaminated groundwater in the Peace/Slave watershed is managed with integrity so that the resource is publicly understood, predictable, sustainable and protected to benefit and meet the needs of the basin's inhabitants.				Short = 3 years, Medium = 5 years, Long = 10 years		
ISSUE	**Outcome**	**STRATEGIES**	**ACTIONS**	**Lead**	**Other partners**	**Time-frame**
			registrations, and water well quality for state of reporting by incorporating this information into the central database (e.g. # of private wells, typical consumption, etc.).			
Lack of general public understanding about the groundwater resource, how it is managed, as well as its connection to surface water, land use changes, climate change, etc.	2. The groundwater resource is better understood by the general public with time.	2.1 Improve general public understanding of groundwater resources (amount, inventory, regulatory process); ground water – surface water interactions; the cumulative effects of land cover/land use on groundwater quantity and quality; and how groundwater will be affected by climate change.	2.1.1 Develop an education plan that identifies appropriate public audiences, messages, communications tools, etc.	MPWA	AEP, Inside Education	Short
			2.1.2 Support the GOA Working Well program as a means to reach landowners with private wells. The MPWA can promote landowner well testing; identification and proper decommissioning of abandoned wells.	AEP/ AHS	MPWA	Short-medium
			2.1.3 In conjunction with the next MPWA state of the watershed report, develop a groundwater atlas similar to the Edmonton-Calgary Corridor atlas showing yield, salinity, possible contaminants, etc.	MPWA	AEP, AGS	medium
			2.1.4 Work with municipalities to distribute information to rate-payers.	MPWA	AEP, AAMDC	short
			2.1.5 Support the AB Science Network and get groundwater speakers into schools and other public venues.	MPWA	AB Education	short

Vision: Abundant, uncontaminated groundwater in the Peace/Slave watershed is managed with integrity so that the resource is publicly understood, predictable, sustainable and protected to benefit and meet the needs of the basin's inhabitants.				Short = 3 years, Medium = 5 years, Long = 10 years		
ISSUE	**Outcome**	**STRATEGIES**	**ACTIONS**	**Lead**	**Other partners**	**Time-frame**
Concerns /perceptions around sector groundwater use.	3. Groundwater users, decision-makers and the public receive credible information about sector groundwater use and how allocation decisions are made.	3.1 Share sector information about the Water Allocation System and specific sector water use (including licence requirements, return flows, wastewater treatment, etc.) with the public and other audiences via MPWA state of reporting, AEP factsheets, industry factsheets, etc.	3.1.1 Promote existing sector information by linking to relevant industry websites or resources where they exist to make licensing and other information more visible.	MPWA	Board member sectors	short
			3.1.2 Develop fact sheets that focus on industry groundwater use and practices including case studies of water sharing/conflict resolution, water re-use between sectors and other innovations.	MPWA	Board member sectors	Short-medium
	4. The Groundwater Allocation system is efficient and effective.	4.1 Promote groundwater BMPs and Conservation, Efficiency and Productivity planning for each sector throughout the watershed.	4.1.1 Create a sector BMP expectation agreement or charter and promote through board member sectors.	MPWA	Board member Sectors	Medium
			4.1.2 Have each water using sector present their CEP plan to the MPWA board.			
		4.2 Encourage improved AEP/AER communications and collaboration in order to continue building the Integrated Approvals Process for new applications that incorporates	4.2.1 Evaluate how well new policies are applied and achieved (e.g. guide to groundwater authorizations, area based regulations, etc.).	AEP	AER, industry, municipalities	Medium-long
			4.2.2 Look at how well policies and regulations are achieving cumulative effects management.			

Vision: Abundant, uncontaminated groundwater in the Peace/Slave watershed is managed with integrity so that the resource is publicly understood, predictable, sustainable and protected to benefit and meet the needs of the basin's inhabitants.				Short = 3 years, Medium = 5 years, Long = 10 years		
ISSUE	**Outcome**	**STRATEGIES**	**ACTIONS**	**Lead**	**Other partners**	**Time-frame**
		continuous improvement from policy to on-the-ground practice.	4.2.3 Look at how well policies and regulations are forward-looking and able to address future areas of interest / hot-spots (e.g. Fox Creek).			
Concern about groundwater sustainability.	5. Groundwater management is integrated and adaptive such that it addresses cumulative effects and climate change and is sustainable, now and in the future.	5.1 Improve communication processes between groundwater stakeholders.	5.1.1 Share groundwater learnings between sectors by making sector presentations to the MPWA board or holding a groundwater forum.	MPWA	AEP, AGS, industry, academia	Short-medium
		5.2 Ensure collaboration between municipal and provincial governments for sustainable groundwater management.	5.2.1 Facilitate periodic stakeholder forums (including Peace Regional Economic Development Alliance, Water North Coalition, Ag Service Boards, etc.) to share issues and concerns about sustainable groundwater management.	MPWA	AEP	medium
Concern about specific aquifers being understood and managed sustainably	6. A management standard for protecting aquifers is known and	6.1 Develop a standard for aquifer management (that identifies roles and responsibilities, assesses risks, provides a process for collaborative management,	6.1.1 Use the Grimshaw Gravel Aquifer as a test case to develop, implement and test an aquifer management plan including source protection and best management practices to be used as a template for other aquifers.	GGAA MA	MPWA	Short-medium

Vision: Abundant, uncontaminated groundwater in the Peace/Slave watershed is managed with integrity so that the resource is publicly understood, predictable, sustainable and protected to benefit and meet the needs of the basin's inhabitants.				Short = 3 years, Medium = 5 years, Long = 10 years		
ISSUE	**Outcome**	**STRATEGIES**	**ACTIONS**	**Lead**	**Other partners**	**Time-frame**
without conflict.	utilized.	local stewardship and conflict resolution and implement it for aquifers and/or groundwater areas of concern (e.g. Grimshaw Gravel, Fox Creek, etc.)	6.1.2 Develop case studies showcasing collaborative water management in Alberta.	AEP	AER, industry, AAMDC, etc.	medium
		6.2 Be on the lookout for emerging issues on individual aquifers.	6.2.1 Via state of reporting and writing and implementing the IWMP, document groundwater issues as they are identified and pass such information on to decision-makers.	MPWA	AEP, board member sectors	ongoing