oldmanwatershed.ca

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September 21, 2020

Joint Review Panel
Grassy Mountain Project
c/o Impact Assessment Agency of Canada
160 Elgin Street, 22nd floor, Ottawa ON K1A 0H3
Email: IAAC.GrassyMountain.AEIC@canada.ca

Dear Joint Review Panel,
Thank you for granting our request to provide a written submission and oral presentation to the panel.

Who we are

Our nonprofit organization represents all the people who live, work and play in the Oldman watershed and who will be directly affected by the grassy mountain coal project. We have a following of thousands of people who are interested in collaborative, practical solutions to the environmental challenges we are facing.

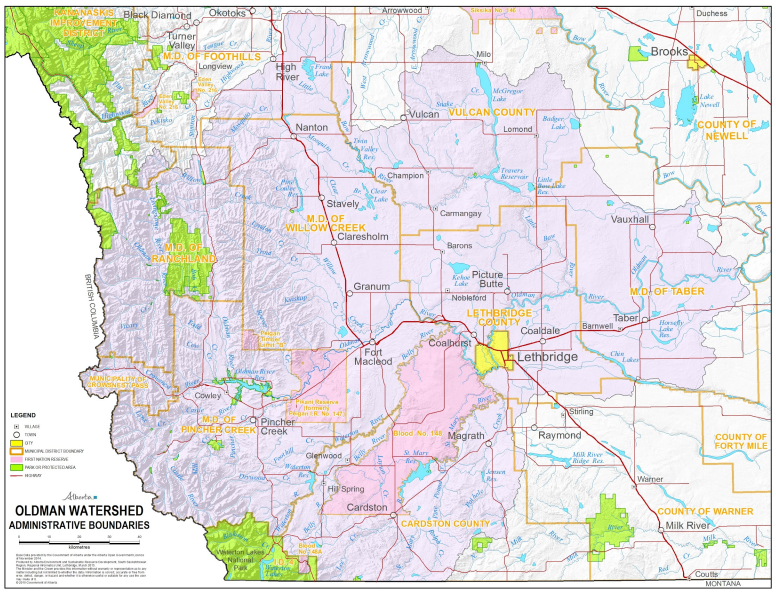

Figure 1: The Oldman watershed in southwest Alberta.

The OWC's expertise and knowledge is at the watershed scale and focuses on how everything - social, environmental and economic - is connected. As a Watershed Planning and Advisory Council (WPAC) designated under the Government of Alberta's Water for Life Strategy, it is our role to consider impacts on all stakeholders and facilitate solutions-based planning for the entire community. We do this by working collaboratively to develop targets with stakeholders; targets that are based on scientific information and that are intended to support informed decision-making. It is from this neutral, fact-based perspective that this information is provided.

Our expertise is watershed science and our knowledge comes not only from peer reviewed research, but also our deep roots to the place we live in. From our Board of Directors we can draw on experience and knowledge from 17 sectors. The stakeholders and Nations actively involved in the work of the OWC at the Board of Directors level include: Municipality of Crowsnest Pass, City of Lethbridge, Piikani Nation, Kainai Nation, Cardston County, University of Lethbridge, Alberta Health Services, Montem Resources, Spray Lake Sawmills, Lethbridge Northern Irrigation District, Alberta Environment and Parks, Alberta Agriculture and Forestry, Lethbridge County, Hays Stock Grazing Association, Southern Alberta Group for the Environment, Water Conservation Trust of Canada, and 4 individual members at large.

Our experience and knowledge of the area

The grassy mountain coal project is located in the headwaters of the Oldman watershed, a narrow, mountainous strip of land that provides about 90% of the water for everyone downstream.

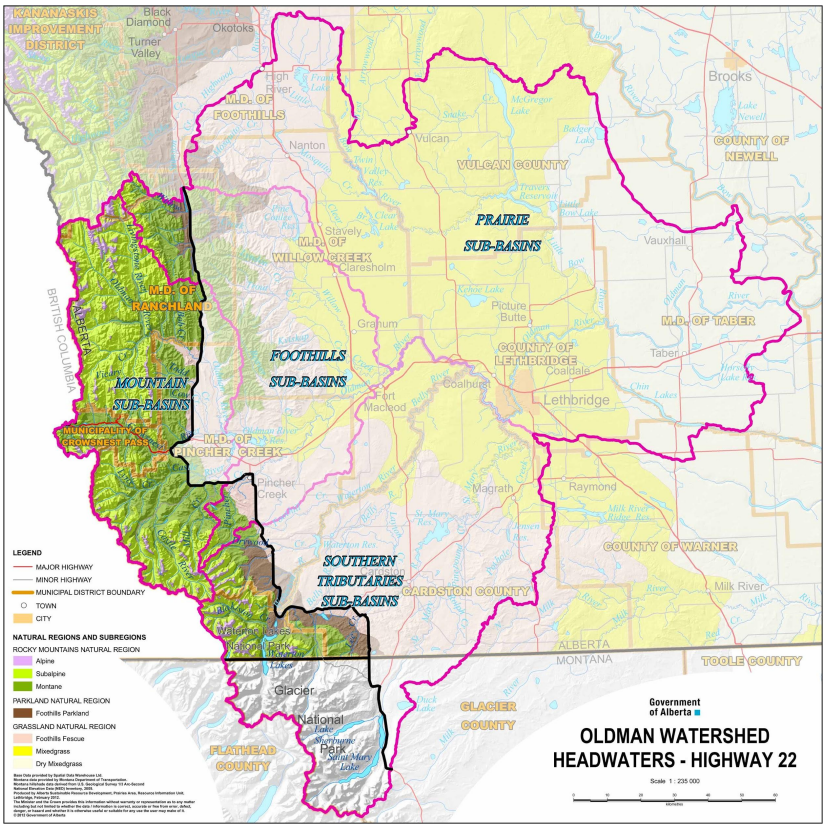

Figure 2: The headwaters of the Oldman watershed as defined by the Oldman Watershed Council, using major roads as boundaries.

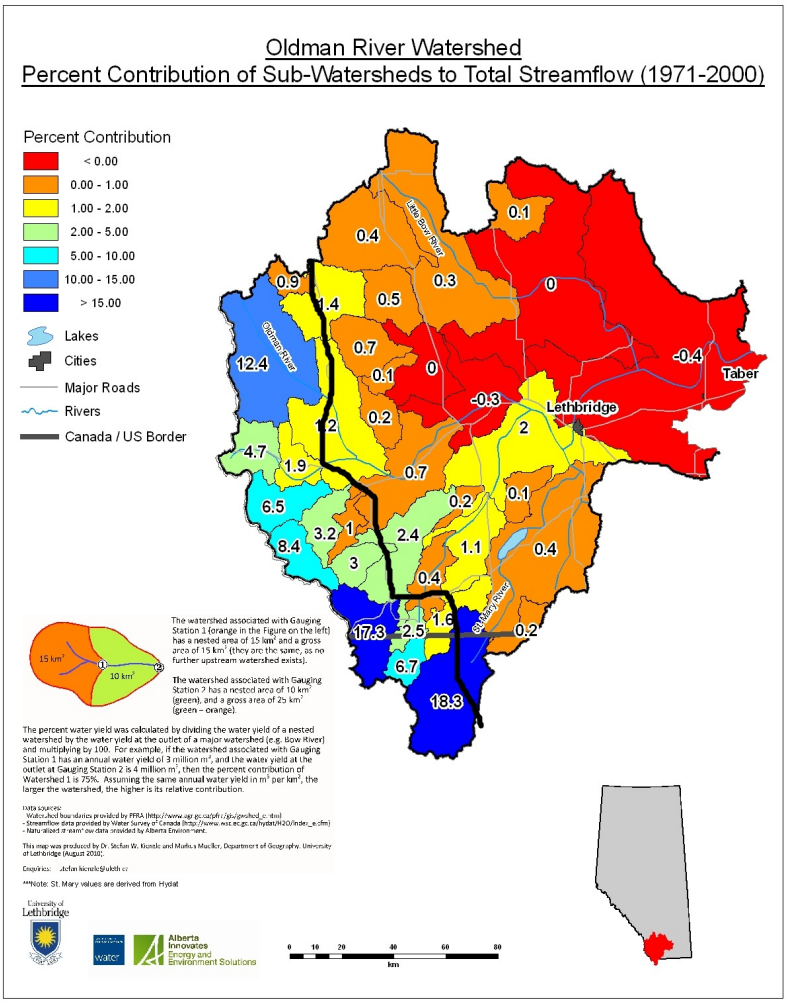

Figure 3: Percent contribution of subwatersheds to total streamflow of the Oldman River at the mouth (1971-2000), indicating that about 90% of the water in the river comes from the headwaters area.[1]

We have focused our work in this headwaters region for the past 7 years and we have the experience, relationships and understanding of the complexity of this landscape. We have completed environmental health assessments, set consensus-based targets with our stakeholders, developed education programs and restored creek banks.

Presenters at the hearing

Our Executive Director, Shannon Frank, will present on behalf of the OWC. Andy Hurly, our Director who brings a perspective from academia to our board, will also participate to assist with answering questions.

Shannon has been OWC's Executive Director for the past 9 years and spearheaded our work in the headwaters so she is knowledgeable about the area and the questions and concerns of our community. Shannon has a Bachelor of Science Degree from the University of Lethbridge with a major in Environmental Science.

Andy Hurly was a founding Director of the OWC 15 years ago and is a Professor Emeritus in the Department of Biological Sciences at the University of Lethbridge where he had taught and conducted research since 1991. His research interests

[1] *Kienzle, S and Mueller, M. Department of Geography, University of Lethbridge. 2010.*

involve two areas - animal behaviour and ecosystem ecology. Andy's interests in ecosystem ecology concern the health of bird and plant communities and how they are affected by activities such as cattle grazing and alterations to river flow.

We request ninety minutes to give our presentation.

The decision we want and why

The Oldman Watershed Council (OWC) is not advocating for an approval or rejection of the project. We are providing scientific information and stakeholder views that are critical for the panel to consider. We do have recommendations about further work that we feel is needed to address the concerns of our community. Below we have provided a high-level overview of the critical issues as we see them and what we are hearing from our stakeholders. As a grassroots nonprofit we want to ensure the voice of the local people is heard.

As a forum for all stakeholders it is our role to bring people together to discuss challenging issues and facilitate practical solutions that everyone can live with. The decision we want is one based on science and broad community support. This decision is difficult and we appreciate there are many facets for you to consider.

We would like to highlight the fact that the Project will be precedent setting for this region.

How we will be affected

Because we speak for the watershed as well as the people and wild species who depend on it, the impacts of the grassy mountain coal project on our stakeholders are complex. We recognize that the mine would have both positive and negative impacts. For the purposes of this hearing we will focus on the key watershed issues that we have expertise in and that are of top priority for our members. These issues are outlined below in the next section.

Watershed Issues of Concern

Critical headwaters area

The proposed Grassy Mountain Coal Project would be located in the headwaters of the Oldman watershed that provide approximately 90% of the water in the Oldman River and support a minimum of 200,000 people downstream. The Oldman watershed is semi-arid and struggles with water supply issues. Residents are highly dependent on the eastern slopes of the Rocky Mountains for annual snowmelt to our rivers and creeks. The Oldman headwaters are currently facing pressure from the cumulative effects of multiple use and watershed integrity has declined across approximately 95% of the headwaters landscape. The Grassy Mountain Coal Project would add another type of use to an already crowded landscape that is a critical source water area, further stressing the headwaters area.

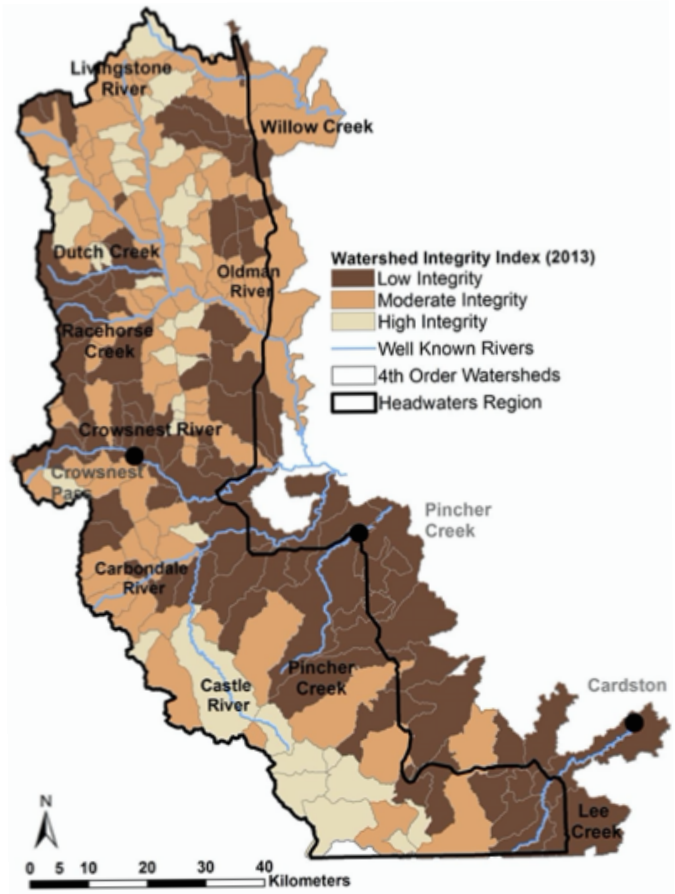

Figure 4: Watershed integrity index (2013), showing that 95% of the headwaters area has declined below the rating of 'high integrity'.[2]

Selenium

Of particular concern to our stakeholders is possible selenium pollution of our waterways, including the Crowsnest River, a blue ribbon trout stream, and downstream to the Oldman Reservoir and Oldman River. Just west of us in British Columbia we have seen how selenium spreads downstream of the much larger Koocanusa Reservoir and into the Kootenai River below.[3]

Urban centres downstream of the Project are concerned about the impact on their water supply. Based on what has already happened nearby in Sparwood, British Columbia, where water wells had to be shut down because of selenium contamination from coal mines, it is not unreasonable to foresee selenium contamination impacting drinking water supplies. Unlike British Columbia, Southern Alberta does not have alternative rivers or lakes to draw water from. The Oldman River is the only option for us and so we are particularly vulnerable to upstream contamination.

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[2] *Fiera Biological Consulting Ltd (Fiera). 2014. Oldman Watershed Headwaters Indicator Project – Final Report (Version 2014.1). Edmonton, Alberta. Fiera Biological Consulting Report #1346*. https://oldmanwatershed.ca/resources-hap.

[3] *Mebane, C.A., and Schmidt, C.G., 2019, Selenium and mercury in the Kootenai River, Montana and Idaho, 2018-2019: U.S. Geological Survey data release, https://doi.org/10.5066/P9YYVV7R.*

Also downstream of the Project is one of Canada's most valuable agricultural regions where irrigated specialty crops and intensive livestock operations depend on clean water and a reputation for high quality Rocky Mountain water to sell their crops nationally and internationally. Our agricultural stakeholders are concerned about the impact of the Project on their water supply, the effects on our multi million dollar agriculture and agri-food processing industry and the perception that the food produced would no longer be of the same quality. If water contamination led to the loss of agricultural production in Southern Alberta, this would have a devastating impact on the livelihood of local residents, as well as the economy of Alberta.

Irrigation district water quality testing over 7 years from the Oldman River at Fort Macleod showed an mean value for selenium at 0.6 ug/L and a median value of 0.5 ug/L[4], which is less than acceptable guideline values (2 ug/L for the protection of freshwater aquatic life, 20 ug/L for continuous agricultural use[5]). This known baseline would be a better benchmark to use for future testing to ensure any releases from the coal mine project, if approved, do not cause exceedances of this level rather than using the higher guideline level.

From the EIA, It appears that Benga is relying on selenium removal methodology that is unproven. It is unproven to work at the large scale required for this coal mine. It is unproven to work over the time period of 24 years proposed for this mine. It is unproven to work in a mountainous environment that has complex geology and hydrology. They are also assuming that if there are problems with the proposed water treatment process, new solutions can be developed by the time selenium concentrations start to exceed guidelines, approximately 10 years after the mine starts operating. This leap of faith is risky, especially in an area limited by water and with only one major river.

Selenium contamination is a concern because we have seen the impact of it nearby at the Teck coal operations just across the Alberta border in British Columbia. Due to the technically challenging nature of the problem, Teck has had limited success at mitigating selenium contamination after investing millions of dollars in mitigation efforts. Although there has been use of bioreactor treatment, and some recent success is showing promise, the problem of selenium in the Elk Valley and Koocanusa Reservoir continues.

Research has indicated that it should be possible to mitigate selenium toxicity in watersheds through large-scale and long-term treatment, however, the high levels of phosphorus and nitrogen that remain can also significantly degrade water quality. Given Benga's surface water management plan for effectively mitigating selenium is untested in this context, there is a risk that it may not work as well as planned and water quality will be impacted considerably more than expected. Further investigation and demonstration of the effectiveness of mitigation strategies is required.

Water Quality

According to the EIA, 6 water quality variables are expected to exceed the Alberta Water Quality Guidelines for the Protection of Aquatic Life at certain times throughout the roughly 24-year life expectancy of the mine. Water quality is expected to recover once mining activities are complete but there will be impacts over the ~24 years the mine is active.

These exceedances are of great concern to our stakeholders. Our high quality rocky mountain water is invaluable and irreplaceable. This water fuels our irrigation and livestock industry, supplies ~200,000 people in urban centres, supports

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[4] *Irrigation District Water Quality Data Tool, updated July 7, 2020, http://www.idwq.ca/.*

[5] *Government of Alberta. 2018. Environmental Quality Guidelines for Alberta Surface Waters. Water Policy Branch, Alberta Environment and Parks. Edmonton, Alberta. https://open.alberta.ca/dataset/5298aadb-f5cc-4160-8620-ad139bb985d8/resource/38ed9bb1-233f-4e28-b344-808670b20dae/download/environmentalqualitysurfacewaters-mar28-2018.pdf*

the tourism and recreation sector and is the lifeblood of the ecosystems of the mountains and the prairies within our watershed.

We appreciate that Benga has provided a draft aquatic monitoring plan but it is still unclear exactly how far downstream water quality may be degraded and how this could impact other water users and the aquatic environment.

Groundwater

The Oldman Watershed Council completed the C*rowsnest River Watershed Aquifer Mapping and Groundwater Management Planning Study* in 2013, which was cited several times in the EIA. Our results and interpretation of the limited data available in the study highlighted the complexity of groundwater in the Crowsnest watershed because of the mountainous geology with extensive folding and faulting. Our key finding was that much more data and study are needed to understand the complex groundwater system and how it interacts with surface water. We warned that these preliminary findings are only the first step and should not be used for site-specific decision making. Given OWC's experience with the area we find the results of the EIA presumptuous and lacking in empirical evidence.[6]

Groundwater is highly connected to surface water as seen by the hydraulic response to precipitation and snow melt. Blairmore and Gold Creeks are fed by groundwater discharge and so will be directly affected by the mine, with Gold Creek seeing the larger impact with a 6-10% decrease in base flow expected, according to the EIA.

There are 35 domestic wells and 11 industrial wells within the local study area and 175 water wells in the regional study area, including 8 for the Municipality of Crowsnest Pass. The Municipality of Crowsnest Pass relies on groundwater to supply its ~5650 residents and more investigation is needed to ensure this resource will not be put at risk.

According to the EIA, chemistry results show that groundwater in some locations already exceeds the Canadian Drinking Water and Freshwater Aquatic Life guidelines for several parameters, mostly metals. The frequency and extent of exceedences could increase with new mining activities and exacerbate the problem.

The EIA states that monitoring wells will have to keep being moved to accommodate mining activities. Monitoring over time requires that the locations remain constant and testing from wells in different locations will not be as valuable as stationary wells. Additional wells can be added to the program over time, but no wells should be removed. Biannual or annual chemistry sampling is also inadequate. Given the high risk to groundwater, reliance on the resource by nearby residents and extreme difficulty in reversing impacts, we suggest that the groundwater monitoring program requires improvement. Frequent and comprehensive monitoring will increase confidence of local and downstream residents and will permit rapid response by the company and the province should problems be detected. Transparent reporting of data would further increase confidence.

Water quantity

New water withdrawals for the Project will likely have impacts on other users and especially aquatic environments in drier years but it is unclear exactly what these impacts will be. Climate change also adds considerable uncertainty that is difficult to account for in local level modelling. Because of our semi-arid climate, the risk of water shortage is higher. Potential impacts for downstream users and the aquatic environment are of great concern to our stakeholders.

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[6] *Waterline Resources Inc. 2013. Crowsnest River Watershed Aquifer Mapping and Groundwater Management Planning Study. Calgary, Alberta. https://oldmanwatershed.ca/publications-list/groundwater-studies.*

One of Benga's proposed water licences is for York Creek but that creek is not within the mine area and it is unclear how the water would be withdrawn from York Creek and transported to the mine site. Or how a water license on York Creek would allow withdrawal from another stream.

The amount of water taken from Gold Creek could have significant impacts due to the creek's lower flow and this creek has one of the top 3 adult densities of westslope cutthroat and a critical habitat order (see native and naturalized trout section below).

We suggest an updated water model be required, that takes into account climate change and long periods of drought, to understand the full impacts on the aquatic environment and other water users, including First Nations rights.

Linear features

Linear features density is a concern in the mountains because fish and wildlife populations and water quality tend to decline as linear footprint density increases. Coal mines will create more roads in a region that is already above the density thresholds for healthy fish and wildlife populations.

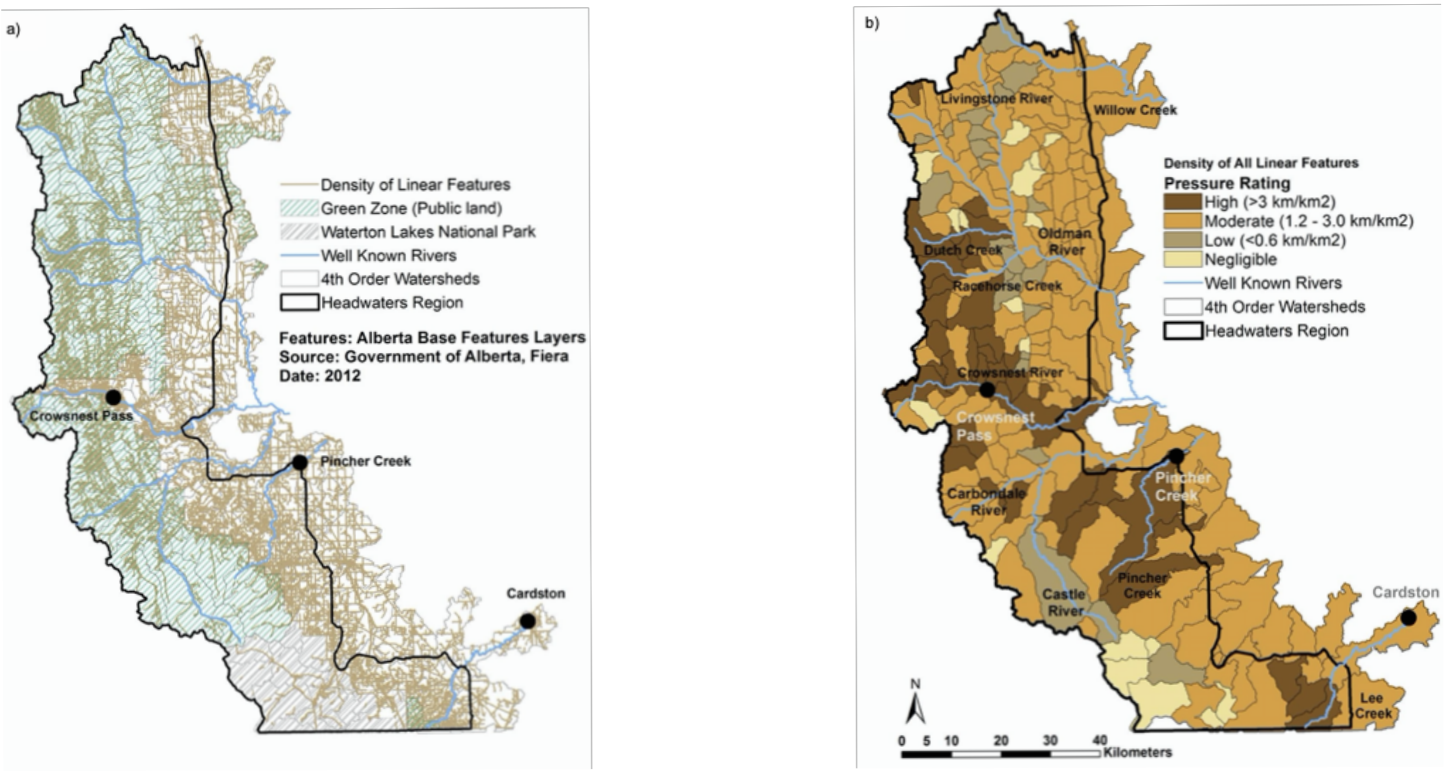


Figure 5: Most of the Oldman headwaters are facing moderate to high pressure from the density of linear features .[7]

The high density of linear features in the headwaters of the Oldman watershed has been identified as a critical issue by OWC stakeholders, including the Government of Alberta. Through the OWC's Headwaters Action Plan and the GOA's Livingstone Porcupine Hills Land Footprint Management Plan, targets have been set to reduce the density of linear features and/or manage their impact.

[7] *Fiera Biological Consulting Ltd (Fiera). 2014. Oldman Watershed Headwaters Indicator Project – Final Report (Version 2014.1). Edmonton, Alberta. Fiera Biological Consulting Report #1346*. https://oldmanwatershed.ca/resources-hap.

In the Gold and Blairmore Creek watersheds where the Grassy Mountain Coal Project is being proposed, OWC's target is to mitigate the impact of linear features, because these 2 watersheds fall along a major transportation corridor (Highway 3). The key action identified to achieve this target is to address connectivity issues across the highway 3 corridor in an effort to protect species that are sensitive to barriers or mortality from collisions. The proposed project will make it even more difficult to address connectivity and linear features density issues in an already fragmented landscape.[8]

Soil Erosion and Stream Sedimentation

One of the most concerning issues related to the Grassy Mountain Coal Project is soil erosion and sedimentation of streams, which cannot be fully mitigated when millions of tonnes of soil, rock and coal is disturbed. The Environmental Impact Assessment identifies "soils in these landscapes are highly susceptible to water erosion upon complete removal of all vegetation and debris" but suggests that these impacts can be reduced through mitigation. The large scale and long timeline of this coal project makes the risk higher compared to other types of land use.

The EIA outlines a reliance on sediment ponds for mitigation; "A key assumption of this assessment is that the surface water management program will provide the appropriate level of TSS and selenium removal, so the water quality will not be degraded. These assumptions will require additional monitoring to validate these predictions." This is a risky assumption and critical to the overall environmental impact. If the management ponds do not perform as hoped then water quality could be severely impacted by nutrients, sediment and metals, which will in turn impact downstream users and aquatic species.

If this project is approved, independent monitoring capacity acceptable to the Government of Alberta will need to conduct regular monitoring to ensure the settling ponds are intact and operating as required, are of adequate size to manage high runoff events, not vulnerable to breach, and that the effluents are not impacting nearby creeks and downstream rivers. Again, transparency and public access to the data would instill confidence in local and downstream residents.

Native and Naturalized Fish

Reaches of Gold and Blairmore Creeks, their tributaries and the Crowsnest River are critical habitat for the westslope cutthroat trout (*Oncorhychus clarki lewisi*), a federally threatened species and subject to a critical habitat order issued by the Federal Government.

Gold Creek is 1 of only 3 streams left in the Oldman watershed that have a 'low' adult density - all other streams are 'very low' or 'functionally extirpated' as shown on the Government of Alberta map below.

[8] *Oldman Watershed Council. 2014. Headwaters Action Plan. https://oldmanwatershed.ca/headwaters-action-plan.*

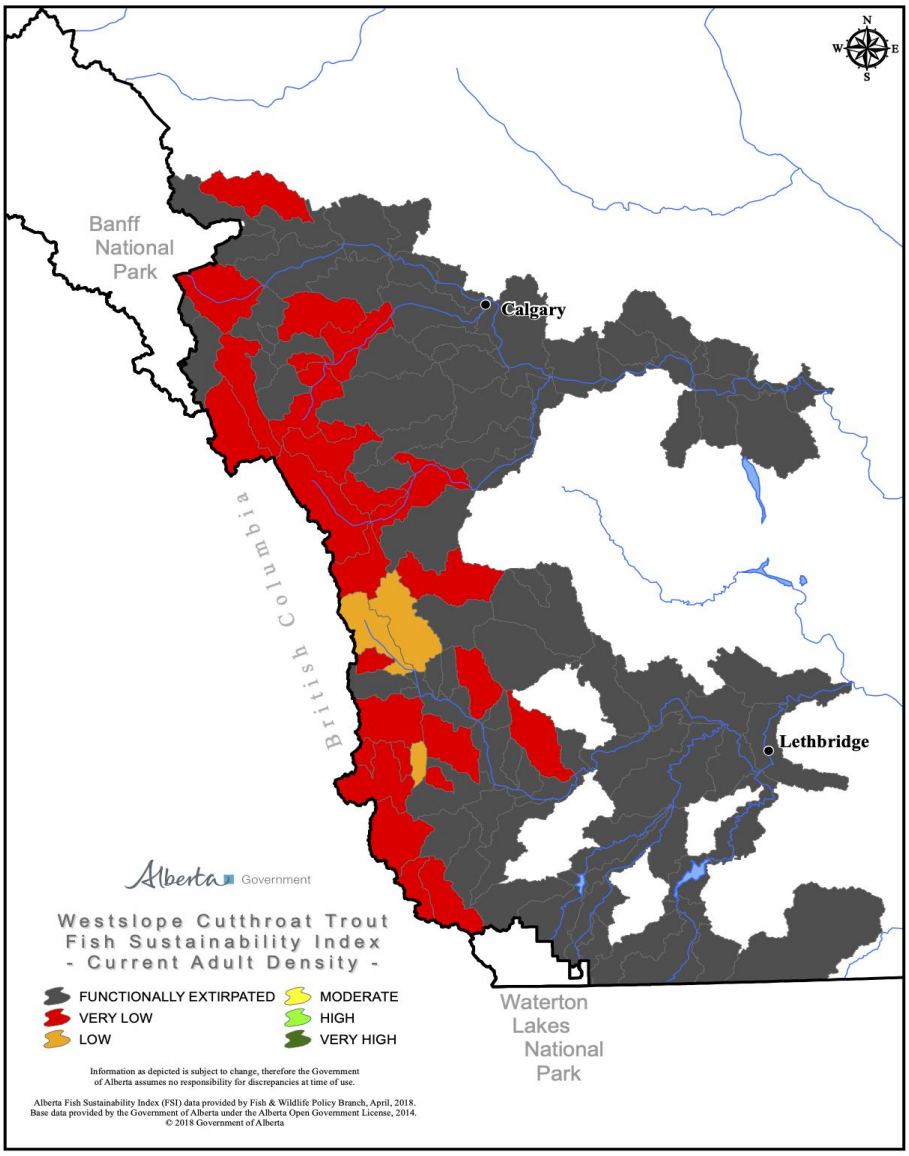


Figure 6: Westslope Cutthroat Trout Fish Sustainability Index - Current Adult Density showing Gold Creek (lowest watershed in orange) is 1 of only 3 streams with a 'low' rating.

Gold and Blairmore Creeks are also the only creeks given the highest habitat protection need of 'very high' as shown on the Government of Alberta map below.

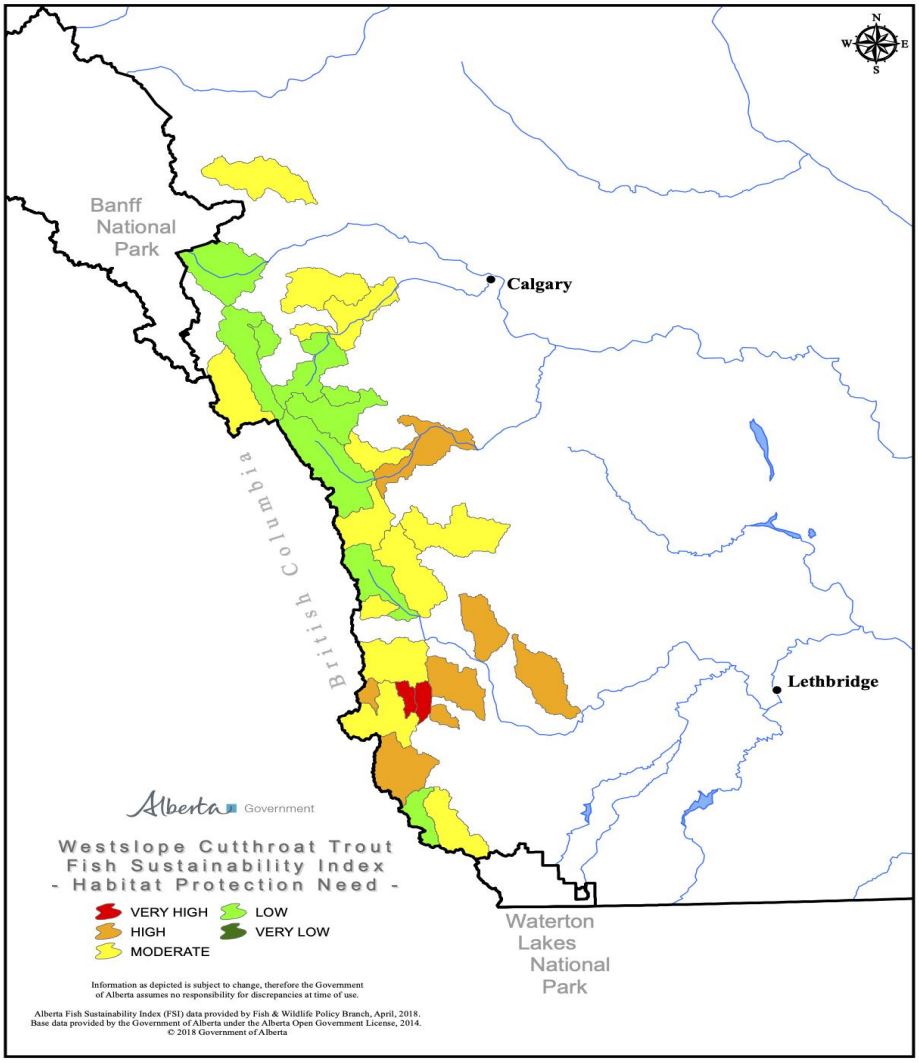


Figure 7: Westslope Cutthroat Trout Fish Sustainability Index - Habitat Protection Need showing Gold and Blairmore Creeks are rated 'very high'.

Bull trout (*Salvelinus confluentus*) and mountain whitefish (*Prosopium williamsoni*) are also native fish found in these streams and brook and rainbow trout are important sport fish that support the angling industry. The EIA predicts 758 m^2 loss of aquatic habitat and 530 m^2 of altered habitat on Gold Creek which will have a negative effect, of unknown magnitude, on fish populations. In addition, whirling disease was detected in the Crowsnest River in April, 2017 placing additional pressures on native fish downstream of Gold and Blairmore Creeks.

The Crowsnest River is a fly-fishing destination in Alberta, touted as second only to the Bow River for spectacular trout populations. This fishery supports an important economic driver for the region that could be put at risk by the Project.

Our stakeholders are concerned that the Project could result in native trout extirpation from Gold and Blairmore Creeks. Westslope cutthroat trout in particular are barely hanging on and may not be able to survive any additional habitat changes.

Biodiversity

In addition to the 2 threatened fish species already discussed the Project would remove 27 species of rare plants within the project footprint, including *Pinus albicaulis* (whitebark pine), which is endangered federally and provincially and *Pinus flexilis* (limber pine), which is endangered provincially and recommended by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to be listed as endangered federally.

The project would also remove 7.8 ha of shrubby open fens and 168.8 ha of old growth forest and impact many wildlife species including grizzly bears (provincially threatened), olive-sided flycatcher, common nighthawk, short-eared owl and little brown myotis. In addition, the project would remove 56.3 ha of native montane grassland and 104.3 ha of native subalpine grasslands, which includes rough fescue grasslands that are extremely difficult to reclaim and known for their high value for carbon storage, livestock forage and wildlife habitat. Grasslands are the most endangered ecosystems on the planet and only 26% of them remain in Alberta.

Our stakeholders are concerned about the loss of this habitat, its impact on rare species and how these seemingly small, incremental losses will add up over time.

Cumulative Effects

The watershed integrity of the Oldman headwaters is at risk because of the cumulative effects of multiple use and this project will further contribute to its decline by increasing linear features density, removing intact forests, grasslands and wetlands, changing groundwater and surface water hydrology and degrading water quality.

Our stakeholders are concerned that our headwaters are becoming overly stressed by the ever increasing demands placed on the land and water. The region is already facing serious threats including climate change, declining biodiversity, sedimentation of streams, whirling disease, mountain pine beetle, fragmentation and habitat loss from multiple land uses. We are fortunate to have this world renowned rocky mountain ecosystem and as the current stewards of this land, it is our responsibility to manage it well for future generations.

An overarching cumulative effects assessment is lacking in the EIA, with some sections stating that one is not necessary. We suggest a more robust cumulative effects assessment is undertaken which includes empirical data and modelling of the known multiple uses in the Local Study Area and Regional Study Area and also includes potential downstream effects beyond these areas. Our stakeholders deserve accurate information on cumulative effects because they are either local or downstream residents.

Capacity for Monitoring, Evaluation and Enforcement

A large project like this will require significant capacity to adequately monitor and evaluate the ongoing operations and if necessary, enforce permit conditions and existing legal requirements. Given tight fiscal realities and current workloads we have concerns about the Government of Alberta's capacity, or the capacity of independent monitoring parties, to regularly monitor this project over the next 24 years.

This concern partly stems from the fact that according to the EIA, there are currently 288.7 ha of unreclaimed lands within the proposed project footprint from previous mining operations. What new measures are in place to ensure this won't happen again and leave even more unreclaimed land?

Reclamation and Offsets

There is an estimated riparian loss of 18,868 m^2 on Gold Creek and 402 m^2 on Blairmore Creek.

Offsets can be a useful tool, but only if equivalent areas are actually restored to the original ecological function of the damaged areas. If existing environmentally valuable areas are simply designated as offset areas, the net effect is still a loss. If the restored areas are not as ecologically functional the net effect is also still a loss. Keeping what we have is much more economical and effective than having to reclaim afterwards, or attempt to restore other damaged areas. We do not have the ability to recreate what nature has created over time and reclamation has proven to be very difficult, expensive and sometimes impossible.

The project is located in an area that is very difficult to reclaim because of shallow soils and we have seen past reclamation efforts nearby fail to establish groundcover. Given these past failings, it is difficult to see how adequate groundcover will be established to control erosion and how ecological function will be restored.

Thank you for the opportunity to participate in the review process. Please do not hesitate to contact the Oldman Watershed Council's Executive Director, Shannon Frank, at <contact information removed> if you have any questions or would like more information.

Sincerely,
<Original signed by>

Doug Kaupp
Chair

oldmanwatershed.ca

Watershed Considerations for the Grassy Mountain Coal Project

Joint Review Panel
October 2020

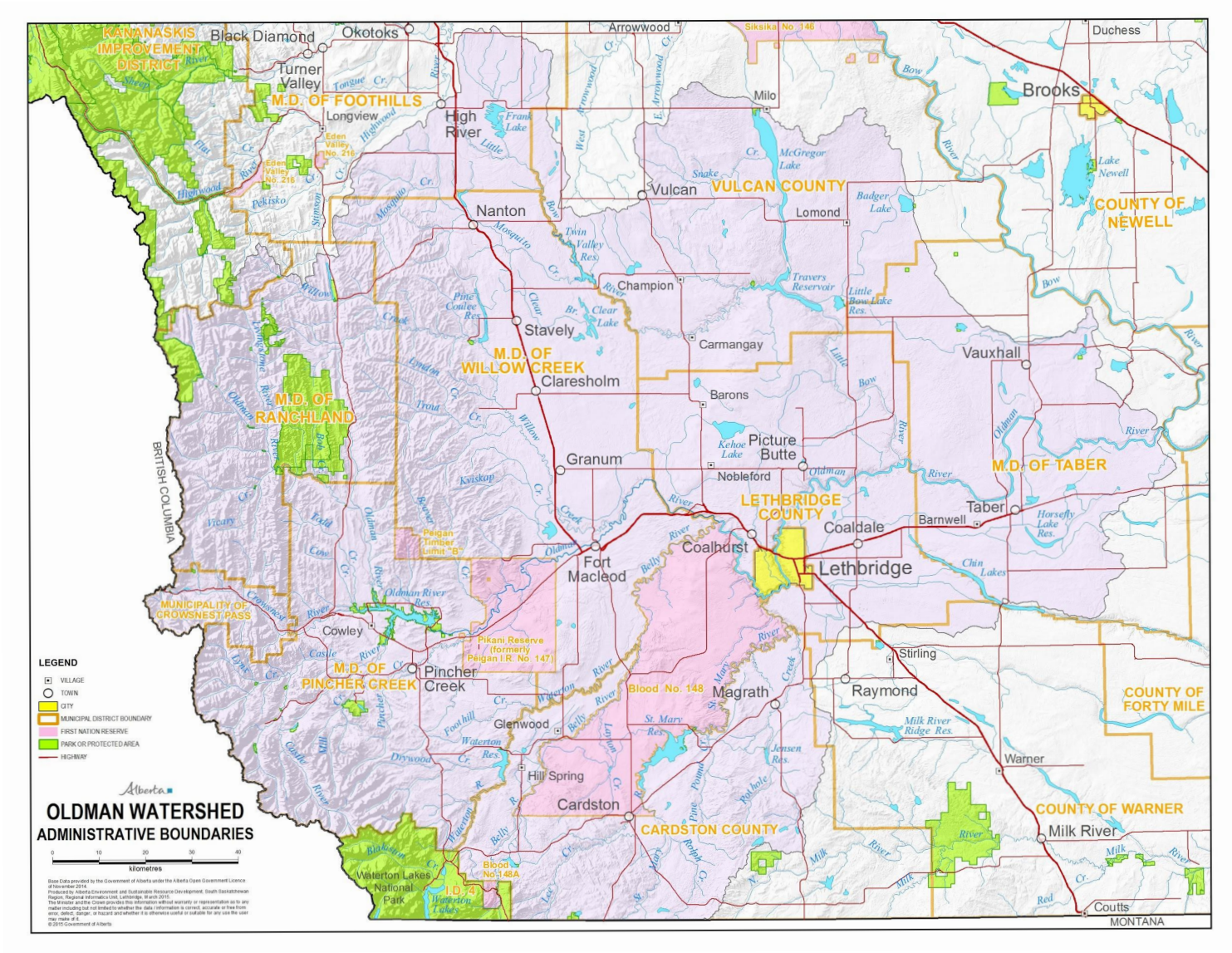
Who we are

Presenters

Shannon Frank

Andy Hurly, PhD

The Oldman watershed



All Sector Board of Directors - 19 seats

Board of Directors

Municipality of Crowsnest Pass

City of Lethbridge

Piikani Nation

Kainai Nation

Cardston County

University of Lethbridge

Alberta Health Services

Montem Resources

Spray Lake Sawmills

Lethbridge Northern Irrigation District

Alberta Environment and Parks

Alberta Agriculture and Forestry

Lethbridge County

Hays Stock Grazing Association

Southern Alberta Group for the Environment

Water Conservation Trust of Canada

4 individual members at large

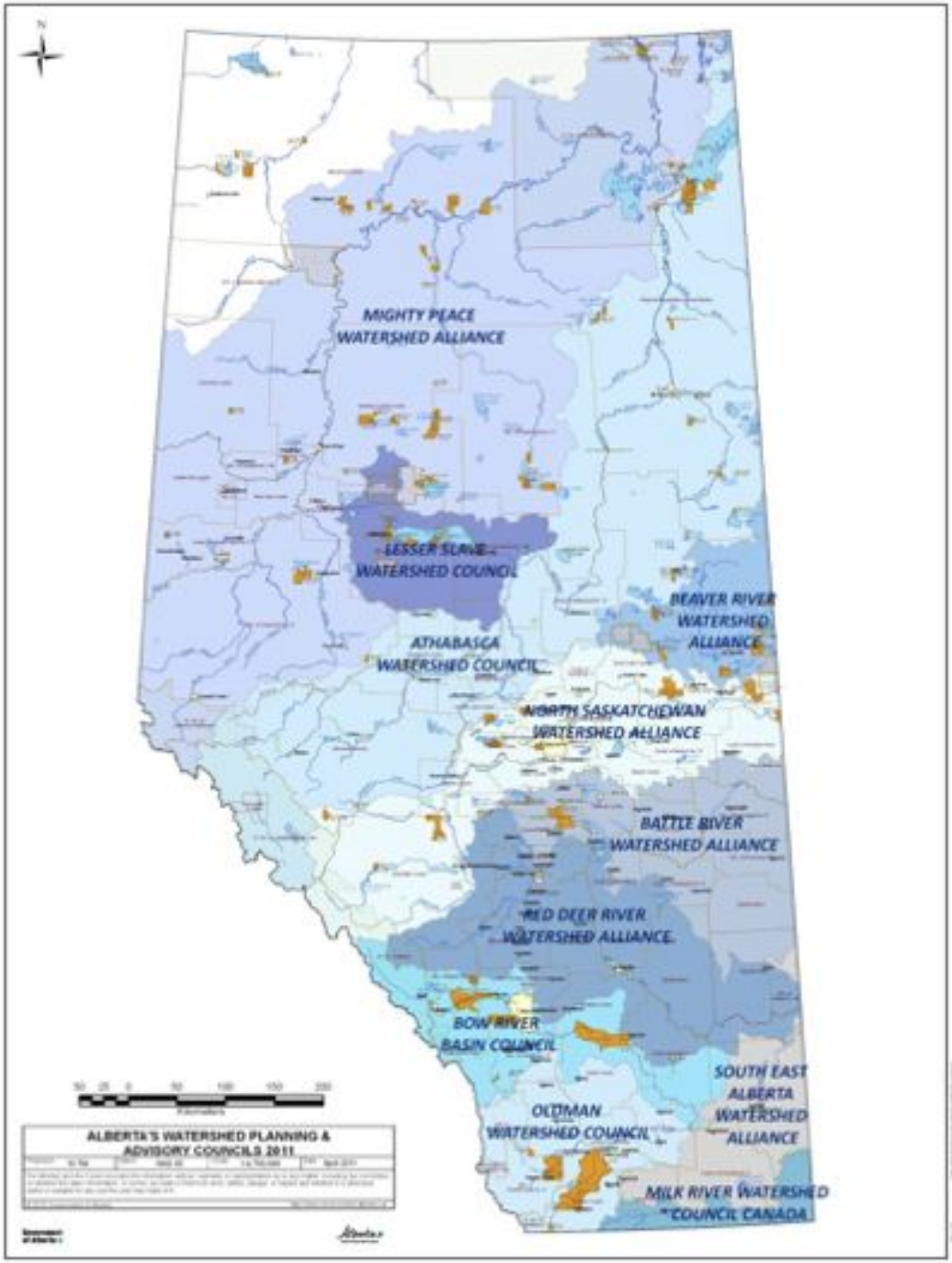
Staff

Kallie Desruisseaux, CPA CA
Office Manager

Sofie Forsström, MSc
Education Program Manager

Jon Martin, MMus
Communications Specialist

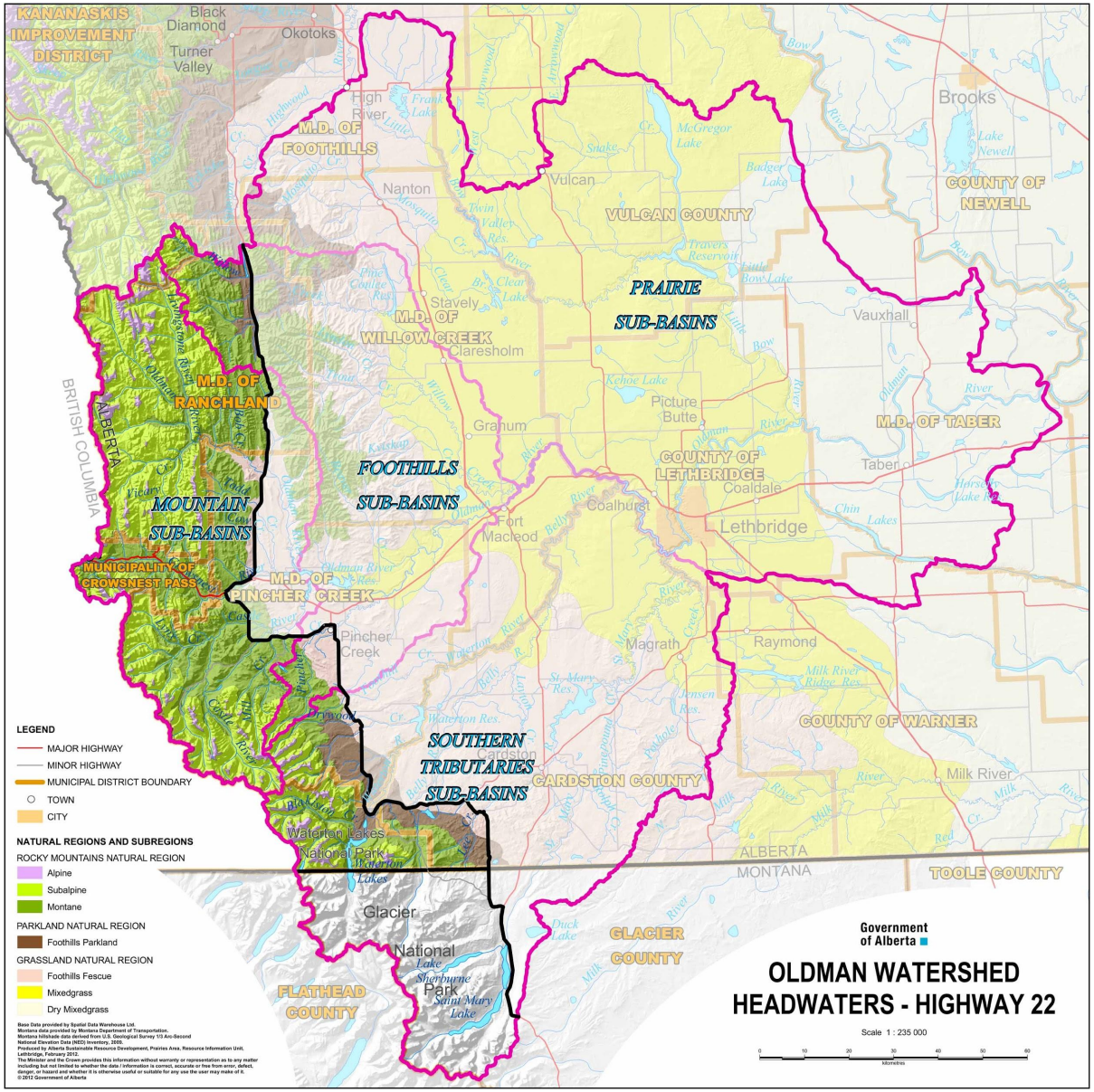
Shannon Frank
Executive Director



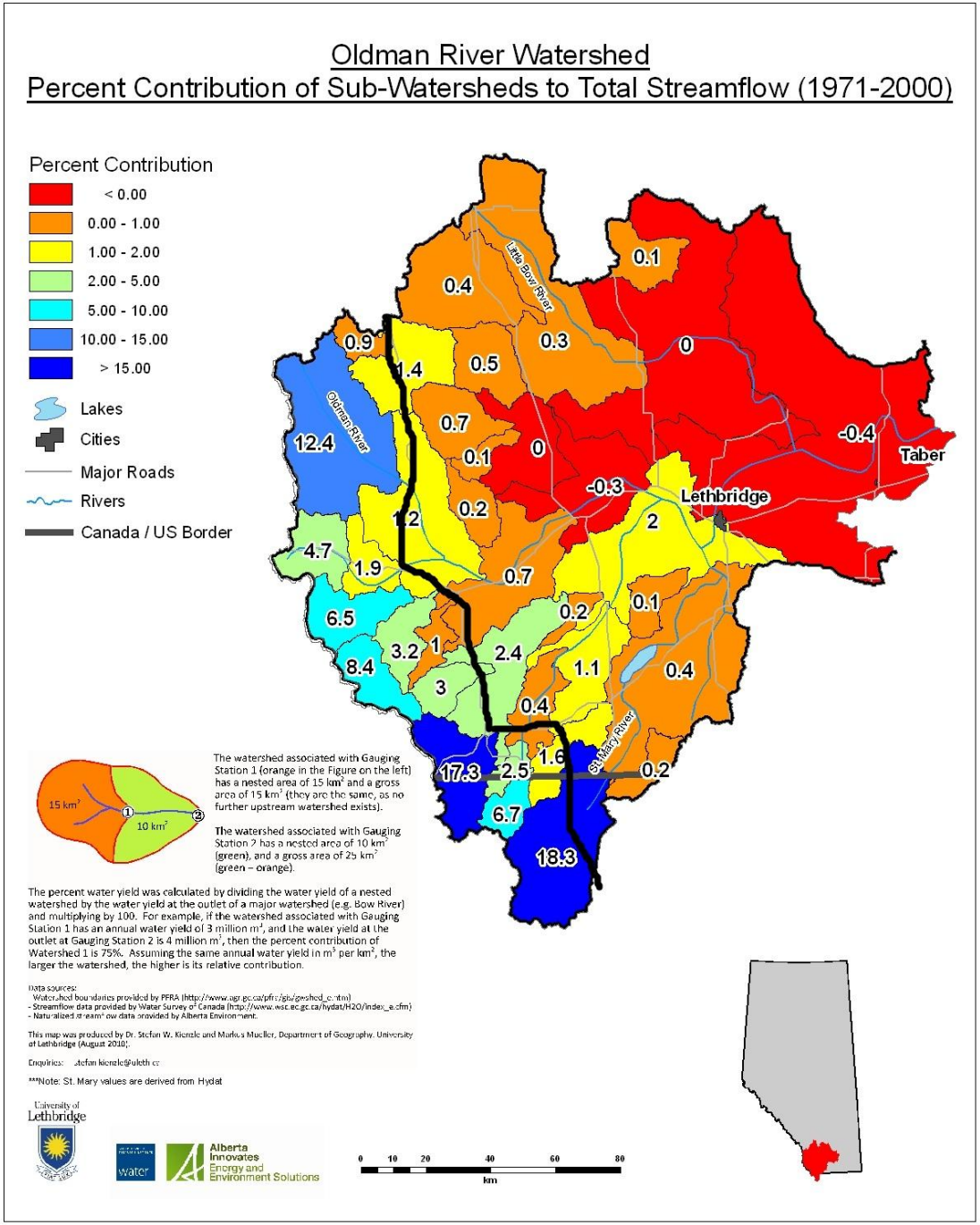
11 Watershed Planning and Advisory Councils (WPACs)

Our experience and knowledge of the area

The Oldman headwaters - the rocky mountains



Approximately 90% of the water in the Oldman River comes from the headwaters



First restoration event in Dutch Creek with 50+ volunteers, October 2015

Atlas Staging Area garbage clean up

Chinook Lake Public Recreation Area pop up education station

The decision we want and why

A forum for all voices

- Not advocating for approval or rejection.
- Want a science-based decision that has broad community support.
- Providing scientific information and stakeholder views.
- Speaking for all residents of the watershed - wild and domesticated.
- Suggesting areas that need more work to address concerns of local community.
- Note this project is precedent setting for the region.

How we will be affected

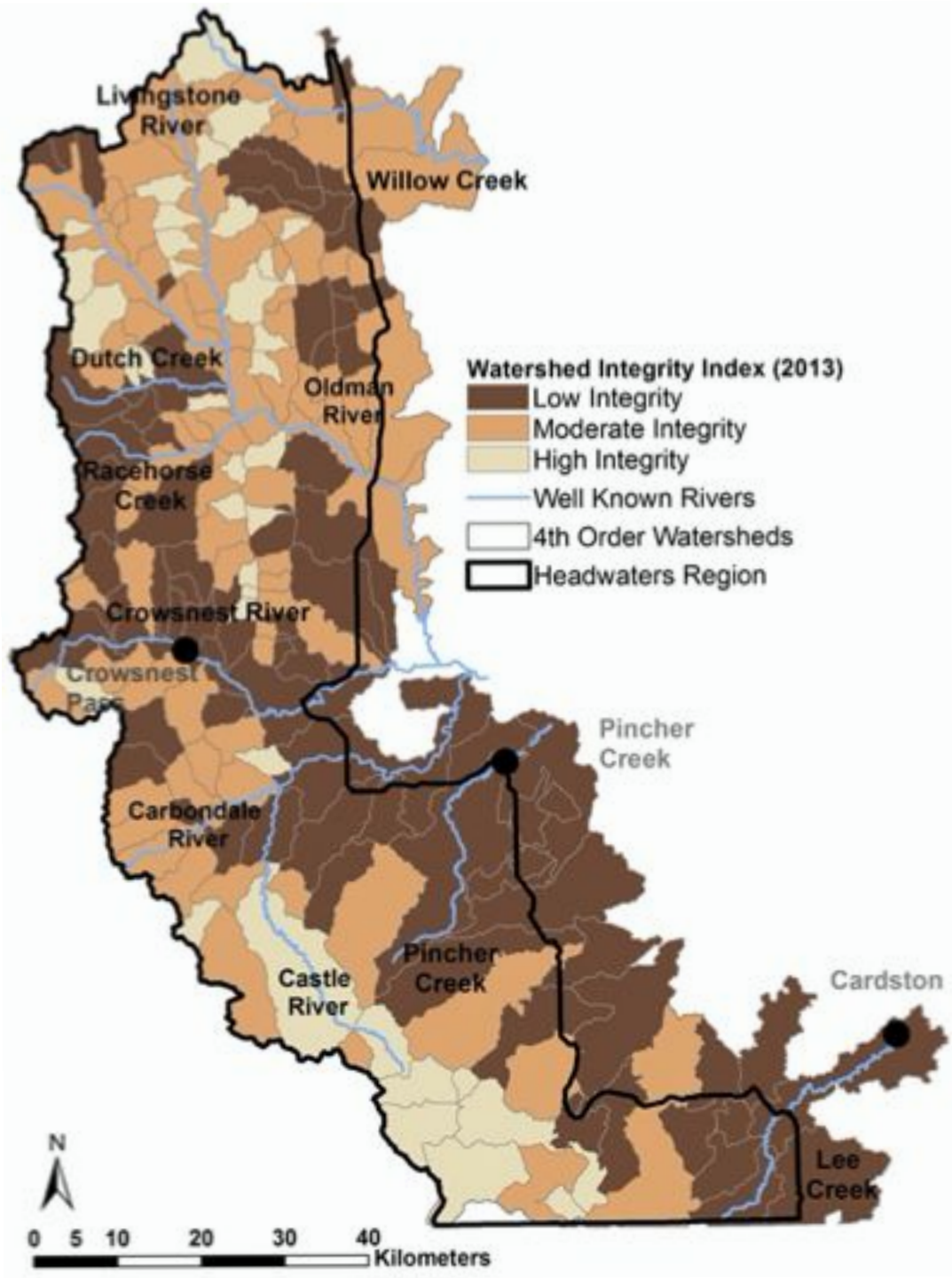
We speak for all

- Speak for the watershed, people, wild species.
- Impacts negative for the watershed and wild species.
- Impacts negative and positive for people.
- Focus our comments on the key watershed issues that are a top priority for our members.

Watershed Issues of Concern

Critical headwaters area

- 90% of the water in the Oldman River is from the headwaters area.
- Source of water for at least 200,000 people downstream.
- Semi-arid grasslands downstream are highly dependent on mountain snowpack.
- Drought is always a possibility.



Watershed Integrity Index

95% of headwaters have low to moderate integrity

Selenium

Se

- Top concern of stakeholders.
- Crowsnest River is a blue ribbon trout stream and selenium is known to cause collapse of fish populations.
- Seeing major challenges in nearby Elk Valley, we don’t want to see a repeat here.
- Drinking water well had to be shut down in Sparwood.

Municipal water treatment

- Key concern is whether selenium is likely to travel downstream to Oldman Reservoir and Oldman River below.
- City of Lethbridge, Fort Macleod, Taber and many other communities draw their water from the Oldman River and have no alternative source.
- We do not have other rivers to draw from like they have in the Elk Valley so our risk is higher.
- Our water treatment plants are not set up to treat selenium.

Agriculture industry

- Downstream of Project is one of Canada's most valuable agricultural regions.
- Near billion dollar primary production and agri-food processing industry.
- Irrigated specialty crops and intensive livestock operations depend on clean water.
- Reputation for high quality Rocky Mountain water important to reputation on international markets.
- Agricultural stakeholders are concerned about the impacts of the Project on the water supply.
- If water contamination led to loss of agricultural production in Southern Alberta, this would have a devastating impact on the livelihood of local residents as well as the economy of Alberta.

Irrigation

- Economy of Southwest Alberta highly dependent on irrigation sector.
- Irrigation adds $3.6 billion annually to provincial GDP, including sales and processing.
- 7X as valuable, compared to dryland.
- Every cubic metre of water delivered for irrigation and other related uses generated about $3.00 to the provincial GDP and $2.00 in labour income.
- Billions of dollars of public and private investment over the last century.

Baseline level of selenium

Irrigation district water quality testing over 7 years from the Oldman River at Fort Macleod showed an mean value for selenium at 0.6 ug/L and a median value of 0.5 ug/L.

Unproven water treatment processes

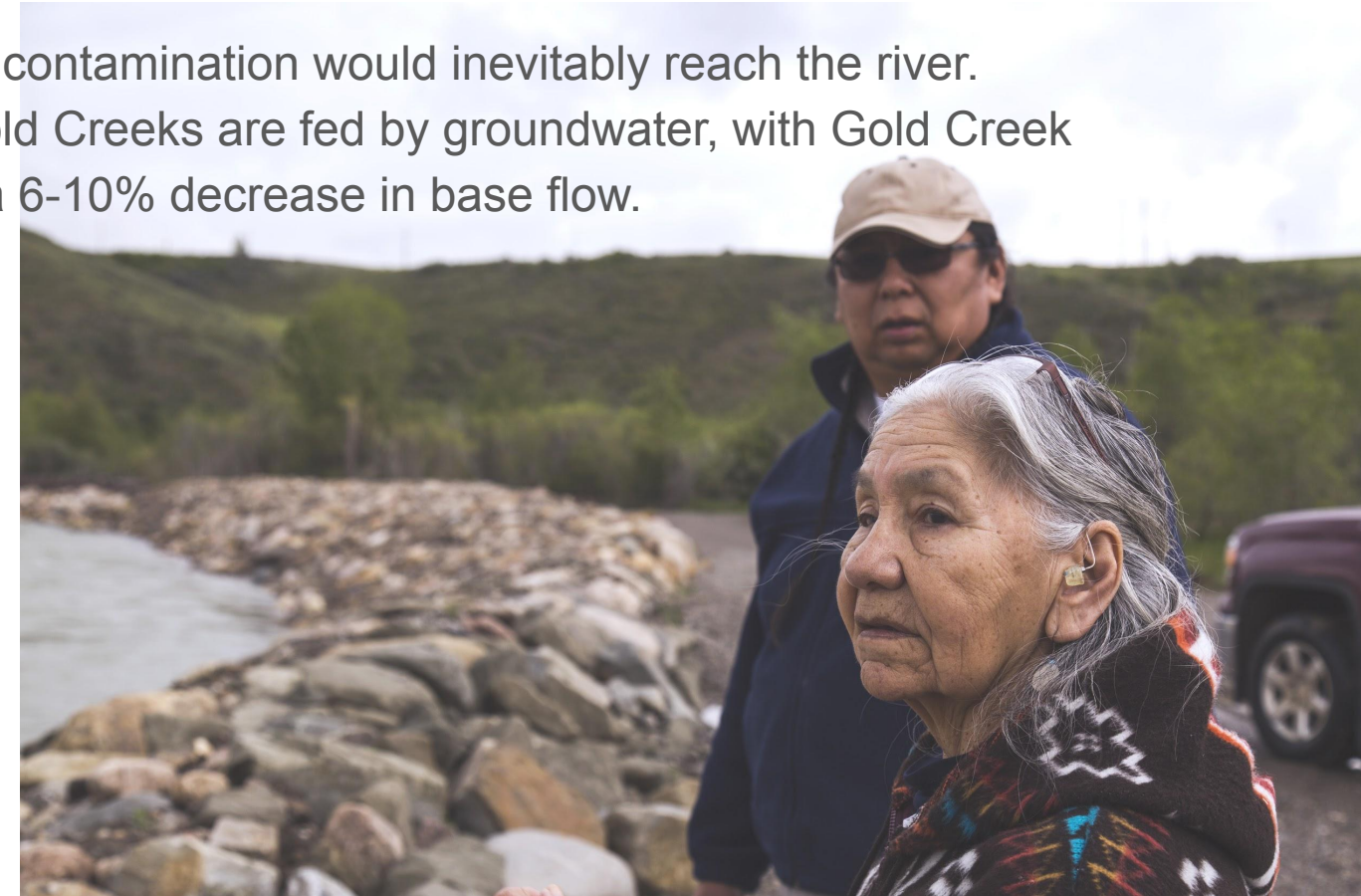
- Saturated rock fill is an unproven treatment process, which is very concerning to our stakeholders.
- Unlikely that all contaminated water will remain onsite.
- Assumption that solutions can be developed over the next decade is not reassuring.
- Risky to approve a project knowing these uncertainties.
- Especially when we are already water limited and we have only one river to draw from.
- Especially given what is happening in the Elk Valley, Koocanusa Reservoir and Kootani River.
- Research shows that even with selenium removal, high levels of nitrogen and phosphorus remain which also significantly degrade water qualiy.
- We suggest further investigation and demonstration of effective mitigation strategies be required.

Water quality

- 6 water quality variables are expected to exceed guidelines at certain times for 24 years.
- There will be impacts but the magnitude of them is unclear.
- Stakeholders are very concerned about these exceedances and the long term implications of declining water quality over such a long period of time (24 years).
- Our Rocky Mountain water is invaluable and irreplaceable.
- Lifeblood of the whole region and for many people and wild species downstream.
- Impacts could be worse than predicted as we have seen in the past.

Groundwater

- We completed a study in 2013 and found that data is extremely limited in the Crowsnest watershed and the groundwater system is highly complex.
- Mountainous geology with extensive folding and faulting makes it very difficult to predict how groundwater interacts with surface water.
- Generally, groundwater flows towards the Crowsnest River and the two are highly connected.
- Any groundwater contamination would inevitably reach the river.
- Blairmore and Gold Creeks are fed by groundwater, with Gold Creek expected to see a 6-10% decrease in base flow.



Groundwater quality

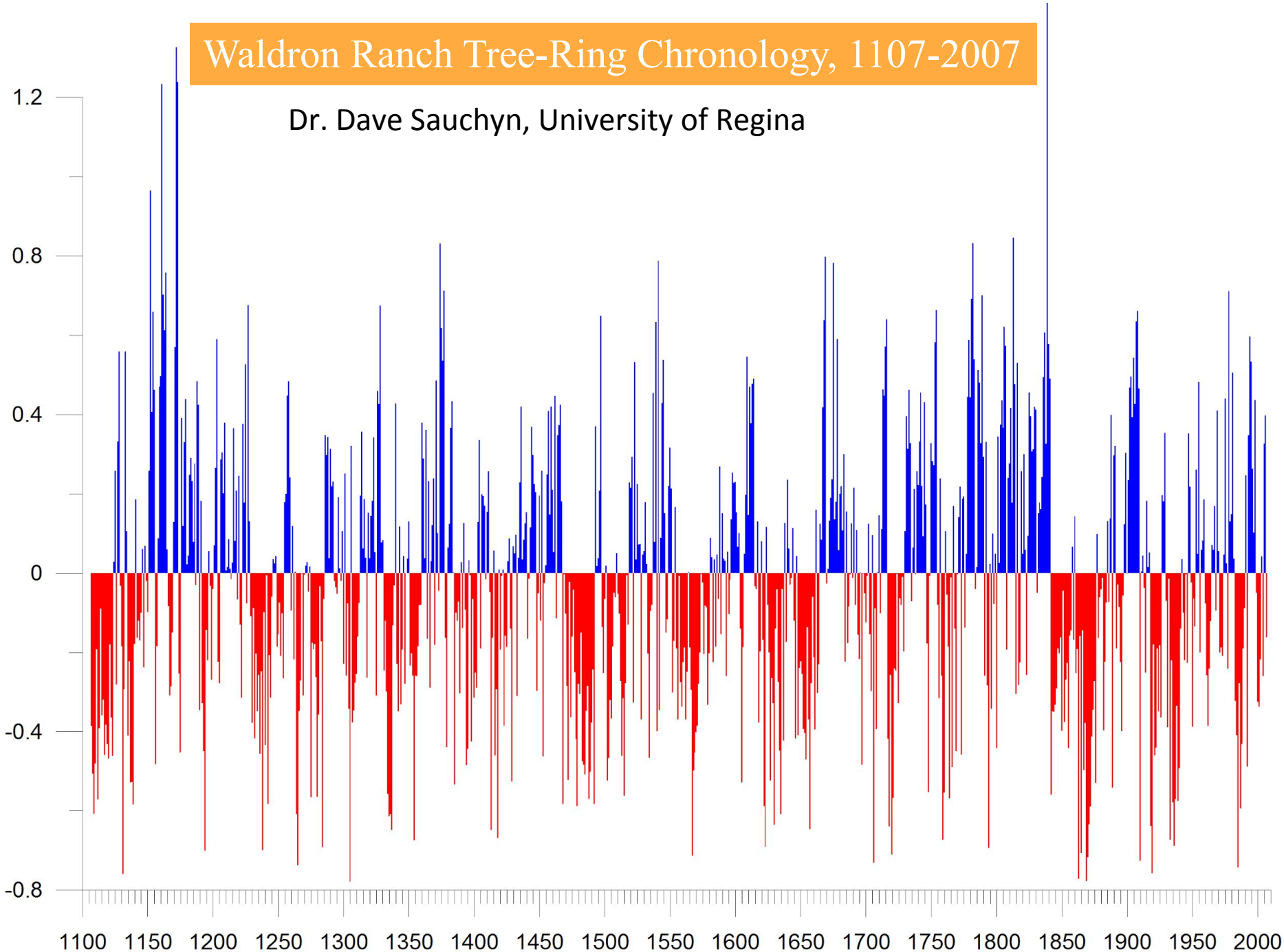
- There are 35 domestic wells and 11 industrial wells in the local study area and 175 in the regional study area.
- Some wells already exceed guidelines, mostly for metals.
- Project could exacerbate this existing problem.
- We suggest more investigation is needed to ensure drinking water wells will not be put at risk.
- Monitoring plan is inadequate - cannot move wells, need to sample more often.
- Frequent, comprehensive monitoring would increase confidence of residents, would permit rapid response if problems arise.
- Transparent, public reporting of data would increase confidence.

Water quantity

- New water withdrawals likely to impact other water users and aquatic environment in dry years.
- Climate change adds considerable additional uncertainty.
- Semi-arid, prairie climate downstream has higher risk of water shortage.
- Stakeholders are very concerned about impacts, there are already contentious debates about water use.

Waldron Ranch Tree-Ring Chronology, 1107-2007

Dr. Dave Sauchyn, University of Regina



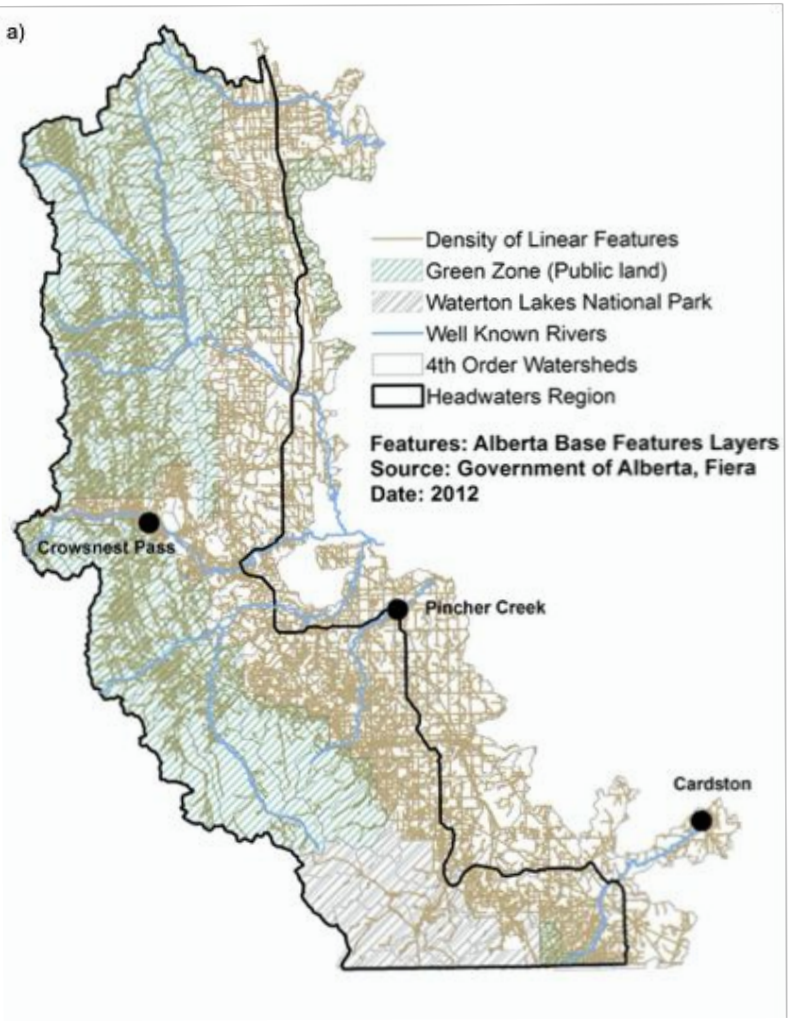
Water quantity

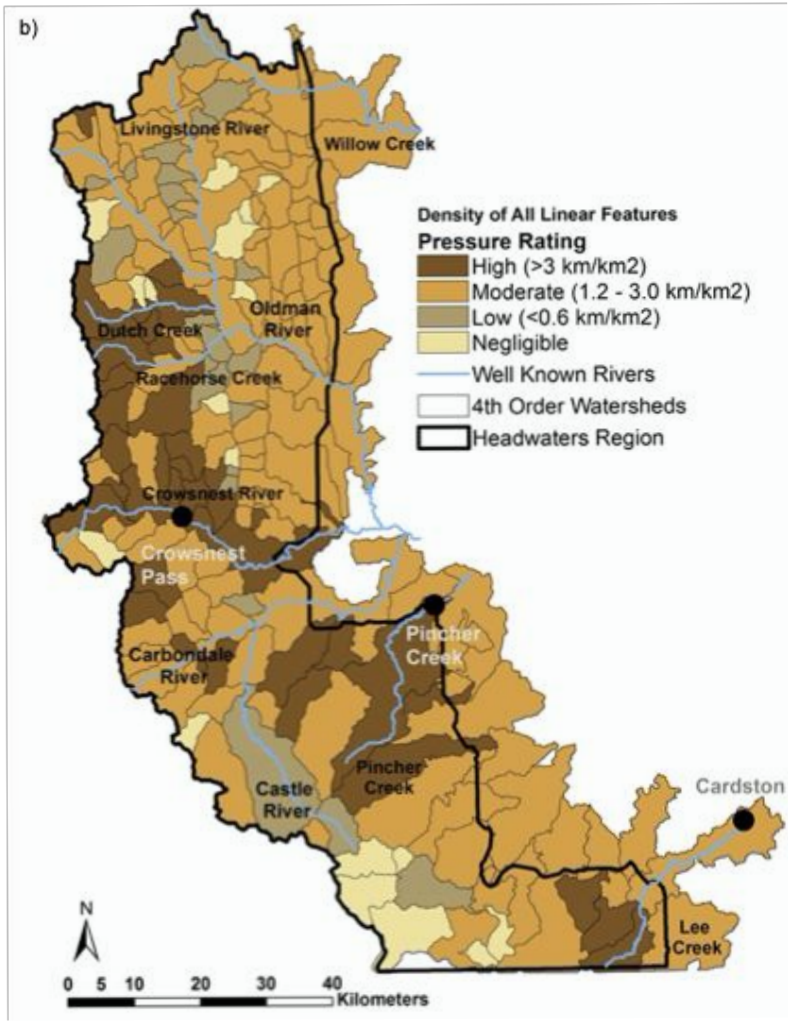
- York Creek licence application is confusing since York Creek is not within the mine area.
- Concerned about withdrawal from Gold Creek and impact on westslope cutthroat trout.
- Suggest an updated water model be required, that takes into account climate change, long periods of drought, First Nations rights, impacts on downstream users, and aquatic environment.
- Modelling needs to be shared publicly to address concerns.

Linear features

- High level of roads, trails, pipelines, etc. in the area already.
- As linear features density increase, fish and wildlife populations and water quality decline.
- Project will create more roads in a region already above thresholds for healthy fish and wildlife populations.
- The critical issue identified by Oldman Watershed Council and Government of Alberta, both have set targets to reduce density.
- Our target is to mitigate the impacts by improving connectivity across highway 3, reducing collisions with wildlife.
- Project will make it more difficult to reach this target because of added fragmentation.

Linear features



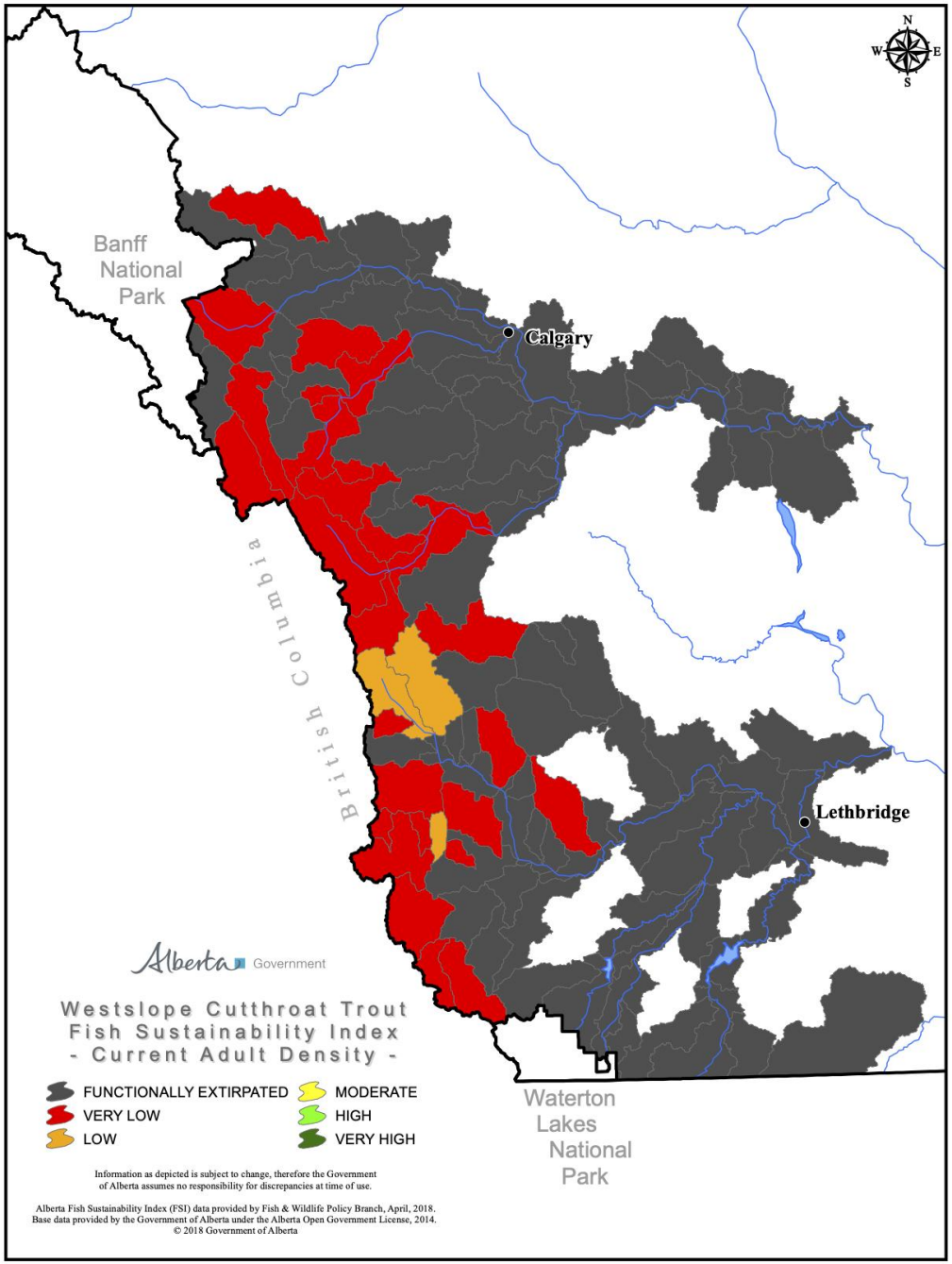


Soil erosion and stream sedimentation

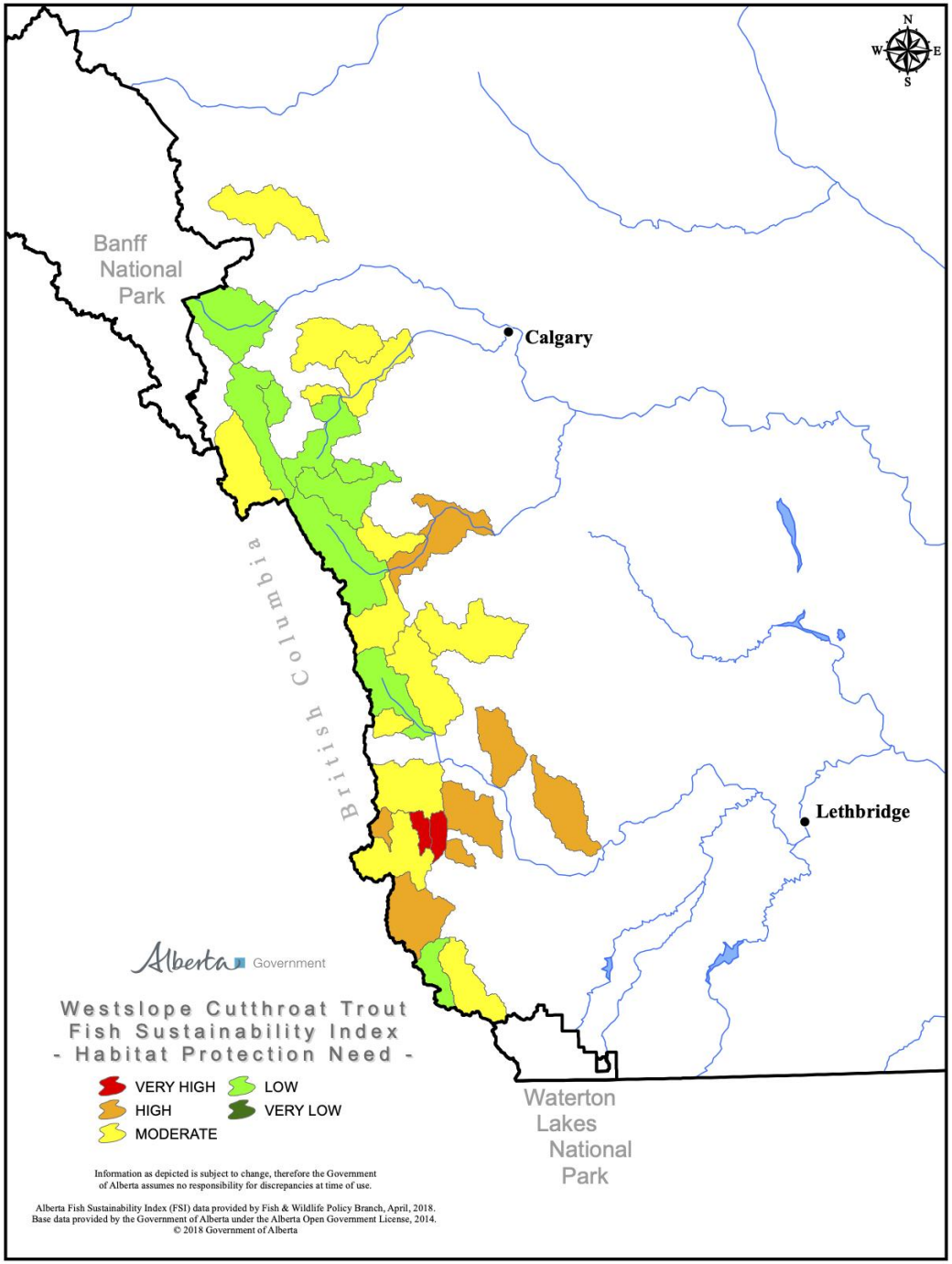
- Very likely when millions of tonnes of soil, rock and coal are disturbed in a steep, mountainous environment.
- Higher risk than other types of land use.
- EIA admits that additional monitoring is needed to validate the prediction that the surface water management program will work for TSS, Se.
- Very concerned that management ponds will not perform as hoped and water quality will be degraded.
- If approved, would like to see conditions around regular, independent monitoring and public reporting.
- Monitoring must ensure ponds are of adequate size to manage high runoff events, are not vulnerable to breach, effluents are not impacting nearby creeks and rivers.

Native and naturalized fish

- Reaches of Gold and Blairmore Creeks, their tributaries and the Crowsnest River are critical habitat for the westslope cutthroat trout (*Oncorhychus clarki lewisi*), a federally threatened species and subject to a critical habitat order issued by the Federal Government.
- Gold Creek is 1 of only 3 streams left in the Oldman watershed that have a ‘low’ adult density - all other streams are ‘very low’ or ‘functionally extirpated’ as shown on the Government of Alberta map below.



Lower watershed in orange is Gold Creek - 1 of 3 with ‘low’ adult densities.



Gold and Blairmore Creeks are also the only creeks given the highest habitat protection need of ‘very high’ as shown on the Government of Alberta map below.

Photo by Joel Sartore, National Geographic

Native and naturalized fish

- Bull trout, mountain whitefish, brook, rainbow trout important sport fish that support angling industry.
- The EIA predicts 758 m^2 loss of aquatic habitat and 530 m^2 of altered habitat on Gold Creek which will have a negative effect, of unknown magnitude, on fish populations.
- Whirling disease was detected in the Crowsnest River in April, 2017 placing additional pressures on native fish downstream of Gold and Blairmore Creeks.
- The Crowsnest River is a fly-fishing destination in Alberta, touted as second only to the Bow River for spectacular trout populations. This fishery supports an important economic driver for the region that could be put at risk by the Project.
- Our stakeholders are concerned that the Project could result in native trout extirpation from Gold and Blairmore Creeks. Westslope cutthroat trout in particular are barely hanging on and may not be able to survive any additional habitat changes.

Biodiversity

- Project would remove 27 species of rare plants, including endangered whitebark pine, limber pine.
- Project would remove 7.8 ha of shrubby open fens, 168.8 ha of old growth forest, impacting many wildlife species including grizzly bears (provincially threatened), olive-sided flycatcher, common nighthawk, short-eared owl and little brown myotis.
- Project would remove 56.3 ha of native montane grassland, 104.3 ha of native subalpine grasslands, which includes rough fescue grasslands that are extremely difficult to reclaim and known for their high value for carbon storage, livestock forage and wildlife habitat.
- Grasslands are the most endangered ecosystems on the planet and only 26% of them remain in Alberta.
- Our stakeholders are concerned about the loss of this habitat, its impact on rare species and how these seemingly small, incremental losses will add up over time.

Cumulative effects

- Area already at risk because of cumulative effects of multiple use and this project will further contribute to its decline by increasing linear features density, removing intact forests, grasslands and wetlands, changing groundwater and surface water hydrology and degrading water quality.
- Our stakeholders are concerned that our headwaters are becoming overly stressed by the ever increasing demands placed on the land and water.
- The region is already facing serious threats including climate change, declining biodiversity, sedimentation of streams, whirling disease, mountain pine beetle, fragmentation and habitat loss from multiple land uses.
- We are fortunate to have this world renowned rocky mountain ecosystem and as the current stewards of this land, it is our responsibility to manage it well for future generations.
- An overarching cumulative effects assessment is lacking in the EIA, with some sections stating that one is not necessary. We suggest a more robust cumulative effects assessment is undertaken which includes empirical data and modelling of the known multiple uses in the Local Study Area and Regional Study Area and also includes potential downstream effects beyond these areas.
- Our stakeholders deserve accurate information on cumulative effects because they are either local or downstream residents.

A stressed watershed

Mountain pine beetle

Blister rust

Fire

Flood

Drought

Industrial activity

Recreational activity

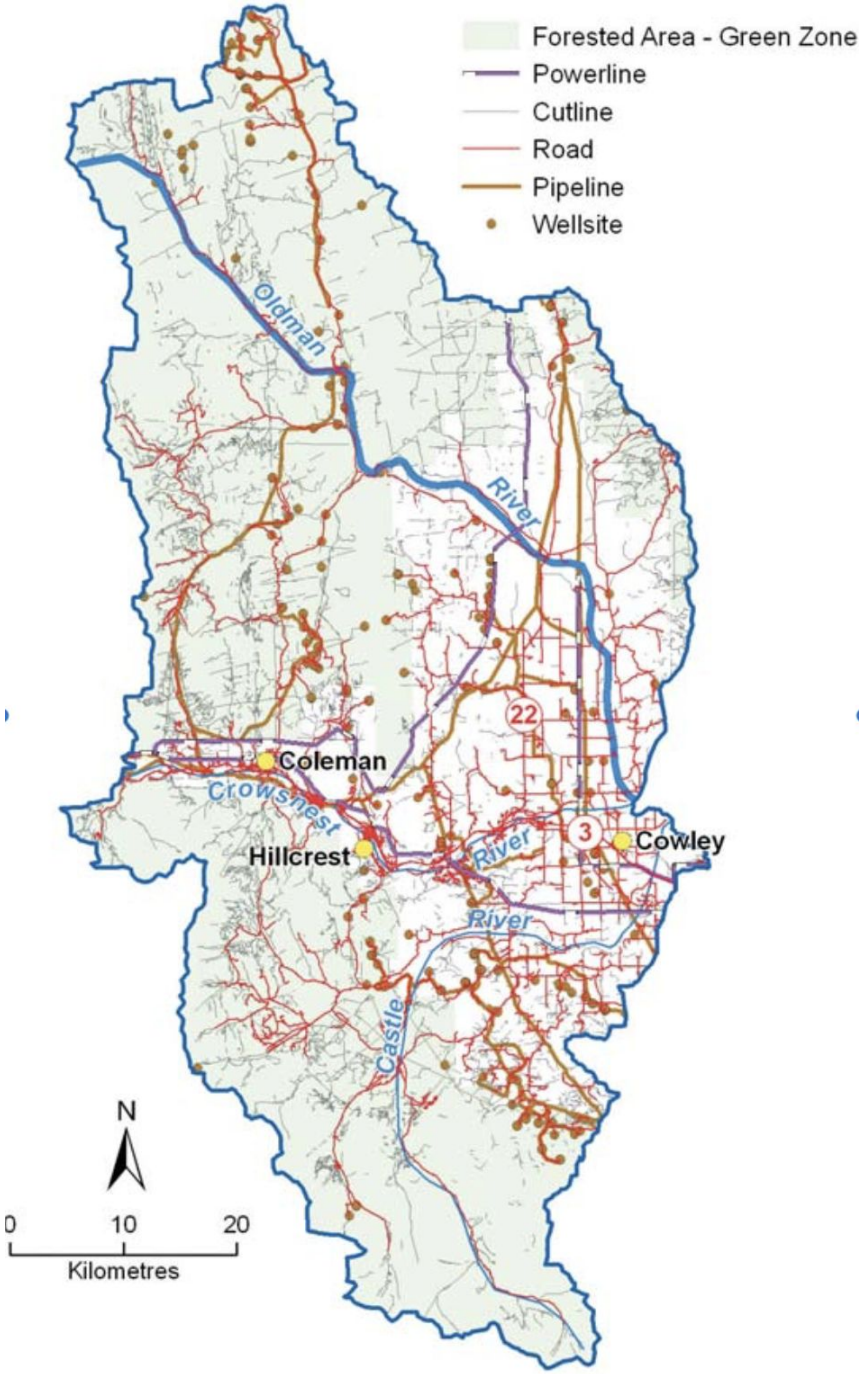


Figure 2.7: Land Use in the Mountain Sub-basins

Capacity for monitoring, evaluation and enforcement

- A large project like this will require significant capacity to adequately monitor and evaluate the ongoing operations and if necessary, enforce permit conditions and existing legal requirements.
- Given tight fiscal realities and current workloads we have concerns about the Government of Alberta's capacity, or the capacity of independent monitoring parties, to regularly monitor this project over the next 24 years.
- This concern partly stems from the fact that according to the EIA, there are currently 288.7 ha of unreclaimed lands within the proposed project footprint from previous mining operations.
- What new measures are in place to ensure this won't happen again and leave even more unreclaimed land?

Reclamation and offsets

- There is an estimated riparian loss of 18,868 m^2 on Gold Creek and 402 m^2 on Blairmore Creek.
- Offsets can be a useful tool, but only if equivalent areas are actually restored to the original ecological function of the damaged areas.
- If existing environmentally valuable areas are simply designated as offset areas, the net effect is still a loss.
- If the restored areas are not as ecologically functional the net effect is also still a loss.
- Keeping what we have is much more economical and effective than having to reclaim afterwards, or attempt to restore other damaged areas.
- We do not have the ability to recreate what nature has created over time and reclamation has proven to be very difficult, expensive and sometimes impossible.
- The project is located in an area that is very difficult to reclaim because of shallow soils and we have seen past reclamation efforts nearby fail to establish groundcover.
- Given these past failings, it is difficult to see how adequate groundcover will be established to control erosion and how ecological function will be restored.

Summary

- Critical headwaters area that is the lifeblood of mountains, dry prairies downstream and everyone that depends on Oldman River.
- Selenium, water is top concern not adequately addressed in EIA.
- Oldman River is only drinking water source for at least 150,000 people - we have no other options.
- World renowned Rocky Mountain water is cornerstone of near billion dollar agricultural industry dependent on irrigation.
- Headwaters are already stressed and fragmented from cumulative effects, local and provincial efforts are focused on restoring function and connectivity.
- Many species at risk will be directly impacted, including westslope cutthroat trout that is on the brink of disappearing.
- Stakeholder confidence is low - more investigation, piloting and testing is needed.
- If approved, many strict conditions would be necessary to address stakeholder concerns.

Questions

The forks - where the Oldman River meets the Bow River

Oldman Watershed Headwaters Indicator Project

FINAL REPORT – Version 2014.1

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March 14, 2014

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Suggested Citation:
Fiera Biological Consulting Ltd (Fiera). 2014. Oldman Watershed Headwaters Indicator Project – Final Report (Version 2014.1). Edmonton, Alberta. Fiera Biological Consulting Report #1346.

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FIERA Biological Consulting

Sassafras consulting
Specializing in Landscape Analytics

Acknowledgements

Fiera Biological would like to thank Connie Simmons and Shannon Frank from the Oldman Watershed Council for their support and advice during the development of this report. In addition, this report benefited greatly from the expertise of members of the Oldman Watershed Indicators Team and Watershed Board, including: Cheryl Fujikawa, Bill Dolan, Ian Dyson, Tony Bruder, Shirley Pickering, Richard Burke, Andrew Hurly, Terry Kerkhoff, Robert Rippin, Anne Stevick, Lorne Fitch, Brian Hills, Matthew Coombs, Axel Anderson, Sarah Elmeligi, Rosemary Jones, and Cheryl Dash.

Funding for this report provided by:

Alberta Government

Executive Summary

As designated by the Watershed Planning and Advisory Council under Alberta's Water For Life, the Oldman Watershed Council (OWC) is mandated to develop a rigorous, understandable and scientifically-defensible framework for watershed assessment and reporting. This watershed assessment process must be transparent and repeatable, requiring the development of a set of standardized tools and reporting strategies.

The Oldman Watershed covers an area of approximately 23,000 km^2 in southwestern Alberta, covering three natural regions, including the Rocky Mountains, Foothills, and Grassland. The Headwaters Region of the Watershed is located along the eastern slopes of the Rocky Mountains, and maintaining the ecological integrity of this area is crucial to the health of the Oldman Watershed. As a result, the OWC has recognized the management of the Headwaters Region, with particular attention being given to source water protection as a priority goal. Therefore, the OWC has decided to focus the initial development of a watershed assessment framework specifically on the Headwaters Region. This framework will be tested and implemented in Headwaters Region as a first step, and then adapted and rolled out to the larger Oldman Watershed in future years. This project is the initial stage of the development and implementation of a watershed assessment framework for evaluating the watershed condition of the Headwaters Region. Specifically, the objectives of this project are to:

1. Develop a watershed assessment approach for standardized reporting on watershed and ecological condition that is relevant and meaningful in the context of local and regional stewardship initiatives in the OWC Headwaters Region
2. Evaluate and/or quantify a subset of watershed assessment indicators that will serve as an initial starting point for future management, research, and monitoring action
3. Develop an indicator rating scheme that will allow for the direct comparison of indicator condition across the Oldman Watershed on a go-forward basis.

The Oldman Watershed Indicators Headwater project used a Criteria & Indicators (C&I) conceptual framework to assess current conditions in the watershed. The five criteria developed were: Criterion 1: Landscape Composition and Condition; Criterion 2: Biological Diversity; Criterion 3: Surface Water Quality; and Criterion 4: Water Levels and Flow.

A preliminary list of 25 indicators was selected within these four criteria. The majority of these indicators are aspirational, and actually measuring, monitoring or reporting on all the indicators listed will require additional data and/or substantial effort by the OWC and other stakeholders. Five indicators which were relevant to identifying hydrologically significant areas or highlighting threats to source water and biodiversity maintenance in the Headwaters Region were selected for assessment. An additional constraint on selecting indicators for this current assessment was that information and/or data had to currently exist, and be freely available. The six indicators were: 1) Intact Landscapes; 2) Road Density; 3) Density of All Linear Features; 4) Sedimentation/Erosion Potential; 5)

Riparian Condition, and 6) Stream Flow Regime. The first four indicators listed here are pressure indicators, while the last two are condition indicators.

For the four pressure indicators, indicator data "modeling" was conducted. This entailed creating indicator models in a Geographic Information System (GIS) that allows for the visual presentation (mapping) of the data across defined 4th Strahler order sub-watershed boundaries. Pressure indicators were directly compared between 4th order watersheds by assigning a "pressure" rating to each indicator. These pressure ratings were derived from scientifically-based thresholds that were taken from empirical peer-reviewed research studies or government management documents. Each 4th order watershed was rated as being at Negligible Pressure, Low Pressure, Moderate Pressure, or High Pressure from human land-use activities for each of the four indicators.

Cows and Fish riparian assessment data was summarized at the scale of 11 large watersheds to examine the Riparian Condition indicator. Stream flow regime was assessed using measures related to the magnitude and timing of flow for this indicator, including: 1) total annual flow, 2) spring flow, 3) summer flow, 4) base flow (the lowest daily flow), 5) date of spring melt initiation, and 6) the date of the 1st peak of the hydrograph. Hydrographs are plots of the temporal variation in discharge, typically over a year. These flow measures were individually assessed for every available hydrograph, and the resulting time-series of flow measures over time were assessed for significant trends using the Mann-Kendall test. Results of the long-term pattern in flows were then used to evaluate if flow measures were decreasing, increasing or showing no change over the period assessed.

Results of the pressure indicator modeling demonstrate that varying levels of risk exist across the Headwaters Region. The Intact Landscape indicator highlighted the watersheds where extensive forestry activity has occurred. The three pressure indicators related to linear features (Road Density, Density of All Linear Features, and Sedimentation/Erosion Potential) all indicated that linear features pose a Moderate to High risk in many areas of the Headwaters Region. The stream flow regime indicators demonstrated that there is general pattern of declining flow magnitude for total flow, and in the spring, and that the initiation date of spring melt is occurring early in the year in many watersheds.

Finally, a Watershed Integrity Index (WII) was constructed to summarize the information from the pressure indicators (combining Criteria 1 – 3). Based on this assessment, many areas in the Headwaters are experiencing high amounts of human land-use, and maybe be demonstrating significant biological and ecological impairments. This report also identifies data and knowledge gaps in the Oldman Watershed, with recommendations on future research and management priorities. In conclusion, this report provides a preliminary *large-scale* overview of the hydrological condition, and various human land-use factors (pressure indicators) that may be impacting the ecological condition of the watershed. Importantly, this Headwaters Indicators project should not be considered a definitive statement on the condition of the Headwater Region of the Oldman Watershed, but rather, a starting point for further management, research, and monitoring action.

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Report Disclaimer

This report represents a preliminary assessment of the status and ecological integrity of the Headwaters Region of the Oldman Watershed. Importantly, this Headwaters Indicators project should considered a starting point for further management, research, and monitoring action, and be viewed as a first step in creating a rigorous and robust watershed assessment framework within the larger Oldman Watershed. It is based on the best available science, research, and spatial data products. The assessment conducted in this report relies heavily on research pertaining to the responses of the wildlife and other biodiversity to human activity on the landscape. For many aspects of watershed health, the information required for a more thorough watershed assessment is either insufficient or is not accessible. Finally, this reports documents knowledge and data gaps hindering watershed assessment in the Headwaters Regions, and the OWC will work to address these in future updates of this report.

1. Watershed Assessment

Water is fundamental to all aspects of human life, prosperity, and ecological integrity in Alberta. The crucial role of water in the long-term sustainability of both human life and the environment is recognized by the Alberta Water for Life Strategy (Government of Alberta 2008). Maintaining healthy aquatic ecosystems, a secure supply of drinking water, and a secure supply of water for a sustainable economy are main goals of the strategy. A key approach to achieving these goals is through the establishment of Watershed Planning and Advisory Councils (WPAC's) for each major watershed in the province.

The role of WPACs is to provide guidance to the government on the management of water and watershed health. One of the major tasks of WPACs is to report on the current ecological state of the watershed using available and accessible monitoring data to identify major threats and concerns, and potential problems to water quality, water supply, and biodiversity. The Government of Alberta has developed guidance documents for watershed assessment (AENV 2008a, AENV 2008b) which provide general recommendations on environmental indicators that can be used to measure and monitor watershed conditions as part of an adaptive ecological management system. However, it is the responsibility of each WPAC to develop a rigorous, understandable and scientifically-defensible framework for watershed assessment and reporting, tailored to the specific needs and human land-uses existing within each watershed. Moreover, this watershed assessment process must be transparent and repeatable, requiring the development of a set of standardized tools and reporting strategies (Alberta Environment 2008a, Davies and Hanley 2010).

The end goal of the watershed assessment process is to inform government and the public about the condition of a watershed relative to what is desired, and secondarily to monitor the effectiveness of environmental mitigation and management activities over time (Alberta Environment 2008b). Typically, determining the "desired condition" of the watershed is done in a collaborative process that includes participation from scientists and stakeholders specific to each watershed. In Alberta, watershed assessments are benchmark tools that are designed to give decision makers and communities scientifically rigorous information for use in making decisions about the integrated management of land and water resources (AENV 2008a, Davies and Hanley 2010). Integral to the process is the concept that watershed assessment is iterative and repeated regularly on a define time interval. This framework allows for:

1. Regular updates on the ecological condition of watershed,
2. A comparison to previous watershed assessments to identify areas with improvement, areas that have not improved, or new threats.
3. A comparison of watershed condition to be made among smaller watersheds (i.e., tertiary watershed) within a larger watershed (i.e., river basin).

The Oldman Watershed Council (OWC) is currently in the process of developing an Integrated Watershed Management Plan (IWMP) and has set 8 goals for the IWMP to achieve:

Goal 1: Improve the understanding and strengthen the commitment of residents to the health of the Oldman watershed.

Goal 2: Optimize the availability of water for the natural ecosystem while supporting the social and economic needs of the community.
Goal 3: Manage and protect the integrity of headwaters and source waters.
Goal 4: Identify and prioritize thresholds to manage threats and impacts on terrestrial and aquatic habitat.
Goal 5: Understand groundwater and how it interacts with surface water.
Goal 6: Identify water quality outcomes and assess factors impacting them for adaptive watershed management.
Goal 7: Prevent and control invasive species.
Goal 8: Understand the status and implications of emerging contaminants.

These 8 goals encompass critical pieces of a watershed including surface water quantity and quality, habitat, groundwater and biodiversity. An IWMP is intended to respond to the needs and wishes of the community and thus the 8 goals reflect the top priorities of the community. As part of the IWMP, a priority goal for the OWC is the management of the Headwaters Region, with particular attention being given to source water protection (OWC 2011). As a result, the OWC has decided to focus the initial development of a watershed assessment framework specifically for the Headwaters Region of the Oldman Watershed (Goal 3). This framework will be tested and implemented in Headwaters Region as a first step, and then adapted and rolled out to the larger Oldman Watershed in future years. This project is the initial stage of the development and implementation of a watershed assessment framework for evaluating the watershed condition of the Headwaters Region. Specifically, the objectives of this project are to:

1. Develop a watershed assessment approach for standardized reporting on watershed and ecological condition. We are proposing a watershed criteria and indicators framework that is relevant and meaningful in the context of local and regional stewardship initiatives in the OWC Headwaters Region;
2. Evaluate and/or quantify a subset of watershed assessment indicators that will serve as an initial starting point for future management, research, monitoring, and guiding local stewardship action in the Headwaters Region;
3. Develop an indicator rating scheme that will allow for the direct comparison of indicator condition across the Oldman Watershed on a go-forward basis.

2. The Oldman Watershed

The Oldman Watershed covers an area of approximately 23,000 km^2 in southwestern Alberta, with an area of approximately 2,100 km^2 extending south into northern Montana (Figure 1; OWC 2010). The Watershed consists of three Natural Regions, including the Rocky Mountains, Foothills, and Grassland, which are divided into seven Natural Subregions: Alpine, Subalpine, Montane, Foothills Fescue, Foothills Parkland, Mixedgrass and Dry Mixedgrass.

The Headwaters Region of the Watershed is located along the eastern slopes of the Rocky Mountains (Figure 1) and maintaining the ecological integrity of this area is crucial to the health of the Oldman Watershed. The eastern boundary of the headwaters region in this project is defined by major highways, and it should be noted that montane areas extend outside the study area. The Headwaters Region is characterized by a high density of small streams and rivers that flow from high-elevation alpine and subalpine areas, down towards lower elevation montane regions. The accumulation of snow in the

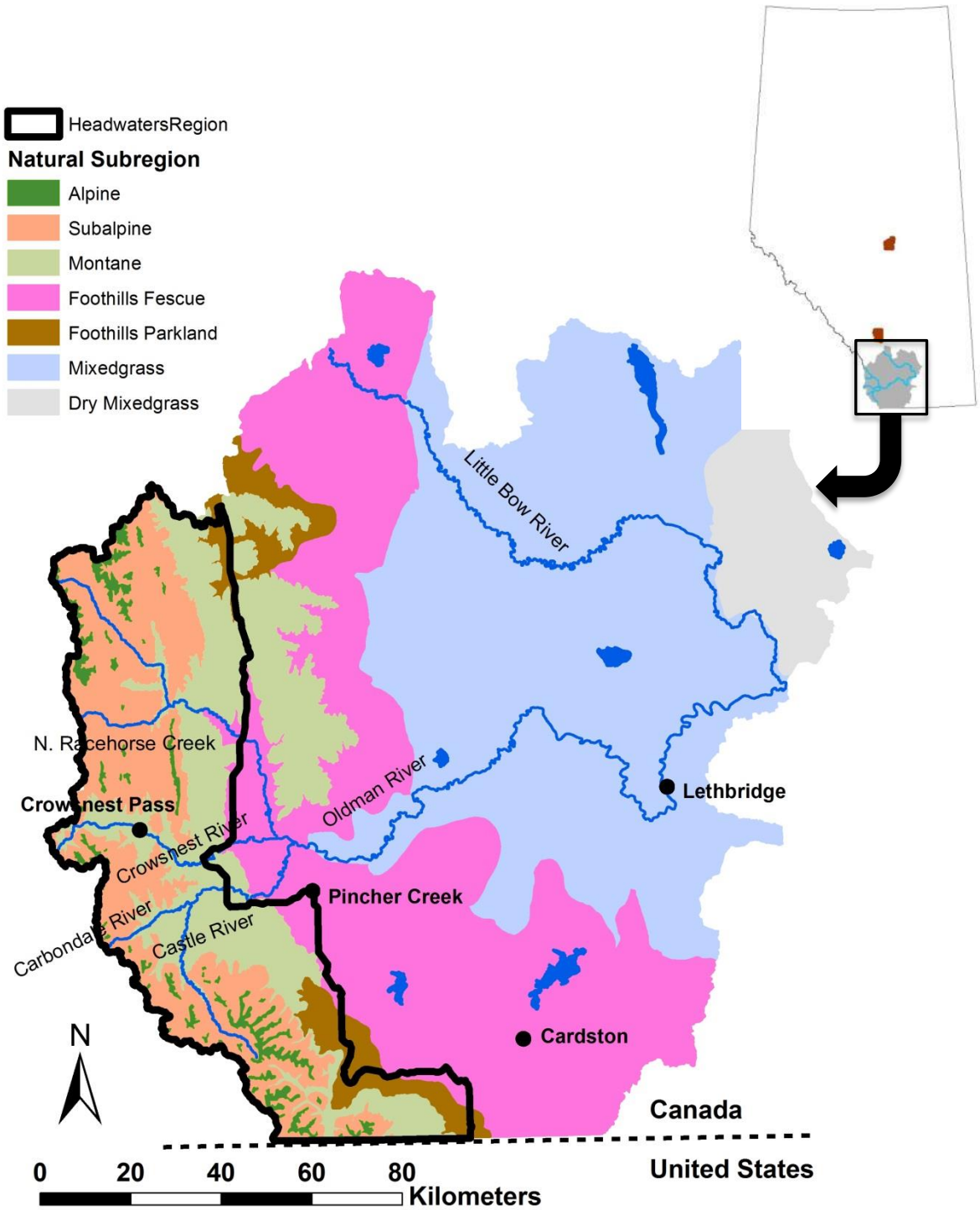

Figure 1. Location of the Oldman Watershed and the Headwaters Region in the province of Alberta. For this project the eastern boundaries of the Headwaters Region are delineated along Highways 22, 3 and 6.

alpine and subalpine regions is the primary source of water for the majority of the watershed (Crowsnest, Oldman, and Castle Rivers), with the Headwaters Region contributing approximately 75% of the total flow to the Oldman River (OWC 2010). The Waterton and Belly Rivers in the southern portion of the Watershed originate from Glacier National Park in Montana.

Forestry is the dominant industrial activity in the Headwaters Region, with forest harvest operations concentrated in areas along Livingstone Creek, upper Oldman River, the central Castle River, and along the tributaries flowing into the upper Crowsnest River (including Allison Creek, Star Creek, McGillvary Creek, Nez Perce Creek, Blairmore Creek and Todd Creek). Cattle grazing is the dominant agricultural land-use, with grazing leases issued throughout the Headwaters Region (including in alpine areas). Some crop and hay production occurs along the eastern boundary of the Headwater Region at lower elevations. Recreational activity is another major human disturbance in the Headwater Region, with off-road vehicle (ORV) use being widespread and concentrated in areas that have been previously disturbed by forestry and oil and gas operations. These industrial activities create a network of linear features (e.g., roads, haul-trails, seismic lines, and pipelines) that have been abandoned, and are now used as ORV trails.

3. Criteria and Indicator Framework

This project uses a criteria and indicators conceptual framework to evaluate the watershed integrity of the Headwaters Region. This approach is well established in forest and watershed management in Canada and the United States, and the resulting framework provides the Oldman Watershed Council with a set of overarching goals and objectives to help maintain the ecological integrity of the watershed (Davies and Hanley 2010; AEVN 2008b; CCFM 2005, 1995; EPA 1996, 1990). The criteria and indicators approach first identifies ecological *criteria* that are critical for maintaining watershed health, and second, identifies related *indicators* that can be used to evaluate changes in the selected criteria over time (Box 1; definitions adapted from CCFM 2005, 1995). The goal of using a criteria and indicator framework is to simplify and summarize complex ecological information to ensure ecological values are effectively communicated, such that this information can be better integrated into land-use planning policies and processes (CCFM 2005; Overton et al., 2002). This is accomplished using standardized rules to combine criteria and indicators into a Watershed Integrity Index (see Section 6).

Box 1. Criteria & Indicators Definitions

Criteria: A criterion is representative of a specific watershed element and embodies the collective conservation values and goals for management of the watershed. Criteria are categories of conditions or processes that characterize the aquatic environment and can be used to evaluate watershed condition. Criteria are related to, and representative of, a specific watershed element (e.g. water quality, water quantity, etc.), are often narrative or aspirational, and embody the collective goals or objectives for the management of the watershed.

Indicator: An indicator is a measureable (quantitative) or descriptive (qualitative) variable that can be used to observe, evaluate, or describe trends as a criterion changes over time. Each specific indicator is associated with a parent criterion.

3.1 Criteria and Indicators Principles

The following principals were used by the Oldman Watershed Indicators Team (OWIT) to help guide the selection of criteria and indicators for the Oldman Watershed:

1. **Ecologically relevant**: Criteria and indicators must provide a meaningful measure of ecological integrity and watershed health, and should be useable in the short-term (i.e., information is available within the past 5 years, which provides a snap-shot of current conditions) and over the long-term (i.e., appropriate for long-term trend analysis (typically requiring a minimum of 20 years of data).
2. **Meaningful and relevant to the public**: Criteria and indicators must be reflective of the views and management goals of the Oldman Watershed Council, as well as other stakeholders in the watershed.
3. **Scientifically defensible:** Criteria and indicators must be scientifically rigorous and reflect the best and most current scientific understanding of watershed management. In addition, indicators must be scalable (i.e. meaningful at multiple spatial scales), repeatable, and effective (i.e. have sufficient power to detect temporal and spatial changes).
4. **Interpretable and understandable**: Indicators must be understandable by a broad audience and should convey information in a way that is accessible to managers, policy makers, and the general public.

3.2 Criteria Definition

The following four Criteria were selected by the Oldman Watershed Indicators Team to provide the basis for evaluating and managing the ecological integrity of the Oldman Watershed and Headwaters Region:

CRITERION 1: Landscape Composition and Condition

Watersheds are a natural functioning ecological unit on the landscape, and both terrestrial and aquatic systems are connected through transfers of energy, water, and matter (Lathrop et al. 2007). The integrity of a watershed is based on the overall physical condition of the watershed, including bedrock, landforms, soils, and drainage ways, within which transfers of energy, matter and water occur. Human activity alters these pathways, and can negatively impact ecosystems functioning, including modifying nutrient balances which can result in contamination of surface and ground water, lead to increased soil erosion and sedimentation, and deleteriously impact wildlife populations, demographics and movement (Brabec et al. 2002, Chapin et al. 2000; Weijters et al. 2008). One of the dominant human impacts globally is habitat loss, where the natural vegetation is removed, and converted to a human land-use (i.e. agriculture, urban/rural development, forestry, industrial development, linear features; Chapin et al. 2000, Booth et al. 2002, Brinkman 1997). Human land conversion alters the permeability of soils and ground cover to runoff water, with impervious surfaces (paved area or areas with extensive soil compaction) being particularly detrimental (Brabec et al. 2002). The change in soil permeability results in increased stormwater runoff and sedimentation loads. Concurrent with the impacts of human land conversion is the loss of natural habitat, such as forest, riparian areas and wetlands, which absorb and clean stormwater and other runoff, and provide critical habitat for wildlife. Hence, understanding landscape composition in a watershed is critical to assessing if a watershed can support healthy terrestrial and aquatic ecosystems, and maintain the long-term sustainability of wildlife populations and other biodiversity.

CRITERION 2: Biological Diversity
Biological diversity is defined as the variation of available habitats and species, and the genetic diversity within those species populations (Chapin et al. 2000). Biological diversity is considered to be a key component of watershed health because biological species have the ability to directly influence the physical environment and alter chemical and nutrient cycling in natural systems. In addition, biological communities and populations with higher species diversity are more resilient to ecosystem disturbance, pest-outbreaks, and disease (Balvanera et al. 2006; Chapin et al. 2000). Furthermore, interactions between species and their environment are complex, with many non-additive processes (e.g., bio-accumulation of chemicals) that are often difficult to understand and measure through physical factors alone (Dube et al. 2006). Thus, measuring and monitoring the health of biological populations and communities is a critical component of understanding and managing watershed condition.

CRITERION 3: Surface Water Quality
Surface water quality is a key concern for maintaining safe and secure drinking water sources for human communities, as well as for conserving and maintaining aquatic and terrestrial biodiversity (CCME 2007). A wide range of anthropogenic activities can impact surface water quality through both point and non-point sources. For example, the removal or clearing of vegetation can increase water velocity, water temperatures, and loadings of sediments, nutrients, and /or contaminants (Pike et al. 2009). Given the potential risks posed by contamination of surface water, the maintenance of surface water quality is a priority goal in the Oldman Watershed.

CRITERION 4: Water Levels and Flow
A key component of watershed health is the maintenance of ecologically significant water flows in lentic (i.e., wetlands and lakes) and lotic (i.e., creeks and rivers) systems (Poff and Zimmerman 2010). Aquatic and semi-aquatic organisms are adapted to intra-annual (i.e., within year) and inter-annual (i.e., between years) fluctuations in water flow and water level (Poff et al. 1997). Thus, when hydrological systems experience changes in water flow or water levels that are outside the range of natural variation, many organisms can be negatively impacted or may be completely lost from the system. Maintaining water flow and water levels within the natural range of variation is an integral part of any watershed management framework (Richter et al. 1996). The main threats to the maintenance of ecologically significant water levels and flows in the Oldman Watershed include changing climate regimes (e.g. change in the amount, timing, and type of precipitation), changes in land cover (e.g. forest harvest, linear features), and the uses of surface water for human consumption, agriculture, or industrial use (e.g. Forbes et al. 2011).

3.3 Indicator Properties and Selection

An indicator is a measureable (quantitative) or descriptive (qualitative) variable that can be used to observe, evaluate, or describe trends as a criterion changes over time. Indicators are very rarely measured or quantified directly; instead, surrogate measures, which can be measured directly, are selected to represent a given indicator. There are two types of indicators that are commonly used to evaluate watershed criteria: condition indicators and pressure indicators (Box 2; definitions adapted from CCFM

2005, 1995, and Davies and Hanley 2010). For any given criterion, multiple indicators may be selected to measure the current state of that criterion, or to quantify changes to a criterion over time.

Box 2. Definition of Indicator Types

Condition Indicators: Condition indicators measure the quality or quantity of ecosystem structure or function (e.g., riparian condition or health), or can measure changes in the structure or persistence of natural flora and fauna populations in response to a gradient of human disturbance.

Pressure Indicators: Pressure indicators focus on measuring the extent or intensity of natural or anthropogenic impacts or stressors (e.g. the density of roads) that pose a risk to ecosystems or ecosystem elements.

A total of 25 indicators were selected to represent and measure condition in the Oldman Watershed (Table 1 and Appendix A). It is important to note that there is no definitive or "correct" way of selecting or categorizing indicators as measures for any given criteria. This is because indicators are often related to one another, thereby resulting in an overlap of the ecological elements being measured or quantified for each criterion. Thus, it is possible that a single indicator may be representative of more than one criterion.

It must be recognized that the indicator list in Table 1 is a preliminary list of indicators. This list has been developed to use as a starting point for watershed assessment in the Oldman Watershed, and it is expected this preliminary list will be modified and refined as work progresses, and specific management goals or targets are developed. While all the indicators in Table 1 have been selected using scientific principles (as defined in Section 3.1), actually measuring, monitoring or reporting on all the indicators listed will require substantial effort by the OWC and other stakeholders. For many indicators (and the condition indicators in particular), appropriate data either does not exist at present or requires extensive effort to assemble the existing information into a suitable format. In addition to data limitations, a robust methodology and reporting approach needs to be developed for each individual indicator. As an example, there are multiple ways to assess and report on the condition of fish communities, and part of the reporting process requires tailoring these methodologies to the specific geography, geology, and community needs and data constraints existing in the Oldman Watershed (Einheuser et al. 2013, Weigel and Robertson 2007).

From the preliminary list of criteria and indicators, a subset of six indicators was selected to evaluate the condition of the Headwaters Region (Table 1 and Appendix A). Indicators included in this phase of the project were selected because they provide an understanding of hydrologically significant areas in the Headwaters Region, as well as highlight threats to source water and biodiversity maintenance within the Headwaters Region. In addition, indicators selected for current evaluation in this project had to be:

1. Measurable: information and/or data must currently exist and be freely available or accessible in order to meaningfully quantify the indicator;

2. Time-bound: the information and/or data used to quantify a selected indicator must be available into the foreseeable future, such that trends in the state or condition of the indicator can be monitored over time.

Table 1. Preliminary list of indicators for the Headwaters Region selected by the Oldman Watershed Council. See Appendix A for more details on each indicator.

Indicator	Indicator Type	Indicator Evaluated in this Report
CRITERION 1: Landscape Composition and Condition		
1.1 Intact Landscapes	Pressure	Yes
1.2 Human Population Density & Growth	Pressure	
1.3 Urban and Industrial Human Land Use	Pressure	
1.4 Land Conversion of Natural Habitat	Pressure	
1.5 Changes in Climate Regime (Past to current)	Pressure	
CRITERION 2: Biological Diversity		
2.1 Road Density	Pressure	Yes
2.2 Density of All Linear Features	Pressure	Yes
2.3 Riparian Condition	Condition	Yes
2.4 Stream Connectivity	Condition	
2.5 Fish Community	Condition	
2.6 Amphibian Community	Condition	
2.7 Macroinvertebrate Community	Condition	
2.8 Rate of Wetland Loss	Condition	
2.9 Rangeland Health	Condition	
CRITERION 3: Surface Water Quality		
3.1 Sedimentation/Erosion Potential	Pressure	Yes
3.2 Stream Crossing Density	Pressure	
3.3 Surface Water Quality	Condition	
3.4 Point Source Contamination	Pressure	
3.5 Non-point Source Contamination	Pressure	
3.6 Sediment Quality	Condition	
CRITERION 4: Water Levels & Flow		
4.1 Stream Flow Regime	Condition	Yes
4.2 Lake or reservoir water level	Condition	
4.3 Lake or reservoir open water area	Condition	
4.4 Water availability (climatic input)	Condition	
4.5 Potential Surface Water Use	Pressure	

3.4 Indicators Evaluated in the Report

Six indicators were evaluated to assess the Headwaters Region of the Oldman Watershed (Table 1). The rational and scientific justification for each indicator is outlined below.

Indicator 1.1: Intact Landscapes (Criterion 1)
In watershed assessment science, the term “intact” means that “all the critical ecosystem components are present and structured in such a way that processes function within normal limits, and that component populations and functions will be maintained over time” (Lee et al. 2003 pg12). Simply put, areas within intact landscapes are better able to maintain native biodiversity and ecosystem functions over time, and are more resilient to disturbance, i.e. are better able to recover from disturbance and return to the original ecological “state” (Lee et al. 2003). Thus, intact landscapes are considered to be relatively pristine, with minimal human disturbance, and these areas should support a

high diversity of plants and animals relative to areas experiencing more intense human activity.

Watersheds are holistic systems that act as catchments for all precipitation, stream flow, and terrestrial runoff (AENV 2008b). This interaction makes freshwater aquatic systems particularly vulnerable to anthropogenic disturbance, given their role in receiving run-off from the surrounding terrestrial land base. It has been clearly demonstrated that the amount of the watershed covered with native vegetation has a strong, positive influence on aquatic habitat condition and water quality (Allen et al. 1997, Booth et al. 2002, Clapcott et al. 2013, Dalm et al. 2013, Linke et al. 2007). For example, healthy riparian habitat is more likely to be found surrounded by landscapes with high amounts of forest and wetland cover (Findlay and Houlahan 1997, Nel et al. 2007, Norris et al. 2007).

In addition to landscape influences, many fish, mammal, and avian species in Alberta require large tracts of undisturbed habitat, including bull trout (*Salvelinus confluentus*), Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*), grizzly bear (*Ursus arctos)*, American marten (*Martes americana*), and northern goshawk (*Accipiter gentiles atricapillus*; Alberta Grizzly Bear Recovery Plan (2008-2013) 2008, Alberta Westslope Cutthroat Trout Recovery Plan 2012-201, Chapin et al. 1998, Dunham et al. 1997, Finn et al. 2002, Patla, 1987, Proctor et al. 2012, Ripley et al. 2005). The species listed here are often considered umbrella species. Umbrella species are typically large, wide-ranging species with large home ranges that are sensitive to human disturbance and habitat change. The protection of umbrella species is a commonly implemented conservation strategy, where by conserving habitat for wide-ranging species with large habitat requirements, the protection of many smaller co-occurring species can be ensured (Roberge and Angelstam 2003).

Indicator 2.1 & 2.2: Road Density & Density of All Linear Features (Criterion 2)

Linear features are a pervasive aspect of human development and land-use. Linear features often penetrate into previously undisturbed areas, and can lead to many unintended consequences including reduced water quality, increased wildlife mortality, increased hunting pressure on game and fish species, and the introduction of non-native species (Trombulak and Frissell 2000). The impact of roads on wildlife and water quality is relatively well documented (see Forman et al. 2003, Trombulak and Frissell 2000), but the negative effects of linear disturbances are not limited to roads. All other linear features, such as rail lines, seismic lines, pipelines, and off-road vehicle trails can have negative influences on water quality, nutrient management, and biodiversity (Ouren et al. 2007).

Increased soil erosion is one of the major ecological concerns of roads and other linear features. Vehicle traffic, the removal of natural vegetation, and soil compaction along linear features can all cause increased runoff and erosion of soil flowing into aquatic habitats, leading to changes in flow regime and an overall reduction in water quality (Rieman and McIntyre 1993, Ouren et al. 2007). Soil erosion introduces deleterious materials into aquatic systems, which can have serious impacts to fish populations. For example, the runoff of fine particles in small spawning streams reduces water clarity, and the subsequent sedimentation can decrease the fish egg survival and spawning success of adult females (Henley et al. 2010). Bull trout stocks in particular are negatively impacted by road development which results in increased soil erosion, sedimentation,

and decreased stream habitat quality (Dunham and Rieman 1999, Eaglin and Hubert 1993, Ripley et al. 2005).

Roads and other linear features also impact terrestrial wildlife. Roads increase mortality risk for wildlife as a result of collisions with vehicles (Lode 2000) and fundamentally alter the amount and arrangement of habitat patches (Carr and Fahrig 2001, Forman et al. 2003). Linear features can act as barriers to dispersal for many terrestrial and semi-aquatic species (e.g. amphibians) that either behaviorally avoid roads or are physically unable to cross roads (Carr et al., 2001, Trombulak and Frissell 2000). Many large mammals, including elk (*Cervus elaphus*) and grizzly bears (*Ursus arctos*) avoid landscapes with a high density of both roads and other linear features (including seismic lines and ORV trails; Alberta Grizzly Bear Recovery Plan 2013 2008, Forman et al. 2003, Holroyd 2008, Proctor et al. 2012).

Indicator 2.3: Riparian Condition (Criterion 2)

Riparian lands exist adjacent to streams, rivers, lakes and wetlands, and exhibit vegetation and soil types that are strongly influenced by the presence of water (Sikina and Ambrose 2012). They protect aquatic ecosystems by filtering out sediments and nutrients originating from upland areas (AENV 2003), and directly contribute to fish habitat by providing shade, cover and food production areas (Government of Alberta 2012). Riparian lands provide essential habitat for wildlife (Petry and Palechek 2010), and can be locations of groundwater discharge or recharge (Ambrose et al 2004). Their surface and subsurface hydrology connect water bodies with their adjacent uplands, producing gradients in biophysical conditions, ecological processes, and biota between the two (NRC 2002).

These areas represent a transition from wet (open water) to dry (uplands), and therefore can buffer the transfer of materials between terrestrial and aquatic ecosystems. In addition to acting as natural filters and sponges for terrestrial runoff and flood water, intact riparian areas improve stream bank stability which reduces further erosion and sedimentation (Brabec et al. 2002, Government of Alberta 2012). Given these properties, riparian areas have a disproportionately greater influence on aquatic ecosystems than other terrestrial areas, and their loss can have major impacts on overall watershed health

The evaluation of riparian condition considered in this report focuses on the ecological functions that are occurring, in relation to its expected normal capacities (Clare and Sass 2012). For example, the status of full cover by native vegetation with minimal anthropogenic disturbance is typically interpreted as indicating that a wide range of functions are occurring, such as bank stabilization, erosion prevention, and habitat provision.

Indicator 3.1: Sedimentation/Erosion Potential (Criterion 3)

As discussed above in the section on Road Density/Density of All Linear Features, roads and other linear features can negatively impact watershed condition as a result of soil erosion. All of the concerns outlined above are amplified on the steep slopes found in the Alpine and Subalpine areas of the Headwater Region. These regions are characterized by thin soil depth with very low water absorption capabilities (Natural Regions Committee 2006). Here topography, and in particular terrain slope, is a major driver of soil erosion (Blanco and Lal 2008). The velocity of runoff water increases as slope increases, more

than doubling in steep mountain areas relative to landscapes with flat grades (Blanco and Lal 2008).

The protection of these headwater streams along the eastern slopes of Alberta is of vital importance for surface water protection, and the protection of fish spawning habitat. Small headwater streams in the Headwaters provide important habitat for several threatened fish species including bull trout, Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*). The goal of this indicator is to highlight areas of the Headwaters Region which may be highly vulnerable to erosion and sedimentation risk. This indicator documents the amount of linear feature development in habitats with a high potential for soil erosion and increased sedimentation, including 1) steep slopes (slope >40% grade), and 2) wet habitats, which includes permanent and semi-permanent water bodies and their riparian zones.

Indicator 4.1: Stream Flow Regime (Magnitude and Timing; Criterion 4)
River ecosystems are structured by the natural variability in the quantity and timing of water flows (Alberta Environment 2008b, Poff et al. 1997, Figure 2). In Alberta, water flows peak in the spring as a result of snow melt and reach their lowest point (base flow) in the winter. Understanding and quantifying this “natural flow regime” is the basis for assessing whether flow patterns are deviating from natural patterns, and are being impacted by human land-use. Natural flow volume (detailed by the central blue line in Figure 2) can either increase or decrease as a result of anthropogenic land-use. The red and green lines in Figure 2 represent an acceptable range of deviation above or below natural flow magnitude. However, as flow magnitude varies further from natural flow, there are increased ecological and economic risks (Poff and Zimmerman 2012). Increased flow magnitude can be observed due to increased runoff from industrial operations (i.e. forestry) or urban development, while decreases in flow may be caused by anthropogenic water consumption (NRC 2008, Pomeroy et al. 2012). Human land-use can also result in changes to the timing of flows, potentially leading to rapid high volume releases of run-off water). In the Headwaters Region, increased runoff and changes in the timing of flow are predicted to be the dominant issues, while water consumption will be a major issue in the developed agricultural regions of the Oldman Watershed.

4. Methods

Separate analytical approaches were required for pressure and condition indicators due to differences in data sources, data types, and constraints on data availability in the Headwaters Region. The data sources for pressure indicators tend to be based on spatial mapping products with broad-scale coverage. In contrast, condition indicators usually require field-based sampling information, and as a result of limited funding for many hydrological, biodiversity, and wildlife monitoring programs, the geographic coverage for condition indicators is limited.

4.1 Pressure Indicator “Modeling”

Four pressure indicators were assessed here: 1) Intact Landscapes; 2) Road Density; 3) Density of All Linear Features and 4) Sedimentation/Erosion Potential (Table 1). For these, we conducted indicator “modeling”. This entailed creating indicator models in a Geographic Information System (GIS) that allows for the visual presentation (mapping) of

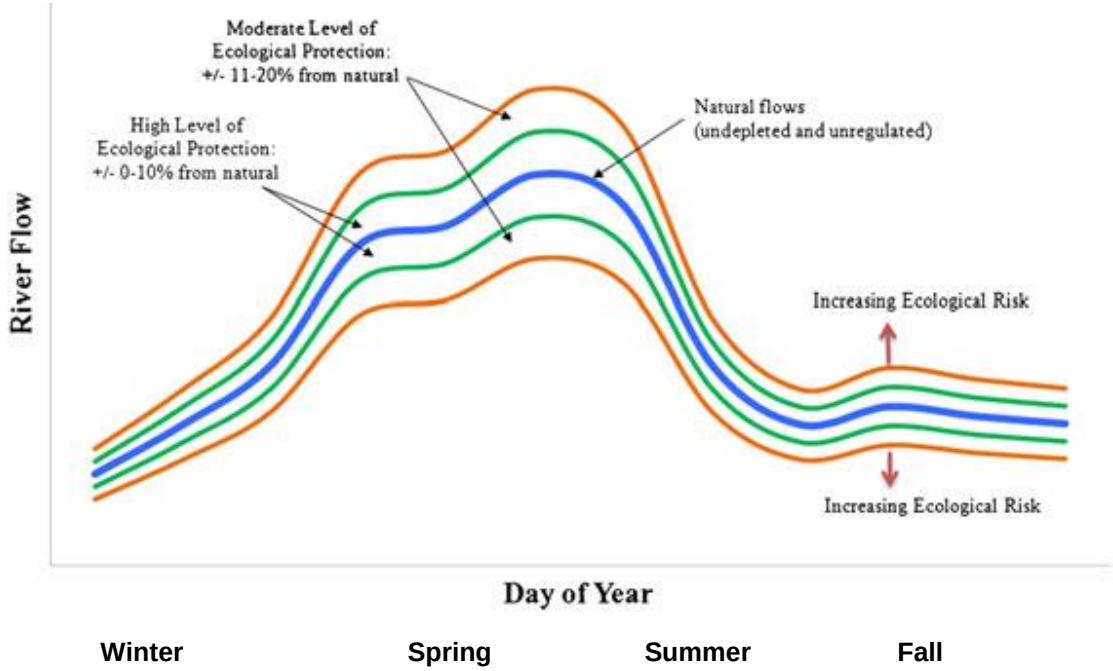

Figure 2: Conceptual model for defining annual flow regime for streams, and how this may change from the natural range of variation, requiring ecologically meaningful protection of natural flows (from Richter et al. 2011).

the data across defined sub-watershed boundaries. For this assessment, indicator data models were developed using existing spatial data collected from various sources, and integrated together to derive new spatially explicit data models.

In evaluating indicators, a key goal of the Headwaters Indicator Project is to provide *spatially explicit* information that allows for *direct comparisons* of indicators across the Headwaters Region. Determining an appropriate unit of analysis (spatial scale and unit of assessment) was a primary objective of this project. A relevant unit of analysis is crucial in the effectiveness of the indicator, and in informing appropriate management action. The spatial scale of assessment will influence the ecological patterns and trends detected, the appropriate species or physical characteristics to use as indicators, as well any thresholds used in rating indicators. Most importantly in implementing a watershed assessment program, the spatial scale will determine the appropriate data sources (Beechie et al. 2013) that can be practically measured and/or monitored (CoP 2005). Watersheds are a commonly used and recommended unit of analysis because they are ecologically relevant in State of the Watershed assessments (USDA 2011). Watersheds are considered an effective unit to summarize complex ecological issues because of the fundamental connection among terrestrial and aquatic components of the landscape along stream networks (Williams et al. 1997, USDA 2011). Moreover, watersheds do not change much over time and a readily recognized unit by local communities.

Based on the spatial scale of information available in this assessment, and a desire for information on local scales, we derived a fourth (4th) order watershed (Strahler 1964) spatial layer (see Appendix B for full methodological details). Within this watershed layer, the 4th order watershed is the minimum unit, however not all parts of the

Headwaters Region belong to a 4th order watershed. Especially at lower elevations, the major river systems (Oldman River, Crowsnest River, Castle River, and Waterton River) belong to 6th or 7th order watersheds. In order to achieve wall-to-wall mapping within the Headwaters, we included watersheds ranging from 4th to 7th Strahler orders.

There are 178-fourth order watersheds in the Headwaters Region, ranging in size from 2.7 to 201.6 km^2 (median size of 20.9 km^2; Figure 3a). The smallest watersheds represent high elevation areas where headwater streams rapidly flow together into larger rivers. The larger watersheds are areas along the major rivers (i.e. Oldman River, Castle River, Crowsnest River), where small tributaries contribute water from higher elevations.

4.2 Pressure Indicator Ratings

Pressure indicators were directly compared between fourth order watersheds by assigning a “pressure” rating to each indicator. These pressure ratings were derived from scientific thresholds that were taken from empirical studies primarily conducted in Alberta or neighbouring US states (Idaho, Montana; see Section 5 for complete details). In the context of this study, we define zone-type thresholds which represent categories within which there is a gradual shift or transition from one state to another rather than an abrupt change at a specific point (i.e. critical thresholds. The threshold values defined here imply ranges or continuum of values at which increasing negative impacts have a high probability of being detected (Booth et al. 2002). The thresholds are adapted from species commonly considered indicator and/or umbrella species, including fish species (bull trout), and wildlife species (grizzly bears, northern goshawks, American marten), and from ecological theory (summary analyses of the effects of habitat fragmentation).

Four rating categories were derived for each pressure indicator evaluated, including: high, moderate, low, and negligible (Table 2). The values used to differentiate between the pressure rating categories are indicator specific, and it is important to note that indicators ratings do not measure watershed health or condition directly. Rather, ratings measure the magnitude and/or extent of one or more human land-use stressors that have the potential to impair watershed health.

For assessing pressure indicators, those Fourth Order Watersheds that are rated as “Negligible Pressure” represent areas at lower risk to anthropogenic disturbance, relative to other watersheds in the Headwaters Region. Based on the best available data, these areas are considered to be largely undisturbed with healthy ecosystems, while indicators ranked as ‘”High Pressure” are considered to be at high risk due to extensive human activity and land conversion (see Appendix B for full details).

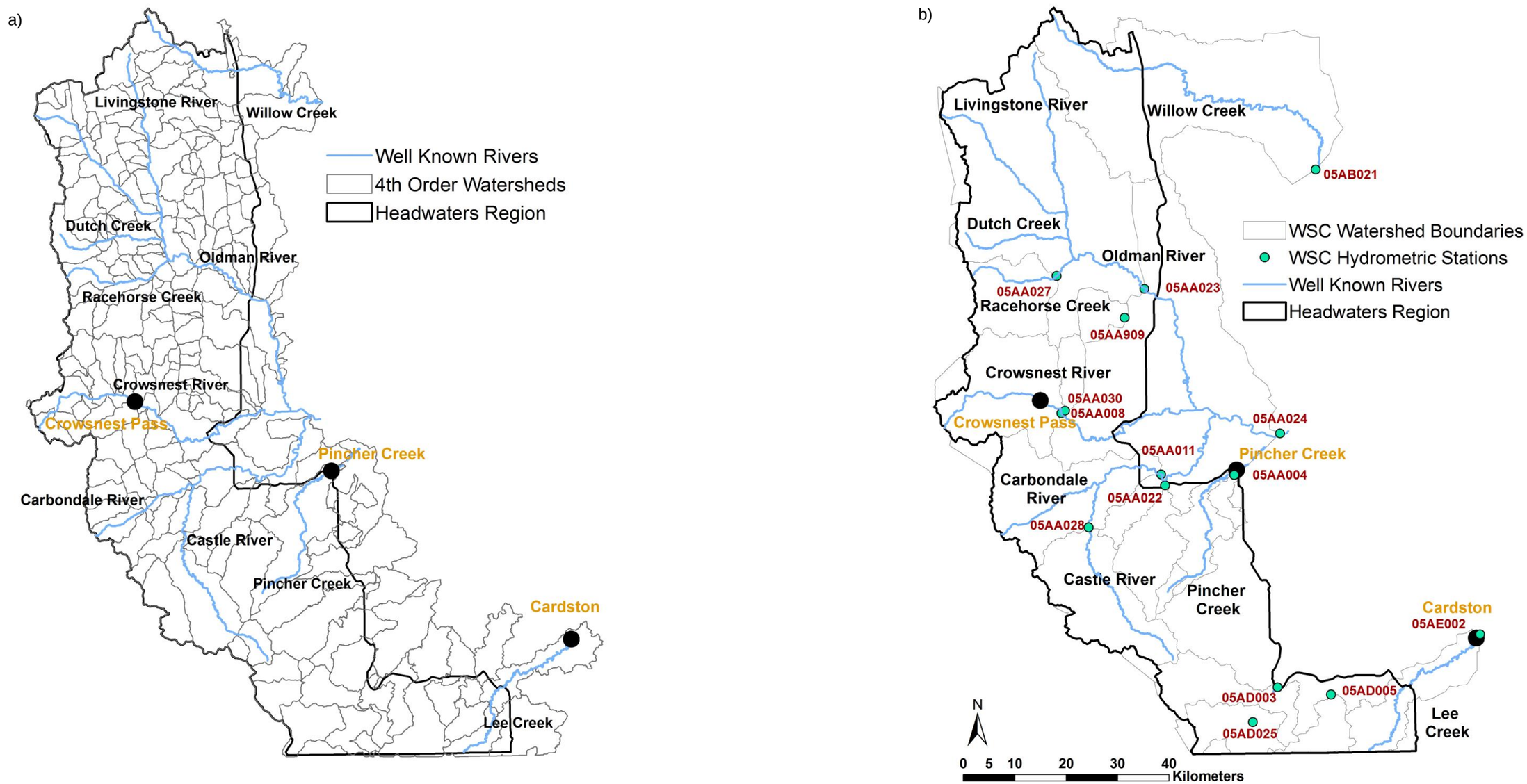

Figure 3. Description of the two scales of watershed assessment in the Headwaters Indicator Project, where: a) Map of fourth (4th) order watersheds, and b) Map of Water Survey of Canada (WSC) Watershed Boundaries (individually derived for each WSC Hydrometric station used for the mapping of the Stream Flow Regime Indicator).

Table 2. Thresholds used to differentiate Pressure Indicator Rating Categories.

Indicator	Unit	High	Moderate	Low	Negligible
Intact Landscapes	% aerial coverage of watershed with intact habitat patches	<30%	>30 – 50%	>50 – 75%	>75%
Road Density	km/km^2	≥0.87	>0.5 to 0.87	>0.1 to 0.5	0 to 0.10
All Linear Feature Density	km/km^2	>3	>1.2 to 3	>0.6 to 1.2	0 to 0.6
Sedimentation/Erosion Potential	km/km^2	>1.5	>0.6 to 1.5	>0.3 to 0.6	0 to 0.3

4.3 Analysis of Condition Indicators

Two condition indicators were assessed for the Headwaters Region here: 1) Riparian Condition and 2) Stream Flow Regime. While pressure indicators can be summarized at consistent, small spatial scales (using the fourth order watershed), the data used for riparian condition and for the flow regime indicators were each measured at different spatial scales.

Riparian Condition (Criteria 2)

The overall condition of riparian lands within the Headwaters Region was determined by field-based assessments of waterbodies conducted by Cows and Fish (also called the Alberta Riparian Habitat Management Society). These assessments were not comprehensive across the Headwaters, and as a result there are areas with no data. The riparian assessments evaluated riparian condition based on various indicators, including canopy and foliar cover, native plant assemblages, invasive weed prevalence, bank alteration and size of the riparian area. This level of assessment was not meant to include in-depth quantification of most indicators, but consisted of an overall impression by an experienced riparian biologist on the intactness of the study area, when considering the listed indicators (see Fitch et al. (2003, 2001) for a more detailed description of the Cows and Fish methods). Using this method, Cows and Fish assigned scores out of 100 to each riparian area, and placed them in categories of:

Healthy (80-100% score range): Little to no impairment of any riparian functions
Healthy with problems (60-79% score range): Some impairment to riparian functions due to management or natural causes
Unhealthy (<60% score): Severe impairment to riparian functions

Cows and Fish summarized those 4th order watersheds with field-based riparian assessment data into eleven larger watersheds (called Cows and Fish Watershed Boundaries; Figure 7), and assigned health categories based on the average scores of the assessed riparian areas they contained (Sikina and Ambrose 2012).

Stream Flow Indicators (Criteria 4)

The flow regime data are measured at Water Survey of Canada (WSC) hydrometric stations, which have limited geographic coverage and variable hydrological scale. As a result, this information had to be analyzed at the scale at which the hydrologic data were collected (i.e. Strahler orders). Watershed boundaries for this analysis were thus derived based on the location of the hydrometric stations (Figure 3b; see Appendix B for full details). Of the 25 active* (we made on exception in the case of 05AA023 which

was a long-term station closed in 2008) WSC stations located within or at the edge of the Oldman Headwaters region, only 15 had at least 30 years of available data between 1971 and 2010, and these stations were used for the analyses.

Stream Flow Regime was described using indicators related to magnitude and timing of flow (Poff et al. 1997; Table 3). Magnitude was characterized by five measures: 1) total annual flow, 2) spring flow, 3) summer flow, 4) base flow (the lowest daily flow), and 5) peak flow (the highest daily flow). Timing of flow was characterized by three measures: 1) date of spring melt initiation, 2) the date of the 1st peak of the hydrograph, 3) and the date of the 2nd peak of the hydrograph. Hydrographs are plots of the temporal variation in discharge, typically over a year. These eight measures (see Table 3) were individually assessed for every available hydrograph (consisting of approximately 800 hydrographs). The resulting time-series of flow measures over time were assessed for significant trends using the Mann-Kendall test (Helsel and Hirsch 1992). Results of the long-term pattern in flows were then used to evaluate if flow measures were decreasing, increasing or showing no change over the period assessed. Two of the 15 hydrometric stations were water level recording stations (located on lakes or reservoirs) which meant that only the timing indicators were assessed for these stations.

There were four hydrometric stations (out of 15) with regulated flows (Table B-1). For these stations, we obtained a naturalized flow dataset at the weekly time interval from Alberta Environment who derived naturalized flows from stream flow records, reservoir data, recorded and estimated irrigation withdrawals, and climate data using the Stream-flow Synthesis and Reservoir Regulation (SSARR) model from U.S. Army Corps of Engineers [AENV 1998]. This is also referred to as the Project Depletion Method [AENV 1998]. Weekly data meant that the precision of timing indicators as well as base flow and peak flow were not at the same level as for the stations with daily data but still provided a useful dataset for trend analysis.

Table 3. Flow regime indicators, the measures used to characterize them and their ecological significance (from Richter et al. 1998; see Appendix B for more detailed methodology)

Indicator	Measure	Ecological significance
Stream Flow Regime	**Flow Magnitude**	
	Total annual flow (mm)	Habitat availability for aquatic organisms Soil moisture availability for plants Availability of water for terrestrial animals Availability of food/cover for fur-bearing animals Access by predators to nesting sites Influences water temperature, oxygen levels, photosynthesis in water column
	Total spring flow (mm)	
	Total summer flow (mm)	
	Base flow (mm/day)	Creation of sites for plant colonization
	Peak flow (mm/day)	Balance of competitive, ruderal and stress-tolerant organisms
	Flow Timing	
	Initiation of spring melt (day-of-year)	Compatibility with life cycles of organisms Predictability/avoidability of stress for organisms Access to special habitats during reproduction or to avoid predation Spawning cues for migratory fish Evolution of life history strategies, behavioural mechanisms
	1st major peak of melt (day-of-year)	
	2nd major peak of melt (day-of-year)	

4.4 Flow Regime (Condition Indicator) Ratings

The long-term pattern in flows (using all available hydrographic data) for each WSC station and each of the eight flow measures were rated on the pattern and significance of the temporal trend (based on Mann-Kendall correlation results; Yip et al. 2012) (Table 4).

Table 4. Flow regime rating categories (positive, neutral or negative trends values) and significance (p-values) used to evaluate Stream Flow Regime in the Headwaters Region.

Rating		Significance Value
No Data		
Strong Decreasing Trend		- (p <0.05)
Moderate Decreasing Trend		- (p <0.10)
No Trend		(p >0.1)
Moderate Increasing Trend		+ (p <0.10)
Strong Increasing Trend		+ (p <0.05)

5. Indicator Results

Understanding Pressure Indicator Models

This project represents a preliminary assessment of a small group of indicators in the Headwaters Region of the Oldman Watershed. The results below provide an initial assessment of the ecological integrity of the Headwater Region relative to scientifically established thresholds and methods, and most importantly, provide a comparison amongst subwatersheds of the condition and land-use pressures that currently exist in the Headwaters Region. In interpreting the indicator results below, a key caveat to understand is that the pressure indicator models displayed are descriptive models, which represent a simplified summary of the current state of human land-use stressors. The models do not provide information on future scenarios or management outcomes, but are important tools to guide future planning, management (see Section 7), and can important tools for public outreach and education.

Importantly, it must be understood that the pressure indicators do not directly measure changes in biological populations and communities or trends in physical/chemical characteristics. Instead, pressure indicators are correlative, based on well-established relationships between human land-use, industrial activity and other stressors to declines in watershed health. Hundreds of studies investigating the effects of human land-use on biodiversity, habitat condition or water quality and quantity have demonstrated that human land use can have profound negative impacts on all aspects of ecosystems function, including changes in chemical and nutrient balances, increased runoff and sedimentation, and alterations in biotic community composition (Booth et al. 2002, Brabec et al. 2002, Chapin et al. 2000, Clapcott et al. 2011, England and Rosemond 2004, Haines-Young 2009, Johnson et al. 1997; Weijters et al. 2008). While based on strong science, the existence of a human land-use stressor does not necessarily ensure negative impacts are occurring (AENV 2008), but that there is a high probability of impairments to biological and environmental integrity of the watershed.

This spatial comparison among watersheds identifies areas within the Headwaters Region that are currently experiencing at high pressure due to human-land use stressors, in addition to identifying areas that appear to be in good ecological condition. At local scales, those areas at high pressure are priority candidates for stewardship activity and focused mitigation activities. The identification of areas in good condition is important to ensure the protection or conservation of intact, healthy ecosystems on the landscape. In the long-term, maintaining undisturbed, intact habitat is a much simpler and cost-effective method for ensuring ecological integrity, rather than undertaking the time and costs associated with habitat restoration. By identifying those areas that are currently in good condition, their protection or conservation can be safeguarded in regional planning exercises.

The results of indicator data modeling and pressure rating classification are shown below. The full methodology, and the data sources used to derive, model, analyze, and rate each indicator can be found in Appendix B.

5.1 Intact Landscapes (Criterion 1)

Indicator Context

This indicator identifies areas on the landscape that are largely undisturbed by human activity, and are of a sufficient size to maintain populations of wildlife that require large tracts of native, intact habitat. Intact habitat patches on the landscape were considered to be a minimum size of 500 hectares (see Appendix B), containing no mapped human disturbance (Figure 4a). This indicator additively sums all mapped human disturbances (all linear features, forest harvesting, agriculture, industrial areas, and urban and rural development) on the landscape, and then "subtracts" these areas to identify Intact Landscapes.

The thresholds used to develop the pressure rating categories for Intact Landscapes were derived from scientific literature on wildlife response to landscape intactness (Table 2). The high pressure category (where <30% of the area in a 4th order watershed contains habitat identified as Intact Landscapes) was taken from a review paper conducted by Andren (1994). This paper focused on studies on birds and mammals, concluding that landscapes with <30% remaining suitable habitat area were more likely to experience greater species loses or population declines due to the synergetic effects of combined habitat fragmentation and habitat loss. In landscapes with >30% remaining native habitat, species loses or population declines were primarily impacted due to simple habitat loss, and experienced negligible additional effects due to the fragmentation and isolations of habitat areas.

The moderate pressure rating threshold came from studies on the impacts of land-use on wetland species richness, which demonstrated that the species richness of mammals and amphibians declined by 50% when approximately 50% of the surrounding forest cover has been removed (Findlay and Houlahan 1997). In addition, research from western Canada and the United States has demonstrated that highly settled areas (where >50% of the landscape has been converted urban, rural and agricultural land-use) leads to significant reductions in grizzly bear movement (Proctor et al. 2012). Finally, low pressure rating threshold was taken from studies on American marten, which have shown that marten respond negatively to small amounts of forest fragmentation and rarely use sites where >25% of forest cover has been removed (Hargis et al. 1999, Chapin et al. 1998).

Results

Intact landscapes are most common in high-elevation alpine and sub-alpine areas removed from the major towns, and the major road corridors associated with Oldman and Crowsnest Rivers. After calculating the amount of intact landscape found within each fourth order watershed and applying the pressure rating classification, the following results indicate that the majority (64%) of the fourth order watersheds fall within the Low and Negligible pressure categories (Figure 4b):

67 watersheds (38%) with Negligible Pressure
52 watersheds (30%) with Low Pressure
37 watersheds (20%) with Moderate Pressure
22 watersheds (12%) with High Pressure

Generally, watersheds along the eastern, more highly developed boundary of the Headwaters Region, and along Racehorse Creek and the Crowsnest River were at High

to Moderate Pressure. Extensive forestry activity has occurred in the watersheds located between North Racehorse Creek, and the upper Oldman River, and at the north-western most extent of Oldman River, resulting in the Moderate – High pressure. Areas at low pressure were concentrated in the southwest or north-central area of the Headwaters Region.

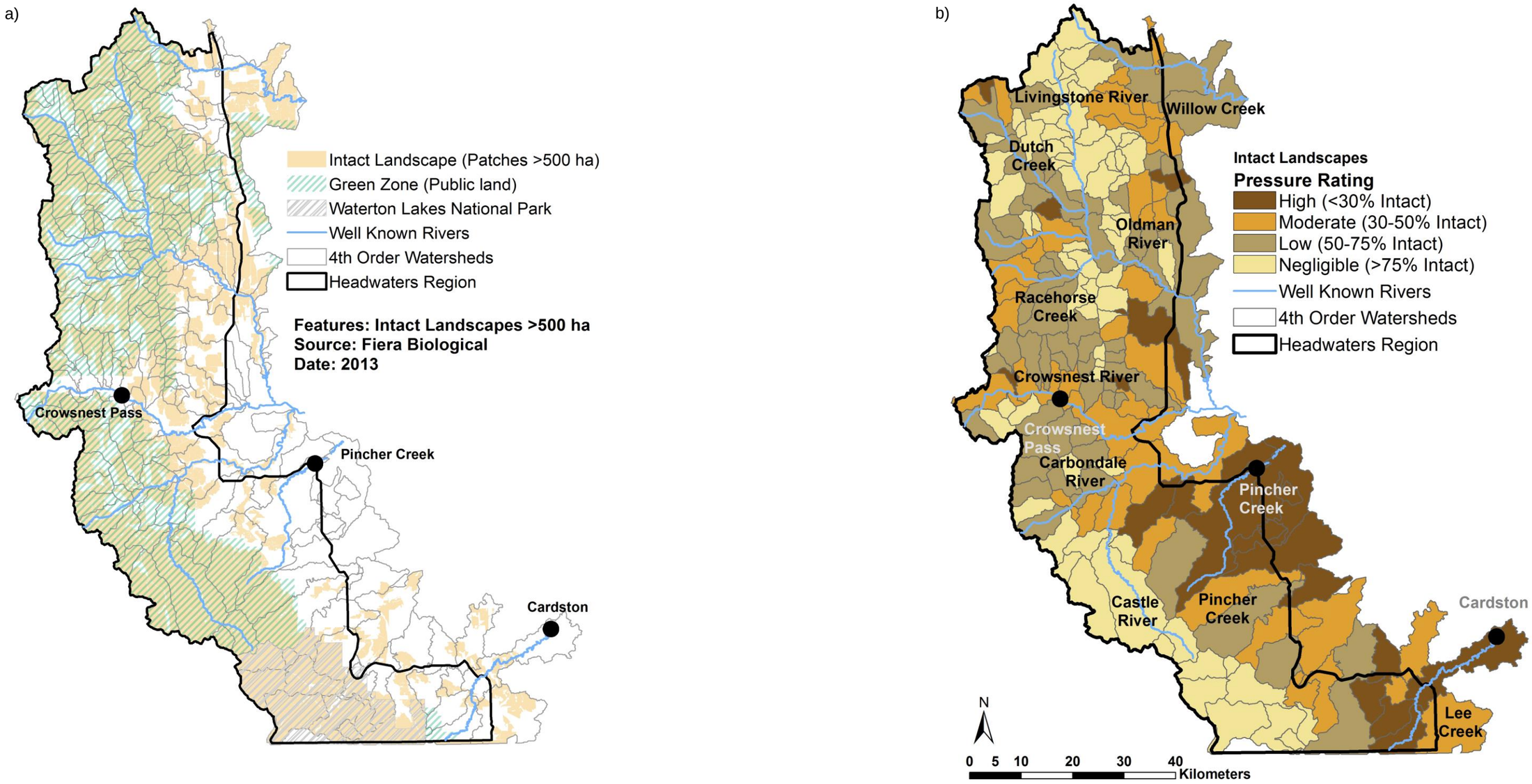

Figure 4. Input data used in pressure indicator data modeling and pressure rating classification results for Intact Landscapes in the Oldman Watershed. The area identified as Intact Landscapes (a) was used to calculate rating categories for each 4th order watershed based on scientific thresholds (b). Public lands (Green Zone) are overlaid in green hatching in (a), while private land comprises the remainder of the Headwaters outside of Waterton Lakes National Park.

5.2 Road Density & Density of All Linear Features (Criterion 2)

Two indicators related to linear features are presented here: 1) Road Density; and 2) the Density of All Linear Features (includes all roads, seismic lines, pipelines, power-lines, railroads, cutlines, and ORV vehicle trails). Road density is presented as a stand-alone indicator separate from all other linear feature types because the science around the impacts of road density on biodiversity and water quality is well established, and roads can potentially have much greater negative effects on water quality and biodiversity at lower densities than other linear features. These possible impacts include direct mortality of wildlife (through vehicle collisions), and the contamination of aquatic systems through the introduction deleterious materials in run-off water. A wide range of contaminants has been measured in water run-off from roads including sand, dust and other particulates, as well as heavy metals such as lead, cadmium, and zinc (Spellerberg 2002).

5.2.1 Road Density

Indicator Context

This indicator measured the density of roads in the Headwater Region. Roads are defined as improved linear features based on the classification in the Alberta Base Feature layer for roads (including improved forestry access roads (those which are maintained through grading), gravel roads, and all paved roads; see Appendix B for exact methods)). Any change to the surface material on roads (through soil compaction, paving or the additional of gravel) reduces or removes the ability of the ground to absorb water, and alters (typically increasing) water run-off patterns (Figure 5a).

The road density (km/km^2) was calculated for each 4th order watershed, and then classed in pressure rating categories based on thresholds taken from the scientific literature and government management documents for wildlife and fish species (Table 2), where: road densities as low as 0.1 km/km^2 have been shown to have negative impacts on bull trout spawning (BCMWLAP 2002, Ripley et al. 2005), while elk and amphibian species richness all show reduced activity or richness at road densities of 0.5 km/km^2 (Frair et al. 2008, Findlay and Houlahan 1997), and finally bull trout demonstrate depressed population at average road densities of 0.87 km/km2 (USFW 1998).

Results

Areas at high pressure from road density are centered around Pincher Creek, Cardston, and along the length of the Crowsnest Pass (Figure 5b). The road density pressure is low throughout most of the Headwater Region. In summary, the majority of 4th order watersheds currently fall into low or negligible pressure categories, with 51 (28%) of the forth order watersheds being rated as High or Moderate Pressure:

71 watersheds (40%) with Negligible Pressure
57 watersheds (32%) with Low Pressure
32 watersheds (18%) with Moderate Pressure
18 watersheds (10%) with High Pressure

5.2.2 Density of All Linear Features

Indicator Context

The density of all linear features was assessed for each 4th order watershed. In the Headwaters Region, cutlines (which includes seismic lines, and some haul trails from forestry activities) and ORV trails comprise the majority of existing linear features. The goal of this indicator is to highlight watersheds at high risk due to intensive linear feature development which can negatively influence many fish (cutthroat trout, bull trout), and mid-to-large size mammal species. Based on known wildlife responses to linear feature density from the scientific literature and government management plans, the following thresholds were used to class watersheds in pressure rating categories (Table 2), where: 1) high quality grizzly bear habitat within Grizzly Bear Priority Areas must have a linear features density at or below 0.6 km/km^2, and linear features densities at or below 1.2 km/km^2 are recommended in all remaining grizzly bear range (Alberta Grizzly Bear Recovery Plan 2008); and 2) the occupancy rate for American marten (*Martes americana*) in Alberta, and northern Idaho decline to 50% at linear features densities around 3 km/km^2 (Tigner 2012, Wasserman et al. 2012).

Results

Linear features are ubiquitous throughout the Headwaters Region, with the exception of the extreme southwestern portion of the study area (Figure 6a). As a result, the majority (77%) of Headwater Region is rated to be at High or Moderate Pressure from the combined density of all linear features (Figure 6b). Overall, the breakdown of pressure ratings across the Headwater Region for density of linear features was:

19 watersheds (11%) with Negligible Pressure
23 watersheds (13%) with Low Pressure
103 watersheds (58%) with Moderate Pressure
33 watersheds (19%) with High Pressure

An important implication of this pressure rating assessment is that nearly all the critical spawning creeks for cutthroat trout and bull trout in the Headwaters Region occur in watersheds with Moderate – High pressure from linear feature development (see Section 7).

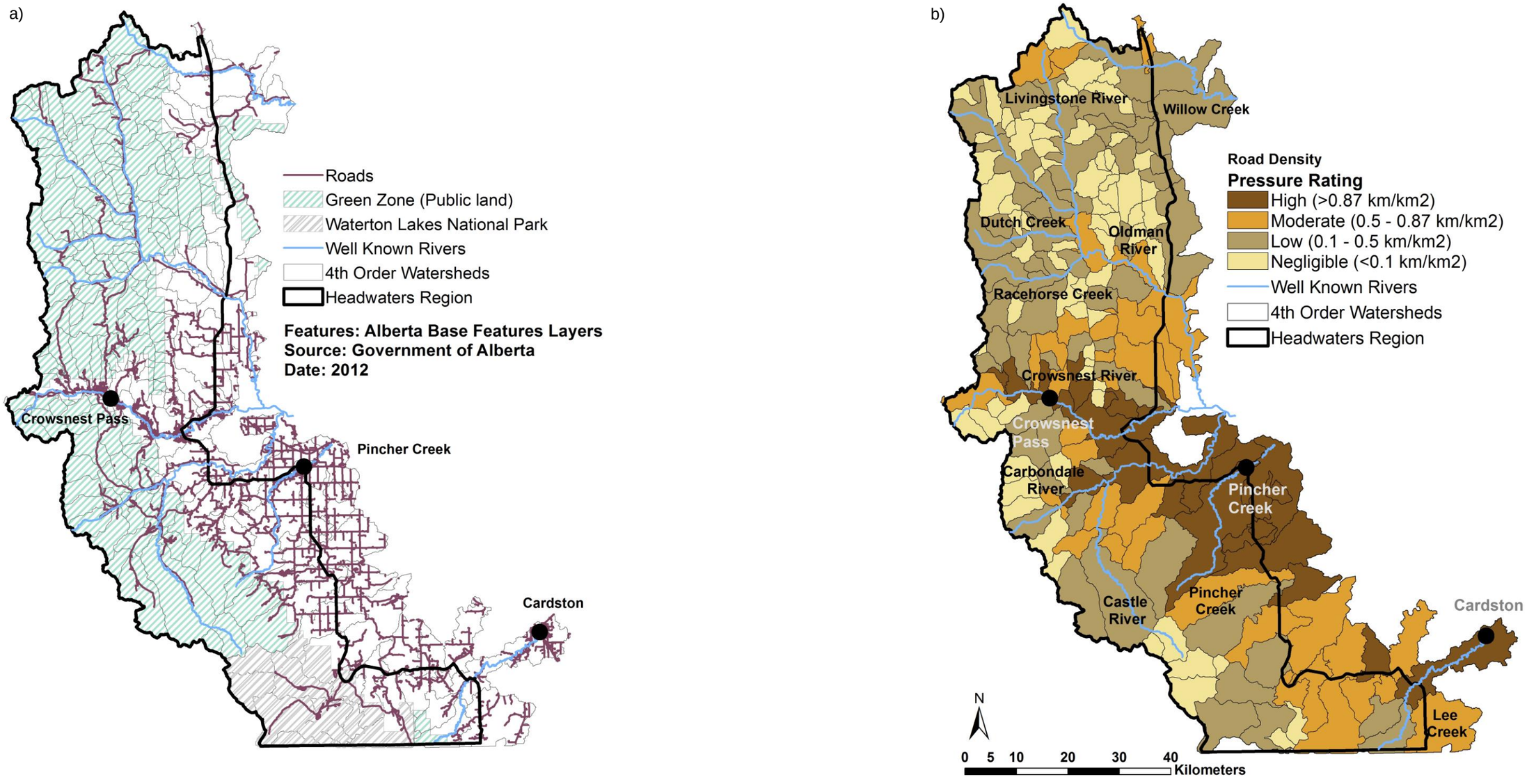

Figure 5. Input data used in pressure indicator data modeling and pressure rating classification results for the Road Density Indicator in the Oldman Headwater Region. The Government of Alberta base feature road layer (a) was used to model and rate road density based on scientific thresholds (b). Public lands (Green Zone) are overlaid in green hatching in (a), while private land comprises the remainder of the Headwaters outside of Waterton Lakes National Park.

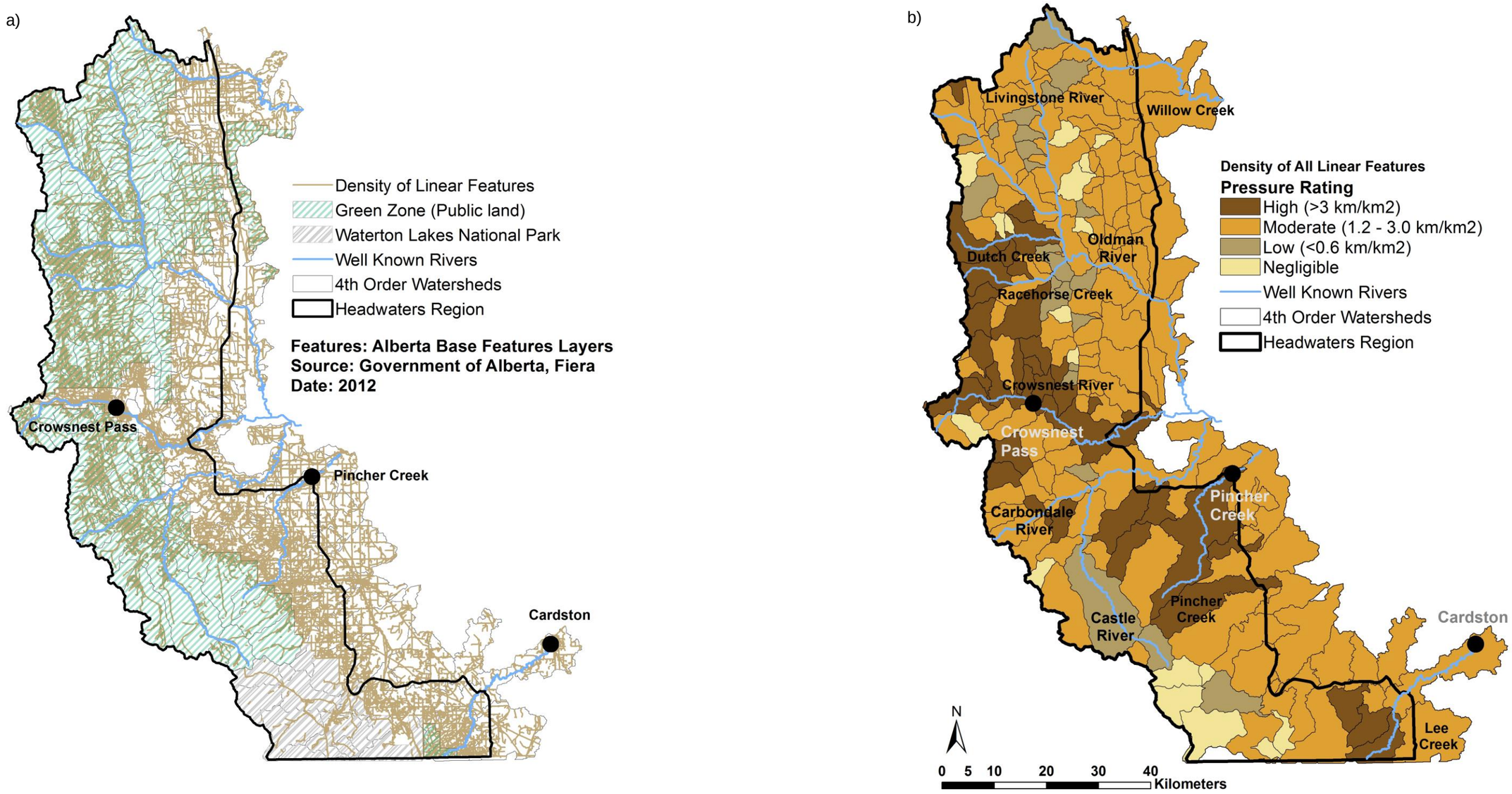

Figure 6. Input data used in pressure indicator data modeling and pressure rating classification results for the Density of All Linear Features in the Oldman Headwaters Region. The Government of Alberta base feature layers for roads, seismic lines, pipelines, power-lines, railroads, cutlines, ORV vehicle trails, and a spatial layer of previously unmapped features created by Fiera Biological (a) were combined together and used to model and rate the Density of All Linear Features based on scientific thresholds (b). Public lands (Green Zone) are overlaid in green hatching in (a), while private land comprises the remainder of the Headwaters outside of Waterton Lakes National Park.

5.3 Riparian Condition (Criterion 2)

Indicator Context

The overall condition of riparian lands within the Headwaters Region was determined by 213 field-based assessments of waterbodies conducted by Cows and Fish (see Sikina and Ambrose 2012) between 1998 and 2011. Cows and Fish identify 3 classes of riparian health: Healthy, Healthy with problems, or Unhealthy.

Cows and Fish summarized those 4th order watersheds with field-based riparian assessment data into eleven larger watersheds (called Cows and Fish Watershed Boundaries), and assigned health categories based on the average scores of the assessed riparian areas they contained (Table 5). Due to the post-hoc assembly of these scores, some of the Cows and Fish watersheds boundaries contained a greater proportion and extent of assessed sites than others. For this reason, some are noted as "data deficient", although they are still included in the summary of data.

Table 5. Scoring of watershed within each Cows and Fish designated boundaries of the Oldman Headwaters Region (from Sikina and Ambrose 2012).

Cows and Fish Watershed Boundary	Health Score		Data Adequacy	
	Number of field assessments	Average Health Score	# of waterbodies assessed	Data Status*
Belly river watershed	4	62.5	2	Data deficient
Castle river watershed	10	77.4	8	Data deficient
Crowsnest river watershed	27	75.6	7	Data deficient
Oldman River Watershed (Racehorse Creek Confluence to HWY 22)	31	66.8	6	**Data adequate**
Pincher Creek Watershed	26	65.5	7	Data deficient
Racehorse Creek Watershed	2	82.5	2	Data deficient
South Willow Creek Watershed	39	65.8	8	**Data adequate**
St. Mary River Watershed	12	73.3	4	Data deficient
Upper Oldman River Watershed	15	83.8	6	Data deficient
Waterton River Watershed	36	74.2	8	Data deficient
Willow Creek Watershed	11	72.7	5	Data deficient

*Data adequate or deficient: this was determined based on the number of waterbodies (lotic systems primarily) and length and number of field assessment sites in each watershed by Cows and Fish.

Results

At the scale of the Cows and Fish watershed boundaries, the 11 watersheds were assessed as (Table 5; Figure 7):

2 watersheds (18%) rated as "Healthy.
9 watersheds (82%) rated as "Healthy with problems"
0 watersheds (0%) rated as Unhealthy.

The majority of the assessed watersheds were considered "Healthy with problems", meaning that these riparian areas are believe to be functioning, however they are currently impacted by human activity, and are at risk of losing some ecosystem functions.

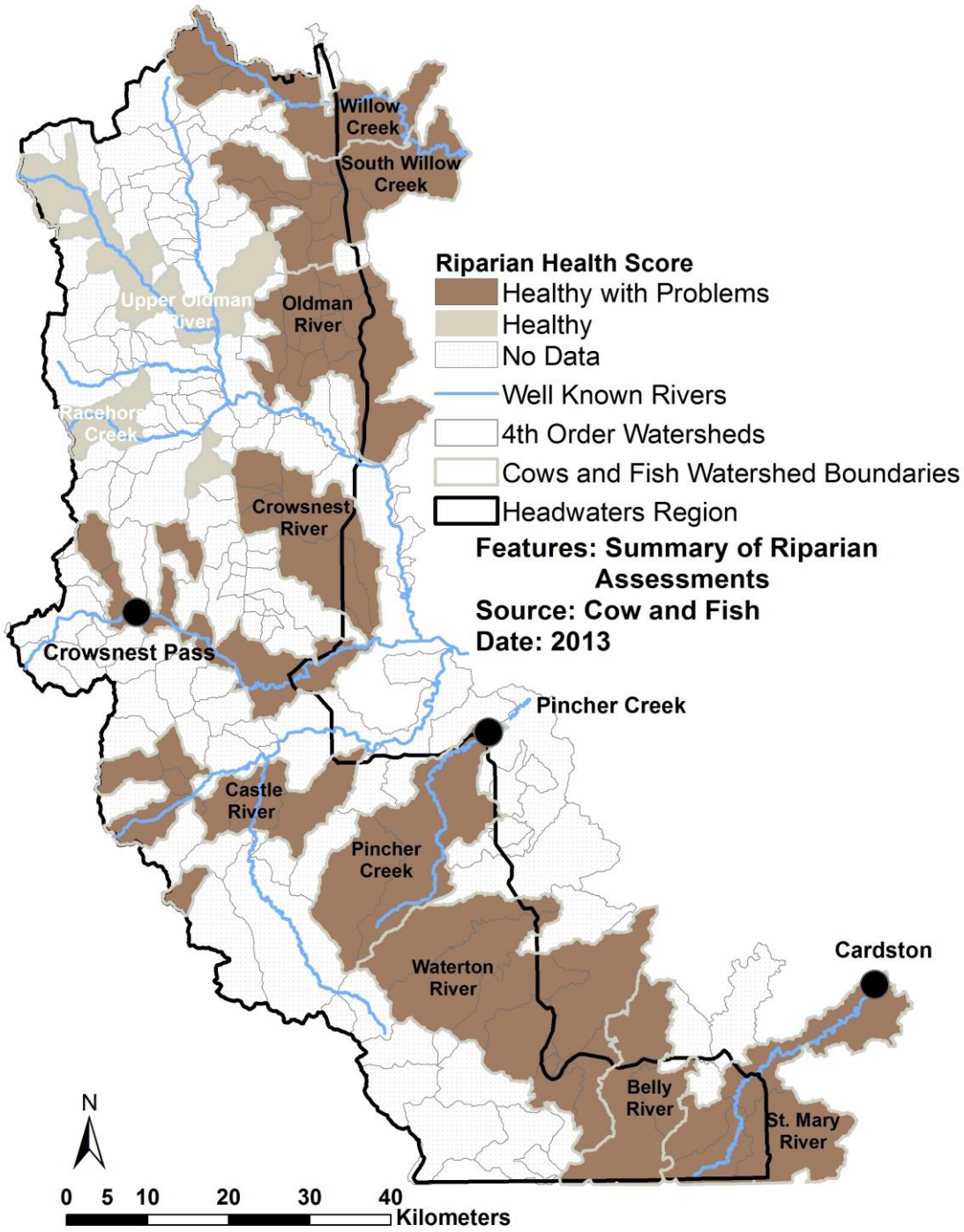

Figure 7. Riparian condition assessment ratings for 11 watershed boundaries defined by Cows and Fish in the Oldman Headwaters Region.

5.4 Sedimentation/Erosion Potential (Criterion 3)

Indicator Context

The Sedimentation/Erosion Potential indicator estimates the amount of linear features (all linear features type including roads, seismic lines, pipelines, power-lines, railroads, cutlines, and ORV vehicle trails) that occur in areas that are at high risk for both increased rates of soil erosion, and sedimentation into adjacent water-bodies. This included areas with steep slopes (>40% slope – high elevation areas) or wet habitats (lakes and wetlands including both permanent and semi-permanent water bodies). The wet area mapping layer was used to identify wet habitat; however this spatial data was not available for the entire Headwater Region, and as a result indicator mapping was only calculated for 4th order watersheds with full spatial data coverage (data was available for 129 out of 178 fourth order watersheds).

The length of linear features with high erosion/sedimentation pressure was standardized into a density measure (km/km^2) for each fourth order watershed. The thresholds developed for the Sedimentation/Erosion Potential indicator were adapted from those developed for the Density of All Linear Features Indicator. This approach was used because there is little scientific literature focusing specifically on the impacts of linear features at high elevations, and in aquatic habitats. Therefore, based on the conservative assumption that the pressures associated with linear features in these high elevation habitats are at least double that found with lower grades (Blanco and Lal 2008), the thresholds used above for the Density of All Linear Features halved to determine Sedimentation/Erosion Potential thresholds.

Results

Linear features in habitats with high Sedimentation/Erosion Potential were pervasive across the Headwaters Region (Figure 8a). The majority of Headwater Region was rated as Moderate Pressure (65%; Figure 8b), with the breakdown by pressure category as follows:

11 watersheds (11%) with Negligible Pressure
26 watersheds (20%) with Low Pressure
83 watersheds (64%) with Moderate Pressure
9 watersheds (7%) with High Pressure

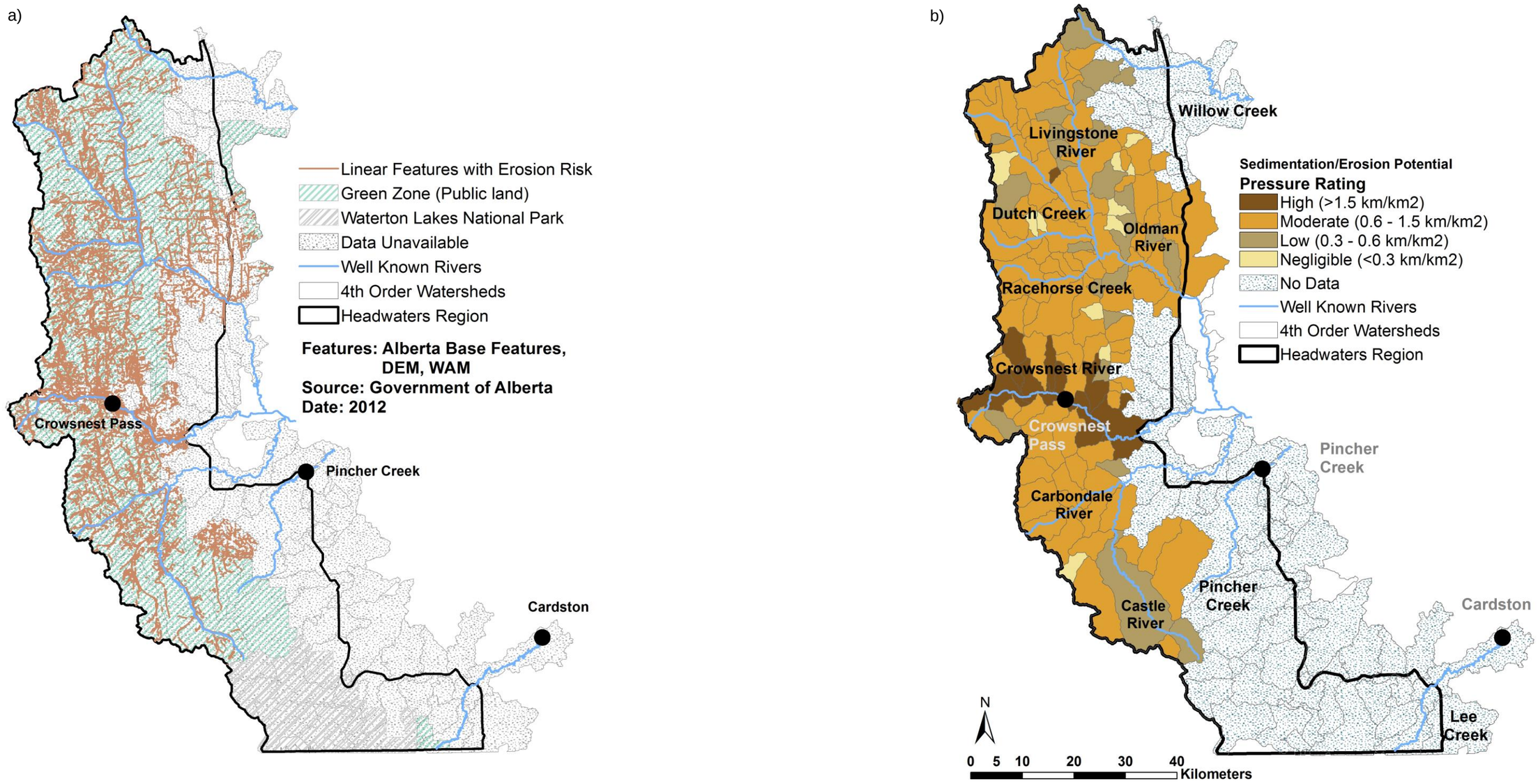

Figure 8. Input data used in pressure indicator data modeling and pressure rating classification results for the Sedimentation/Erosion Potential Indicator in the Oldman Watershed. The amount of linear features in areas vulnerable to erosion (a) was used to calculate pressure rating categories for each 4th order watershed using derived scientific thresholds (b). Public lands (Green Zone) are overlaid in green hatching in (a), while private land comprises the remainder of the Headwaters outside of Waterton Lakes National Park.

5.5 Flow Regime (Magnitude and Timing; Criteria 4)

Of the eight flow regime measures assessed in this study, two of the measures (daily peak flow, and date of the 2nd hydrograph peak) did not demonstrate any strong trend patterns (see Table B-2 in Appendix B). For the remaining magnitude measures, total annual flow and summer flow demonstrated nearly identical results (Figure 9a and Table B-2; only total annual flow is mapped below). For both, the overall magnitude of flows has declined over time for many WSC watersheds based on hydrometric station records. In the same vein, total spring flows were significantly decreasing at 5 of 13 stations (2 of the stations did not collect April flow data; Figure 9b). At this point, one can only speculate about the driving factor behind these trends, but smaller snowpack (due to either less snow falling or increased sublimation) is most likely a dominant contributing factor. The pattern for daily base (lowest) flow is inconsistent across the Headwaters Region (Figure 9c), with some watersheds demonstrating increasing trends, and others demonstrating a decreasing flow trend.

For the flow regime timing measures, decreasing trends in initiation date of spring melt are apparent. This decreasing trend result means that the initiation date of spring melt is starting to occur sooner at some of the stations, with 6 out of 15 (40%) showing significant decreasing trends (Figure 10a and Table B-2). Correspondingly, the 1st peak of the hydrograph is occurring sooner at some stations (Figure 10b). Earlier thaws have now been documented across much of the temperate and boreal zones in both terrestrial and aquatic systems across North America as a direct result of a warming climate (Magnuson 2001).

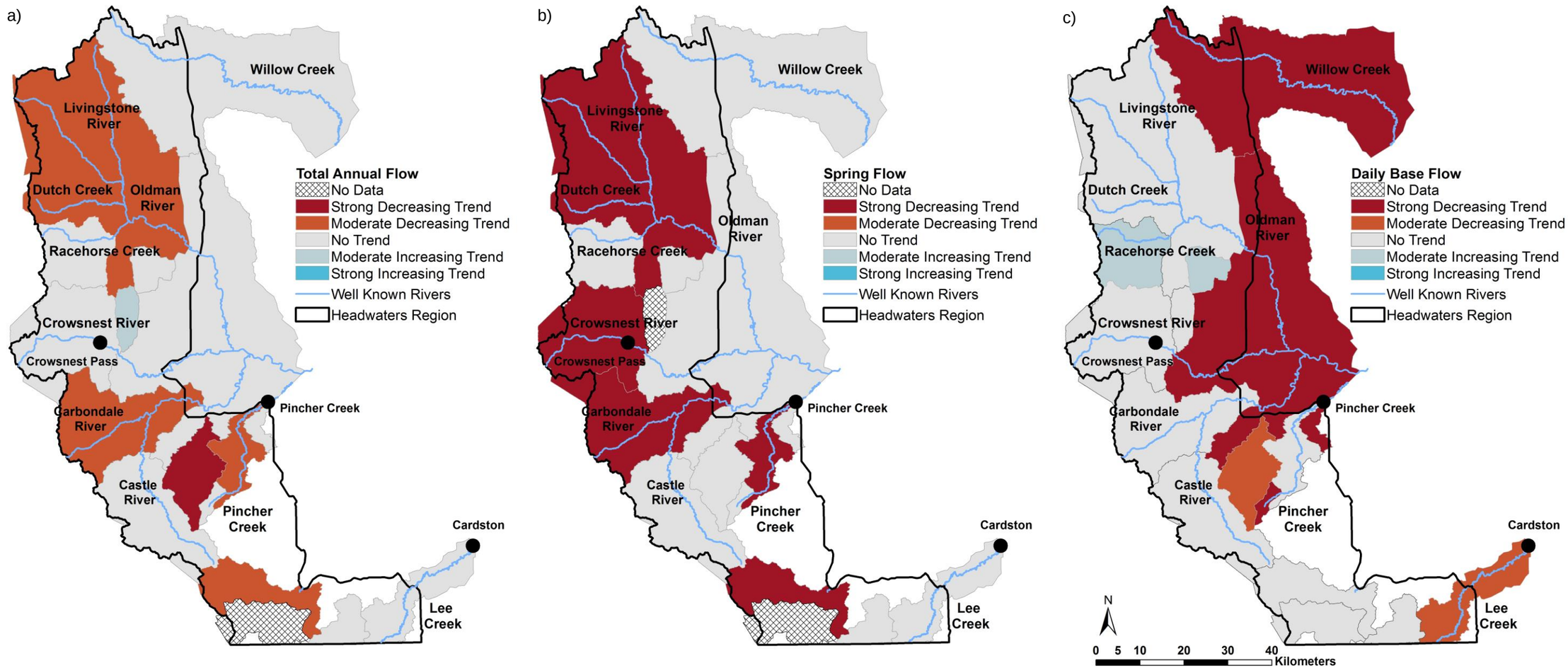

Figure 9: Flow regime trend rating maps for Magnitude measures for: (a) total annual flow, (b) spring flow, and (c) daily base flow for WSC watershed boundaries with all available data.

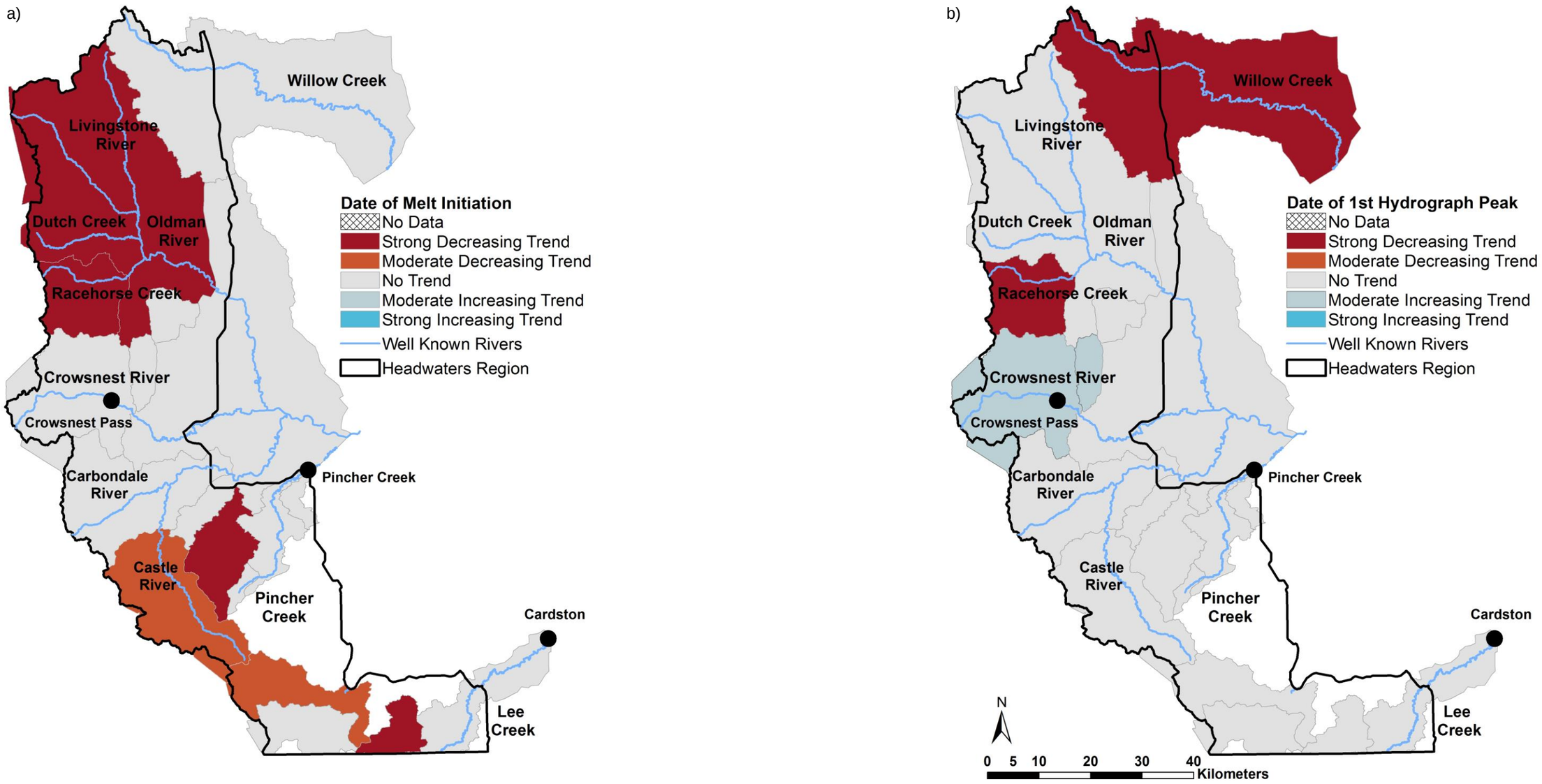

Figure 10: Flow regime trend rating maps for Timing measures for: (a) initiation date of spring melt and (b) date of the 1st hydrographic peak for WSC watershed boundaries with available data.

5.6 Limitations of Indicator Models and Caveats

Every attempt was made to use the best and most reliable data in the development of indicator models for this Oldman Headwaters Indicator Project; the base feature spatial data provide by the Government of Alberta (for roads and other linear features) was current up to 2011 or 2012, while the Water Survey of Canada data was current to 2010 or 2011. A major information source for the Intact landscape indicator (Section 5.1) is the Alberta Biodiversity Monitoring Institutes' human footprint map for Alberta. This spatial layer was created based on satellite imagery from between 2007 and 2010. It must be recognized that the models are only as good or as accurate as the data used to produce them. The caveats, assumptions, and limitations of the indicators modeled are outlined below to ensure an accurate interpretation of the results.

Intact Landscapes (Criterion 1)

This indicator is an areal measure of human disturbance, where the distribution of large-scale human land-uses such as forestry, urban development, and agriculture are the dominant factors in determining the indicator results. Unlike the indicators related to linear disturbances (Road Density & Density of All Linear Features), it is important to understand that while linear features may have many indirect effects related to habitat fragmentation, and cause behavioral avoidance by some wildlife species, on an areal basis they comprise only a small proportion (<10%) of the landscape in the Oldman Watershed which has been disturbed by human activity. In the Headwater Region, the extent and location of firstly forestry, and secondarily urban development and agricultural activity are the major drivers dictating where Intact Landscapes occur.

Road Density & Density of All Linear Features (Criterion 2)

The Alberta Base Features data for linear features effectively capture larger and persistent linear features (such as roads, pipelines, powerlines), but are missing many smaller linear features (and more recent linear features). These include quad trails, some cutlines, and in particular, in-block logging roads. The Forestry Division does not require logging trails/roads which occur on harvest blocks to be tracked in the central provincial database. This is a concern in the Headwaters Region because many of these in-block logging trails are later converted to quad trails, and remain a persistent disturbance on the landscape. Given this concern, as part of the Headwaters Indicators project, Fiera Biological mapped all visible unmapped linear features based on 2012 imagery (see Appendix B for full details). This new inventory may overestimate the amount of ORV accessible trails due to linear feature closures, and forest regeneration along trails. However, without any supplementary information regarding the location of trail closures, and ground verification of forest successional recovery, this is the best estimate of potential ORV accessible trails available.

A factor not measured in this assessment is the intensity of use (i.e. number of vehicles/hours). It is known that roads with high traffic volume can have far greater mortality and avoidance rates by wildlife than lower traffic (Dodd and Gagnon 2011, Colescott and Gillingham 1998), in addition to increased erosion. In addition, these two indicators assume all roads and linear features are equal in their impact in terms of soil erosion/sedimentation rates. Well-constructed and maintained roads/trails can significantly reduce erosion rates and the volume of sediments being washed into adjacent water bodies (Blanco and Lal 2008).

Riparian Condition (Criterion 2)

The overall condition of riparian lands within the Headwaters Region was determined by 213 field-based assessments of waterbodies conducted by Cows and Fish. There are limitations to the Cows and Fish methodology because the location of site-specific assessments is non-

random. The program relies on volunteer and community support, and occurs in collaboration with participating land-owners. A large portion of the eastern Headwaters Region is private land, hence this limits where riparian assessments occur to participating communities and/or persons.

Sedimentation/Erosion Potential (Criterion 3)
The intent of this indicator was to provide a simple model of areas at very high risk from sedimentation and erosion. In the future we recommend detailed hydrological models integrating run-off, slope, and soil type be developed.

Flow Regime (Magnitude and Timing; Criteria 4)
It must be recognized that hydrological modeling is very complex, and is impacted both human factors and by multi-year global climate phenomena (i.e. Pacific Decadal Oscillation PDO, El Nino-Southern Oscillation, North Atlantic Oscillation). In the Headwaters, there is a reasonable distribution of hydrometric stations across the region. However, the data record is not complete and many stations may not have enough data for identification of long-term trends. These limitations make the estimation of natural flow variability difficult and challenging.

6. Cumulative Watershed Integrity Index

The last step in the Criteria and Indicator Framework is the construction of an overall Watershed Integrity Index (WII; USDA 2011; Davies and Hanley 2010). This index combines together all the information captured by the individual criteria and indicators into a single index. This type of index (also called Multi-metric Indices) is a common approach to synthesizing complex ecological data into a composite index of status and trend (Boyd and Murray 2001; Buckland et al. 2005; Moyle and Randall 1998). The WII is used to assess the current and future state of areas of interest, and can be effective in measuring the success of management activities to improving ecological integrity.

The construction of a WII is based on a standardized rule-based methodology for objectively identifying, assessing, and ranking watershed indicators. A schematic for building and calculating the WII in the Headwaters Region of the Oldman Watershed is outlined in Figure 11 (adapted from the USDA Watershed Condition Framework (2011)). This standardized framework ensures the methods are scalable, repeatable, and consistent across all watersheds. Moreover, users are able to drill down to the individual unit of analysis scale, and identify specific regions that are in poor condition (i.e. specific 4th Order Watershed requiring management actions).

Criteria can be weighed equally, or differential weights can be assigned to specific criteria based on the goals and any management objectives of the Oldman Watershed. Given the time constraints in the project, we used equal weights as the simple base case. Criteria weights can be reviewed and revised in future assessments of the Headwaters Indicators based on expert opinion, or using consensus approaches such as Delphi evaluations.

At present, only 4 pressure indicators have been evaluated at the 4th order watershed scale. As a result, the WII constructed here should be viewed a preliminary WII model, integrating the best information available. As more information, especially for biological condition indicators becomes available, the WII model will be updated and revised to integrate new indicators, and updates of the existing indicators.

Methodology for Constructing WII

The cumulative Watershed Integrity Index (WII) focused only on the pressure indicators (from Criteria 1, 2, and 3) at present. Given the differences in scale of assessment, data types, and identified issues with data deficiencies used in the riparian condition indicator, and the flow indicators, it would be a challenging task to combine these 2 indicators with the 4 pressure indicators.

Criterion was the basis of combining indicators (see Figure 11), with each Criterion weighted equally. At present, there is only 1 indicator each for Criteria 1 (Intact Landscapes) and Criteria 3 (Sedimentation/Erosion Potential), and two for Criteria 2 (Density of All Linear Features and Road Density). Because road density is double counted (roads are included in the Density of All Linear Features indicators), only the Density of All Linear Features was included for Criteria 2.

To construct the WII, the following steps were taken:

1. Each 4th order watershed indicator rating (negligible, low, moderate, high) was be converted to a corresponding numeric value (1, 2, 3, and 4) respectively (where low scores are good).
2. A complication of the WII at present is that the Sedimentation/Erosion Potential indicator does not have full coverage of the entire 4th order watershed layer (due to limitations in the Wet Area Mapping data). For those 4th order watersheds with data on the Sedimentation/Erosion Potential indicator, the WII included Criteria 3 in the index. However, therefore in order to standardize the WII between 4th order watersheds (some which included Criteria 3, and which did not), the final WII value was calculated as an average value across the component Criteria. Hence, a score of 1 – 4 will occur for each criteria, and then an average value was taken across all input Criteria (the summed scores of all Criteria, divided by the number of criteria included; see Figure).
3. The final WII scores for the 178 - 4th order watersheds ranged from 1 – 4. This distribution of values was differentiated into 3 categories based on a Jenks Natural Classification Analysis (Jenks 1977), where **High Integrity** = 1 – 1.99, **Moderate Integrity** = 2 – 2.99, and **Low Integrity** = 3 – 4 (see Figure 12 for final WII scores at the 4th order watershed level).

   A Jenks analysis is based on natural groupings that are inherent in the data and identifies break points that group similar values to maximize the differences between classes (i.e., identifies breaks in the ordered distribution of values that minimizes within-class sum of squared differences). This approach has been used in other State of the Watershed Assessments (for example “The Saskatchewan State of the Watershed Report”; Davies and Hanley 2010).

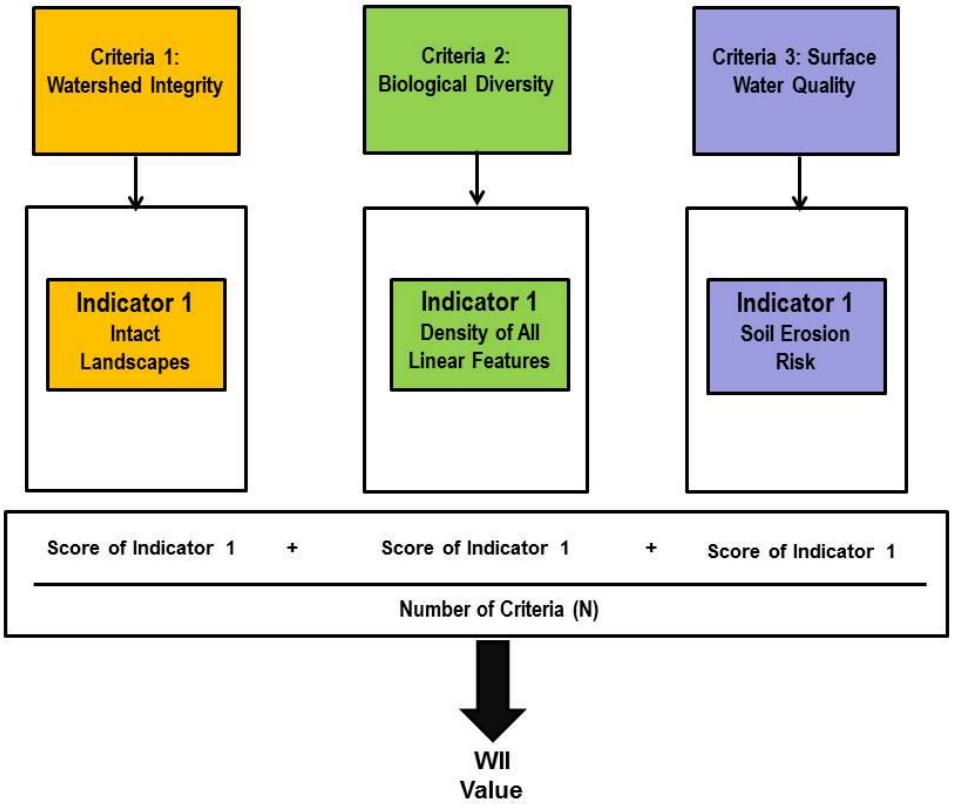

Figure 11. Schematic of Watershed Integrity Index (WII) to be constructed in the Headwaters Region of the Oldman Watershed.

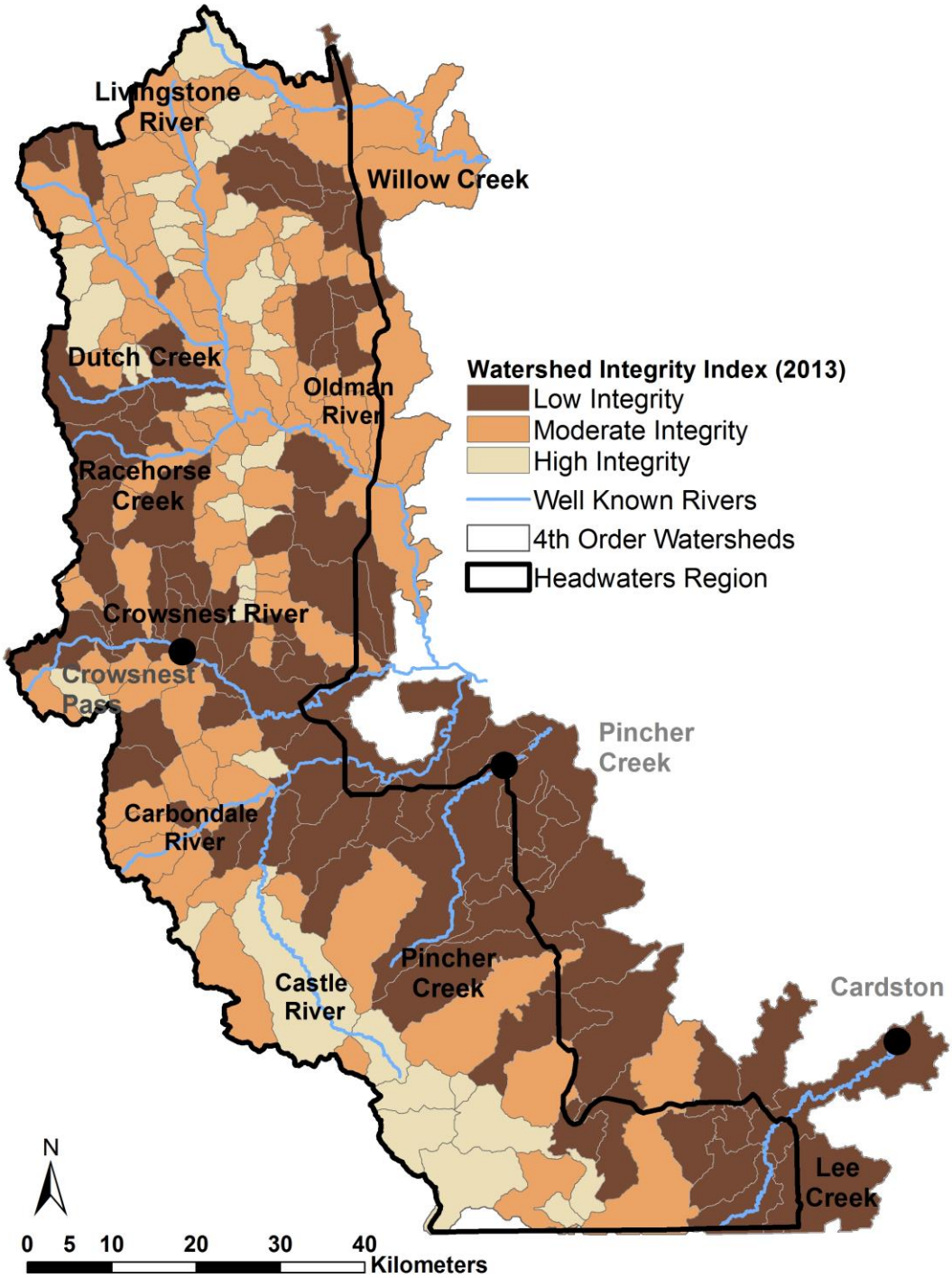

Figure 12. Results of the Watershed Integrity Index (WII) across the 178 - 4th order watersheds. Three categories of integrity are differentiated: High, Moderate, and Low based on average values across the input Criteria.

7. Application of Indicators and Watershed Integrity Index

A key purpose of the indicators and WII is to identify areas within the Headwaters Region that are currently at high pressure due to human land-use stressors. An example of how this assessment is conducted is outlined below for Headwaters Fisheries. This is a descriptive habitat based assessment which does not include on-the-ground information about the condition of fish populations. What is does provide is strong guidance on which watersheds are predicted to be at high risk for fisheries based on current land-use practices.

Bull trout and Westslope cutthroat trout are designated as threatened in Alberta by both the federal and provincial governments (Coombs 2013). Under Alberta's Management/Recovery Plans for bull trout and Westslope cutthroat trout, a common goal is to maintain populations throughout the species' historic ranges in the province at viable, self-sustaining levels (Alberta Westslope Cutthroat Trout Recovery Plan 2012 – 2017, 2013, Alberta Bull Trout Conservation Management Plan 2012 – 17, 2012). Both trout species are negatively impacted by increasing linear feature densities, and the cumulative impacts of multiple human disturbances (Coombs 2013; also see Section 3.4 for full details). In order to demonstrate the land-use threats currently affecting identified critical habitat for bull trout and Westslope cutthroat trout, a spatial analysis examining the distribution of critical trout habitat compared with: 1) the Density of All Linear Features; and 2) the cumulative WII was conducted

Alberta Environment and Sustainable Resource Development (AESRD) has identified critical stream habitat for the 2 trout species. The data is based on two different sampling methods, primarily on genetic data or sampling for juvenile trout (redds). Three different types of critical habitat are recognized: 1) important bull trout spawning areas, 2) critical habitat for Westslope cutthroat trout, and 3) genetically pure or near-pure population of Westslope cutthroat trout. Important spawning areas are characterized by a high density of trout redds. As an important caveat, these streams identify known critical habitat, but do not document the full extent of bull trout and Westslope cutthroat trout populations throughout the Headwaters.

When overlaid with the Density of All Linear Features Indicator (Figure 13a) and the cumulative WII (Figure 13b), only 18 – 27% of identified critical stream sections (by stream length) occur in either areas rated as High Integrity by the WII, or in Negligible - Low Pressure categories for the Density of All Linear Features (Table 5). In fact, the majority of stream sections identified as critical habitat for bull trout and cutthroat trout occurred in watersheds identified as being at High Pressure based on the Density of All Linear Features (Table 5, Figure 13a).

Table 5. Summary of % stream length of known critical stream sections broken down by WII Integrity Rating, and Density of All Linear Features Pressure Ratings for bull trout (BLTR) and Westslope cutthroat trout (CTTR).

Index/Indicator	Index/Indicator Rating	BLTR Spawning Areas (%)	Critical CTTR Habitat (%)	CTTR Near Pure Populations (%)
WII	High Integrity	26.6	17.5	25.3
	Moderate Integrity	50.0	44.0	49.4
	Low Integrity	23.4	38.5	25.3
Density of All Linear Features	Negligible Pressure	0.0	5.9	0.8
	Low Pressure	26.6	11.6	26.2
	Moderate Pressure	23.4	32.6	25.3
	High Pressure	50.0	49.9	47.8

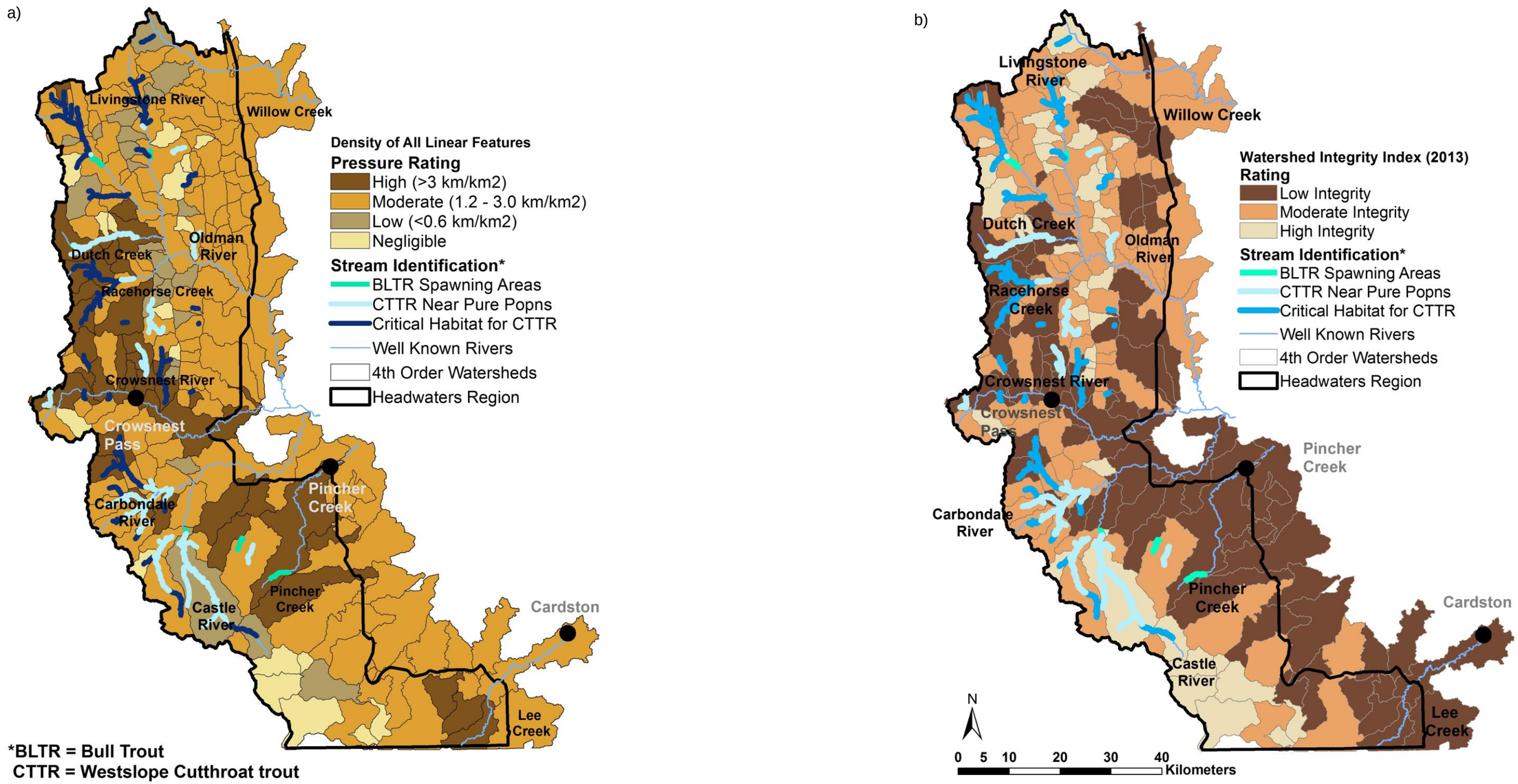

Figure 13 Comparison between streams identified as critical habitat for bull trout (BLTR) and Westslope cutthroat trout (CTTR) compared with **(a)** Pressure Ratings for the Density of All Linear Features and **(b)** the Integrity Ratings for the cumulative Watershed Integrity Index (WII) in the Headwaters Region.

8. Data Gaps and Future Priorities

Watershed assessments in an area as diverse as the Oldman Watershed Headwaters Region is a complex and challenging task. Obtaining and compiling appropriate, comparable, and reliable data from stakeholders and other third parties for many indicators is difficult and time consuming. As a result, this project focused on indicators where spatial and non-spatial data were readily available. In the future, additional work will be challenged by constraints associated with data ownership, data sharing, and data organization. All these factors can present major barriers to evaluating indicators and watershed assessment over the timeframes of many projects. For each criterion listed below, the data gaps, and priorities for future work are outlined to help guide future work of the OWC.

CRITERION 1: Landscape Composition and Condition

The intent of this criterion is to document the current state of land-use pressures, as well as past, present, and future trends in human activity and climate in the Headwaters Region. The indicator that we evaluated for this criterion is strongly related to ALCES modeling that is currently being conducted by Brad Stelfox in the Oldman Watershed. Because the goal and scales of assessment differ between this Headwaters Indicator project (small local scale) and the ALCES (township scale) project, the results of each should be complementary. In future, a key priority for the OWC is to better understand how climate change, and the associated shifting patterns in natural disturbances impact hydrology (see Criteria 4 below), and the implications of these potential impacts on wildlife, water quality, and human land-use (Einheuser et al. 2013). As part of this research avenue, it is crucial to ensure that accurate and up-to-date land cover and human land-use data is available. A key data gap recognized by the OWC is the need to better understand the extent and intensity of use of linear features and OHV trails throughout the Headwaters Region. This information is critical to developing a regional management plan, and working with OHV user groups to create maintained and well-designed trail networks which will reduce soil erosion and other environmental impacts.

CRITERION 2 & 3: Biological Diversity and Surface Water Quality

Watersheds are incredibly complex, and teasing apart direct mechanistic linkages between species responses and anthropogenic stressors is a challenging and time consuming task. Within all monitoring programs, most ecological indicators measure the response of watersheds and ecosystems to anthropogenic stressors, but do not necessarily identify specific anthropogenic stresses causing impairment (EPA 2002). However, having good information on biological condition indicators is crucial because they directly measure the state of biological populations or communities, and moreover because they act as early warning signals of negative human impacts on aquatic biodiversity (Barbour et al. 2000, Niemi and McDonald 2004). Changes in species composition or declines in the physical condition of aquatic organisms are often detectable well before noticeable changes in water quality (EPA 1990). Within these 2 criteria, the majority of the aspirational indicators are condition Indicators that require extensive field-based biological and habitat sampling (e.g., Fish Community, Amphibian Community, Macro-Invertebrate Community, Surface Water Quality parameters, and Sediment Quality parameters). Although the Oldman Headwaters Region is a small area (23,000km^2) relative to other Watersheds in Alberta (e.g. North Saskatchewan or

Athabasca Watersheds), it is still orders of magnitude larger than the average research study or monitoring program. While there has been extensive research and monitoring work done on fish and wildlife in the Headwaters Region by government and university researchers, there are several challenges in using these data for a larger watershed assessment project, including:

1. This information is typically conducted at relatively small spatial scales (typically less than 500 hectares).
2. Each project/monitoring program has different objectives, research methodologies, and sampling efforts.
3. Much of this information is not readily accessible. It exists as Master's or PhD theses, academic papers, and government or consulting reports. Assembling and compiling this information together into a standardized and comparable format requires extensive effort.
4. Much of the data is considered proprietary and getting permission to use the raw data from many of these studies can be difficult (or not possible) and time consuming.

In moving forward on these indicators, the OWC can take two approaches which are complementary. The first is to select priority indicators (i.e. fish communities) and commit the effort, time, and funding to assemble a standardized regional database. Secondly, the OWC can work with partners and stakeholders to begin a monitoring program to collect the necessary field data needed to address the information gaps for priority indicators. The science on the development, management, and data analysis of fish and aquatic macro-invertebrate monitoring programs is extensive and rigorous. In the United States, monitoring programs on aquatic invertebrates and fish have been running since the 1970's under the umbrella of the federal Clean Water Act (EPA 1990). Under conventional regulatory processes, watershed assessment based on condition indicators (typically fish and macro-invertebrates) are frequently conducted (EPA 2002). The survey information is stored in national and/or state databases, and available to the scientists. The critical difference between the United States and Canada is funding and assistance from federal agencies, where watershed assessment funding has been available to government scientists, university researchers, and local communities (EPA 2001).

CRITERION 4: Water Levels and Flow

In the Headwaters Region, the available hydrological information is applicable only at relatively large spatial scales. Most of the hydrometric stations are measuring flow and level at the fifth order watershed, or higher. At this scale, there is a substantial amount of hydrological averaging is occurring, meaning that localized effects, especially important for land cover change, are not being detected. From the perspective of water supply for downstream communities (ecological and human), and how this supply might be impacted by climate change (which would have more of a blanket effect), the current distribution of stations is most likely adequate; however, identifying local ecologically important changes at the smaller watershed scale (first to fourth order) requires much more information than is currently available.

This study, like many others, highlights the limited information available on lower order systems. If understanding small-scale land use impacts on hydrology is a priority for the OWC, more hydrometric stations will need to be installed and run within lower order

systems. This could be a collaborative area of research and stewardship conducted in association with universities and/or local conservation organizations (i.e. University of Alberta, University of Lethbridge). A good distribution of discharge stations coupled with hydrological modeling (which can be 'taught' to predict flow in ungauged systems), could provide an adequate assessment of the hydrologic conditions in the Headwaters Region. Good first order approximations of the effects of forest fire on flow regime are already available based on paired-watershed work (Silins et al. 2009). These types of observational data are crucial but might miss the integrated effects of climate, land cover and land use change across the larger Headwaters region. Based on the analysis completed in this study, the next step would be to link the observed hydrological trends to both climatic indicators as well as land cover indicators.

9. Conclusions

This report provides a framework for evaluating the watershed and ecological integrity of the Headwaters Region of the Oldman Watershed, as well as a preliminary assessment of a small subset of watershed indicators for this region, and an initial watershed integrity index (WII). Results from these indicators and the WII demonstrate that significant land-use pressures exist in many areas of the Headwaters, with an associated high potential for ecological impairments occurring in these areas.

We have recommended a Criteria and Indicator approach for the Headwaters Region, which can be expanded and applied to assess condition throughout the Oldman Watershed. The work conducted as part of this project forms the basis for local and regional stewardship initiatives in the Headwaters Regions, and provides information to help prioritize future research and assessment projects.

10. Literature Cited

ABMI (Alberta Biodiversity Monitoring Institute). 2009. ABMI_RSG Brief Report, 2007 Human Footprint Characterization and Preliminary Statistics, Version 2009-01-23. Alberta Biodiversity Monitoring Institute, Alberta, Canada. Report available at: abmi.ca [November 2011].

Adams, B.W., G. Ehlert, C. Stone, M. Alexander, D. Lawrence, M. Willoughby, D. Moisey, C. Hincz, A. Burkinshaw, J. Carlson and K. France. 2009. Range Health Assessment for Grassland, Forest, and Tame Pasture. Public Lands and Forests Division, Alberta Sustainable Resource Development. Pub. No. T/044. No. 0-7785-2848-0

AENV (Alberta Environment). 2008a Handbook for State of the Watershed Reporting: A Guide for Developing State of the Watershed Reports in Alberta. Edmonton, AB

AENV (Alberta Environment). 2008b. Indicators for Assessing Environmental Performance of Watersheds in Southern Alberta. Edmonton, AB.

AENV (Alberta Environment) 1998. South Saskatchewan River Basin historical weekly natural flows 1912 to 1995, 181 pp., Edmonton, Alberta, Canada

Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017. 2013. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Recovery Plan No. 28. Edmonton, Alberta. 87 pp.

Alberta Bull Trout Conservation Management Plan 2012 – 17. 2012. Alberta Sustainable Resource Development (ASRD). 2012. Alberta Species at Risk Conservation Management Plan No. 8. Edmonton, AB, 90 pp.

Alberta Grizzly Bear Recovery Plan 2008-2013. 2008. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Recovery Plan No. 15. Edmonton, Alberta. 68 pp.

Allen, J.D., D. L. Erickson and J. Fay. 1997. The influence of catchment land use on stream integrity across multiple spatial scales. Freshwater Biology 37: 149–161.

Ambrose, N., G. Ehlert, and K. Spicer-Rawe. 2004. Riparian Health Assessment for Lakes, Sloughs, and Wetlands - Field Workbook. 90 pp. [Modified from Fitch, L., B.W. Adams, and G. Hale. 2001.]

Andren, H. 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. Oikos 71:355-366.

Balvanera, P., A.B. Pfisterer, N. Buchmann, J-S. He, T. Nakashizua, D. Raffaelli, and B. Schmid. 2006. Quantifying the evidence for biodiversity effects on ecosystem functioning and service. Ecology Letter 9:1146-1156.

Barbour, M.T., W.F. Swietlik, S.K. Jackson, D.L. Courtemanch, S.P. Davies, and C.O. Yoder. 2000. Measuring the attainment of biological integrity in the USA: a critical element of ecological integrity. Hydrobiologica 422/423: 453-465.

BCMWLAP (British Columbia Ministry of Water, Land and Air Protection). 2002. Environmental Indicators: Habitat in British Columbia. British Columbia Ministry of Water, Land and Air Protection. Report available at: http://www.env.gov.bc.ca/soe/et02/14_habitat/technical_report/Habitat_2002.pdf

Beechie, T., G. Pess, S. Morley, L. Butler, P. Downs, A. Maltby, P. Skidmore, S. Clayton, C. Muhlfeld, and K. Hanson. 2013. Stream and Watershed Restoration: A guide to Restoring Riverine Processes and Habitats. 1st Edition; Ch. 3, Watershed Assessment and Identification of Restoration Needs. Pp 50-113. Toronto, Canada. John Wiley & Sons Ltd. Print.

Blanco, H., and R. Lal. 2008. Principles of soil conservation and management. Spring Press, New York, USA.

Booth, D.B., D. Hartley, and R. Jackson. 2002. Forest Cover, Impervious-Surface area, and the mitigation of stormwater impacts. Journal of the American Water Resources Association 38 (3): 835-947,

Boyd, I.L. and A.W.A. Murray. 2001. Monitoring a marine ecosystem using responses of upper trophic level predators. Journal of Animal Ecology 70: 747-760.

Brabec, E., S. Schulte, and P.L. Richards. 2002. Impervious surfaces and water quality: A review of current literature and its implications for watershed planning. Journal of Planning Literature 16:499-514.

Brinkman, R. 1997. Land quality indicators and their use in sustainable agriculture and rural development. FAO Land and Water Bulletin. Report available at: http://www.fao.org/docrep/W4745E/W4745E00.htm.

Buckland, S.T., A.E. Magurran, R.E. Green, and R.M. Fewster. 2005. Monitoring change in biodiversity through composite indices. Philosophical Transactions of the Royal Society B. 360: 243-254.

Buskirk, S.W. and L.L. McDonald. 1989. Analysis of Variability in Home Range Size of the American Marten. Journal of Wildlife Management 53: 997-1004.

Carr, L.W. and L. Fahrig. 2001. Effect of road traffic on two amphibian species of differing vagility. Conservation Biology 15:1071 – 1078.

CCFM (Canadian Council of Forest Ministers). 1995. Defining Sustainable Forest Management: A Canadian Approach to Criteria and Indicators. Canadian Council of Forest Ministers: Ottawa, Ontario. 22 pp.

CCFM (Canadian Council of Forest Ministers). 2005. Criteria and indicators of sustainable forest management in Canada: national status 2005. Report available at: www.ccfm.org/pdf/C&I_e.pdf. [August 2011]

CCME (Canadian Council of Ministers of the Environment). 2007. Canadian water quality guidelines for the protection of aquatic life: Summary table. Updated December, 2007. *In* Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Chapin III, F.S., E.S. Zavaleta, V.T. Eviner, R.L. Naylor, P.M. Vitousek, H.L. Reynolds, D.U. Hooper, S. Lavorel, O.E. Sala, S.E. Hobbie, M.C. Mack, and S. Díaz, S. 2000. Consequences of changing biodiversity. Nature 405: 234–242.

Chapin, T.G., D.J. Harrison, and D.D. Katnik. 1998. Influence of landscape pattern on habitat use by American marten in an industrial forest. Conservation Biology 12: 1327-1337.

Clapcott, J.E., K.J. Collier, R.G. Death, E.O. Goodwin, J.S. Harding, D. Kelly, J.R. Leathwick and R.G. Young. 2011. Quantifying relationships between land-use gradients and structural and functional indicators of stream ecological integrity. Freshwater Biology. Published online: DOI: 10.1111/j.1365-2427.2011.02696.x.

Clare, S. and G. Sass. 2012. Riparian lands in Alberta: Current state, conservation tools, and management approaches. Report prepared for Riparian Land Conservation & Management Team, Alberta Water Council, Edmonton, Alberta. Fiera Biological Consulting Ltd. Report #1163.

Colescott, J.H., and M.P. Gillingham. 1998. Reaction of moose (*Alces alces*) to snowmobiles traffic in the Greys River Valley, Wyoming. Alces 34: 329-338.

CoP (City of Portland). 2005. Framework for Integrated Management of Watershed Health. Appendix G: Selecting Indicators of Watershed Health. Published online: http://www.portlandoregon.gov/bes/article/108302. {Sept 3, 2013}.

CoP (City of Portland).2005. Appendix G: Selecting Indicators of Watershed Health.Framework for Integrated Management of Watershed Health. In Framework for Integrated Management of Watershed Health. Portland, Oregon. Report available at: http://www.portlandoregon.gov/bes/33528

Coombs, M. 2013. Requirements for maintaining native trout on the East Slopes of the SSRP region. Unpublished Document, Alberta Environment and Sustainable Resources Development

Crites, S. 2006. A comparison of early succession understory plant communities following fire and harvesting. Fire and Harvest Residual Project: The impact of wildfire and harvest residuals on forest structure and biodiversity in aspen-dominated boreal forests of Alberta. A Final Report.

Dahm,, V., D. Hering, D. Nemitz, W. Graf, A. Schmidt-Kloiber, P. Leitner, A. Melcher, C.K. Feld. 2013. Effects of physic-chemistry, land use and hydromorphology on three riverine organism

groups: a comparative analysis with monitoring data from Germany and Austria. Hydrobiologia 704: 389-415.

Davies, H., and P.T. Hanley. 2010. 2010 State of the Watershed Report, Appendix B – Stressor Indicators. Saskatchewan Watershed Authority.138 pp. Report available at: http://www.swa.ca/StateOfTheWatershed/Default.asp [September 2011].

Dodd, N.L., and J.W. Gagnon. 2011. Influence of underpass and traffic on white-tailed deer highway permeability. Wildlife Society Bulletin 35: 270-281.

Dube, M., B. Johnson, G. Dunn, J. Culp, K. Cash, K. Munkittrick, I. Wong, K. Hedley, W. Booty, D. Lam, O. Resler, and A. Storey. 2006. Development of a new approach to cumulative effects assessment: a northern river ecosystem example. Environmental Monitoring and Assessment 113:87-115.

Dunham, J.B., and B.E. Rieman. 1999. Metapopulation structure of bull trout: influences of physical, biotic, and geometrical landscape characteristics. Ecological Applications 9:642-655.

Dunham, J.B., G.L. Vinyard, and B.E. Reiman. 1997. Habitat fragmentation and extinction risk of Lahontan cutthroat trout. North American Journal of Fisheries Management 17: 1126-1133.

Eaglin, G.S., and W.A. Hubert. 1993. Management briefs: effects of logging and roads on substrate and trout in streams of the Medicine Bow National Forest, Wyoming. North American Journal of Fisheries Management 13: 844:846.

Einheuser, M.D., A. P. Nejadhashemi, L. Wang, S.P. Sowa, and S.A. Woznicki. 2013. Linking biological integrity and watershed models to assess the impacts of historical land use and climate changes on stream health. Environmental Management 51: 1147-1163.

England, L.E., and A.D. Rosemond. 2004. Small reductions in forest cover weaken terrestrial-aquatic linkages in headwater streams. Freshwater Biology 49: 721-734.

EPA (Environmental Protection Agency). 1990. Biological Criteria: National program guidance for surface waters. Report #EPA-440-5-90-004. Report available at: http://www.epa.gov/bioiweb1/pdf/EPA-440-5-90-004Biologicalcriterianationalprogramguidanceforsurfacewaters.pdf [August 2011]

EPA (Environmental Protection Agency). 1996. Biological Criteria: Technical guidance for streams and small rivers. Report # EPA--822/B-96/001. Report available at: http://www.epa.gov/bioiweb1/pdf/EPA-822-B-96-001BiologicalCriteria-TechnicalGuidanceforStreamsandSmallRivers-revisededition1996.pdf [August 2011]

EPA (Environmental Protection Agency), 2001. Overview to Watershed Assessment: Tools for Local Stakeholders. Report # EPA—832/B-01/004. Report available at: http://water.epa.gov/scitech/wastetech/upload/overview-to-watershed-assessments-tools-for-stakeholders.pdf

EPA (Environmental Protection Agency), 2002. A framework for Assessing and Reporting on Ecological Condition. Report available at: http://yosemite.epa.gov/sab/sabproduct.nsf/7700D7673673CE83852570CA0075458A/$File/epec02009.pdf

Esseen, P-A., and K-E. Renhorn. 2008. Edge effects on an epiphytic lichen in fragmented forests. Conservation Biology 12:1307-1317.

Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution, and Systematics. 34: 487-515.

Fiera (Fiera Biological Consulting Ltd.). 2012. Athabasca State of the Watershed Report: Phase 2. Report prepared for the Athabasca Watershed Council. Fiera Biological Consulting Report #1142. Pp. 100.

Findlay, C.S., and J. Houlahan. 1997. Anthropogenic correlates of species richness in southeastern Ontario wetlands. Conservation Biology 11:1000-1009.

Finn, S.P., J.M. Marzluff, and D.E. Varland. 2002. Effects of Landscape and Local Habitat Attributes on Northern Goshawk Site Occupancy in Western Washington. Forest Science 48: 427-436.

Fitch, L., B.W. Adams and G. Hale, 2001. Riparian Health Assessment for Streams and Small Rivers - Field Workbook. Lethbridge, Alberta: Cows and Fish Program. 90 pp. [adapted from Riparian and Wetland Research Program, School of Forestry. 2001. Lotic health assessments:

Riparian health assessment for streams and small rivers (Survey) User Guide. University of Montana, Missoula, Montana, January 2001.]

Fitch, L., and N. Ambrose 2003. Riparian Areas: A User's Guide to Health. Lethbridge, Alberta: Cows and Fish Program. ISBN No. 0-7785-2305-5.

Forbes, K.A., S.W. Kienzle, C.A. Coburn, J.M. Byrne, and J.J. Rasmussen. 2011. Modeling the impacts of selected GCM derived climate scenarios on the future hydrology of a hybrid watershed in the Oldman River watershed, Alberta, Canada. Climatic Change 105: 555-565.

Forman, R.T.T., D. Sperling, J.A. Bissonette, A.P. Clevenger, C.D. Cutshall, V.H. Dale, L. Fahrig, R. France, C.R. Goldman, K. Heanue, J.A. Jones, F.J. Swanson, T. Turrentine, T.C. Winter. 2003. Wildlife Population *in* Road Ecology: Science and Solutions, pp. 113-138. Island Press, Washington, USA.

Frair, J.L., E.H. Merill, H.L. Beyer, and J.M. Morales. 2008. Thresholds in landscape connectivity and mortality risks in response to growing road networks. Journal of Applied Ecology 45:1504-1513.

Furniss, M.J., T.D. Roelofs, and S.C. Yee. 1991. Road construction and maintenance *in* Influences of forest and rangeland management on salmonid fishes and their habitats. W.R. Meehan [Ed.], Pp. 297-323.

Government of Alberta. 2012. Stepping Back from the Water: A Beneficial Management Practices Guide for New Development Near Water-bodies in Alberta's Settled Region. Alberta Environment and Water, Edmonton, Alberta.

Haines-Young, R. 2009. Land use and biodiversity relationships. Land Use Policy 26S:S178 0 S186.

Hargis, C.D. J.A. Bissonetta, and D.L. Turner 1999. The influence of forest fragmentation and landscape pattern on American martens. Journal of Applied Ecology 36:157-172.

Hart, S.A., and H.Y.H, Chen. 2008. Fire, logging, and overstory affect understory abundance, diversity, and composition in boreal forest. Ecological Monographs. 78:123-140.

Helsel, D.R., and R.M. Hirsch. 1992. Statistical Methods in Water Resources, Elsevier Science Publishers, Amsterdam.

Henley, W.F., M.A. Patterson, R.J. Neves, and A.D. Lemly. 2010. Effects of sedimentation and turbidity on lotic food webs: a concise review for natural resource managers. Reviews in Fisheries Science 8:125-139.

Hilderbrand, R.H., R.M. Utz, S.A. Stranko, R.L. Raesly. 2010. Applying thresholds to forecast potential biodiversity loss from human development. Journal of the North American Benthological Society 29 (3): 1009-1016.

Hobson, K.A., and J. Schieck. 1999. Changes in bird communities in boreal mixedwood forest: Harvest and Wildfire effects over 30 years. Ecological Applications 9: 849-863.

Holroyd, P. Towards acceptable changes: A thresholds approach to manage cumulative effects of lands use in the southern foothills of Alberta. MSc. Thesis, University of Calgary, Calgary, AB.

Jenks, G. 1977. Optimal Data Classification for Choropleth Maps. Occasional paper No. 2, department of geography, University of Kansas.

Johnson, L.B., C. Richards, G.E. Host, and J.W. Arthur. 1997. Landscape influence on water chemistry in Midwestern stream ecosystems. Freshwater Biology 37:193-208.

Kurulok, S.E. and S.E. Macdonald. 2007. Impacts of postfire salvage logging on understory plant communities of the boreal mixedwood forest 2 and 34 years after disturbance. Canadian Journal of Forest Research. 37(12):2637-2651.

Lathrop, R.G., D.L. Tulloch, C. Hatfield. 2007. Consequences of land use change in the New York–New Jersey Highlands, USA: Landscape indicators of forest and watershed integrity, Landscape and Urban Planning, 79: 150-159.

Lee, D.C., J. Sedell, B. Rieman, R. Thurow, and J. Williams. 1997. Broadscale assessment of aquatic species and habitats. US Forest Service, Pacific Northwest Research Station General Technical Report, PNW-GTR-405, Portland, Oregon.

Lee, P., D. Aksenov, L. Laestadius, R. Nogueron, and W. Smith. 2003. Canada's large intact forest landscapes. Global Forest Watch Canada, Edmonton, Alberta. 84 pp.

Lee, P. and S. Crites. 2006. Early successional deadwood dynamics in wildfire and harvest stands. Fire and Harvest Residual Project: The impact of wildfire and harvest residuals on forest structure and biodiversity in aspen-dominated boreal forests of Alberta. A Final Report.

Lindsay, J.B. 2005. The Terrain Analysis System: a tool for hydro-geomorphic applications. Hydrological Processes. 19: 1123–1130.

Linke, S., R. L. Pressey, R. C. Bailey, and R. H. Norris. 2007. Management options for river conservation planning: condition and conservation re-visited. Freshwater Biology 52:918-938.

Lode, T. 2000 Effect of a motorway on mortality and isolation of wildlife populations. Ambio, 29: 163–166.

Magnuson, J.J. 2001. Historical trends in lake and river ice cover in the Northern Hemisphere, Science 291: 254.

Mazur, K.M., S.D. Frith, and P.C. James. 1998. Barred owl home range and habitat selection in the boreal forest of central Saskatchewan. Auk 115: 746–754.

McGarigal, K, W.H. Romme, M. Crist, and E. Roworth. 2001. Cumulative effects of roads and logging on landscape structure in the San Jan Mountains, Colorado, USA.

Mensing, D.M., S.M. Galatowitsch, and J.R. Tester. 1998. Anthropogenic effects on the biodiversity of riparian wetlands of a northern temperate landscape. Journal of Environment Management 53: 349 – 377.

Moyle, P.B., and P.J. Randall. 1998. Evaluation the Biotic Integrity of Watershed in the Sierra Nevada, California. Conservation Biology 1318-1326.

Muria, C. 1995. Edge effects in fragmented forests: implications for conservation. Trends in Ecology and Evolution 10: 58-62.

Natural Regions Committee 2006. Natural Regions and Subregions of Alberta. Compiled by D.J. Downing and W.W. Pettapiece. Government of Alberta. Pub. No. T/852.

Nel, J. L., D. J. Roux, G. Maree, C. J. Kleynhans, J. Moolman, B. Reyers, M. Rouget, and R. M. Cowling. 2007. Rivers in peril inside and outside protected areas: a systematic approach to conservation assessment of river ecosystems. Diversity and Distributions 13:341-352.

Nellemann, C., I. Vistnes, P, Jordhoy, O. Strand, and A. Newton. 2003 Progressive impact of piecemeal infrastructure development on wild reindeer. Biological Conservation, 113: 307–317.

Niemelä, J. 2000. Biodiversity monitoring for decision making. Ann. Zool. Fennici 37: 307-317.

Niemi, J, and M.E. McDonald. 2004. Application of Ecological Indicators. Annual Review of Ecology, Evolution and Systematics. 35: 89-111.

Norris, R. H., S. Linke, I. Prosser, W. J. Young, P. Liston, N. Bauer, N. Sloane, F. Dyer, and M. Thoms. 2007. Very-broad-scale assessment of human impacts on river condition. Freshwater Biology 52:959-976.

National Research Council (NRC). 2002. Riparian Areas: functions and strategies for management. National Academy Press, Washington, D.C. 428 pp.

National Research Council (NRC). 2008. Hydrologic Effects of a Changing Forest Landscape. Committee on Hydrologic Impact of Forest Management. Water Science and Technology Board, Division of Earth and Life Studies, National Research Council of the National Academies. The National Academies Press, Washington, DC. 156 pp.

Oldman Watershed Council (OWC), 2011. Priorities for the Oldman Watershed: Promoting action to maintain and improve our watershed. Oldman Watershed Council, Lethbridge, Alberta. 54 pgs.

Oldman Watershed Council (OWC), 2010. Oldman River State of the Watershed Report 2010. Oldman Watershed Council, Lethbridge, Alberta. 284 pgs.

Olive, N.D., and J.L Marion. 2009. The influence of use-related, environmental, and managerial factors on soil loss from recreational trails. Journal of Environmental Management 90:1483-1493.

OMOE (Ontario Ministry of Environment). 2009. Technical Bulletin: Proposed Methodology for Calculating Percentage of Managed Lands and Livestock Density for Land Application of Agricultural Source of Material, Non-Agricultural Source of Material and Commercial Fertilizers

Ouren, D.S., C. Haas, C.P. Melcher, S.C. Stewart, P.D. Ponds, N.R. Sexton, L. Burris, T. Fanche and Z.H. Bowen. 2007, Environmental effects of off-highway vehicles on Bureau of Land

Management lands: A literature synthesis, annotated bibliographies, extensive bibliographies, and internet resources: U.S. Geological Survey, Open-File Report 2007-1353, 225 pgs.

Overton, J. M. C., Stephens, R.T.T., Leathwick, J.R., Lehmann, A. 2002. Information pyramids for informed biodiversity conservation. Biodiversity and Conservation 11: 2093-2116

Patla, S.M. 1997. Nesting Ecology and Habitat of the Northern Goshawk in Undisturbed and Timber Harvest Areas on the Targhee National Forest, Greater Yellowstone Ecosystem. Ph.D. Dissertation, Idaho State University, Idaho Falls.

Petry, S. and S. Palechek. 2010. Oldman River – State of the Watershed Report. Oldman Watershed Council. Lethbridge, Alberta

Pike, R.G, M.C. Feller, J.D Stednick, K.J. Rieberger, and M. Carver. 2009. Chapter 14: Water Quality and Forest Management. In Compendium of Forest Hydrology and Geomorphology in British Columbia R.G. Pike et al. [Eds.]. B.C. Ministry of Forests and Range, Research Branch, Victoria, B.C. and FORREX Forest Research Extension Partnership, Kamloops, B.C. Land Management Handbook (TBD).

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R. E Sparks, and J.C. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. BioScience 47: 769–784.

Poff N.L., and J.K.H. Zimmerman. 2010. Ecological responses to altered flow regimes: a literature review to inform the science and management of environmental flows. Freshwater Biology 55: 194–205.

Pomeroy, J., X. Fang, and C. Ellis, 2012. Sensitivity of snowmelt hydrology in Marmot Creek, Alberta, to forest cover disturbance. Hydrological Processes, 26: 1892-905

Proctor, M.F., D. Paetkau, B.N. McLellen, G.B. Stenhouse, K.C. Kendall, Richard D. Mace, W.F. Kasworm, C. Servheen, Cori L. Gibeau, W.L. Wakkinen, M.A. Haroldson, G. Mowat. C.D. Apps, L.M. Ciarniello, R.M.R. Barclay, M.S. Boyce, C.C. Schwartz, and C. Strobeck. 2012. Population fragmentation and inter-ecosystem movements of grizzly bears in Western Canada and the Northern United States. Wildlife Monographs 180: 1-46.

Richter, B.D., J.V. Baumgartner, J. Powell, and D.P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. Conservation Biology 10: 1163-1174.

Richter, B.D., M.M. Davis, C. Apse, and C. Konrad. 2011. A presumptive standard for environmental flow protection. River Research and Applications, DOI: 10.1002/rra.1511

Rieman, B., and J. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society 124:285-296.

Rieman, B. E., and J. D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. U.S. Forest Service, Intermountain Research Station General Technical Report INT-302, Ogden, Utah, USA.

Ripley, T., G. Scrimgeour, M.S. Boyce. 2005. Bull trout (*Salvelinus confluentus*) occurrence and abundance influenced by cumulative industrial development in a Canadian boreal forest watershed. Canadian Journal of Fisheries and Aquatic Sciences 62: 2431-2442.

Roberge, J-M., and P. Angelstam. 2004. Usefulness of the umbrella species concept as a conservation tool. Conservation Biology 18: 76-85.

Scott, M.C., G.S. Helfman, M.E. McTammany, E.F. Benfield, and P.V. Bolstald. 2002. Multiscale influences on physical and chemical stream conditions across Blue Ridge landscape. Journal of the American Water Resources Association 38: 1379-1392.

Sikina, C. and N. Ambrose. 2012. Riparian health data summary Oldman River Basin Headwaters Region 1998-2012. Alberta Riparian Habitat Management Society (Cows and Fish). Lethbridge, Alberta. Prepared for Oldman Watershed Council.

Silins, U. M. Stone, M.B. Emelko, and K.D. Bladon. 2009. Sediment production following severe wildfire and post-fire salvage logging in the Rocky Mountain headwaters of the Oldman River Basin, Alberta, Catena 79: 189–197.

Sly, P.G. and D.O. Evans. 1996. Suitability of habitat for spawning lake trout. Journal of Aquatic Ecosystem Health 5: 153–175.

Spellerberg, I. 2002. Ecological effects of roads and traffic: a literature review. Global Ecology and Biogeography 7:317:333.

Squires, J.R. and R.T. Reynolds. 1997. Northern Goshawk (*Accipiter gentilis*). *In*: A. Poole and F. Gill (Eds.). The Birds of North America, No. 298. The Birds of North America, Inc., Philadelphia, PA.

Strahler, A. N. 1964. Quantitative geomorphology of drainage basins and channel networks *in* Handbook of Applied Hydrology, V.T. Chow [Ed.]. McGraw Hill, New York. Pp 4-39 - 4-76.

Tate, K.W. 2012. Management option to reduce pollutants in runoff from irrigated pastures. Report available at: http://rangelandwatersheds.ucdavis.edu/main/projects/irrigated_pasture_mgmt.htm [May 2013].

Tigner, D.J. 2012. Measuring wildlife response to seismic lines to inform land use planning decisions in northwest Canada. MSc. Thesis, University of Alberta. Edmonton, Alberta.

Trombulak, S.C. and C.A. Frissell. 2000. Review of ecological effects on roads on terrestrial and aquatic communities. Conservation Biology 14: 18-30.

USDA (United States Department of Agriculture). 2011.Watershed Condition Framework. United States Department of Agriculture.

USFW (United States Fish and Wildlife Service). 1998. Bull Trout Interim Conservation Guidance. Lacey, Washington: United States Fish and Wildlife Service.

Wasserman, T. N., S.A. Cushman, D.O., Wallin, and J. Hayden. 2012. Multi scale habitat relationships of *Martes americana* in northern Idaho, U.S.A. Res. Pap. RMRS-RP-94. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 21 pgs.

Webb, R.H. 1982. Off-road motorcycle effects on a desert soil: Environmental Conservation 9: 197–208.

Weigel B.M., and D.M. Robertson. 2007. Identifying biotic integrity and water chemistry relations in nonwadeable rivers of Wisconsin: toward the development of nutrient criteria. Environmental Management 40:691–708

Weijters, M.J. J.H. Janse, R. Alkamade, and J.T.A. Verhoeven. 2009. Quantifying the effect of catchment land use and water nutrient concentrations on freshwater river and stream biodiversity. Aquatic conservation: Marine and Freshwater Ecosystems 19: 104-112.

Williams, J.E, C.A. Wood, and M.P. Dombeck. 1997. Chapter 1: Understanding Watershed-Scale Restoration *In*: Watershed restoration: principles and practices, Williams, J.E, C.A. Wood, and M.P. Dombeck [Eds.]. American Fisheries Society, Bethesda, MD.

Yip, Q.K.Y., D.H. Burn, F. Seglenieks, A. Pietroniro, and E.D. Souliset. 2012. Climate impacts on hydrological variables in the Mackenzie River Basin. Canadian Water Resources Journal 37: 209-230.

Appendix A - Preliminary Criteria and Indicator List

Table A-1. Aspirational list of pressure and condition indicators selected to assess the current state of the Headwaters Region in the Oldman Watershed for Criteria 1. The list was adapted from the Indicator Guide for Watersheds in Southern Alberta (AENV 2008b) and USDA Watershed Condition Framework (USDA 2011).

Name of Indicator	Indicator Type	Potential Measures	Data	Potential Threshold Source
CRITERIA 1. Landscape Composition and Condition				
Intact Landscapes	Condition	% Area of Watersheds with Intact Landscapes (no human disturbance)	AVI/GVI/ABMI footprint data, Alberta Base Feature Data, Wildfire Data	Landscape Fragmentation Theory/Threatened Species Responses
Human Population Density and Growth	Pressure (Trend)	Watershed Human Population Density and Growth Rate (% change over time)	Canada Censure Data (2001, 2006, 2011)	TBA
Urban and Industrial Human Land Use	Pressure	% Area of Watersheds with Forestry, Agriculture, and Oil and Gas Development	AVI/GVI/ABMI footprint data, Alberta Base Feature Data	Threatened Species Responses to Landuse
Land Conversion from Natural Habitat	Pressure (Trend)	% Change in Human Land-use Over Time (i.e. % change in forestry activity between 1971 and 2011)	Landsat remote sensing imagery (available from ≈ 1970 – present)	TBA, Biodiversity Research Studies
Changes in Climate Regime (Past to Current)	Pressure (Trend)	Long-term Trends in Precipitation, Temperature, # of Growing Degree Days (GDD), Timing and Length of Growing Season	Environment Canada - National Climate Data and Information Archive	Range of natural variability paradigm (Poff et al. 1997)

Table A-2. Aspirational list of pressure and condition indicators selected to assess the current state of the Headwaters Region in the Oldman Watershed for Criteria 2. This list was adapted from the Indicator Guide for Watersheds in Southern Alberta (AENV 2008b) and USDA Watershed Condition Framework (USDA 2011).

Name of Indicator	Indicator Type	Specific Measures	Data	Potential Threshold Source
CRITERION 2. Biological Diversity				
Road Density	Pressure	Road Density (km/km^2)	Alberta Base Feature Data	Threatened Species Responses (i.e. Established Grizzly Bear/Bull Trout thresholds)
Density of All Linear Features	Pressure	Linear Feature Density (km/km^2)	Alberta Base Feature Data	Threatened Species Responses (i.e. Established Grizzly Bear thresholds)
Stream Connectivity	Pressure	Watershed Culvert Density (no/km^2), Culvert Stream Fragmentation Metrics	Alberta Base Feature Data	Fish/Aquatic Invertebrate Landuse Research Studies
Fish Community	Condition	Community Composition Indicators (IBI's), Indicator Species RSF (i.e. Bull trout, Cutthroat trout)	Standardized, regional dataset of fish sampling and research studies	Modification of existing IBIs or RSF models
Amphibian Community	Condition	Community Composition Indicators, Species Abundance/ RSF models	Standardized, regional dataset of amphibian sampling and research studies	Modification of existing IBIs
Macroinvertebrate Community	Condition	Community Composition (Abundance of Indicator Taxa): i. Ephemeroptera, Plecoptera, & Trichoptera (EPT), ii. Oligochaetes, Molluscs, Chironomids	Standardized, regional dataset of macro-invertebrate monitoring, and research studies (EEM, AENV – LTNR, University studies)	Modification of existing IBIs
Rate of Wetland Loss	Condition	Historical Time Series Analysis of Wetland Loss (i.e. % wetland area loss between 1971 and 2011)	Landsat remote sensing imagery (available from ≈ 1970 – present)	Wetland Research Studies
Riparian Condition	Condition	Condition Measures of Wetland and Riparian Health – i. *ARHMS Index (Cows & Fish)* ii. Wetland Physical Condition Indicators (hydrological connectivity, emergent zone slope and distance)	ARHMS surveys, high resolution modeling of wetland condition (modeling of LiDAR imagery)	Existing ARHMS methodology, Wetland Research Studies
Rangeland Health	Condition	Range Health Condition Measures i. Alberta Rangeland Health	Alberta Rangeland Health Database	Existing Alberta methodology, TBA

Table A-3. Aspirational list of pressure and condition indicators selected to assess the current state of the Headwaters Region in the Oldman Watershed for Criteria 3. The list was adapted from the Indicator Guide for Watersheds in Southern Alberta (AENV 2008b) and USDA Watershed Condition Framework (USDA 2011).

Name of Indicator	Indicator Type	Specific Measures	Data	Potential Threshold Source
CRITERION 3. Surface Water Quality				
Sedimentation/Erosion Potential	Pressure	i. Regional Model of Soil Erosion ii. Area with High Erosion/Sedimentation Risk	i. Headwater model needs to be created i. Alberta Base Feature Data, DEM, Wet Areas Mapping	i. TBA ii. TBA
Stream Crossing Density	Pressure	Density of Stream/Wetland Crossing Density	Alberta Base Feature Data, Wet Areas Mapping	Forestry Guidelines (BCME), Threaten Species Responses
Surface Water Quality	Condition	Water Quality Measures, including: i. Nutrients (Nitrogen, Phosphorous) ii. Trace Metals (i.e. Mercury, Aluminum, Iron, Vanadium) iii. Base Chemistry (Dissolved Oxygen. Total suspend solids, (TSS)) iv. Major Elements (Sulfate, Chlorine, Sodium) v. Organics (Pesticides, Organochlorine Pesticides)	Alberta Environment LTRN Stations, EEM Monitoring, Parks Canada, Individual Research Studies	CCME/EPA guidelines
Point Source Contamination	Pressure	Effluent Discharges (Municipal and Industrial)	Effluent discharge reports (to Alberta Environment under the Water Act)	CCME/EPA guidelines, Contaminant regulations
Non-point Source Contamination	Pressure	Chemical Application (Fertilizer, Pesticides, Manure),	2011 Census, Fertilizer Sales Statistics, Contained Feedlot Density	TBA
Sediment Quality	Condition	Sediment Quality Measures, including: i. Trace Metals (Selenium, Mercury, Lead) ii. Organic Compounds (Pesticides, Organochlorine Pesticides)	Alberta Environment LTRN Stations, EEM Monitoring, Parks Canada, Individual Research Studies	CCME/EPA guidelines

Table A-4. Aspirational list of pressure and condition indicators selected to assess the current state of the Headwaters Region in the Oldman Watershed for Criteria 4. The list was adapted from the Indicator Guide for Watersheds in Southern Alberta (AENV 2008b) and USDA Watershed Condition Framework (USDA 2011).

Name of Indicator	Indicator Type	Specific Measures	Data	Potential Threshold Source
CRITERION 4. Water Levels & Flows				
Stream Flow Regime	Condition	Magnitude i. Total annual flow ii. Total spring (melt), summer flow iii. Peak annual flow rate (/day) Timing i. Initiation of melt ii. 1st and 2nd peak Frequency i. No. of low and high pulses Duration i. Mean duration of low and high pulses Rate of Change **i.** Means of all positive/negative changes between consecutive daily values	Water Survey of Canada	Range of natural variability paradigm (Poff et al. 1997)
Lake or reservoir water level	Condition	Lake Level at Spring Peak (depth (m)) Lake Level at Fall Low (depth (m))	Water Survey of Canada	Range of natural variability paradigm (Poff et al. 1997)
Lake or reservoir open water area	Condition	Lake Area at Spring Peak (depth (m)) Lake Area at Fall Low (depth (m))	Remote sensing analysis of Landsat imagery	Range of natural variability paradigm (Poff et al. 1997)
Water availability (climatic input)	Condition	Effective Precipitation (P-PET) Snow Pack Depth at Initiation of Melt	Environment Canada - National Climate Data and Information Archive	Range of natural variability paradigm (Poff et al. 1997)
Potential surface water use	Pressure	Rate and Timing of Water Extraction	OWC	Range of natural variability paradigm (Poff et al. 1997)

Appendix B - Detailed Indicator Assessment Methods

Derivation of Fourth (4th) Order Watersheds

Data Sources:

1) Alberta Base Features - Simplified Linear Stream Network (SLN)
2) Alberta Base Features - Simplified Hydropolygons Grouping
3) Alberta Base Features - Strahler Stream Order
4) Alberta Base Features Derived – 1st Strahler Order Watershed Boundaries for the Oldman Watershed (bfd_pfwtrr0) produced by Alberta Environment and Sustainable Resource Development (AESRD)
5) Digital Elevation Model (DEM) for the Oldman Watershed

Modeling steps:

1. The Strahler Stream Order was joined to all streams in Simplified Linear Stream Network spatial layer to determine the stream Strahler Order
2. All contributing watersheds associated with lower order streams that flow into 4th or high order streams were grouped together to define a 4th Order Watershed. This was accomplished by dissolving all lower order streams (orders 1,2, and 3) from the SLN spatial layer and all connecting hydropolygon features (lakes, wetlands) into the higher orders streams (4th Order or higher). Multiple dissolve calculations were conducted because in many instances small streams (i.e. 2nd order) flow directly into 5th or 6th order rivers (the major rivers in the Headwaters where:
    a. Stream orders 1 - 3 and all connected hydropolygon features were dissolved in all connected 4th Order streams
    b. Stream orders 1 - 3 and all connected hydropolygon features were dissolved in all connected 5th Order streams
    c. Stream orders 1 - 3 and all connected hydropolygon features were dissolved in all connected 6th Order streams
    d. Stream orders 1 - 3 and all connected hydropolygon features were dissolved in all connected 7th Order streams
    e. A unique identifier was assigned to all stream segments dissolved into 4th or higher order watershed branches, and this information was added to the 1st Strahler Order Watershed Boundaries layer using spatial joining techniques. This process identified all the corresponding 1st Order watersheds which comprised the larger 4th Order Watershed.
3. This GIS stream analysis approach captured and assigned a 4th Order or higher watershed grouping to approximately 95% of the 1st Order Watersheds in the Headwaters Region. The remaining 5% of watersheds did not contain streams, and are upslope terrestrial areas containing small lakes and wetlands. Based on elevation (using a DEM), all upslope (higher elevation areas) were joined to nearest downslope adjacent 4th order watershed. The final 4th order watershed map, and the associated stream order is displayed in Figure B-1

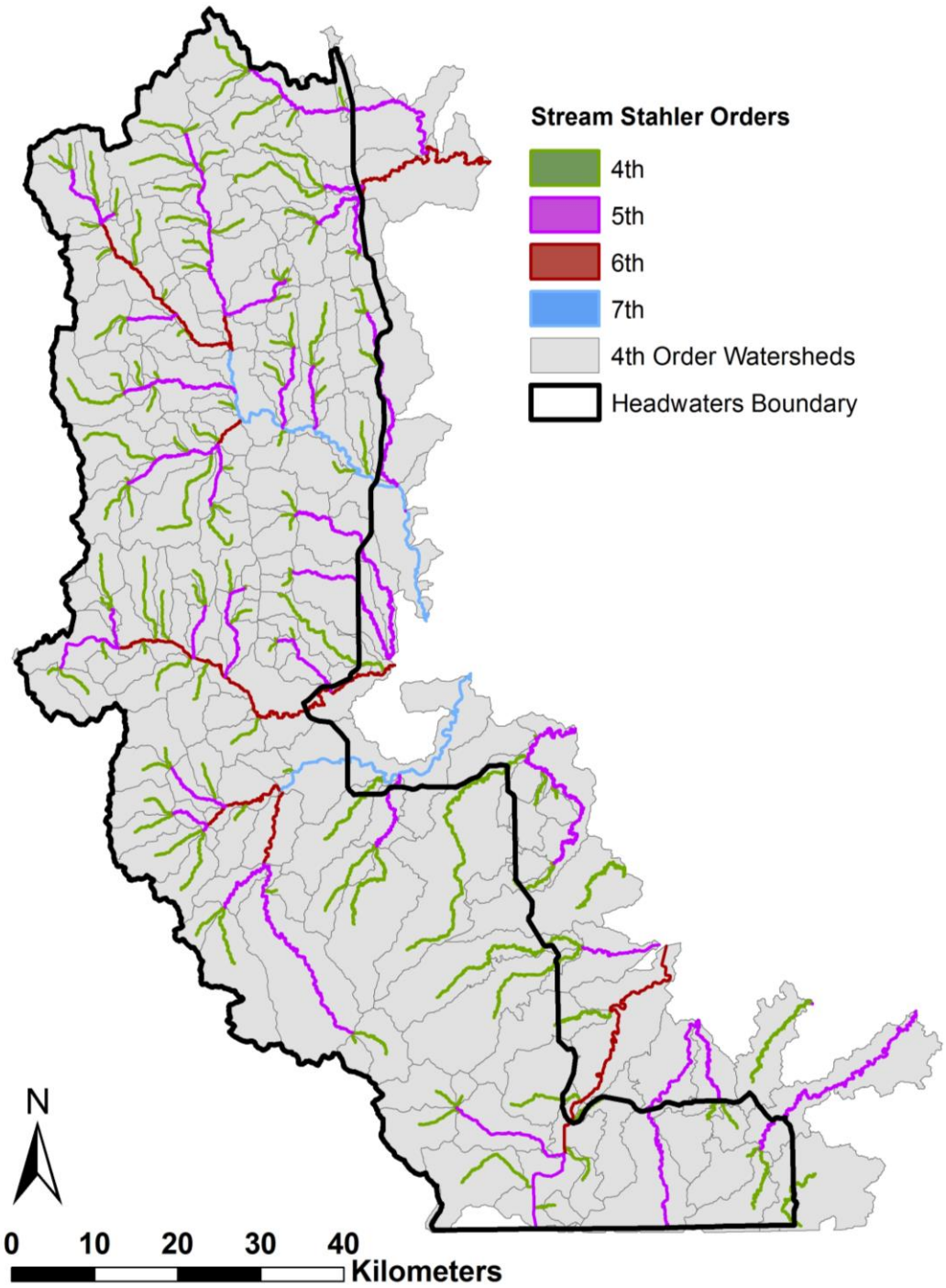

Figure B-1. Final 4th order watershed boundaries for the Headwaters and associated major streams (those 4th to 7th order).

CRITERION 1: Landscape Composition and Condition

Intact Landscapes

Data Sources:

1) Alberta base features layer for roads (ab.base.SDE.roads)
2) Alberta base features layer for pipelines (ab.base.SDE.pipelines)
3) Alberta base features layer for powerlines (ab.base.SDE.powerlines)
4) Alberta base features layer for raillines (ab.base.SDE.raillines)
5) Alberta base features layer for cutlines (ab.base.SDE.cutlines)
6) SRA_Cutlines_South_93.gdb (Inventory of ORV trails)
7) SRA_Cutlines_North_93.gdb (Inventory of ORV trails)
8) Unmapped Linear Features in the Headwaters Region (spatial layer created by Fiera Biological – see Item #1 below)
9) Crown Alberta Vegetation Inventory (AVI) and Crown Cutblocks (current to 2011)
10) Grassland Vegetation Inventory (GVI)
11) 2007 – 2010 Alberta Biodiversity Monitoring Institute (ABMI) Human Footprint Layer (developed by ABMI)

Indicator Modeling:

1. The existing Alberta Base Features for linear features do a good job of capturing larger linear features (roads, pipelines, powerlines), but are missing many smaller linear features (and more recent linear features). These include quad trails, some cutlines, and in particular, in-block logging roads. The Forestry Division does not require logging trails/roads which occur on harvest blocks to be tracked in the central provincial database. This is a concern in the Headwaters Region because many of these in-block logging trails are later converted to quad trails, and remain a persistent disturbance on the landscape. In addition, those trails which are considered reclaimed under AESRD standards can still be sources of sediment and can interrupt ground water flow and wildlife movements long after they are reclaimed.

2. Given this concern, as part of the Headwaters Indicators project, Fiera Biological mapped all visible unmapped linear features based on 2012 imagery. The steps were:
    a. The major imagery source was 2.5 m resolution Spot Imagery from Blackbridge from 2012. However, in some regions of the Headwaters the imagery resolution was lower, and this was supplemented by Bing Imagery (freely available with an ArcGIS license), which had a superior resolution to the 2.5 m Spot in some regions of the Headwaters. Because photo age in the Bing imagery was variable, all mapped features had to be visible on the 2012 2.5m Spot. However, where the Bing was superior, it was used to map linear features.
    b. In conducting the mapping, a grid with 1-kilometer cells was overlaid on the Headwaters Region, and searched systemically for unmapped linear features. Greater search effort was placed in areas with existing linear features, and industrial activity (oil and gas, and forestry).

c. The final spatial layer of new linear features in the Headwaters Region was edge-tied to the existing Alberta Base Features for Roads, Pipelines, Powerlines, and Cutlines following AESRD standards.

d. All new linear features were assigned a feature type of cutline (Alberta Base Feature field FEATURE_TY = CUTLINE-TRAIL) because of the unknown history of these features. This is the smallest type of mapped linear feature. The spatial layer of unmapped linear features created by Fiera Biological is the best available product given the limitation of the imagery and the air-photo interpretation process. There is an inherent uncertainty in the process, and the interpreter required a reasonably high certainty of linear feature presence before any features were mapped. Unmapped linear features which connected to currently mapped linear features were more likely to be interpreted because they were easier to detect. Possible linear features with a high uncertainty as to their actual presence, particular in high elevation areas, were not mapped.

3. All linear feature spatial layers (i.e. roads, power lines, rail lines, pipelines, seismic lines, cutlines, and including the new linear layer) were converted into polygon areas by buffering each line type by the average feature type widths specified by the Alberta Biodiversity Monitoring Institute (ABMI 2012).

   a. In order to account for edge effects and indirect habitat loss, seismic lines, cutlines, pipelines, powerlines and ORV trails were buffered by an additional 10 m, while all roads were buffered by an additional 25 m (Esseen and Renhorn 2008, Muria 1995).

4. All forest harvesting which has occurred in the last 30 years (between 1983 – and 2011; Figure B-2a) was classified as a human disturbance based on AVI and forest harvest data. This value was derived from the scientific literature examining successional patterns observed in young post-fire and post-logged forest stands. For both forest songbirds and understory plant species, a convergence in species abundance and composition is observed between post-burned and post-logged stands at approximately 30 years since disturbance (Hart and Chen 2008, Hobson and Schieck 1999, Kurulok and Macdonald 2007). These species groups respond in large part to the redevelopment of the overstory canopy cover which creates similar light condition under both disturbance histories. However, it must be recognized that post-fire and post log stands exhibit strong structural differences, in terms of features characteristic of old forests (including snag density, density of large veteran overstory tree, and downed woody material; Lee and Crites 2006). All of these features are significantly reduced in post-logged forest compared with post-fire forests. These structural features offer important habitat for cavity nesting wildlife species, and act as nutrient sources to old growth forests. Post-logged stands therefore require a much longer succession period to regenerate in these capacities (Lee and Crites 2006).

   a. Finally all forest harvests were buffered 25 meters to account for edge effects (Muria 1995).

5. The spatial footprints of extraction industry, heavy industry, urban, rural and agricultural areas were derived primarily from the ABMI human footprint layer, where:
    a. Extraction industry was classed as oil and gas well sites, mining sites, gravel pits, burrow-pits/sumps, and other disturbed vegetation (Figure B-2b).
    b. Heavy industry was considered rural industrial sites (i.e. fertilizer factories and agricultural processing facilities), high-density livestock operations, oil and energy processing facilities, and energy generating facilities (including well generation facilities; (Figure B-2b).
    c. Urban areas were considered high-density population areas including towns and hamlets, while rural sites were rural farmyards and homesteads (Figure B-2a).
    d. For agricultural landuse, the areas primarily represented lands with cultivated crops, hay, and other extensive evidence of human modification (i.e. tilling). Only extensively impacted agricultural lands are included in the ABMI layer because it can be difficult to distinguish pasture from natural grasslands in aerial photos. Pasture with intensive land use (i.e. high cattle density of 250 – 400 animals/km^2) should be considered a human disturbance because of the potential for negative impacts on water quality (OMOE 2009, Tate 2012); however there is no existing spatial inventory for pasture land which incorporates the intensity of use and/or management practices. Low-impact pasture systems were not considered a human disturbance here, and hence all pasture was excluded given the inability of existing spatial data to differentiate different pasture management systems and practices.

    The only available information for pasture is an assessment of overall rangeland health for grazing dispositions within the Oldman Watershed (Figure B-3). These health ratings were determined by field assessments conducted by agrologists using health assessment guidelines for tame pasture (Adams et al. 2009). Similar to the Cow and Fish riparian assessment methods, a ranking of Healthy, Healthy with Problems, and Unhealthy are assigned to individual grazing dispositions. This information is provided to demonstrate the existing health rankings of grazing leases in the Oldman Headwaters. However, this information has **not** been included in the calculation of the Intact Landscapes indicator.

6. A small amount of human disturbance is missing from the ABMI human footprint layer. This information was extracted from the GVI Site View spatial layer using the same classification (light industry, heavy industry, urban, rural and agricultural). Only polygons missing from the ABMI layer, but present in the GVI Site View were classified and extracted from the GVI.

7. All human footprint types derived in Steps 3 – 5 (forestry, light industry, agriculture), except urban and heavy industrial development were buffered by 25 meters (Esseen and Renhorn 2008, Muria 1995). Urban and heavy industrial development was buffered by a larger area (100 meters) due to their potential for greater edge effects and habitat loss (McGarigal et al. 2001).

8. Each of the human disturbance layers created in Steps 2 through 6 were UNIONED together to create a single Human Footprint layer.

9. All polygons in the Human Footprint layer were subtracted (deleted) from the Headwaters boundary layer to create an “intact vegetation” layer.

10. The intent of this indicator is to identify large contiguous patches of intact habitat suitable to a variety of wildlife species; therefore, intact landscapes were considered to be areas ≥500 hectares (Scott et al. 2002; Findlay and Houlahan 1997; Mensing et al. 1998). This landscape patch size is appropriate for many avian species and meso-carnivores, including northern goshawk (Squires and Reynolds 1997), barred owl (Mazur et al. 1998), and American marten (Buskirk and McDonald 1989). However, this is smaller than that recommend for grizzly bears (1000 ha; Holroyd 2008) and bull trout (2500 ha; Rieman and McIntyre 1995). This indicator only considered landscape patch size. No measure of patch connectivity was included in identifying intact landscapes.

11. Finally, all polygons smaller than the above size criteria were deleted from the Intact Vegetation layer to create a layer depicting Intact Landscape in the Headwaters Region >500 ha.

12. The total area of intact vegetation was summarized by each 4th Order Watershed, and was expressed as a percentage of the total area of each watershed ranging from 0 – 100%.
13. This range was split into four rating categories, based on values from peer-reviewed scientific literature:

    a. In a review of studies on birds and mammals, Andren (1994) concluded that landscapes with <30% remaining suitable habitat area were more likely to experience greater species loses or population declines due to the synergetic effects of combined habitat fragmentation and habitat loss. In landscapes with >30%, species loses or population declines were primarily impacted due simple habitat loss, and experienced negligible additional effects due to the fragmentation and isolations of habitat areas.

    b. Studies of the impacts of land-use on wetland species richness has demonstrated that the species richness of both mammals and amphibians decline by 50% when approximately 50% of the surrounding forest cover has been removed (Findlay and Houlahan 1997). In addition, in a large-scale analysis across Western Canada, and the north-western United States, genetic research on grizzly bears demonstrated that highly settled areas (where >50% of the landscape has been converted urban, rural and agricultural land-use) leads to significant reductions in grizzly bear movement, and increases in population fragmentation (Proctor et al. 2012). Finally, American marten studies has shown the marten respond to small amounts of forest fragmentation and rarely use sites where more than 25% of forest cover has been removed (Hargis et al. 1999, Chapin et al. 1998 and others 1999).

14. The following thresholds were used to differentiate between pressure rating categories for Intact Landscape based on scientific thresholds, where:

    Negligible Pressure was >75% aerial coverage of Intact Habitat
    Low Pressure was >50 to 75% aerial coverage of Intact Habitat
    Moderate Pressure was >30 – 50% aerial coverage of Intact Habitat
    High Pressure was <30% aerial coverage of Intact Habitat

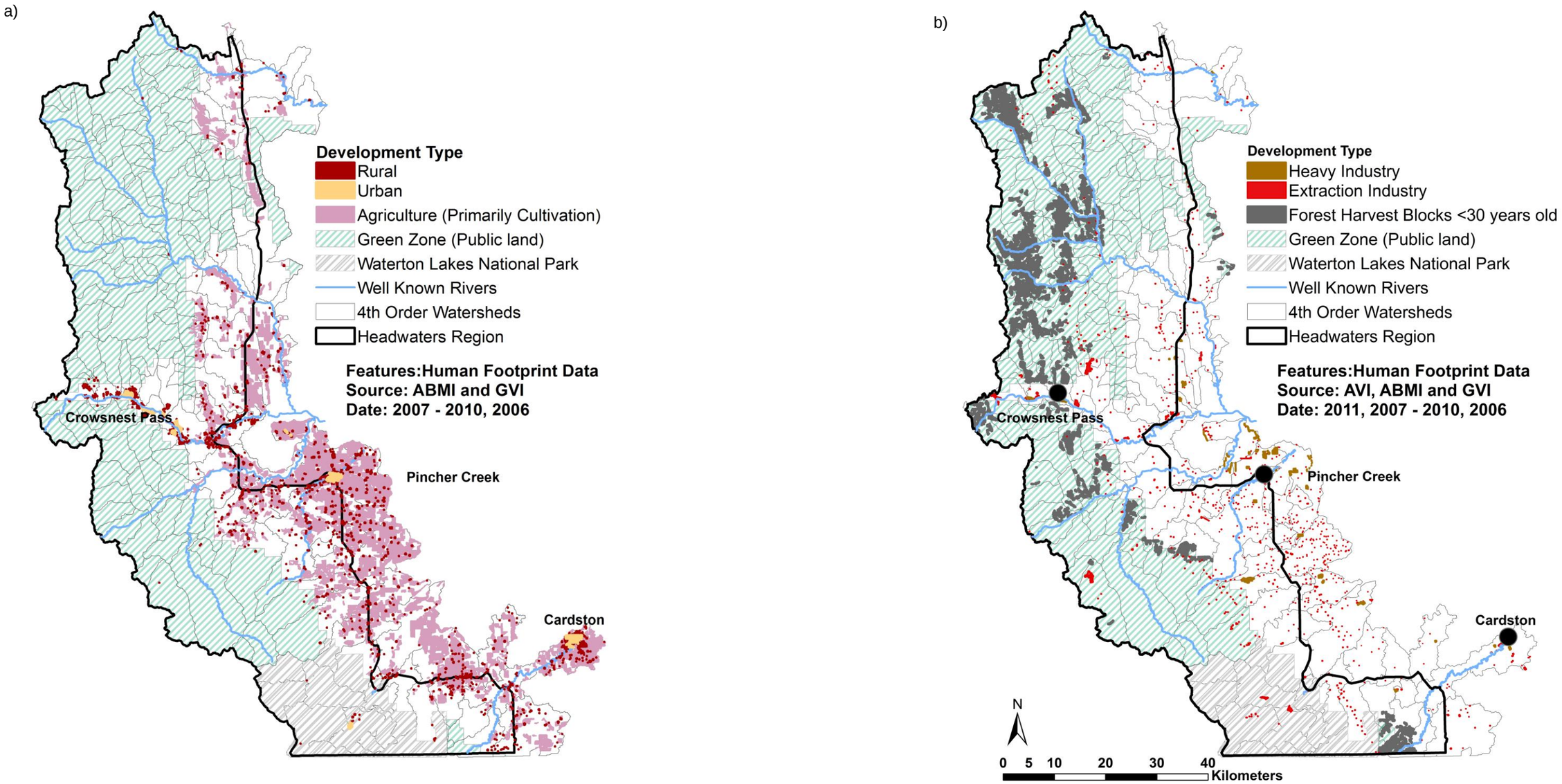

Figure B-2. Human footprint data used to generate the Intact Landscape Indicator. Only human footprint data for urban and rural development, agriculture, and industrial development are displayed here (the linear features data is displayed in Figure 5a and 6a). The data is derived primarily from the Alberta Biodiversity Monitoring Institute (ABMI) Human Footprint layer (created using imagery from 2007 – 2010), displaying (a) areas with agricultural land-use and urban and rural development, and (b) areas with industrial development including extraction industry (mining, gravel pits), heavy industry, and forest harvest activity. Public lands (Green Zone) are overlaid in green hatching, while private land comprises the remainder of the Headwaters Region.

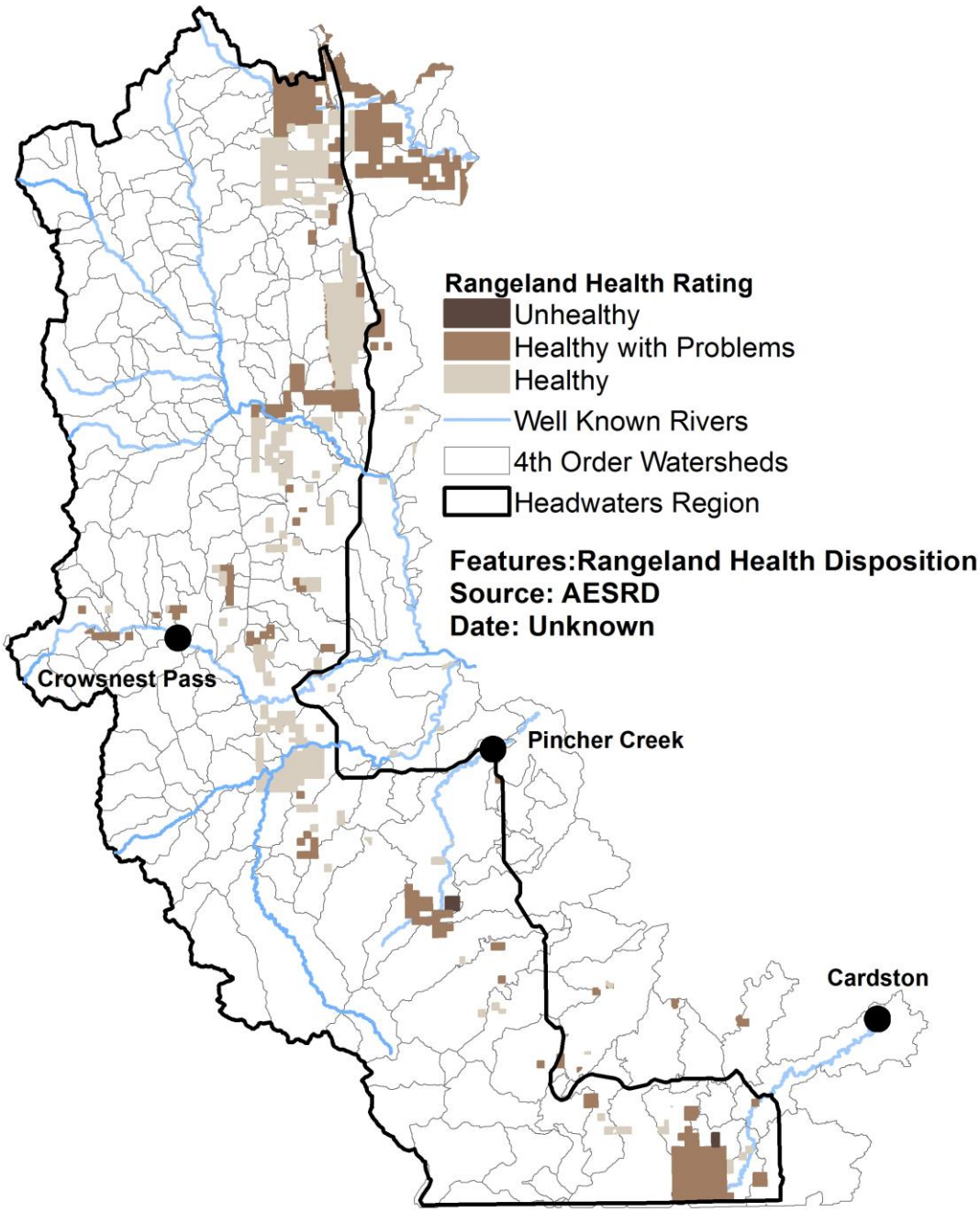

Figure B-3. Overall rangeland health ratings for grazing dispositions within the Oldman Watershed. Grazing leases are assigned a rank of Healthy, Healthy with Problems, or Unhealthy based on field assessments by field agrologists using assessment guidelines by Adams et al. (2009).

CRITERION 2: Biological Diversity

Road Density and Density of All Linear Features

Data Sources:

1) Alberta base features layer for roads (ab.base.SDE.roads)
2) Alberta base features layer for pipelines (ab.base.SDE.pipelines)
3) Alberta base features layer for powerlines (ab.base.SDE.powerlines)
4) Alberta base features layer for raillines (ab.base.SDE.raillines)
5) Alberta base features layer for cutlines (ab.base.SDE.cutlines)
6) SRA_Cutlines_South_93.gdb (Inventory of ORV trails)
7) SRA_Cutlines_North_93.gdb (Inventory of ORV trails)
8) Unmapped Linear Features in the Headwaters Region (spatial layer created by Fiera Biological – see Intact Landscape Indicator Item #1)

Indicator Modeling:

1. Using the Alberta base feature road layer, the total length of all roads (those feature navigable by trucks, defined as FEATURE_TY = Interchange-Ramp, Road-Gravel-1L, Road-Gravel-2L, Road-Paved-Div, Road-Paved-Undiv-1L, Road-Paved-Undiv-2L, Road-Paved-Undiv-4L, Road-Unclassified, Road-Unimproved) was calculated for each 4th Order Watershed.
2. Using all the data sources listed above, the total length of all linear features was calculated for each 4th Order Watershed.
3. Both road length and length of linear features were standardized into a density measure (km/km^2) by taking the total length of linear features in a watershed, and dividing that value by the area of the 4th Order Watershed.
4. The **Density of Roads** by 4th Order Watershed ranged from 0 to 1.7 km/km^2. Road densities as low as 0.1 km/km^2 have been shown to have negative impacts on Bull trout spawning (BCMWLAP 2002, Ripley et al. 2005), while elk and amphibian species richness all show reduced activity or richness at road densities of 0.5m/km^2 (Frair et al. 2008, Findlay and Houlahan 1997), and finally bull trout demonstrate depressed population at average road densities of 0.87 km/km2 (USFW 1998). Consequently, the following road density thresholds were used to differentiate Pressure Rating Categories:

   Negligible Pressure: ≤0.1 km/km^2
   Low Pressure: >0.1 to 0.5 km/km^2
   Moderate Pressure: >0.5 to 0.87 km/km^2
   High Pressure: >0.87 km/km^2
5. **Density of All Linear Features** ranged from 0 to 6.2 km/km^2. This range was split into three categories based on values from peer-reviewed scientific literature and government management guidelines. High quality grizzly bears habitat within Grizzly Bear Priority Areas must have a linear features density at or below 0.6 km/km^2, and linear features densities at or below 1.2 km/km^2 is recommended in all remaining grizzly bear range (Alberta Grizzly Bear Recovery Plan 2008). The

occupancy rate for American marten (*Martes americana*) in Alberta, and northern Idaho have been shown to decline to 50% at linear features density around 3 km/km^2 (Tigner 2012, Wasserman et al. 2012). The following thresholds were used to differentiate between Pressure Rating categories for the density of linear features:

Negligible Pressure: ≤0.6 km/km^2
Low Pressure: >0.6 to 1.2 km/km^2
Moderate Pressure: >1.2 to 3.0 km/km^2
High Pressure: >3.0 km/km^2

CRITERION 3: Surface Water Quality

Sedimentation/Erosion Potential Indicator

Data Sources:

1) Alberta base features layer for roads (ab.base.SDE.roads)
2) Alberta base features layer for pipelines (ab.base.SDE.pipelines)
3) Alberta base features layer for powerlines (ab.base.SDE.powerlines)
4) Alberta base features layer for raillines (ab.base.SDE.raillines)
5) Alberta base features layer for cutlines (ab.base.SDE.cutlines)
6) SRA_Cutlines_South_93.gdb (Inventory of ORV trails)
7) SRA_Cutlines_North_93.gdb (Inventory of ORV trails)
8) Unmapped Linear Features in the Headwaters Region (spatial layer created by Fiera Biological – see Intact Landscape Indicator Item #1)
9) 25-m Federal Digital Elevation Map (DEM)
10) Wet Area Mapping product (LiDAR derived)

Indicator Modeling:

1. Using all the linear features data sources listed above (1-8), the total length of all linear features was calculated for each 4th Order Watershed.
2. The 25m federal DEM was converted to a raster layer measuring percent slope using Spatial Analyst tools in ArcGIS, and then all areas with slope >40% were converted to a polygon features (SlopesGT40).
3. We used the Wet Areas Mapping (WAM) product to define all permanent and semi-permanent water bodies and their riparian zones in the Headwaters Regions. The Wet Areas mapping product (all areas which have a high probability of being wet) was converted to a polygon feature, and then buffered by 30 meter to estimate the riparian zone. In Alberta, 30 meters is recommended as a standard guide to riparian setbacks (Government of Alberta 2012).
4. The Wet Area Mapping product did not have complete coverage for all of the 178 - 4th order watersheds. As a result, all following analysis was restricted to 129 watersheds. There was complete coverage for 127 of the 4th order waters. An additional two large watersheds with incomplete coverage by WAM data (the two long sinuous watersheds which extended along the montane portions of the Oldman and the Crowsnest Rivers) were also included. This was done because WAM data existed for >75% of each watershed, and these are important watersheds to examine given the intensive human land-use along both. However, to account for the missing WAM data, each watershed was clipped at boundary of the Headwaters Region (along Hwy 22). The included portions of the watersheds had complete coverage by the WAM data.
5. The combined linear feature layer created in step 1 was intersected with the SlopeGT40 layer, and the buffered Wet Area Mapping layer to determine the length of linear features which occurred in habitats with a high erosion/sedimentation potential.
6. The length of linear features with a high Sedimentation/Erosion Potential was standardized into a density measure (km/km^2) by taking the total length of linear

features in a watershed, and dividing that value by the area of the 4th Order Watershed.

7. The density of linear features with high Sedimentation/Erosion Potential ranged from 0 to 2.8 km/km^2 (Figure 8a). There is little scientific literature focusing specifically on the impacts of linear features at high elevations, and in aquatic habitat. However, based on the assumption that the risks associated with linear features in these high elevation habitats are at least double that found with lower grades (Blanco and Lal 2008), the following pressure ratings were applied to the 4th Order watersheds. The thresholds derived above for the Density of All Linear Features was divided by two to determine Sedimentation/Erosion Potential thresholds, where:

   Negligible Pressure: ≤0.3 km/km^2
   Low Pressure: >0.3 to 0.6 km/km^2
   Moderate Pressure: >0.6 to 1.5 km/km^2
   High Pressure: >1.5 km/km^2

CRITERION 4: Water Levels and Flow

Stream Flow Regime

Data Sources:

1) Hydrological flow data was collected from 25 Water Survey of Canada hydrometric stations, most of which were located within or just outside of the Headwaters Region study boundary (Figure B-4).
2) Federal 25-meter resolution digital elevation model (DEM).

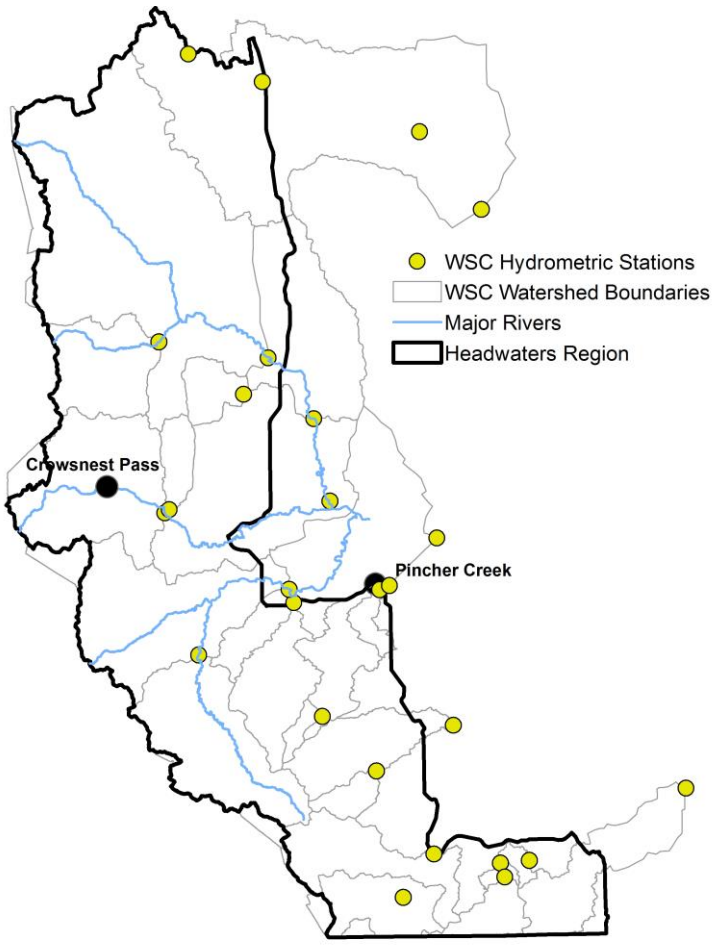

Figure B-4: Location of the Water Survey of Canada hydrometric stations that were considered in assessing water flow and water level in the Headwaters Region of the Oldman Watershed.

Indicator Analysis and Modeling:

1. In order to characterize the flow regimes within the Headwaters Region, all available hydrometric data (water flow and water level) compiled by the Water Survey of Canada (WSC) from stations active as of 2011 was obtained (see Table B-1 for station details).
2. The hydrologic fluctuations at these stations measure the cumulative hydrologic response to climatic forcing (precipitation and evaporation) across the land area that 'sheds' water to the hydrometric station. The boundaries of WSC watersheds used in this analysis were identified using the federal DEM, and a digital terrain analysis (Lindsay et al. 2004).
3. Digital terrain analysis was also used to identify the stream network from which we could identify the "scale" of the hydrological system based on the Strahler stream classification. Scale considers how much water flows past a given point, with considerably less water flowing per unit of time past locations in the "headwaters" than, for example, locations located along the Oldman River near Lethbridge. In the Strahler stream classification system, streams that contain a lower volume of water per unit time (e.g., the headwaters) would have a class of 1 (or 2), whereas the Oldman River at Lethbridge would be classified as class 8. On average within the Oldman Headwaters region, the WSC stations are measuring flow of mostly 5th order (Strahler) streams (Figure B-5). Most WSC stations are on higher order streams (order ≥5), with on one 3rd order stream with WSC station. This distribution limits our information and understanding of anthropogenic impacts on smaller headwater streams.
4. In order to derive indicators of flow, the annual hydrographs for all of the stations collecting data were analyzed. An example hydrograph is shown in Figure B-6). There were in excess of 800 annual hydrographs. Of the five main ways to describe the hydrograph, we chose the two most important indicators: 1) magnitude or how much water is available within the hydrological system, and 2) the timing of key events within the annual hydrologic cycle. A recent study analyzed stream water quantity and quality after the Lost Creek fire also focused on these two indicators and found significant changes between burned and unburned catchments (Silins et al. 2011).
5. In this study, magnitude was characterized by five measures: total annual flow; spring flow (April – May); summer flow (June – August); base flow (the lowest daily flow); and peak flow (the highest daily flow). Flow is measured as volume per unit of time (m^3/s). In order to allow for per unit area comparisons amongst watersheds of different sizes, the flow data was converted to a water depth (mm/day) using the area of the watershed. In order to characterize the timing of flow, we assessed the date of melt initiation, the first peak of the hydrograph as well as the second peak of the hydrograph). The date of melt initiation corresponded to the first day of significant increase in flow, doubling or tripling in flow within a few days; Figure B-6).

Table B-1: Descriptive information for the Water Survey of Canada hydrometric stations that were compiled initially to assess water flow and water level in the Headwaters Region of the Oldman Watershed. The final results shown in Section 5.4 above only included stations with at least 30 years of data between 1971 and 2010 (15 stations which are shaded in grey). Note: We included station 05AA023, which had over 30 years of data, but was closed at the end of 2008. Due to the low sample size we also added 05AA909 which had 28 years of data available. For stations where the flow regime is regulated we used a 'naturalized' (using the Project Depletion Method) weekly dataset obtained from Alberta Environment (all stations except 05AD010).

Station ID	Station Name	Strahler order	Area (km^2)	From	To	Regulated	Flow	Operation
05AA004	PINCHER CREEK AT PINCHER CREEK	4	157.5	1910	2010	NO	YES	Seasonal
05AA008	CROWSNEST RIVER AT FRANK	6	402.7	1911	2011	NO	YES	Continuous
05AA011	MILL CREEK NEAR THE MOUTH	5	179	1911	2010	NO	YES	Seasonal
05AA022	CASTLE RIVER NEAR BEAVER MINES	7	820.7	1945	2011	NO	YES	Continuous
05AA023	OLDMAN RIVER NEAR WALDRON'S CORNER	7	1446	1949	2008	NO	YES	Continuous
05AA024	OLDMAN RIVER NEAR BROCKET	8	4401.1	1966	2011	YES	YES	Continuous
05AA027	RACEHORSE CREEK NEAR THE MOUTH	5	217.6	1967	2010	NO	YES	Seasonal
05AA028	CASTLE RIVER AT RANGER STATION	6	375.3	1967	2010	NO	YES	Seasonal
05AA030	GOLD CREEK NEAR FRANK	5	63.3	1976	2011	NO	YES	Seasonal
05AA032	OLDMAN RESERVOIR NEAR PINCHER CREEK	7	4375.3	1992	2011	YES	LEVEL	Continuous
05AA033	KETTLES CREEK AT PINCHER CREEK	3	38.4	2005	2010	NO	YES	Seasonal
05AA034	PINCHER CREEK AT FRONT RANGE ROAD	4	24	2005	2011	NO	YES	Seasonal
05AA035	OLDMAN RIVER AT RANGE ROAD 13A	7	1834.1	2009	2010	NO	YES	Continuous
05AA909	TODD CREEK NEAR HIGHWAY NO.22	5	74	1983	2011	NO	YES	Seasonal
05AB021	WILLOW CREEK NEAR CLARESHOLM	6	1180.6	1908	2011	YES	FLOW	Continuous
05AB037	CHAIN LAKES RESERVOIR NEAR NANTON	5	213.4	1979	2011	YES	LEVEL	Continuous
05AB040	WILLOW CREEK AT SECONDARY 532	5	65.3	1996	2010	NO	YES	Seasonal
05AB041	WILLOW CREEK AT OXLY RANCH	6	832.9	1997	2010	YES	YES	Seasonal
05AD003	WATERTON RIVER NEAR WATERTON PARK	6	612.7	1908	2011	NO	YES	Continuous
05AD005	BELLY RIVER NEAR MOUNTAIN VIEW	5	319.2	1912	2011	YES	YES	Continuous
05AD010	DRYWOOD CREEK NEAR THE MOUTH	5	238.6	1920	2010	YES	YES	Continuous
05AD025	WATERTON LAKE AT WATERTON PARK	5	403.3	1959	2011	NO	LEVEL	Continuous
05AD042	YARROW CREEK AT SPREAD EAGLE ROAD	4	47.9	2005	2010	NO	YES	Seasonal
05AD940	PAYNE LAKE RESERVOIR NEAR MOUNTAIN VIEW	3	18.7	2002	2010	YES	LEVEL	Seasonal
05AE002	LEE CREEK AT CARDSTON	5	312.3	1909	2011	YES	YES	Continuous

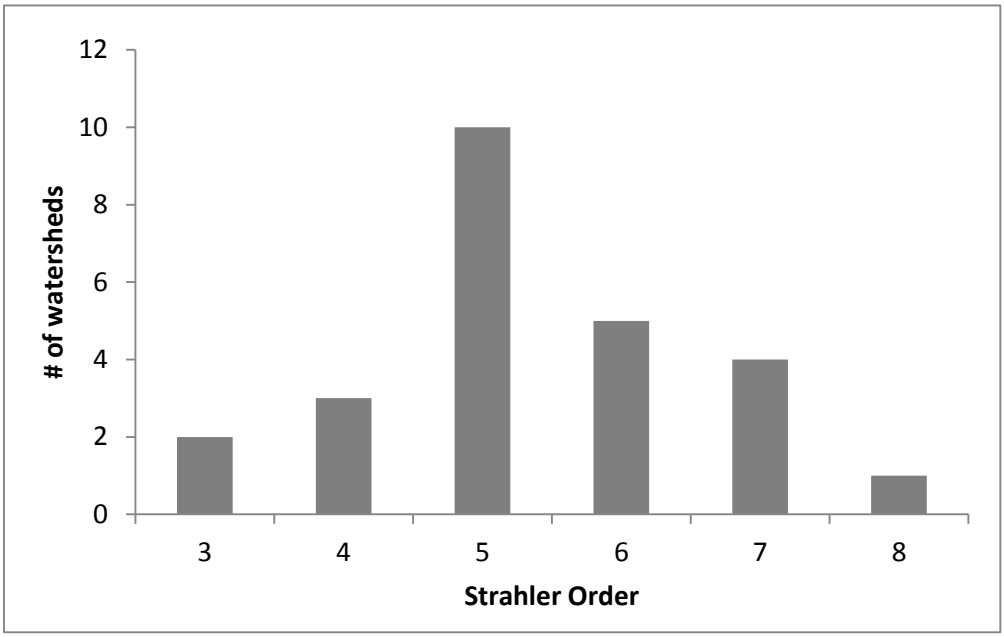

Figure B-5: Strahler order distribution of streams being monitored by the 25 WSC in or near the Headwaters of the Oldman Watershed.

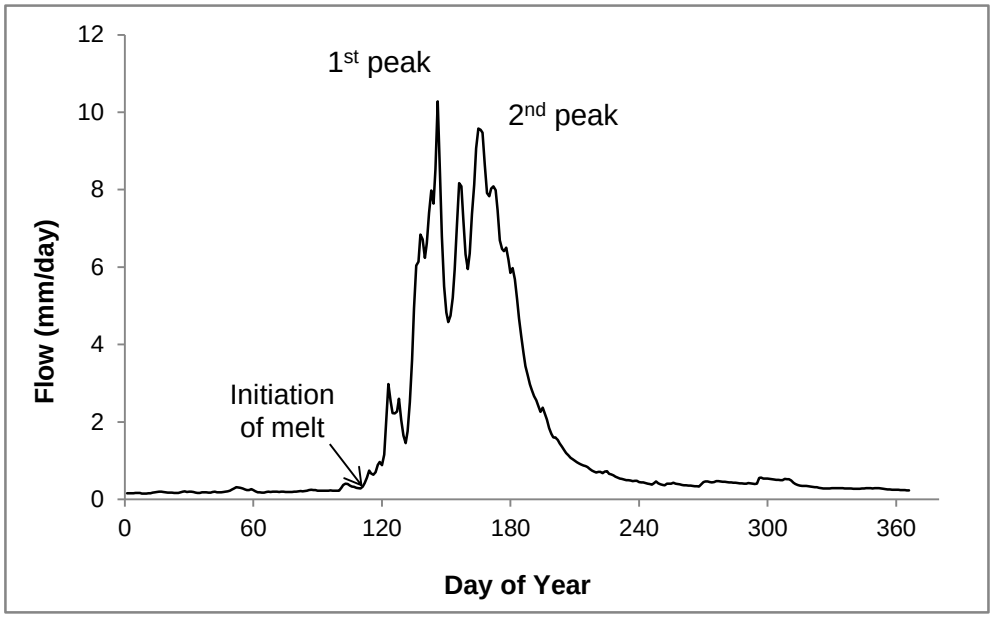

Figure B-6: Example of annual hydrograph from WSC stations. Initiation of melt, and timing of the flow peaks are measures used to assess the flow regime timing.

6. Once these measures were automatically computed or visually assessed, they were analyzed for temporal trends (Figure B-7). The appropriate statistical test for time-series data is the Mann-Kendall test (Helsel and Hirsch 1992). Kendall's tau (τ) uses a rank-based procedure to determine the correlation between two variables. The test was run twice for all WSC stations with a minimum of 30 years of data. A significance value of $p<0.05$ was used to identify highly significant correlations, meaning that there is a 5% or smaller probability that the observed results occurred by chance only. We also identified moderate significance correlations at $p<0.10$ (Table B-2).
7. The flow results shown above in Section 5.4 used all the data available for a given WSC station (as per Table B2) with the caveat that the stations had at least 30 years of data within the 1971-2010 window.

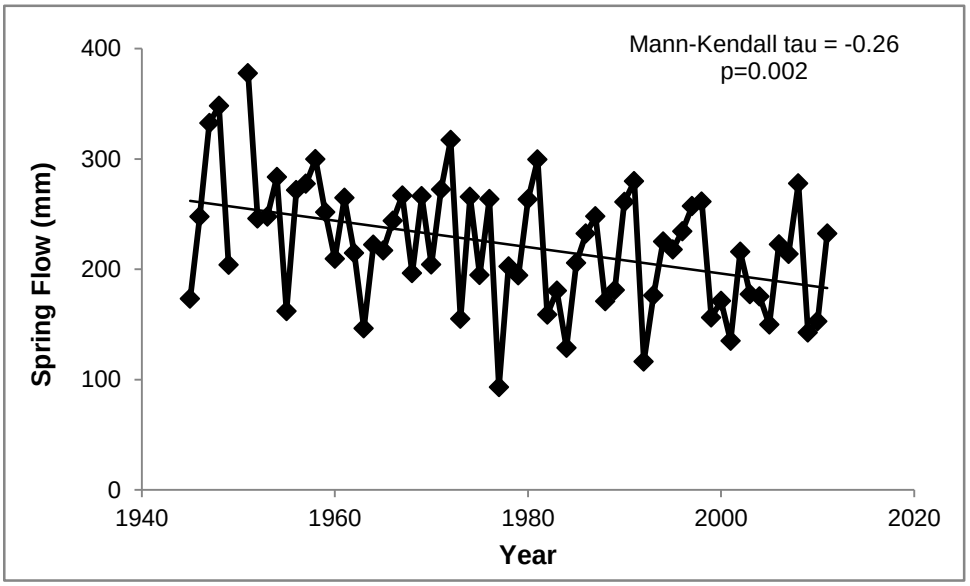

Figure B-7. Example for the temporal trends analysis conducted using the Mann-Kendall test. This is the result for spring flow for WSC station AA022.

Table B-2. Summary of Mann-Kendall (M-K) correlation (tau) coefficients assessing the sign (indicating decreasing or increasing trend) and strength (p-value) of trend relationship over time for 8 different flow regime measures. Tests are based only on WSC stations with a minimum of 30 years of data (see Table B1 for station details). The M-K correlation coefficients and regression p-value (in brackets, with significant correlations (p<0.1) in bold font) are shown below for each station and magnitude/timing measures.

WSC Station ID	WSC Station Name	Flow Magnitude Measures					Flow Timing Measures		
		Total Annual Flow	Spring Flow	Summer Flow	Daily Base Flow	Daily Peak Flow	Date of Melt Initiation	1st Hydrograph Peak	2nd Hydrograph Peak
05AA004	PINCHER CREEK AT PINCHER CREEK	**-0.15 (0.09)**	**-0.18 (0.04)**	-0.05 (0.57)	-0.02 (0.84)	0.03 (0.69)	0.03 (0.73)	0.04 (0.69)	0.09 (0.31)
05AA008	CROWSNEST RIVER AT FRANK	-0.13 (0.11)	**-0.29 (0.00)**	**-0.14 (0.09)**	-0.03 (0.72)	-0.09 (0.27)	0.00 (1.00)	**0.14 (0.09)**	-0.07 (0.39)
05AA011	MILL CREEK NEAR THE MOUTH	**-0.24 (0.04)**	-0.15 (0.23)	-0.18 (0.13)	**-0.21 (0.08)**	-0.04 (0.75)	**-0.24 (0.05)**	0.00 (1.00)	-0.10 (0.43)
05AA022	CASTLE RIVER NEAR BEAVER MINES	**-0.16 (0.06)**	**-0.26 (0.00)**	-0.11 (0.20)	0.13 (0.12)	-0.11 (0.20)	-0.08 (0.36)	-0.07 (0.42)	-0.02 (0.80)
05AA023	OLDMAN RIVER NEAR WALDRON'S CORNER	**-0.15 (0.10)**	**-0.20 (0.03)**	**-0.15 (0.10)**	-0.08 (0.40)	-0.04 (0.66)	**-0.22 (0.02)**	-0.06 (0.53)	-0.01 (0.30)
05AA024	OLDMAN RIVER NEAR BROCKET	-0.08 (0.24)	-0.08 (0.23)	-0.07 (0.31)	**-0.26 (0.00)**	-0.02 (0.82)	-0.05 (0.54)	-0.10 (0.17)	**0.16 (0.03)**
05AA027	RACEHORSE CREEK NEAR THE MOUTH	-0.11 (0.32)	-0.07 (0.54)	-0.14 (0.19)	**0.17 (0.10)**	-0.13 (0.23)	**-0.22 (0.04)**	**-0.23 (0.03)**	-0.16 (0.13)
05AA028	CASTLE RIVER AT RANGER STATION	-0.14 (0.19)	-0.16 (0.14)	-0.07 (0.51)	0.11 (0.31)	-0.08 (0.46)	**-0.20 (0.06)**	-0.05 (0.64)	0.05 (0.65)
05AA030	GOLD CREEK NEAR FRANK	**0.22 (0.07)**	na	**0.22 (0.10)**	-0.06 (0.65)	0.13 (0.30)	-0.03 (0.84)	**0.21 (0.09)**	0.06 (0.63)
05AA909	TODD CREEK NEAR HIGHWAY NO.22	0.18 (0.18)	-0.06 (0.68)	0.12 (0.37)	**0.26 (0.05)**	0.11 (0.40)	-0.03 (0.84)	0.01 (0.94)	-0.15 (0.27)
05AB021	WILLOW CREEK NEAR CLARESHOLM	-0.02 (0.76)	-0.07 (0.30)	-0.03 (0.62)	**-0.30 (0.00)**	0.02 (0.75)	0.08 (0.30)	**-0.15 (0.04)**	-0.06 (0.39)
05AD003	WATERTON RIVER NEAR WATERTON PARK	**-0.14 (0.07)**	**-0.14 (0.05)**	**-0.12 (0.10)**	-0.12 (0.11)	-0.11 (0.16)	**-0.14 (0.07)**	0.05 (0.54)	0.01 (0.86)
05AD005	BELLY RIVER NEAR MOUNTAIN VIEW	-0.04 (0.53)	-0.02 (0.83)	-0.04 (0.53)	-0.04 (0.56)	0.02 (0.78)	**-0.18 (0.01)**	-0.05 (0.47)	-0.06 (0.39)
05AD025	WATERTON LAKE AT WATERTON PARK	na	na	na	0.06 (0.48)	-0.03 (0.77)	-0.01 (0.93)	-0.01 (0.90)	na
05AE002	LEE CREEK AT CARDSTON	-0.025 (0.72)	-0.093 (0.17)	0.017 (0.81)	**-0.12 (0.08)**	0.01 (0.90)	-0.06 (0.40)	-0.04 (0.60)	0.08 (0.23)

Appendix C – Occurrence of rare and unique habitat or biota

Occurrence of rare/unique habitats or biota in the Headwaters

The occurrence of rare and unique habitats or biota as recognized by the Alberta Conservation Information System (ACIMS) is provided as additional information to identify priority watersheds for conservation or stewardship focus by the OWC. The occurrence elements for rare or unique landforms is shown below in Figure C-1a. Rare landforms are uncommon landscape features resulting from unique geological, erosional and/or sedimentation processes. The occurrence elements for rare or unique plant communities is shown in Figure C-1b. These mapped occurrences are for plant communities which are ranked as threatened or at risk by ACIMS based on the S-rank (Table C-1). S-ranks ranges between S1 and S5, with plant communities listed are S1 being the most at risk.

Table C-1. Threatened or at risk plant communities identified by ACIMS in Headwaters Region of the Oldman Watershed, and their associated S-ranks.

Plant Community Common Name	Plant Community Scientific Name	ACIMS S_RANK
Alder-leaved buckthorn shrubland	Rhamnus alnifolia shrubland	S1S2
Aspen / thimbleberry forest	Populus tremuloides / Rubus parviflorus forest	S2
Balsam poplar - aspen / alpine foxtail - bluejoint	Populus balsamifera - P. tremuloides / Alopecurus alpinus - Calamagrostis canadensis	S1S2
Bear-grass herbaceous vegetation	Xerophyllum tenax herbaceous vegetation	S1S2
Big sagebrush - alder-leaved buckthorn	Artemisia tridentata ssp. vaseyana - Rhamnus alnifolia	S1
Big sagebrush - saskatoon	Artemisia tridentata ssp. vaseyana - Amelanchier alnifolia	S1
Bolander's quillwort aquatic community	Isoetes bolanderi aquatic community	S1
Douglas-fir - limber pine / ground juniper / mountain rough fescue	Pseudotsuga menziesii - Pinus flexilis / Juniperus communis / Festuca campestris	S2
Drummond's willow / bluejoint shrubland	Salix drummondiana / Calamagrostis canadensis shrubland	S1
Idaho fescue - bluebunch wheat grass grassland	Festuca idahoensis - Pseudoroegneria spicata grassland	S1S2
Limber pine / common bearberry - creeping juniper	Pinus flexilis / Arctostaphylos uva ursi - Juniperus horizontalis	S2
Limber pine / common bearberry woodland	Pinus flexilis / Arctostaphylos uva-ursi woodland	S2
Subalpine fir - limber pine - aspen / veiny meadow rue	Abies bifolia - Pinus flexilis - Populus tremuloides / Thalictrum venulosum	S2?
Subalpine fir - whitebark pine - Engelmann spruce / crowberry	Abies bifolia - Pinus albicaulis - Picea engelmannii / Empetrum nigrum	S2
Western larch / thimbleberry	Larix occidentalis / Rubus parviflorus	S1
Whitebark pine / ground juniper - common bearberry	Pinus albicaulis / Juniperus communis - Arctostaphylos uva ursi	S2S3

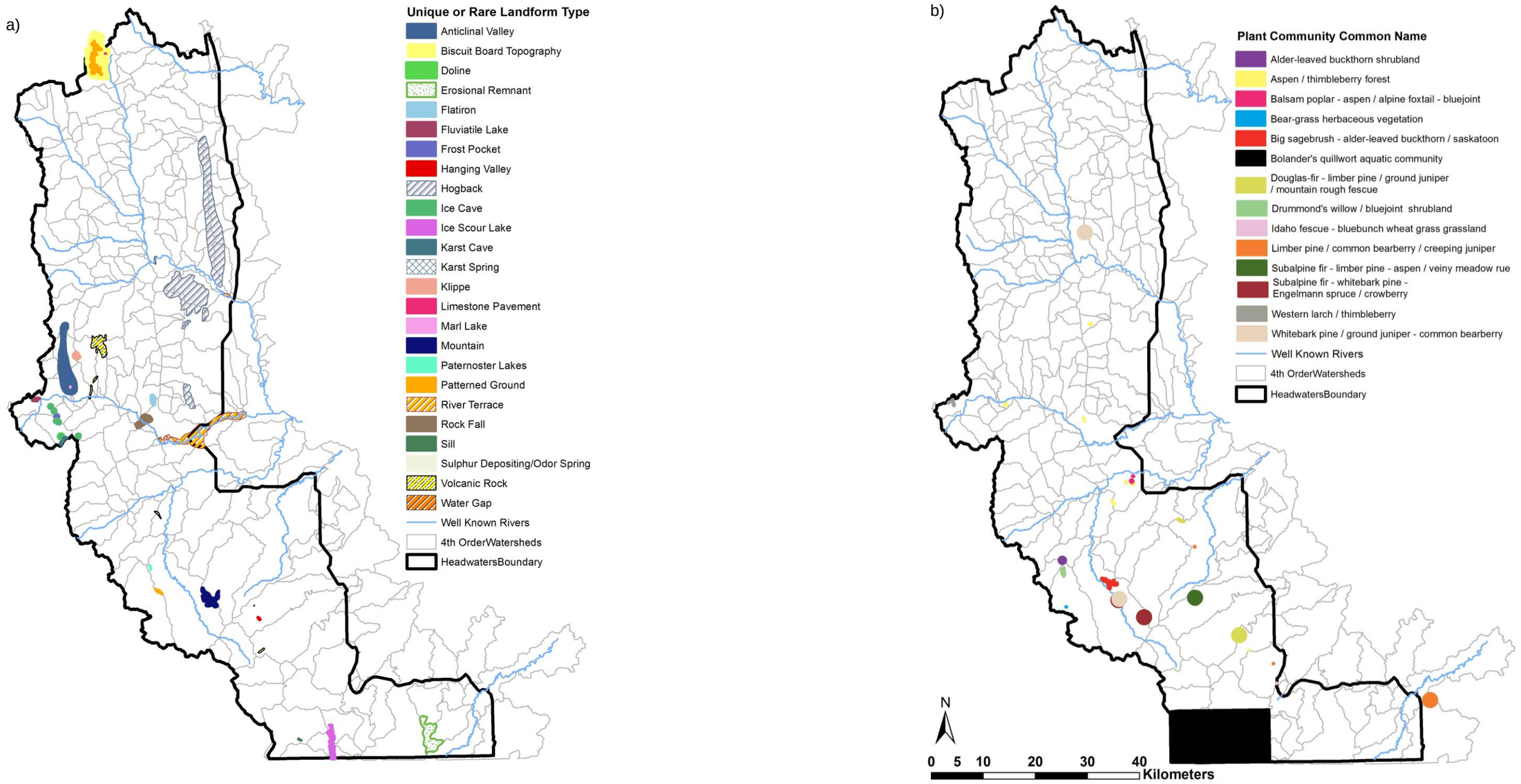

Figure C-1. Occurrence of unique or rare landforms (a), and plant communities (b) as classified by the Alberta Conservation Information Management System (ACIMS) in the Headwaters Region of the Oldman Watershed.

OLDMAN INTEGRATED WATERSHED MANAGEMENT PLAN

HEADWATERS ACTION PLAN 2013-14

OLDMAN WATERSHED COUNCIL

ACKNOWLEDGEMENTS

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Cheryl Dash	Government of Alberta
Bill Dolan	OWC Board Member; Government of Alberta
Ian Dyson	OWC Board Member; Government of Alberta
Shannon Frank	Oldman Watershed Council; Executive Director
Cheryl Fujikawa	OWC Board Member; Southern Alberta Group for the Environment
Rosemary Jones	Government of Alberta
Erin McIlwraith	City of Lethbridge
Shirley Pickering	OWC Board Member; Member at Large
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Connie Simmons	Oldman Watershed Council, Planning Manager

CONSULTANTS

Fiera Biological Consulting Ltd.	Oldman Headwaters Indicators Project
ALCES Landscape and Landuse Ltd.	Oldman Watershed Historical Trends Mapping Project

Message from the OWC Executive Director:
I am very excited that together we have set targets and identified actions to achieve them. Now we can focus on putting those actions on the ground to really make a difference for the health of the headwaters. It has been inspiring to see the passion people have for the mountains! Water connects us and we owe it to ourselves and to future generations to protect it.
A huge thank you to Connie Simmons, OWC Planning Manager, and the volunteers on the IWMP Team for all your enthusiasm, wisdom and hard work!

Shannon Frank, OWC Executive Director <Signature removed>

Message from the Chair:
The Headwaters Action Plan is a big accomplishment for the OWC and for all the local residents, organizations and governments who were a part of its creation. Having specific targets for what the community wants to achieve in the headwaters can now guide the practices of all users. Working collaboratively towards these targets will be challenging at times but nowhere is it more important than in the headwaters, the source of 90% of our water. I'd like to thank the Integrated Watershed Management Plan Team for all the time and energy they have put into facilitating this plan and especially to Connie Simmons, OWC's Planning Manager, for leading the process.

Andy Hurly, OWC Vice-Chair and Acting Chair <Signature removed>

ISBN Number
Printed: 978-0-9939120-0-9
Online: 978-0-9939120-2-3

Additional print copies of this document are available from:
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This document should be cited as:
Oldman Watershed Council, 2014.
Oldman Integrated Watershed Management Plan - Headwaters Action Plan 2013-13 Final,
Oldman Watershed Council, Lethbridge, Alberta. 64pp.

Funding for this document was provided by the Government of Alberta.

Photo: Anne Stevick; inset: Craig Ellis

TABLE OF CONTENTS

LIST OF FIGURES

The Headwaters Action Plan is endorsed by:

Municipal District of Willow Creek
Municipal District of Pincher Creek
Municipal District of Ranchlands
Waterton Biosphere Reserve Association
Trout Unlimited Canada - Oldman Chapter
Livingstone Landowners Group
Water Matters
CPAWS Southern Alberta

Photo: Jollin Charest; inset: Brian Coffey

EXECUTIVE SUMMARY

The Oldman headwaters are the source of 90% of the water in the Oldman River. The headwaters area lies along the Rocky Mountains and foothills of southwest Alberta and into Montana, extending from Chain Lakes in the north to Glacier National Park in the south. The area is an iconic landscape, rich in beauty, wildlife, history and opportunity, and as such, attracts a myriad of uses. From communities and rural residential development to recreation, tourism, forestry, mining, agriculture and grazing, the headwaters provides important ecological, social and economic benefits to society.

In a region where water is precious, the health of the headwaters region is very important and requires focused commitment and effort to address increasing pressures and risk of further degradation to key headwaters values and functions. These include surface water quality and quantity, biodiversity, and the integrity of the headwaters terrestrial and aquatic landscape.

The Oldman Watershed Council (OWC) is committed to working with the greater watershed community to ensure we maintain and protect the headwaters and source waters in the Oldman River watershed. This is one of eight important goals of the 'Oldman Integrated Watershed Management Plan', and a key task under *Water For Life: Alberta's Strategy for Sustainability.*[1]

The Headwaters Action Plan 2013-14 (HAP) process was initiated in 2012 and has moved through several steps to develop a foundation for an iterative process of adaptive management[2] for headwaters health over time. Each element of the process was essential and has been shared and integrated into the process of developing the plan:

- scientific assessment of headwaters health,
- hearing what the community has to say about headwaters health and stewardship needs,
- engagement of key stakeholders who have capacity and commitment to work for headwaters health, and
- a review of other initiatives related to the headwaters to include their work into the process of the Headwaters Action Plan.

The Headwaters Action Plan 2013-14 is starting with three important indicators of headwaters health and has achieved agreement from participating stakeholders on targets (desired outcomes), recommendations to decision-makers, and stewardship action needed to begin to address issues and concerns related to each indicator. The first three indicators of headwaters health addressed are:

1. presence and abundance of fish - especially native populations (an indicator of biodiversity and watershed integrity),
2. density of linear features (cumulative disturbance of roads, seismic lines, pipelines, power-lines, railroads, cut-lines, off-road vehicle trails across each sub-watershed in the headwaters area), and
3. aquatic invasive species (zebra mussels; quagga mussels and Eurasian watermilfoil[3] are all classified as major threats to aquatic ecosystem health that we need to keep out of Alberta).

The Headwaters Action Plan 2013-14 is the first iteration in a process of adaptive management committed to implementing actions that address key pressures and risks to headwaters health. A Headwaters Action Team, comprised of representatives from key sectors who participated in the development of this plan, will work on an implementation strategy of prioritized actions in 2014-15, and will monitor, evaluate and report on progress annually. The success of the plan depends on the collaborative strength and commitment of key stakeholders, the public and the OWC to make it happen.

We are starting here to work for headwaters health. Together we make a difference.

[1] *Water For Life: Alberta's Strategy for Sustainability.* www.waterforlife.alberta.ca

[2] Adaptive management involves a continuous cycle of planning, implementation, measuring progress and as new information becomes available, making adjustments that improve the plan over time.

[3] Zebra mussel (Dreissena polymorpha); quagga mussel (Dreissena rostriformis bugensis); Eurasian watermilfoil (Myriophyllum spicatum).

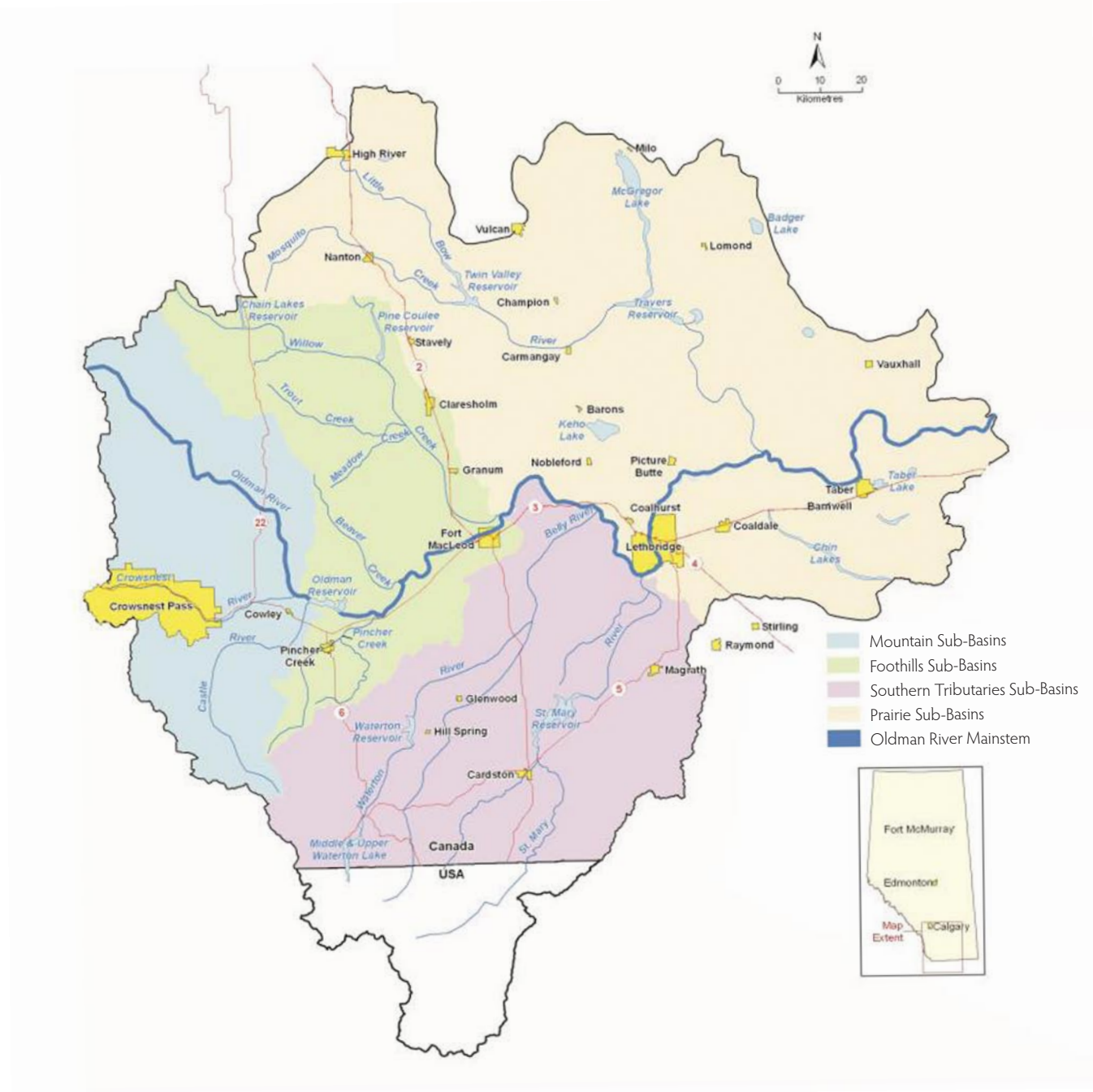


FIGURE 1: The Oldman Watershed

The Oldman watershed is the area of land that drains, through small to large streams and rivers into the Oldman River.

The Oldman River is 362km long, with a watershed area of 26,700 km^2, and is home to approximately 210,000 people.

The Oldman River watershed extends from the Canadian Rocky Mountains in the west to Grassy Lake in the east. There the Oldman River meets the Bow River and joins the South Saskatchewan River, which flows across Saskatchewan and into Lake Winnipeg.

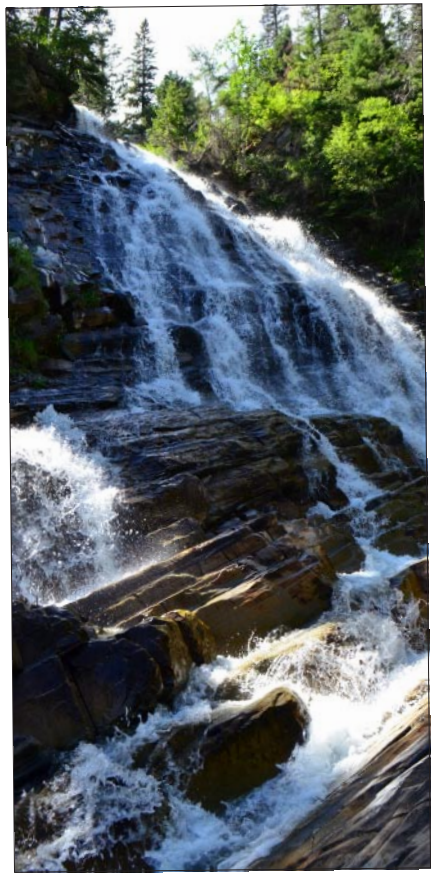


Photo: Connie Simmons

OLDMAN WATERSHED COUNCIL

What is the Oldman Watershed Council?

The Oldman Watershed Council (OWC) is a not-for-profit organization working in partnership with communities and residents to improve the Oldman River watershed through sustainable water management and land use practices. The OWC is one of eleven designated Watershed Planning and Advisory Councils (WPACs) who work to achieve the three principles of Government of Alberta's Water for Life Strategy for Sustainability[4]:

- safe, secure drinking water,
- healthy aquatic ecosystems, and
- reliable quality water supplies for a sustainable economy.

As a designated WPAC, the OWC is tasked with completing scientific assessments of the condition of the watershed, and learning from local and traditional knowledge about watershed health concerns and issues. From this foundational information, the OWC informs and works with the greater watershed community (individuals, groups, stakeholders, and First Nations) to develop an Integrated Watershed Management Plan (IWMP) that results in measureable on-the-ground stewardship actions to maintain, protect and continually improve watershed health.

[4] Water For Life - Alberta's Strategy for Sustainability was renewed in 2003. http://environment.gov.ab.ca/info/library/8035.pdf

Photo: Oldman Watershed Council

What do we do?

The OWC supports the responsible management of the watershed, while working with the challenges of a growing population and a vibrant economy by partnering with stakeholders, planning for the future and adapting to the needs of local communities.

The OWC is active in the greater watershed community

As an action-oriented organization with dedicated volunteers, a wealth of expertise and strong partnerships, the OWC continues to promote environmental/watershed stewardship practices, work with people from all walks of life, improve and share watershed knowledge, build stakeholder partnerships, and engage watershed residents on issues related to watershed management.

How do we do this?

The OWC benefits from the diverse knowledge and abilities of volunteers from the community – our Watershed Partners. Project Teams develop and implement a variety of projects to improve watershed health, including:

- leading the development of the Integrated Watershed Management Plan that sets specific environmental targets for watershed health and outlines actions to achieve them
- determining the scientific metrics of assessment needed to provide a 'report card' of health of the watershed
- supporting agricultural producers and encouraging the adoption of beneficial management practices through facilitated programs like the Holding the Reins Landowner Summit and the Watershed Legacy Program
- working with municipal governments to provide input on policy/plans and encourage environmental action through programs like the Prairie Urban Garden project
- completing research projects, encouraging collaboration within the research community and raising awareness of research taking place in the Oldman Watershed through science forums and tours and a Research and Monitoring Directory.

"...working together is beneficial for all of us."
- Judy Cook (Crowsnest Pass Conservation Society; Partnership Advisory Network)

OLDMAN INTEGRATED WATERSHED MANAGEMENT PLAN

A process to achieve our community vision for the Oldman watershed

An Integrated Watershed Management Plan (IWMP) process is intended to address priority land and water resource issues within a specific watershed. This process enables residents, stakeholders and all levels of government to make informed decisions and take responsible action.

An IWMP is a collaborative effort between sectors, stakeholders, First Nations and the public that engages people so that it becomes the community's plan. It is recognized that the development and implementation of an IWMP is a shared responsibility for maintaining and improving watershed health.

An IWMP is an iterative process of adaptive management – it builds over time on accomplishments, increased knowledge, evaluation of progress and subsequent adjustments for improvement.

The IWMP process works to gather the best available science, and local and traditional knowledge about the condition of the watershed in relation to the goals of the IWMP. This information is shared with the broader community to help identify actions that are needed to meet the goals.

With a good understanding of the current ecological condition of the watershed, and input from local communities, the IWMP process engages community members and stakeholders to determine environmental targets for watershed health, and ways to achieve the targets through creating, implementing and evaluating Action Plans, and providing recommendations to governments for policies that help achieve the targets.

The IWMP process focuses on the ecological needs of improving watershed integrity, while keeping in mind the social, cultural and economic needs of communities. Recognizing that a strong, resilient economy depends on a healthy environment, working together for watershed integrity is the foundation for a sustainable future.

IWMP Foundations
Important phases along the way

The OWC IWMP process is a long-term commitment to the watershed and the OWC is in it for the duration. Each phase in the process will build from and integrate existing research and process outcomes, while having the ability to adapt to changing priorities and issues in the watershed.

The key to success will be the identification and affirmation of clear goals or outcomes to be achieved in the watershed. In order to achieve these outcomes, the OWC has completed several important milestones in the IWMP process that provide important information on the risks and priorities for planning, action and ongoing evaluation and adjustments that are part of an IWMP process.[5]

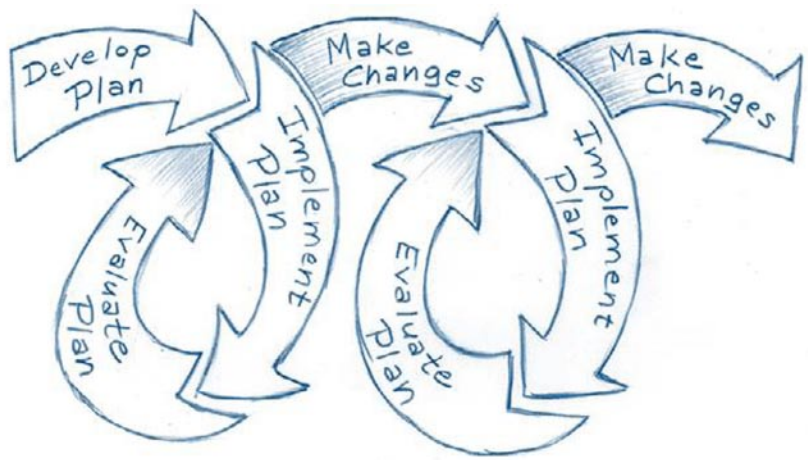
1. Oldman River State of the Watershed Report (2010) is the first assessment of the condition of the Oldman watershed. The report provides solid foundation for understanding the health of the watershed, but also points to areas that need further assessment at smaller sub-watershed scales. The Oldman River State of the Watershed Report is also a key deliverable under Alberta's Water for Life Strategy, and is required of the Oldman Watershed Council as a designated Watershed Planning and Advisory Council in Alberta.

2. In 2009-10, extensive community input and direction was gathered to create a planning vision for the Oldman Watershed. The process is outlined in 'Oldman Watershed Planning Vision: A Process Summary' (2010).

3. In 2011, the OWC brought together experts in various science disciplines and local people who had actively participated in the visioning and risk assessment process to determine the priorities for the IWMP process in the Oldman watershed. The outcomes of this work are documented in the 'Oldman Watershed Planning Priorities: Process Summary and Recommendations' which outlines 8 priority goals for the Oldman IWMP.

[5] See all documents of the IWMP process at www.oldmanwatershed.ca

Photo: Ian Dyson



Adaptive Watershed Management (US EPA 2005)

The Oldman Integrated Watershed Management Plan: Eight Priority Planning Goals

Goal 1 Improve the understanding and strengthen the commitment of residents to the health of the Oldman watershed.

Goal 2 Optimize the availability of water for the natural ecosystem while supporting the social and economic needs of the community.

Goal 3 Manage and protect the integrity of headwaters and source waters.

Goal 4 Identify and prioritize thresholds to manage threats and impacts on terrestrial and aquatic habitat.

Goal 5 Understand groundwater and how it interacts with surface water.

Goal 6 Identify water quality outcomes and assess factors impacting them for adaptive watershed management.

Goal 7 Prevent and control invasive species.

Goal 8 Understand the status and implications of emerging contaminants.

The eight IWMP goals are prioritized by the OWC and the watershed community to develop Action Plans. Although the goals are broad and general, they provide a foundation for integration of planning and actions that benefit the watershed as a whole.

Action Plans: Moving to action for watershed health

Action Plans are critical elements of the IWMP process; they engage the greater community to address the 8 goals of the IWMP process by:

1. setting targets (desired outcomes) for watershed integrity based on the best available science, local and traditional knowledge;
2. developing a plan of collaborative stewardship action;
3. making recommendations to decision-makers for policy development that help achieve defined targets.

Implementation of the action plans is a collective endeavor by the OWC, key stakeholders, the Government of Alberta and the public. Each action plan of the IWMP will have an implementation strategy that engages and encourages key stakeholders and the public to work towards maintaining and protecting watershed health.

Goal 1: Action Plan

The OWC completed the Action Plan for Goal 1 - Improve the understanding and strengthen the commitment of residents to the health of the Oldman watershed in 2012.[6] While there is natural linkage and interconnection between the eight planning goals, Goal 1 - Action Plan supports, connects, communicates and emphasizes the OWC's direction in understanding and improving the watershed throughout the IWMP process. As the other seven action plans are developed, education and communication activities will be identified to help improve understanding and commitment to the health of the watershed.

[6] See the OWC-IWMP Goal 1 Action Plan at www.oldmanwatershed.ca

> The Integrated Watershed Management Plan is a process focused on continual improvement of watershed health, learning from the lessons and outcomes of each initiative, and integrating our understanding and actions across all 8 priority goals for the Oldman Watershed.

Photo: Rochelle Coffey

OLDMAN HEADWATERS ACTION PLAN 2013-14

In 2012-13 the OWC began work on the second action plan of the IWMP process, addressing IWMP planning Goal 3: Manage and protect the integrity of headwaters and source waters. The decision to address this goal was fourfold:

1. The headwaters region is a priority because it is the main source of water for the greater Oldman watershed. The headwaters area is approximately 30 kilometres wide, encompasses 24% of the total area of the Oldman watershed, and accounts for 90% of the flow at the mouth (end) of the Oldman River.
2. The Headwaters area is a growing 'hotspot' of land-use concerns and cumulative effects on watershed integrity.
3. The Headwaters is in need of an informed watershed constituency willing to implement stewardship action to meet the greater community's defined targets for headwaters health, and provide recommendations for policy development to maintain and protect source waters and headwaters in the Oldman watershed.
4. The OWC recognizes the importance of providing strong, credible science, community and stakeholder input that supports the maintenance and protection of Oldman headwaters and source water to the South Saskatchewan Regional Plan (SSRP).[7]

The 3 key objectives of Goal 3 provide guidance for action plan:

1. Identify and understand the hydrologically significant areas in the headwaters.
2. Identify, mitigate and prevent threats to headwaters and source waters.
3. Define the kinds and intensity of land use activities as they relate to source water and headwater significant areas.

The aim of the Headwaters Action Plan is to begin a process of collaborative stewardship work that will address key issues to headwaters health - over time, and within the capacity of participating stakeholders, First Nations and the public.

[7] South Saskatchewan Regional Plan - Alberta Land-Use Framework: https://landuse.alberta.ca/REGIONALPLANS/SOUTHSASKATCHEWANREGION/Pages/default.aspx

Where are the Oldman Headwaters?

The Headwaters of the Oldman River watershed are found in the western portion of the Oldman Watershed along the eastern slopes of the Rocky Mountains. The primary rivers include the Crowsnest, Castle, Upper Oldman and the Alberta portions of the St. Mary River, Belly River, Waterton River and northwest reaches of Willow Creek.

The Headwaters planning area includes the mountains that receive the highest levels of precipitation and contribute the majority of the flow to rivers in the Oldman watershed. The headwaters of these streams rise in the high peaks of the continental divide. Dams are absent in this area, so these streams have near natural flows. The western boundary of the planning area is the B.C./Alberta border; the northern boundary extends from the continental divide to the Chain Lakes Reservoir; the eastern boundary is defined by the sub-watersheds that cross Highway 22, Secondary Hwy 507, and Highway 6 to the Canada/U.S.A. border; and the southern boundary is the Canada/U.S.A. border (see map on page 14 for headwaters sub-watershed boundaries)..

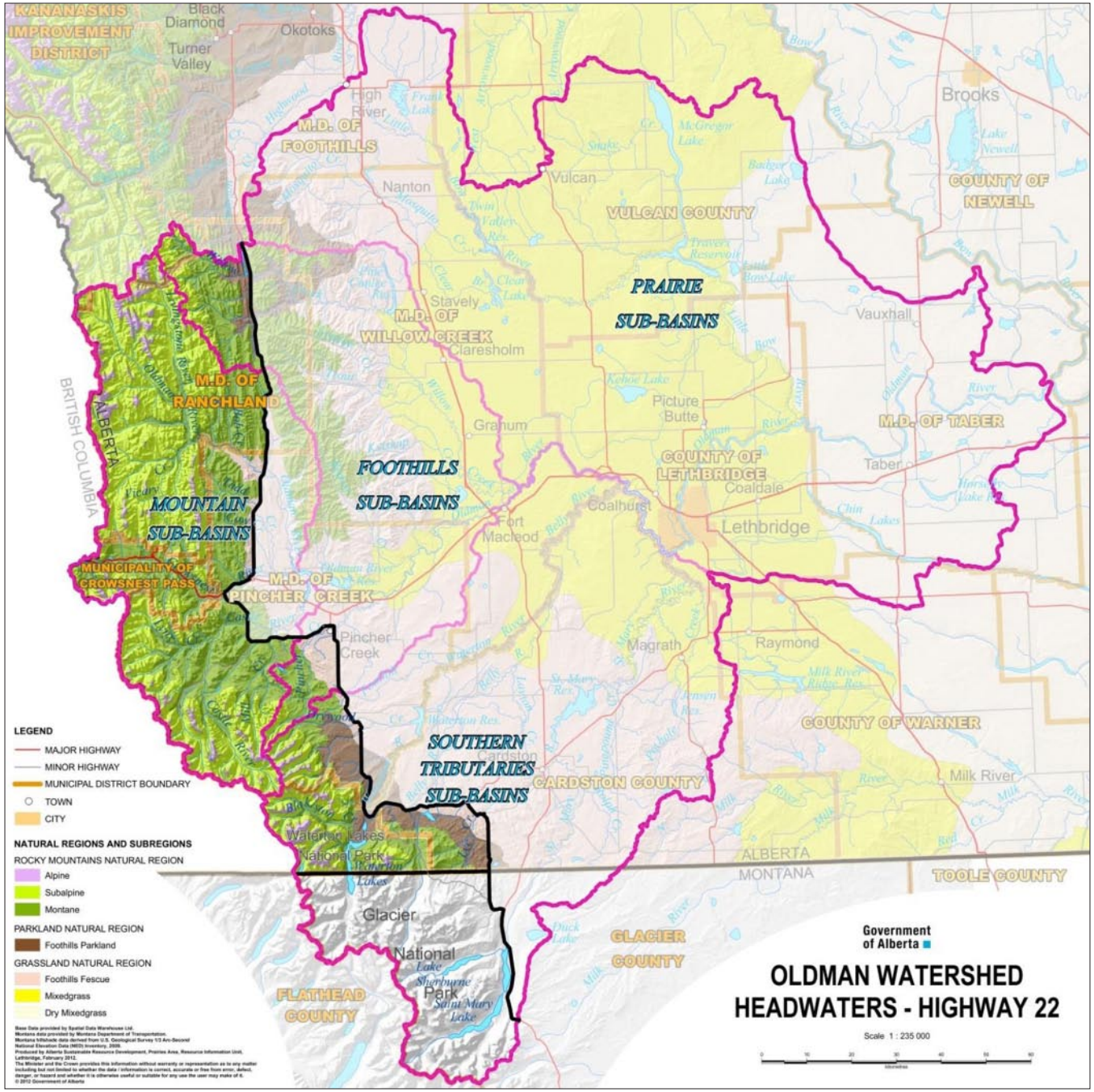
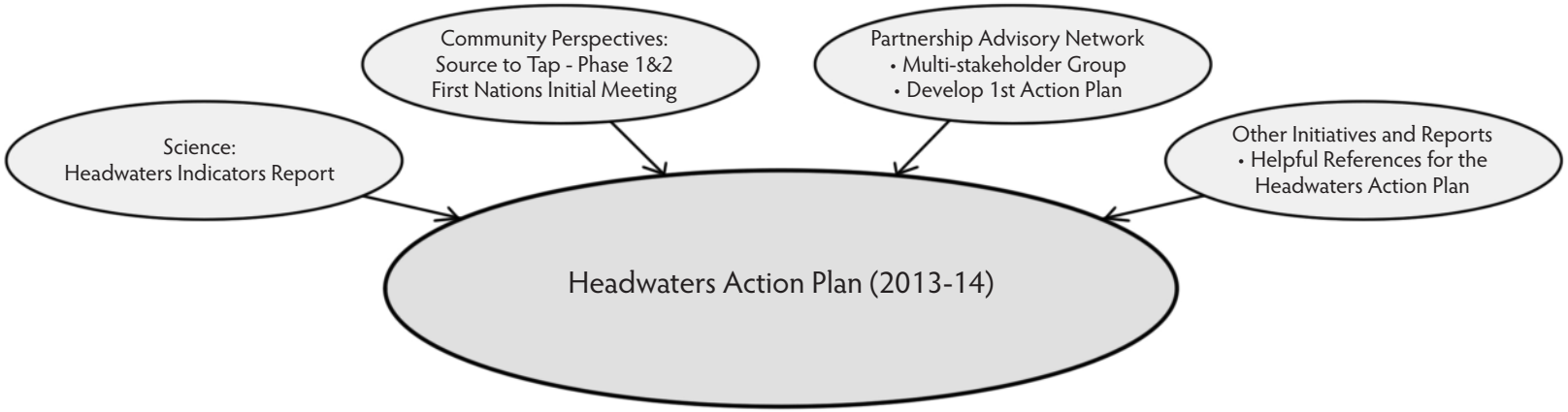


FIGURE 2: Oldman Headwaters Area



Moving Forward

Through 2012-13, the OWC has moved forward with the Headwaters Action Plan process with key initiatives:

1. Oldman Headwaters Indicator Project[8]: a scientific assessment of headwaters health.
2. Source to Tap Community meetings: gaining perspectives from local residents on what they think of the health of the headwaters, and what stewardship actions are most important to address. An introductory meeting with a few members of the Piikani Nation and Kainai First Nation people as a first step to initiate a relationship of understanding on water and headwaters concerns that are important to First Nations communities.
3. Partnership Advisory Network: inviting and engaging stakeholders who have the capacity and commitment to begin real on-the-ground actions to improve headwaters health.
4. A review of relevant reports and initiatives developed by other groups/ organizations to ascertain how they support and inform the priority indicators of headwaters health in the Headwaters Action Plan process.

[8] Oldman Headwaters Indicator Project (March 14, 2014), Fiera Biological Consulting, Ltd. http://www.oldmanwatershed.ca

Preparation for the Headwaters Action Plan process

The Headwaters Action Plan 2013-14 process was initiated in 2012 and the Terms of Reference was approved by the OWC Board of Directors in October 2012.

As an important foundation for the Headwaters Action Plan process, the OWC completed several scientific research projects to provide the best available, scientifically defensible foundations for the planning process. The research projects completed are:

- Oldman Headwaters Indicator Project (Fiera Biological Consulting Ltd.)
- ALCES Historical Trends Mapping for the Oldman watershed (ALCES Landscape and Land Use Ltd.)
- Crowsnest Pass Aquifer Mapping and Groundwater Management Planning Study (Waterline Resources Inc.)
- Landscape Patterns Environmental Quality Analysis. (O2 Planning and Design)

Each report provides important information for understanding cumulative effects in the Oldman headwaters, and supports the development and outcomes of the Headwaters Action Plan 2013-14.

OLDMAN HEADWATERS INDICATORS PROJECT

The Oldman Headwaters Indicators Project was an important step in the development and implementation of a watershed assessment design for evaluating the pressures on or condition of the Oldman headwaters area.

As a key element of this project, a watershed criteria and indicators framework was developed to be relevant and meaningful in the context of local and regional stewardship initiatives in the Oldman Headwaters area, and to simplify and summarize complex ecological information to ensure ecological values could be effectively communicated and integrated into land-use planning policies and processes.

The Oldman Headwaters Indicators Project determined four Criteria for watershed assessment, and accessed data for six indicators to provide a scientifically defensible report on headwaters integrity (see Table 2). The project used the most current and accessible data from the Government of Alberta, Water Survey of Canada and the Alberta Riparian Habitat Management Society (more widely known as 'Cows & Fish').

Four of the six indicators (intact landscapes; road density; linear features density; soil erosion risk) are considered pressure indicators, and were used in an indicator 'modeling' process using Geographic Information System (GIS) to create visual mapping of pressure ratings of these indicators across 180 sub-watersheds in the headwaters area. Two other indicators (riparian condition and stream flow regime) are condition indicators, and provide an assessment of the general condition of the riparian areas surveyed by Cows and Fish, and the seasonal flow rates and quantity of water recorded at Water Survey of Canada gauge stations in or near the headwaters area.

The Oldman Headwaters Indicators project utilized 4th order Strahler sub-watershed boundaries.[9] This geographical scale of assessment was used to provide the best possible detail in understanding the condition or pressure on smaller sub-watersheds in the headwaters area. In the headwaters area, 4th order watershed boundaries resulted in assessment of 180 sub-watersheds ranging in size from 3 to 200 km^2.

[9] Strahler stream order is used to define stream size based on a hierarchy of tributaries. A fourth order stream is where tributary streams of a first, second and third order have merged to become a 4th order stream.

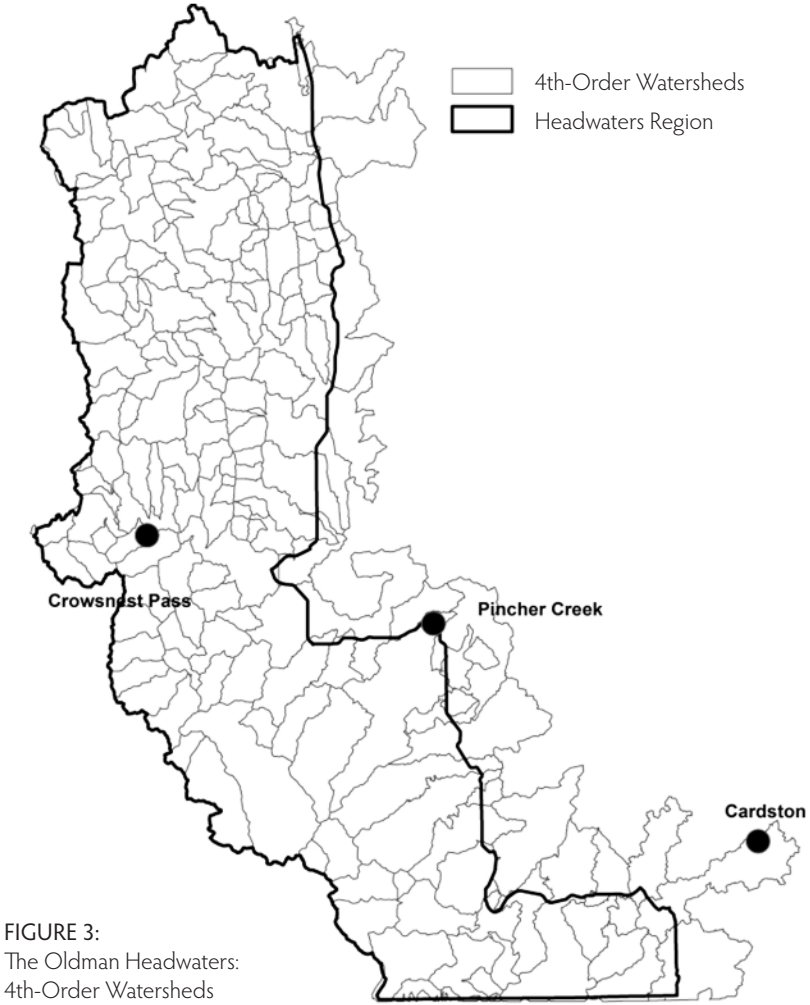


FIGURE 3:
The Oldman Headwaters: 4th-Order Watersheds

Overview of results of Oldman Headwaters Indicator Project (version 2013.3)

In determining the level of headwaters integrity in the 180 sub-watersheds of the Oldman headwaters area, pressures ratings were used to create a report card of watershed health. Pressure ratings were derived from scientific thresholds in peer-reviewed research studies and government management documents. Each of the 180 sub-watersheds is rated at a high, moderate, low or negligible pressure ranking.

FIGURE 4: Results of headwaters integrity assessment

Criteria **Landscape Composition and Condition**	Criteria **Biological Diversity**	Criteria **Surface Water Quality**	Criteria **Water Levels and Flow**
Indicator (pressure) Intact Landscapes	Indicators (pressure) Road Density Density of all linear features Indicator (condition) Riparian condition	Indicator (pressure) Sedimentation/Erosion Potential	Indicator (condition) Stream Flow Regime
Results of assessment of the 180 sub-watersheds in the Oldman headwaters			
Intact Landscapes: 67 watersheds (38%) with Negligible Risk 52 watersheds (30%) with Low Risk 37 watersheds (20%) with Moderate Risk 22 watersheds (12%) with High Risk	Road Density: 71 watersheds (40%) with Negligible Risk 57 watersheds (32%) with Low Risk 32 watersheds (18%) with Moderate Risk 18 watersheds (10%) with High Risk Density of all linear features 19 watersheds (11%) with Negligible Risk 23 watersheds (13%) with Low Risk 103 watersheds (58%) with Moderate Risk 33 watersheds (19%) with High Risk Riparian Condition (at the scale used by Cows and Fish Program): 9 watersheds are considered healthy with problems (at risk of losing function).	Sedimentation/Erosion Potential: 11 watersheds (11%) with Negligible Risk 26 watersheds (20%) with Low Risk 83 watersheds (64%) with Moderate Risk 9 watersheds (7%) with High Risk	Stream Flow Regime: Metrics used with data from Water Survey of Canada (WSC) gauge stations show: Overall magnitude of flows has declined over time at most WSC stations. Total Spring flows are significantly decreasing in 5 out of 10 WSC stations Patterns of daily base flow (lowest amount) is inconsistent across all WSC stations, with some increasing, and others decreasing.

What are Criteria and Indicators?
Criteria are categories of watershed conditions or processes that characterize aquatic and terrestrial environments used to evaluate watershed condition. They include a suite of conservation values and goals for watershed management and are representative or related to specific watershed elements (e.g. water quality, water quantity)
Indicators are measures of watershed condition within each Criteria. They are used to observe, evaluate and describe trends within each watershed assessment Criteria (e.g. under Water Quality Criteria, an indicator would include (but not be limited to) measures of surface water quality and sediment loads).

Historical Trends Mapping of the Oldman Watershed

An understanding of how the Oldman watershed has changed over time is important information for planning its future. Fourteen land use trends were mapped from 1905 to 2010, including native landscapes, edge density, population growth and well density. Maps are presented in a time lapse format to give a powerful visual representation of how the landscape has changed over time and to demonstrate cumulative effects by layering changes onto one map. These maps show where development has been concentrated and how the watershed has changed over the years.

Crowsnest River Watershed Aquifer Mapping and Groundwater Management Planning Study

The objective of the study was to compile existing groundwater information in the Crowsnest watershed and to set the stage for what needs to be done in the near future to fill knowledge gaps. The Crowsnest study summarizes what groundwater resources exist; groundwater quality; groundwater geology in the region; how groundwater is connected to surface water; and how much groundwater is being used.

Landscape Patterns and Environmental Quality Analysis

The OWC, along with 7 other partners, commissioned an extensive literature review to identify metrics (thresholds) of environmental quality to assist in planning, monitoring and resource management decision-making. The report is structured to provide 1) foundational understanding of the principles and theories in landscape ecology established to date, and 2) a toolbox of ecological targets and thresholds relating to major landscape indicators of environmental quality drawn from published literature. Concise pattern-based indicators and targets for environmental quality inform cumulative effects management by providing measurable criteria for how resource extraction and other human activities can be managed on the landscape in concert with ecosystem function.

Integration of science in the Headwaters Action Plan process

The Headwaters Action Plan requires a scientifically defensible assessment of headwaters health[10] to help guide stewardship action on key concerns and threats to watershed integrity. Science also provides assistance in determining root causes of issues and threats to headwaters health, and helps focus discussion on potential solutions to maintain and protect important watershed values.

Science has been part of all aspects of the Headwaters Action Plan process. It has been an essential element of community meetings, stakeholder forums and workshops, and presentations to groups, municipalities and Government of Alberta agencies. The outcomes of the Oldman Headwaters Indicators Project were shared with the South Saskatchewan Regional Planning process to assist in understanding cumulative effects and associated issues in the Oldman headwaters area.

[10] The Oldman Headwaters Indicators Project underwent an independent third party review and was acknowledged as a credible assessment of headwaters health. The project used the most current (2012) and available Government of Alberta data.

Photo: Saikut Basu

Photo: Connie Simmons

HEADWATERS ACTION PLAN 2013-14 Community, First Nations and Stakeholder Engagement

The Headwaters Action Plan is an iterative process, building on successive years of headwaters health assessment and stewardship work to maintain and protect headwaters and source waters health. Working with stakeholders and the public, the Oldman Watershed Council has heard that watershed management is a shared responsibility, and that action to manage and protect headwaters and source waters is best accomplished through collaboration with those who live, work, recreate or otherwise have an interest in the Headwaters area.

In 2012-13, the Headwaters Action Plan (2012-13), the process involved three streams of engagement:

1. Community Engagement: 'Source to Tap' public meetings in 8-9 communities (Phase 1: Nov-Dec. 2012; Phase 2: Feb-March 2013).

The OWC and Water Matters (a not-for-profit group committed to fostering watershed stewardship in Alberta) agreed to work together on Source to Tap, a community-based initiative to engage people in sharing their local knowledge and thoughts on priorities for stewardship in the Oldman headwaters and source waters. The two phases of Source to Tap community meetings focused on connecting urban and rural residents together with people who use and steward the land in the headwaters (e.g. ranchers, resource industry, recreation groups) to build common understanding of issues and stewardship practices related to the Oldman headwaters area.

2. First Nations: The OWC and Water Matters initially invited a small group of people from Kainai First Nation (Blood Tribe, Standoff, AB) and the Piikani Nation (Brocket, AB) to an introductory meeting on January 4th, 2013 at Head Smashed In Buffalo Jump World Heritage Site. The meeting resulted in a request from the OWC to meet with Elders and youth to ask them what they saw as important about water, and how they wanted to begin a relationship to further conversations about water and watershed health with their communities.

Following this initial meeting, the Piikani Traditional Knowledge Services (PTKS) worked with the OWC to co-host a "Protect Our Water" Sharing Circle meeting in Brocket, AB on January 23, 2014. Seventeen people from the Piikani and Kainai tribes attended the meeting, and as a result of their comments and suggestions, the OWC and PTKS are now working on three potential initiatives to raise awareness and education of Blackfoot traditional knowledge and science on water and watershed well-being.

The OWC will continue to build a relationship of understanding with the Blackfoot people to hear their concerns related to water and watershed health, and to work on water or watershed initiatives that they feel are of benefit to their people and communities.

3. Stakeholder Engagement: The OWC invited stakeholders and groups to participate in a broad-based collaborative effort to assist in development of the Headwaters Action Plan. The Partnership Advisory Network (PAN) participants were encouraged to work together with the foundational values of inclusivity, respectful dialogue, and willingness to find common ground despite different interests and values. Each stakeholder represented a public, private or municipal sector that has interest in the headwaters area, and also has the organizational capacity to commit to implementing stewardship action for headwaters health.

Photo: Denise Pezderic

Sectors invited to participate as members of the Partnership Advisory Network include:

- agriculture (irrigated and non-irrigated)
- business
- recreation
- academia
- industry
- municipalities
- provincial government
- non-government organizations
- environmental non-government organizations

The Partnership Advisory Network members were asked to fulfill these tasks:

- advise the OWC of their interests and provide a description of their current stewardship activities in the Headwaters that relate to managing and protecting headwaters integrity (May 2013 Stewardship Inventory);
- inform their sector or group of the Headwaters Action Plan process, and invite their sector or group to become involved in the process;
- participate in Headwaters Action Plan meetings and workshops;
- request that their sector or group endorse the Headwaters Action Plan 2013-14 outcomes (targets, recommendations and actions) that are achieved through consensus agreement of the PAN;
- commit (within organizational mandates and capacity) to implement or support stewardship action as a contribution to the Headwaters Action Plan in an adaptive management cycle over time.

During 2013-2014, The Partnership Advisory Network worked collaboratively with the OWC through several key steps to develop the Headwaters Action Plan 2013-14 (see Figure 5).

All community and stakeholder processes were integrated with other streams of input and information in the development of the Headwaters Action Plan 2013-14. These included scientific assessment of headwaters health, public perspectives on headwaters health and stewardship, supporting information from other initiatives related to the headwaters, and engagement and sharing of information and knowledge between the members of the Partnership Advisory Network.

STEP 1
Public Engagement
November-December 2012
OWC and Water Matters

Source to Tap
Community Meetings
in 5 communities

Source to Tap
Interim Report
(shared with
stakeholders)

STEP 2
Public Engagement
February-March 2013
OWC and Water Matters

Source to Tap
Community Meetings
in 8 communities

Source to Tap
Final Report
(shared with
stakeholders)

Stakeholders welcome to community meetings

Summary of Headwaters Forum shared with communities

STEP 1
Stakeholder Engagement
Partnership Advisory Network
Orientation Meeting
January 23, 2013

- Introduction to process
- Learning what stewardship action is already underway

STEP 2
Stakeholder Engagement
Partnership Advisory Network
Headwaters Indicators Forum
February 5, 2013

- Current headwaters integrity assessment results
- AECES historical trends mapping
- Aquatic Invasive Species
- Climate change
- Source to Tap Interim Report

STEP 3
Stakeholder Engagement
Partnership Advisory Network
Headwaters Action Plan -
Stewardship Inventory
May 2013

Partnership Advisory Network contribute to Headwaters Stewardship Inventory of current actions

STEP 4
Stakeholder Engagement
Partnership Advisory Network
Workshop #1
Determining Indicators of
Headwaters Integrity
June 24, 2013

Review and discussion of Headwaters Indicators; report findings; determining priority indicators for the Headwaters Action Plan 2013-14

STEP 5
Stakeholder Engagement
Partnership Advisory Network
Preliminary Meeting to
Workshop #2
September 10, 2013

How decisions will be made; principles of collaborative engagement and decision-making; Headwaters Integrity Handbook overview

STEP 6
Stakeholder Engagement
Partnership Advisory Network
Headwaters Integrity
Workshop #2
October 2-3, 2013

A collaborative approach on targets, policy, recommendations and stewardship action for headwaters health

STEP 7
Stakeholder Engagement
Draft Headwaters Action Plan
Partnership Advisory Network
Review
October-November 2013

Comments from PAN by
November 8, 2013

STEP 8
Public Engagement
Draft Headwaters Action Plan
Public Review
November 13-21, 2013

Presentation and review in 5 communities: Cordston, Nanton, Lethbridge, Cowley, Springpoint

STEP 9
Oldman Watershed Council
(OWC), Government of Alberta
Review and approval of the
Headwaters Action Plan
2014-15

Photos: Connie Simmons

FIGURE 5: Headwaters Action Plan
Community and Stakeholder Integrated Process

SOURCE TO TAP

Public Engagement: Conversations about water and headwaters health

Source to Tap Community Meetings

(Phase 1 - Nov/Dec 2012; Phase 2 - Feb/March 2013)

In Source to Tap Community meetings, Water Matters and the Oldman Watershed Council co-hosted local conversations in two phases of community meetings that focused on the use, health and stewardship action needs in the Oldman headwaters. Community participants shared local knowledge and understanding about water use, water quality, the health of headwaters and source waters, and identified activities or factors that impacted headwaters health. Community members also provided ideas and suggestions on stewardship action solutions to headwaters issues - an important foundation of public input in the development of the Headwaters Action Plan 2013-14.

Photo: Connie Simmons

Source to Tap
Phase 1: Use and Health of the Headwaters

Key focus: To share local knowledge and increase understanding about water use, water quality, and river health, and to identify activities or factors that impact headwaters health.

Phase 1 community conversations provided important perspectives on activities and factors that impact the health of the Oldman headwaters, and allowed community members to learn from each other, share their concerns and begin to consider what could be done for stewardship action in the headwaters.

1. Activities and factors that were seen to negatively impact the headwaters. The following themes, discussed by workshop participants across the Oldman Basin, identify activities or factors perceived or known by local residents to affect headwaters health in a negative way, thus providing opportunity for mitigation or stewardship activities to improve headwaters health:

- cumulative effects and linear disturbances
- recreation
- fire management
- grazing
- industrial and residential development
- invasive species
- regulatory and enforcement capacity
- political influence
- public awareness and education
- climate change and snowpack

2. Activities and factors that were seen to positively impact the health of the Oldman River headwaters and need to be encouraged, strengthened and supported:

- implementation of 'best management practices'
- recreation stewardship
- forest management practices
- local and traditional knowledge
- increased engagement and capacity of local citizens
- municipal government support
- provincial government support
- non-government organization and collaborative efforts

The themes of activities and factors that negatively or positively impact health of the Oldman headwaters provided a framework to move to community discussions in Phase 2 meetings.

Source to Tap
Phase 2: Caring for the Headwaters

In Source to Tap: Phase 2, community participants were informed about the outcomes of the first round of community Source to Tap meetings; provided an overview of the outcomes of the science research on the headwaters indicators assessment; and heard local stewardship presentations from ranchers, groups, industry and individuals. Community participants were then asked to consider what key priorities for stewardship action and potential solutions to the issues would be to manage and protect the integrity of headwaters and source waters.

Key focus: To encourage and gather local input on ways to protect the health of the Oldman headwaters.

Outcomes of Phase 2 community conversations provide important perspectives and ideas for stewardship action in the headwaters, and key points from participants were grouped to provide important context for consideration in the Headwaters Action Plan process.

A. Current Stewardship Practices

Community participants shared their understanding of current stewardship action and were supportive of what is currently happening to support headwaters health. Key points made by participants:

- healthy diversity of groups working on stewardship from a variety of interest perspectives and agendas – common concern re: sustainability of landscape for long-term health and human use. Recognition that all land uses have an impact
- general awareness of other stewardship efforts; however, lack of coordination between groups and agencies, therefore gaps and redundancies exist. Also, there is limited funding between players
- importance of working at the community level to engage local people and users is recognized by many
- important to balance economic and environmental benefits of stewardship; e.g. landowner stewardship activities must allow for economic and environmental benefits to landowners themselves, as well as to the public.

B. Stewardship Requirements and Opportunities

Community participants provided significant input on requirements and opportunities for stewardship in the headwaters and source water areas of the Oldman watershed.

Overarching requirements:

Land/Water Integration: The integration of land use and watershed planning and management, through the Land Use Framework, is essential to headwaters protection in the Oldman Basin. Water (both surface and groundwater) and the maintenance of the integrity and health of the watershed must be considered a primary value in land use decision-making.

Increased Funding Necessary for Stewardship Projects: Consolidation of and access to funding sources (grants, tax and cash incentives, compensation, rewards, etc.) is necessary to support individual landowners and watershed stewardship groups who are doing stewardship work to improve watercourses and riparian areas. Important to evaluate the benefits of good stewardship compared to the costs of mitigating damage to watersheds and water quality.

More Monitoring: Enhanced and ongoing monitoring and citizen science efforts that provide data and information are important for decision-making and provide a meaningful way of educating and engaging local people. Water and air quality monitoring are important objectives, especially in relation to oil and gas activity.

Education and Awareness/Capacity Building: The call for education, information sharing and capacity building was a strong theme across all communities, to help people to better understand the issues, impacts of land and human use activities on the headwaters ecosystems, and stewardship practices/tools available. Communications need to focus on certain audiences to maximize impact, e.g. youth audiences can be reached through social media, school field trips, outdoor clubs. Other ideas include:

- education for stewardship project planning
- education for school children; NGOs to work collaboratively to deliver classroom (school) programs so it is coordinated and adds value
- more youth education outdoors - especially in the headwaters - to connect them to water that comes out their tap
- adopt a stream bank/river bank
- educational presentations for communities, landowners
- connect art with stewardship - create a strong link
- education for kids, parents/teachers, ranchers/farmers/landowners, recreationalists, governments and Chambers of Commerce.

Communities engaged in Source to Tap: Phases 1 & 2
Cardston, Picture Butte, Twin Butte (phase 1 only), Lethbridge, Springpoint Hall, Crowsnest Pass, Stavely, Pincher Creek, Fort McLeod (phase 1 only), Lundbreck (phase 2 only).

Research, Information Sharing and Celebration of Best Practices: Recognition of successful stewardship activities and lessons learned are important to share and analyze. Research is needed on innovative ideas from other countries and regions, and impacts/benefits of certain practices. More targeted/applied science and specifically, the sharing of science studies that already exist is called for to support the application of stewardship projects. It is important to recognize and celebrate stewardship work and share stories amongst landowners, government agencies, communities, etc.

Building Partnerships and Collaboration: There is recognition that working through partnerships and collaborative efforts greatly enhances the chances of success for headwaters stewardship. It is necessary to work with others - neighbors, WPACs, MDs and conservation coordinators, Cows and Fish, Alberta Conservation Association, Ducks Unlimited, local communities, ranchers, conservation, community and recreation groups, churches, schools, etc. to get the job done. Collaboration is a skill and needs support to be successful.

Governance/Enforcement: Land use plans, management and strategies need to link with and be built upon grassroots needs, values and actions. Line of sight is required between the Landuse Framework and Water for Life - through regional and municipal planning and grassroots stewardship. Regulatory enforcement by government is needed. It is important to define conservation areas and stewardship opportunities under the South Saskatchewan Regional Plan, and manage/enforce accordingly. Enforcement is a clear government role and expectation (e.g. Natural Resources Conservation Board).

Participants also provided specific input on the needs and opportunities for stewardship focused key areas of concern: ranching, recreation, forestry, resource extraction and farming and irrigation.

Idea Generation: How to Build Long Term Stewardship Support

Community participants addressed the question of how to build support for stewardship, and provided substantial input on overarching ideas, as well as specific input for the key areas of concern: ranching, recreation, forestry, resource extraction, and farming and irrigation.

Overarching ideas for stewardship support include:

Water as Priority of Public Land Management: Set a higher political priority for water management in land use planning and implementation, redirecting public funding to support management. Enhancing and strengthening enforcement of regulations is critical. Public and community groups have a role to play in funding and supporting watershed management and stewardship.

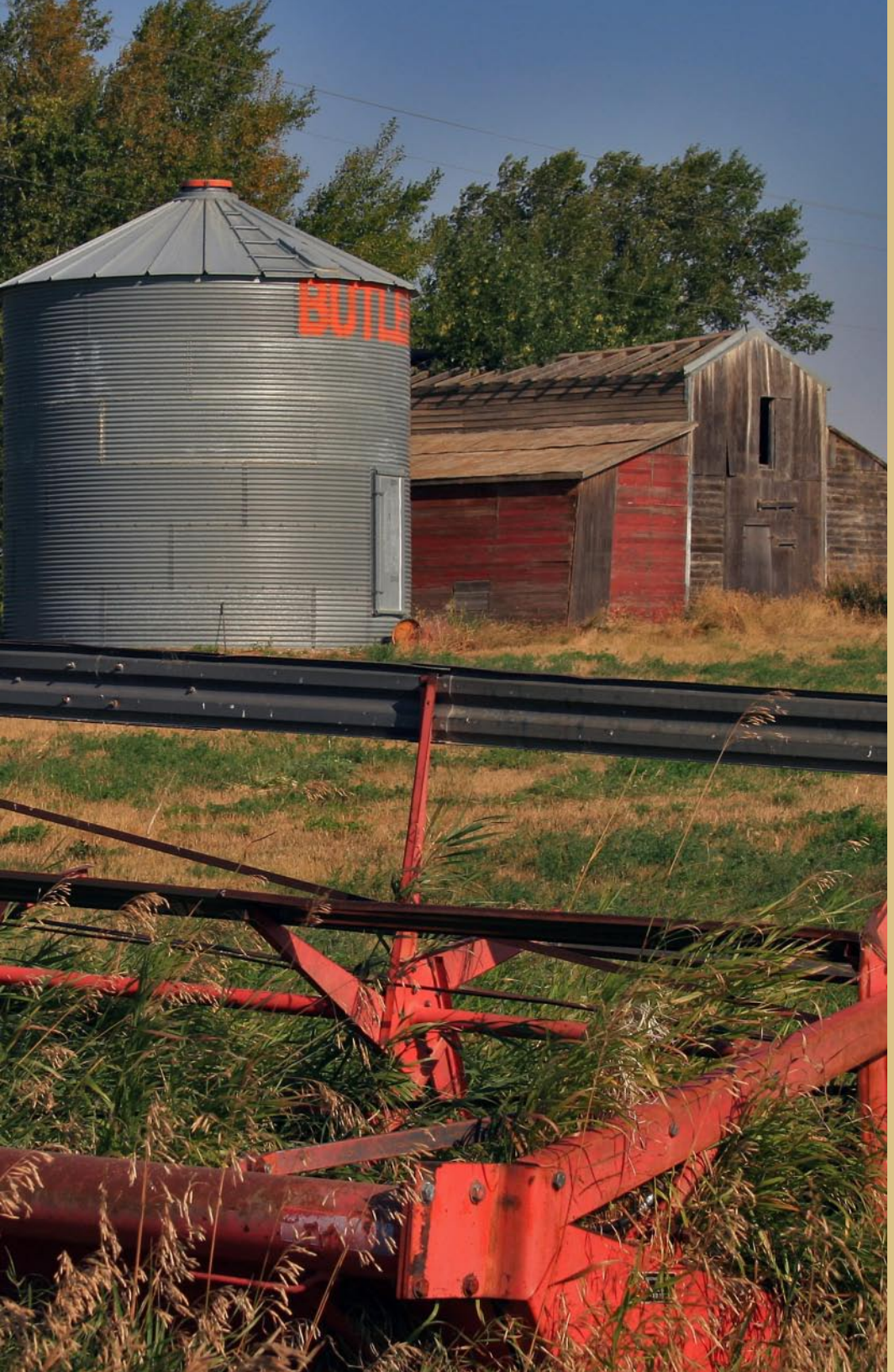
Enhance and Support Future Watershed Stewards: Stewardship initiatives need to attract more committed and active participation with the support of municipal governments, along with sustainable funding and resources for projects. Recruitment and engagement of the younger generation is important as a way of building future support for legislation, regulations and tools for stewardship. Ownership by the younger generation is necessary for long-term stewardship implementation.

Stewardship and Public Input into Land and Watershed Planning: Conservation and stewardship requires a stronger value and role in land use planning, and could be integrated into the planning and regulation of a number of land uses e.g. recreational activities, rural residential expansion, industrial development. Ongoing and meaningful public consultation in watershed management is called for. Public input is critical regarding changes in land use planning and changes to status of by-laws e.g. permitted uses or discretionary uses.

Strengthening the Link Between Education and Stewardship Action: Stewardship education is most meaningful when it links people with a special place or geography, especially if it is a home place. It is important to develop an understanding of watershed values and stewardship in schools and neighbourhoods, focused on local interests and hands-on learning. Also, it is important to connect people between sectors to share knowledge and perspectives, and build cross-sector partnerships: e.g. between recreation groups, farmers, oil and gas, ranchers and consumer groups like Slow Food. Linking education to action projects related to stewardship initiatives helps to build appreciation and deliver concrete results.

Source to Tap Phase 1 and 2 provide invaluable insights into public concerns about watershed and headwaters health, as well as input on stewardship action challenges, needs and opportunities. Of particular focus and importance is the growing recognition of the need for a collaborative approach across all sectors to address the complexity and growing need for real action on the ground to ensure long term sustainability and health of source waters and headwaters. The need to work with the public, private land-owners, government (municipal and provincial) and stakeholders has received support from the community participants. Information and support for focused stewardship action generated at the Source to Tap community meetings was shared with the Partnership Advisory Network for consideration in their work to develop the first iteration of the Headwaters Action Plan 2013-14.

Photo: Barry Olson



PARTNERSHIP ADVISORY NETWORK (PAN)
Stakeholder Engagement

The Headwaters Action Plan 2013-14 process included several key steps for the Partnership Advisory Network; each step provided important context and information for the planning process, and allowed the PAN members to work together to build the foundations for a collaborative approach to maintaining and protecting headwaters integrity.

Step 1: Headwaters Action Plan Orientation Meeting – January 23, 2013

An orientation meeting for invited stakeholders was held in Cowley, AB to introduce the concept and process of the Headwaters Action, and to request participation in the Partnership Advisory Network. The participants acknowledged that concerns related to headwaters health required a broader stewardship response from stakeholders and communities. A discussion about the meaning of stewardship also reflected the diversity of ideas, values and actions inherent in this central concept of the Headwaters Action Plan.

Step 2: Headwaters Indicators Forum - February 5, 2013

The Headwaters Indicators Forum, held in Pincher Creek, provided current information from scientific assessments of watershed integrity; an overview of current issues related to headwaters health; and a review of preliminary public input from the Source to Tap community conversations. The Forum provided participants the opportunity to hear from watershed science experts on the risks and pressures on headwaters health, and to hear and consider the general themes of public concern for the headwaters area. This information provided an important foundation for the next steps in the development of the Headwaters Action Plan 2013-14.

Headwaters Indicators Forum presentations included:

- Historical Trends Mapping of the Oldman Watershed
- Oldman Headwaters Indicators Report - assessment of indicators of headwaters health
- Aquatic Invasive Species - a threat to aquatic ecosystem health
- Climate Change and the Oldman Headwaters
- Source to Tap - Phase 1: Community input on themes of concern related to headwaters health.

Step 3: Headwaters Action Plan Interim Report - Stewardship Inventory - May 31, 2013

An interim report on the progress of the Headwaters Action Plan process included an inventory of current stewardship actions by members of the Partnership Advisory Network. Understanding the good work already being done in the headwaters provides a foundation for the Headwaters Action Plan 2013-14.

Step 4: Determining Indicators of Headwaters Integrity - Workshop #1 - June 24, 2013

The Partnership Advisory Network met in Pincher Creek for a full day workshop to review the finer points of the Headwaters Indicators Project (scientific assessment of headwaters health) and to determine the priority indicators of headwaters health the group will address in the Headwaters Action Plan 2013-14.

At the workshop, the Partnership Advisory Network provided:

- input on the Indicators of headwaters integrity from the Headwaters Indicators Project: what was most useful, what was missing, and what was most important to work on for additional information for the Headwaters Action Plan;
- input on what the PAN participants felt were the most important priority indicators to address in the current Headwaters Action Plan;
- input on the principles of engagement in the PAN as we move forward with the Headwaters Action Plan process;
- input on decision-making processes – what the PAN suggested would be the best way to collectively make decisions in the Headwaters Action Plan process.

After a thorough review and discussion on the outcomes of the scientific assessment of headwaters health, the Partnership Advisory Network voted on the priority indicators to address in the Headwaters Action Plan 2013-14.

> "We live and work in the headwaters. Our biggest and simplest action is to minimize impacts."
>
> "If you want to adapt, then you need to try different new things and move forward…. (but) how do you embrace adaptive management if rules stop this?"
>
> "We need to collaborate with education…. whatever we can promote collectively will be positive."
>
> (Partnership Advisory Network members, Feb. 5, 2013)

Partnership Advisory Network - Priority Indicators vote (June 24, 2013) (top 10 highlighted)

Indicator of Headwaters Integrity	Votes by the PAN members
Linear Features (intensity of use)	18
Water Quality	12
Intensity of Recreation use	11
Urban and industrial human land use	10
Riparian and range conditions	8
Invasive Species	8
Intact Landscapes	7
Soil Erosion Risk	7
Presence and abundance of native fish	6
Cumulative effects management	5
Changes in Climate	4
Natural disturbance and water flows	3
Storage capacity of wetlands	3
Stream Flow regime	3
Sediment disposition	3
Human population density and growth	1
Effectiveness of setback from water	1
Soil quality	0
Road density	0

The OWC took the advice of the PAN group, and where data was available, worked to fill gaps in information related to the priority ranking of headwaters indicators.

Linear features density and intensity of use was the top ranked priority concern of the PAN. A linear features density risk assessment rating is provided for 180 4th order sub-watersheds in the headwaters area in the Oldman Headwater Indicator Project. The OWC recognizes that reliable, current information and mapping of intensity of use (recreation and all other uses) in relationship to linear features density in the headwaters was a key request of the Partnership Advisory Network. In discussion with researchers and Environment and Sustainable Resource Development, the OWC found that there is no complete and reliable database available to provide a reasonable assessment of intensity of use of linear features in the Oldman headwaters at this time.

To address this key issue as it relates to headwaters health, the PAN worked from local knowledge of intensity of use in specified sub-watersheds in the Headwaters. During the June 24th workshop, PAN participants noted several geographic areas of concern related to intensity of use. These areas include (but may not be limited to):

- Racehorse Creek
- Dutch Creek
- Livingstone area
- West and South Castle River watersheds
- Crowsnest Pass/Star Creek
- Lynx Creek/Carbondale River
- Hidden Creek

Surface water quality was the second priority concern for the PAN. Government of Alberta data sets for water quality monitoring in the Oldman headwaters were not available at this time due to the immediate need to address June 2013 flood water assessments, and to complete 'Quality Assurance/Quality Control' (QAQC) reviews on the data before releasing it to the public. The OWC was assured that this would be completed in the near future.

Further to the unavailability of water quality data at this time, the OWC was also advised by ESRD that water quality testing in the Oldman headwaters may not provide a fine enough scale to pick up on certain aspects of headwaters water quality concerns - in particular, sediment loading and impacts on aquatic species.

As an important part of the Oldman Integrated Watershed Management Plan, the OWC will be working towards a full basin assessment on specific parameters of water quality assessment in the future. For this large task, a more in-depth discussion with the Partnership Advisory Network, and other key stakeholders across the Oldman Watershed will be needed to determine what standard of water quality (metrics) will be used for comparative analysis (i.e.: Alberta Water Quality Guidelines; Environment Canada Water Quality Objectives and Guidelines; U. S. Environmental Protection Agency Water Quality Standards). This discussion will also need to address exactly what parameters for testing need to be analyzed within the OWC's Water Quality Study.

To increase understanding of urban and industrial land-use and riparian and range condition, the OWC requested these additional assessments and mapping to be included in the Oldman Headwaters Indicator Project. A cumulative watershed integrity index assessment and map was also requested to provide a cumulative watershed integrity rating based on sound science and mapped at the 4th order sub-watershed level. The Watershed Integrity Index (WII) provides an overall assessment of risk to the headwaters, ranking each sub-watershed as either high-medium-low integrity, and is an important tool to assist prioritizing focused attention for stewardship and recommendations for policy action. All of this information is provided in the Headwaters Indicator Project report and shared with the Partnership Advisory Network members.

The OWC also requested a mapping overlay on what is currently known on the presence and abundance of native fish. ESRD Fish and Wildlife provided GIS spatial data on what is currently known in sub-watersheds that have been surveyed to date about critical habitat and spawning grounds for westslope cutthroat trout and bull trout. It is important to note that the entire headwaters region was historically home to bull trout and westslope cutthroat trout, and they have been extirpated from most of this historic range.

In 2002, bull trout (BTR) were listed under the Wildlife Act as a Species of Special Concern because of the declines in distribution and abundance, as well as continued threats from habitat alteration and introduced competitive species. The Alberta Bull Trout Conservation Management Plan 2012-2017 (AESRD; 2012) provides important information on impacts to bull trout population persistence, and management direction for the recovery of this important native fish species.

In 2013, the Alberta population of westslope cutthoat trout (WSCT) was listed as threatened under the Federal Species at Risk Act. WSCT are now listed in Alberta as threatened and an Alberta Westslope Recovery Plan (WSCT Recovery Plan) has been approved by the Minister of Environment and Sustainable Resource Development. The goal of the WSCT Recovery Plan is "to protect and maintain the existing ≥0.99 pure populations at self-sustaining levels and re-establish additional pure populations to self-sustaining levels, within the species historical range in Alberta. (Government of Alberta; March 2013). The WSCT Recovery Plan lists several threats to continued persistence of self-sustaining populations of this important native fish, including adverse impacts on habitat, invasive species and climate change.

Native fish are sensitive to both terrestrial and aquatic adverse impacts, and are an important indicator to help assess biodiversity and headwaters integrity. Adverse impacts on WSCT populations include threats from changes in water flow; forest removal (harvest; fire); water extraction (surface and groundwater); sedimentation (forest harvest, linear disturbance, grazing, OHV recreational access etc.); habitat loss and alteration; and loss of connectivity. Native fish can be linked also to water quality concerns (in particular - sediment loading on key spawning areas). In recognition of both terrestrial impacts on fisheries habitat and sedimentation as a top water quality concern in the headwaters area, the OWC included "presence and abundance of fish - especially native populations" as a priority indicator to be addressed in the Headwaters Action Plan 2013-14.

Invasive species are a priority concern in the Oldman watershed, and are a key focus in the Headwaters Action Plan. In partnership with ESRD and the Crown Manager's Partnership, the OWC and the PAN agreed to address the looming threat of three aquatic invasive species (AIS): zebra mussels, quagga mussels and eurasian water milfoil. These three AIS are considered a high threat to aquatic ecosystem health. Once introduced to a water-body, these species are virtually impossible to eradicate. They can transform and damage entire ecosystems, impact native species, and threaten Alberta's biodiversity. They can also damage boats, water equipment and are especially damaging to water infrastructure such as municipal water intakes, treatment plants and irrigation systems. The inclusion of AIS in the first iteration of the Headwaters Action Plan makes sense due to the threat of contamination in Alberta.

The OWC addressed further gaps in the assessment of the headwaters by requesting a map of unique landscapes and native plant communities in the Oldman headwaters. This map was created using data requested from ACIMS (Alberta Conservation Information Management Systems), and identifies where unique landscapes and known rare plant communities are in the headwaters area.

Photo: (US) National Park Service, Lake Mead

In reviewing the scientific information available and the priority ranking of indicators by the PAN, the focus for the development of Headwaters Action Plan 2013-14 narrowed to three important indicators of headwaters integrity:

1. presence and abundance of fish - especially native populations (an indicator of biodiversity and watershed integrity)
2. density of linear features (cumulative disturbance of roads, seismic lines, pipelines, power-lines, railroads, cut-lines, off-road vehicle trails across each sub-watershed in the headwaters area)
3. aquatic invasive species (AIS; zebra mussels, quagga mussels and eurasian watermilfoil.[11] All are classified as major threats to aquatic ecosystem health that we need to keep out of Alberta.

A Headwaters Indicators Workbook was developed and shared with the Partnership Advisory Network members to assist their organizations to prepare for the development of the Headwaters Action Plan. Information and maps on the three indicators, with questions that considered a full spectrum of possible actions were included in the workbook.

Step 5: Setting the Stage Meeting - consensus decision-making; priority indicator selection update; Headwaters Indicators Workbook introduction - September 10, 2013

Partnership Advisory Network members were invited to a meeting to review the Headwaters Indicators Workbook, and have an opportunity to discuss the selection of indicators for the first step to develop the Headwaters Action Plan 2013-14. A group discussion on how the PAN will work together through the process included clarification of representation of each stakeholder group, and agreement on a consensus decision-making model to use in the development of the Headwaters Action Plan.[12] PAN members were also advised that they would have opportunity to review and comment on the draft of the Headwaters Action Plan 2013-14, and would also be requested, through a signatory of their stakeholder group, to endorse the Final Headwaters Action Plan 2013-14. Endorsement of the plan is purely voluntary, and the option of a 'Statement of Concern' regarding the plan in whole or in part is also an option.

[11] Zebra mussel (Dreissena polymorpha); Quagga mussel (Dreissena rostriformis bugensis); Eurasian watermilfoil (Myriophyllum spicatum).

[12] Consensus Decision-Making Toolkit - a Martha Kostuch Legacy, Clean Air Strategic Alliance (CASA), May 2010. http://www.casahome.org/DesktopModules/Bring2mind/DMX/Download.aspx?Command=Core_Download&EntryId=670&PortalId=0&TabId=78

Step 6: Headwaters Integrity - Targets, Recommendations and Actions for Headwaters Health - Workshop #2 - October 2-3, 2013

The Partnership Advisory Network attended a two-day workshop to develop the first iteration of the Headwaters Action Plan. Representation at the workshop included 18 stakeholder groups, including municipalities, ranchers, non-government organizations, land-owners, industry and provincial government. The focus of the workshop was to address the 3 priority indicators of headwaters health, as determined at the June 24th workshop and availability of data and information related to these indicator priorities. The main goals of the workshop were to achieve three outcomes:

1. reach agreement on targets (desired outcomes) for headwaters health
2. reach agreement on recommendations for policy development to assist in achieving defined targets
3. develop a draft plan of stewardship action to achieve targets for headwaters health.

The Headwaters Indicators Workbook provided a foundation for discussion among the workshop participants. Additional supporting information and resources were also available for reference:

- Oldman Headwaters Indicators Project - Dr. Gillian Holloway (Fiera Biological Consulting Ltd) attended the second day of the workshop to clarify questions on the scientific assessment of headwaters integrity
- synthesis of public dialogue from Source to Tap Phase 2 community forums
- overview of other initiatives and reports related to headwaters integrity.

The Partnership Advisory Network participants were able to address each priority indicator of headwaters health and through in-depth group discussion and respectful consideration of all points of view. Working through facilitated discussion, the participants reviewed a broad range of action options, discussed and worked through the best possible action options, and achieved consensus on targets, recommendations to decision-makers, and stewardship actions for each indicator.These outcomes are included in this report in a table format (pages 34-51) outlining the target, action, target area, time-frame, links to other initiatives, community support, evaluation of success and progress to date.

Step 7: Stakeholder review of the Draft Headwaters Action Plan 2013-14 (Oct-Nov. 2013)

The Draft Headwaters Action Plan was reviewed by the Partnership Advisory Network in early November 2013. As requested and agreed upon by the workshop participants, the outcomes were not open to major amendments, but minor revisions were allowed to ensure clarity and minimize redundancies. The participants also agreed that a 'Statement of Concern' from any dissenting opinion to the plan, in whole or in part, be included as an addendum to the Headwaters Action Plan final report.

Step 8: Community review of the Draft Headwaters Action Plan 2013-14 (Nov. 2013)

The Oldman Watershed Council hosted 5 public meetings for community review of the draft Headwaters Action Plan 2013-14. Meetings were held in November 2013 in Cardston, Springpoint, Nanton, Cowley and Lethbridge. Presentations on the draft plan and facilitated group discussions were completed to evaluate and record community response to the draft Headwaters Action Plan 2013-14. An online survey was also shared with the OWC membership to encourage further public input.

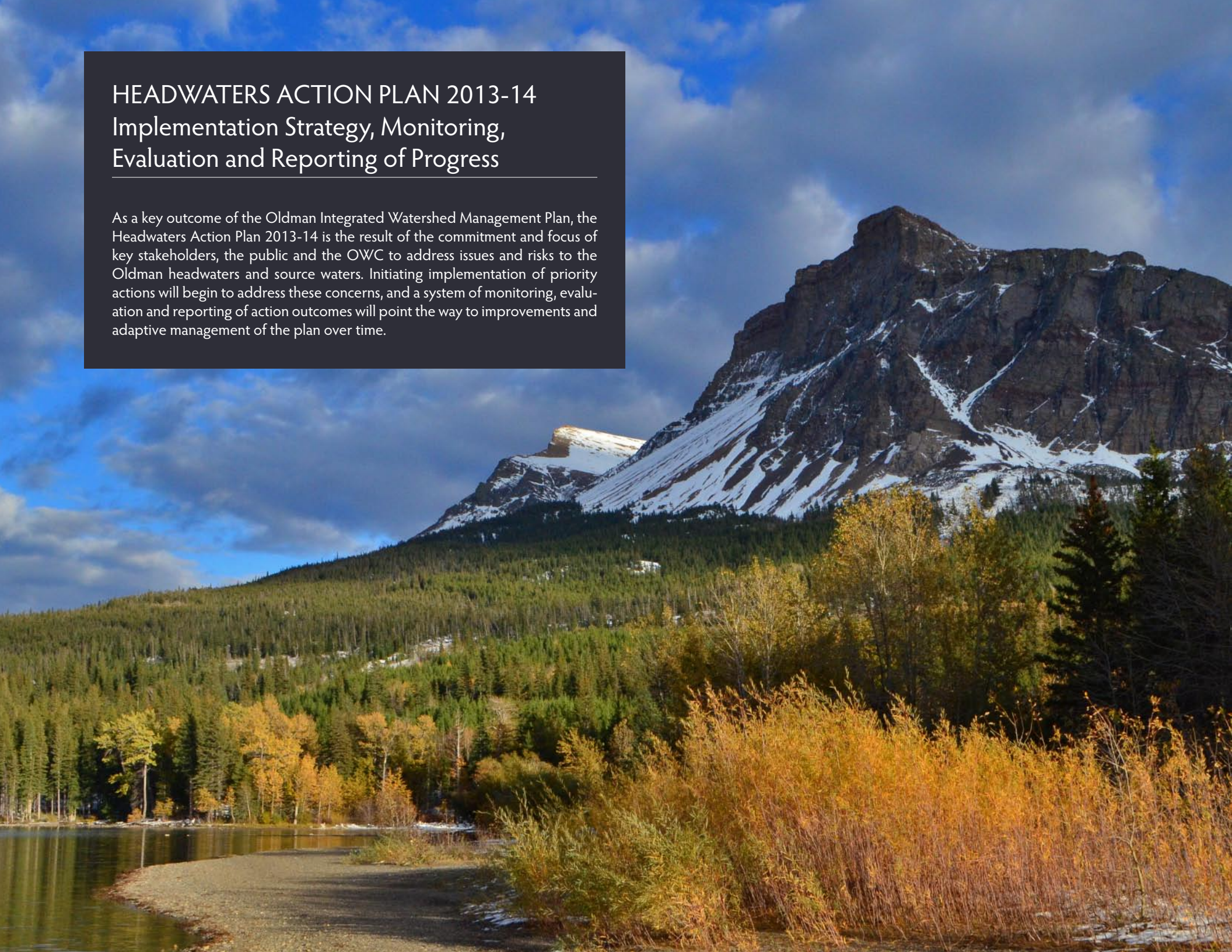
A report on "Headwaters Action Plan 2013-14 Public Review - November 2013 - "What We Heard" was completed and the outcomes shared with the Partnership Advisory Network and the greater public. The community evaluation provided suggestions for revisions and clarification to the action plan, and helped determine priority actions for implementation. These concerns were subsequently reviewed and discussed by the Partnership Advisory Network members, and revisions to the plan to address these concerns were agreed upon by consensus.

Step 9: Approval of the Plan (2014-15)

The Headwaters Action Plan 2013-14 was approved by the Oldman Watershed Council Board of Directors, and submitted to the Government of Alberta for review and approval as a deliverable of the Oldman Integrated Watershed Management Plan.

HEADWATERS ACTION PLAN 2013-14
Implementation Strategy, Monitoring, Evaluation and Reporting of Progress

As a key outcome of the Oldman Integrated Watershed Management Plan, the Headwaters Action Plan 2013-14 is the result of the commitment and focus of key stakeholders, the public and the OWC to address issues and risks to the Oldman headwaters and source waters. Initiating implementation of priority actions will begin to address these concerns, and a system of monitoring, evaluation and reporting of action outcomes will point the way to improvements and adaptive management of the plan over time.



Prioritizing Action for the Headwaters

The OWC and the Partnership Advisory Network met January 31, 2014 for an 'Implementation Strategy' workshop. The purpose of the workshop was to:

1. agree on priority actions for Year 1 and Year 2 of implementing the Headwaters Action Plan 2013-14
2. form the Headwaters Action Team as a representative group of the Partnership Advisory Network. The purpose of the Headwaters Action Team is to begin the work of implementing the priority actions of the Headwaters Action Plan 2013-14 through seeking and engaging collaborative partnerships for each action; fund-raising and/or requesting in-kind contributions; and completing a monitoring, evaluation and annual reporting process for the Headwaters Action Plan 2013-14
3. request endorsement of the Headwaters Action Plan 2013-14.

Headwaters Action Plan 2013-14 - Implementation Strategy

The Headwaters Action Team is comprised of representatives from agriculture/land-owners, industry, non-government organizations, municipal and provincial government, recreation and the Oldman Watershed Council.

The Headwaters Action Plan 2013-14 was reviewed by the Partnership Advisory Network participants, and priority actions were agreed upon through a consensus process. For the first two years of implementation of the Headwaters Action Plan (2014-16), four key actions were rated as highest priority:

1. complete a 'Classification of Linear Features' project (a priority prerequisite action)
2. complete a fine scale cumulative effects assessment of fish populations and habitat streams
3. assist ESRD with education and awareness program (Stop Aquatic Hitchhikers!) for stakeholders and the public on how to prevent AIS from entering Alberta
4. explore options for recreation user fees to fund enforcement, education and stewardship projects.

In addition to these priority actions, the PAN participants recognized that awareness and education action were important to integrate into the implementation of all priority actions. Working with the diversity of PAN participants within their organizational capacities, these projects allow innovative and collaborative opportunities between sectors, and are an important part of the Headwaters Action Plan 2013-14 implementation strategy.

Photo: Connie Simmons

Headwaters Action Team members commit to 2 years at a time to implement priority actions, and monitor, evaluate and report on progress, lessons learned and adaptive management needs. During each two year implementation period, the Headwaters Action Team will inform the Partnership Advisory Network on progress, and at the end of the implementation effort, will recommend and seek approval from the Partnership Advisory Network to adapt and/or change priority actions as required.

Thank You

The Oldman Watershed Council expresses sincere appreciation and thanks to the commitment and continued interest of the members of the OWC Integrated Watershed Management Team, Partnership Advisory Network, Headwaters Action Team and the public.

The Headwaters Action Plan is truly the 'community's plan'. Working collaboratively within the greater watershed community, we can solve problems, make informed trade-offs, and ensure a healthy watershed that supports a high quality of life for all.

GLOSSARY

Adaptive Management
Involves a continuous cycle of planning, implementation, measuring progress and making adjustments that improve the plan over time.

Alluvial Aquifer
Subsurface geological unit along a river or stream that is hydraulically connected to the surface water body. This is an unconfined aquifer but not all unconfined aquifers are in alluvial deposits (Bow River Basin Council, 2008).

Aquatic Ecosystem
The Water Act defines the aquatic environment as the components of the earth related to, living in or located in or on water or the beds or shores of a water body, including but not limited to: 1. all organic an inorganic matter, and2. living organisms and their habitat, including fish habitat, and their interacting natural systems (Alberta Environment, 2011).

Criteria
Criteria are categories of watershed conditions or processes that characterize aquatic and terrestrial environments used to evaluate watershed condition. They include a suite of conservation values and goals for watershed management and are representative or related to specific watershed elements (e.g. water quality, water quantity).

Ecological Goods and Services (EGS)
Economic and social benefits resulting from the natural processes of a healthy environment and biodiversity. These are available to all of society and are essential to sustaining a healthy and prosperous way of life. They include groundwater recharge, flood and erosion control, wildlife habitat, productive soils, carbon dioxide sequestration and abundant clean air and water (Bow River Basin Council, 2008).

Goal (as used in this report)
A goal is the desired result a person or a system envisions, plans and commits to achieve; personal or organizational desired end-point in some sort of development within a finite time period through setting deadlines Objectives, Goals, Strategies. (http://en.wikipedia.org/wiki/Objective_(goal)).

Groundwater
Water located beneath the ground surface in soil pore spaces and in the fractures of geologic formations. A formation of rock/soil is called an aquifer when it can yield a useable quantity of water. Groundwater that is in an aquifer that readily flows naturally under the ground to surface water bodies is considered surface water for licensing purposes in Alberta (Alberta Environment, 2006).

Hydrologically Significant Areas
Hydrologically significant areas most actively contribute to runoff generation. They are the regions more susceptible to producing run off which provide a direct hydrological link between landscape and primary source water bodies. They are the areas within a watershed where the distribution of surface water is concentrated i.e., lakes, rivers, swamps.

Headwaters
The source for a stream, located in the upper tributaries of a drainage basin. (South Saskatchewan Regional Advisory Council, 2011).

Indicator
Indicators are measures of watershed condition within each Criteria. They are used to observe, evaluate and describe trends within each watershed assessment Criteria (e.g. under Water Quality Criteria, an indicator would include (but not limited to) measures of surface water quality and sediment loads).

Instream Objectives (IO)
Flows that are to remain in the stream to protect instream values or some portion of them. IOs in the Oldman watershed have been developed using a variety of methodologies, some of which have a more scientific basis and provide a higher degree of protection than others. Some IOs provide limited protection of the aquatic environment (Oldman Watershed Council, 2010a).

Integrated Land Management (ILM)
The strategic planned approach to managing and reducing the human-caused footprint on public land. ILM is not a plan or a process. ILM is a way of doing business and a way of thinking, by sharing the land and working together so that land users can reduce their impact on the land (South Saskatchewan Regional Advisory Council, 2011).

Main Stem
In relation to hydrology, a main stem is "the primary downstream segment of a river, as contrasted to its tributaries". Another common term for the main stem, the final large channel of a riverine system, is the trunk. Water enters the main stem from the river's drainage basin, the land area through which the main stem and its tributaries flow (http://en.wikipedia.org/wiki/Main_stem).

Native Fish
Fish species that are native to the Oldman watershed. These species include (but not limited to) westslope cutthroat trout, bull trout and mountain whitefish.

Naturalized fish
Fish species that have been introduced, and have adapted to a new range of aquatic habitat, e.g. rainbow trout in the Oldman headwaters area.

Non-point Source
Pollution that cannot be traced to a single site or source. It is often characterized by garbage, trash, fertilizers, oils, pesticides and other waste and debris (La Salle River Watershed Planning Authority, 2010).

Objective (as used in this report)
An end that can be reasonably achieved within an expected timeframe and with available resources. In general, an objective is broader in scope than a goal, and may consist of several individual goals. Objectives are basic tools that underlie all planning and strategic activities. They serve as the basis for policy and performance appraisals. Objectives, Goals, Strategies (http://www.businessdictionary.com/definition/objective.html).

Point Source
Pollution from a single identifiable source, such as a wastewater effluent pipe discharging into a river (La Salle River Watershed Planning Authority, 2010).

Potable Drinking Water
Drinking water or potable water is water pure enough to be consumed or used with low risk of immediate or long term harm. (http://en.wikipedia.org/wiki/Drinking_water)

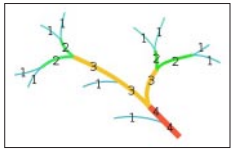
Private Water Source
A surface or groundwater source that provides water to a single connection, most often a home or farm (Little Saskatchewan River Conservation District, 2010).

Public Water Source
A surface or groundwater source that provides water to a system with 15 or more service connections (Little Saskatchewan River Conservation District, 2010).

Riparian
The area along streams, lakes and wetlands where water and land interact. These areas support plants and animals, and protect aquatic ecosystems by filtering out sediments and nutrients originating from upland areas (South Saskatchewan Regional Advisory Council, 2011).

Source Water
Raw/untreated water received for treatment to provide potable water to municipal, industrial or private users. Sources may include high quality groundwater, groundwater under the influence of surface water and surface water from a lake, stream, river or watercourse (South Saskatchewan Regional Advisory Council, 2011).

Strahler 4th Order Stream
Strahler stream order is used to define stream size based on a hierarchy of tributaries. A fourth order stream is where tributary streams of a first, second and third order have merged to become a 4th order stream.
(See: www.http://en.wikipedia.org/wiki/Strahler_number)



Stream Channelization
Stream channelization describes any activity that moves, straightens, shortens, cuts off, diverts, or fills a stream channel, whether natural or previously altered. Such activities include the widening, narrowing, straightening, or lining of a stream channel that alters the amount and speed of the water flowing through the channel. Examples of channelization are: lining channels with concrete; pushing gravel from the stream bed and placing it along the banks; and placing streams into culverts (from US EPA; Fact Sheet 1; Region 7).

Terrestrial Ecosystem
A terrestrial ecosystem is an ecosystem found only on a landform. Five primary terrestrial ecosystems exist: tundra, taiga, temperate, deciduous forest and grassland. A community of organisms and their environment that occurs on the land masses of continents and islands. Terrestrial ecosystems are distinguished from aquatic ecosystems by the lower availability of water and the consequent importance of water as a limiting factor (http://en.wikipedia.org/wiki/Terrestrial_ecosystem).

Total Suspended Solids (TSS)
A qualitative measure of the solid organic or inorganic particles that are held in suspension in wastewater, effluent, or water bodies, determined by tests for "total non-filterable residue" (Oldman Watershed Council, 2010a).

Tributary
A tributary or affluent is a stream or river that flows into a main stem (or parent) river or a lake. A tributary does not flow directly into a sea or ocean. Tributaries and the mainstem river serve to drain the surrounding drainage basin of its surface water and groundwater by leading the water out into an ocean or sea. A confluence where two or more bodies of water meet together, usually referring to the joining of tributaries (http://en.wikipedia.org/wiki/Tributary).

Water Conservation Objective (WCO)
The Water Act defines WCOs as the amount and quality of water necessary for the protection of a natural water body or its aquatic environment, or any part of them; protection of tourism, recreational, transportation or waste assimilation uses; or management of fish or wildlife. WCOs were established in the Oldman watershed following completion and government approval of the South Saskatchewan River Basin Water Management Plan (Oldman Watershed Council, 2010a).

Watershed Integrity
The quantity and quality of water a watershed produces relative to natural conditions and climate variability; a measure of the degree of natural ecological structure and function within a watershed (South Saskatchewan Regional Advisory Council, 2011).

Wetland
Land saturated with water long enough to promote wetland or aquatic processes as indicated by the poorly drained soils, vegetation and biological activity that is adapted to a wet environment (South Saskatchewan Regional Advisory Council, 2011).

REFERENCES

Alberta Environment, 2003. *Water for Life: Alberta's Strategy for Sustainability,* Alberta Environment, November 2003. http://www.waterforlife.gov.ab.ca

Alberta Environment, 2008. *Water for Life: A Renewal*. Alberta Environment, November 2008. http://www.waterforlife.alberta.ca

Alberta Environment and Sustainable Resource Development, 2012. *Stepping Back from the Water: A Beneficial Management Practices Guide for new development near water bodies in Alberta's settled region*. http://environment.gov.ab.ca/info/library/8554.pdf

Alberta Environment and Sustainable Resource Development, 2008. *Alberta Grizzly Bear Recovery Plan 2008-2013*. Alberta Species at Risk Recovery Plan No. 18. http://esrd.alberta.ca/fish-wildlife/wildlife-management/bear-management/grizzly-bears/documents/GrizzlyBear-RecoveryPlan2008-13-revJuly23-2008.pdf

Alberta Environment and Sustainable Resource Development, 2012. *Watershed Management Audit of Risks to Regional Water Supply as a Result of Forest Management - C5 Forest Management Unit*. Prepared for the Forest Management Branch, Forestry Division, Alberta Sustainable Resource Development; Urban Systems Ltd; July 31, 2012. USL File No. 3021.0008.01

Alberta Environment and Sustainable Resource Development. *Stop Aquatic Hitchhikers from entering Alberta*. http://aesrd.wordpress.com/2013/06/19/stop-aquatic-hitchhikers-from-entering-alberta/

Alberta Water Council, 2008. *Strengthening Partnerships - A Shared Governance Framework for* Water For Life *Collaborative Partnerships, September 2008*. http://www.albertawatercouncil.ca/Portals/0/pdfs/SG%20Final%20Report%2009-01-28.pdf

Chief Mountain Cumulative Effects Study, 2011. Prepared by Silvatech Consulting Ltd. for the Chief Mountain Landowners Information Network. www.watertonbiosphere.com

Clean Air Strategic Alliance, 2010. *Consensus Decision-Making Toolkit - a Martha Kostuch Legacy.* Clean Air Strategic Alliance (CASA), May 2010. http://www.casahome.org/DesktopModules/Bring2mind/DMX/Download.aspx?Command=Core_Download&EntryId=670&PortalId=0&TabId=78

Community Values Assessment for M.D. Pincher Creek No. 9, 2009. Prepared by: The Praxis Group for the Southwest Alberta Sustainable Community Initiative and the Municipal District of Pincher Creek No. 9, March 2012. http://www.sasci.ca/display/ShowFiles?moduleId=5001781&directoryId=777662&SSScrollPosition=173

Government of Alberta, 2013. *Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017 - Alberta Species at Risk Recovery Plan No. 28.* Government of Alberta, March 2013.
Publication No: I/604.
ISBN No. 978-1-4601-0231-2 (on line edition)
ISSN: 1702-4900 (On-Line Edition)
http://www.srd.gov.ab.ca/fishwildlife/speciesatrisk/default.aspx

Government of Alberta, 2012. *Bull Trout Conservation Management Plan 2012-2017 - Alberta Conservation Management Plan No. 8.* Government of Alberta, March 2012
Publication No.: 1/604
ISBN: 978-1-4601-0230-5 (Printed Edition)
ISBN: 978-1-4601-0231-2 (On-line Edition)
ISSN: 1922-9976 (Printed Edition)
ISSN: 1922-9984 (On-line Edition)
http://srd.alberta.ca/BioDiversityStewardship/SpeciesAtRisk/Default.aspx

Holroyd, Peggy. Towards Acceptable Change: A Thresholds Approach to Cumulative Effects of Land use Change in the Southern Foothills of Alberta. Masters Thesis, Faculty of Environmental Design, University of Calgary, January 2008. http://www.salts-landtrust.org/sfs/docs/D_080128_holroyd_thesis_thresholds.pdf

Landscape Patterns Environmental Quality Analysis, 2013. Prepared by: O2 Planning and Design, May 9, 2013 for Department of National Defense: Canadian Forces Base Suffield; U.S. Fish and Wildlife Service: Great Northern and Plains; Prairie Potholes Landscape Conservation Cooperatives; Alberta Environment and Sustainable Resource Development; Crown Managers Partnership; Prairie Conservation Forum; The Oldman Watershed Council. May 2, 2013. http://environment.gov.ab.ca/info/library/8882.pdf

Mirau, Neil A. *South Saskatchewan Regional Plan (SSRP) Traditional Use Studies Project,* March 2009. Additional contributors: First Rider, Dorothy. http://epl.bibliocommons.com/item/show/829659005_south_saskatchewan_regional_plan_(ssrp)_traditional_use_studies_project#sthash.ak2dy0Mx.dpuf

Oldman Watershed Council, 2010. *Oldman River State of the Watershed Report 2010.* Oldman Watershed Council, Lethbridge, Alberta. 284 pgs.
ISBN: printed 987-0-09866051-2-3
ISBN: online 987-0-9866031-3-0
http://www.oldmanwatershed.ca

Oldman Watershed Council. 2010. *Oldman Watershed Planning Vision: A Process Summary.* Oldman Watershed Council. Lethbridge, Alberta. 32pp.
ISBN: printed 978-0-9866051-0-9
ISBN: online 978-0-9866051-1-6
http://www.oldmanwatershed.ca

Oldman Watershed Council, 2011. *Oldman Watershed Planning Priorities: Process Summary and Recommendations*. Oldman Watershed Council, Lethbridge, Alberta. 96pp.
ISBN: printed 978-0-9866051-4-7
ISBN: online 978-0-9866051-5-4
http://www.oldmanwatershed.ca

Oldman Watershed Council, 2011. *Priorities for the Oldman Watershed: Promoting action to maintain and improve our watershed*. Oldman Watershed Council, Lethbridge, Alberta. 54pp.
ISBN: printed 978-0-9866051-6-1
ISBN: online 978-0-9866051-7-8
http://www.oldmanwatershed.ca

Oldman Watershed Council, 2012. *Goal 1 – Action Plan "Promoting Action to Maintain and Improve our Watershed"*.
http://www.oldmanwatershed.ca

Oldman Watershed Council, 2013. *Crowsnest River Watershed Aquifer Mapping and Groundwater Management Planning Study - TWPS 006 to 009, RGES 01 to 06 W5*. Prepared for the Oldman Watershed Council by Waterline Resources Inc., Calgary, AB., March 2013. 2170-12-001 ALBERTA.
http://www.oldmanwatershed.ca

Oldman Watershed Council, 2014. *Headwaters Action Plan 2013-14 Public Review - November 2013 - "What We Heard" Report*.
http://www.oldmanwatershed.ca

Oldman Watershed Council, 2014. *Oldman Headwaters Indicators Project - Final Report version 2014.1*. Prepared for the Oldman Watershed Council by Fiera Biological Consulting Ltd., February 20, 2014.
http://www.oldmanwatershed.ca

Southern Foothills Study - the Changing Landscape of the Southern Alberta Foothills, 2007. Prepared for the Southern Alberta Land Trust Society by Alan Gardner; Southern Alberta Land Trust Society and Dr. B. Stelfox; Alberta Landscape Cumulative Effects Simulator (ALCES). http://www.salts-landtrust.org/sfs

United States Environmental Protection Agency, 2008. *Handbook for Developing Watershed Plans to Restore and Protect our Waters*. Office of Water. Non-point Source Control Branch, Washington, D.C. 20460. EPA 84-B-08-002. March 2008.
http://water.epa.gov/polwaste/nps/handbook_index.cfm

University of Alberta, 2008. Southern Rockies Watershed Project: *Impact of natural disturbance by wildfire on hydrology, water quality, and aquatic ecology of Rocky Mountain watersheds*. Phase I (2004-2008).
http://www.srwp.ualberta.ca or http://www.oldmanwatershed.ca

Valdal, Eric J. and Michael S. Quinn, 2010. Spatial Analysis of Forestry Related Disturbance on Westslope Cutthroat Trout (corhynchus clarkii lewisi): Implications for Policy and Management. Appl. Spatial Analysis. DOI 10.1007/s12061-009-9045-5. Published online January 12, 2010.

Values and Voices: Stewardship Priorities for the Southern Alberta Foothills, 2011. Report of the Southern Foothills Community Stewardship Initiative, November 2011. http://www.pekisko.ca or http://www.aref.ab.ca/resourcelibrary/documents/values-and-voices.pdf

Water Matters Society of Alberta; 2013. *Source to Tap: Community Conversations on Headwaters Health and Stewardship in the Oldman Basin*. Summary of Community Dialogues, November 2013. http://www.oldmanwatershed.ca

Photo: Jollin Charest

OLDMAN HEADWATERS ACTION PLAN

Moving towards implementation of priority actions

Alberta's Water For Life Strategy emphasizes the need for shared responsibility in watershed management planning and implementation of planning outcomes. The Oldman Headwaters Action Plan includes the development of recommended actions to protect, restore and maintain headwaters integrity, while supporting the needs and values of the greater watershed community. While all watershed management plans in Alberta are non-regulatory and have no statutory authority, their strength resides in the agreement of stakeholders, government and the public to work collaboratively to realize common goals and desired outcomes for watershed health.

The Headwaters Action Plan outcomes are provided in table format in the following pages, and are organized according to defined targets, actions (through engaged partnerships), and recommendations to decision-makers. Actions and recommendations are further clarified through alignment with current government policy, support from the community, links to other initiatives, and the role of the Oldman Watershed Council in the implementation of collaborative actions.

The Headwaters Action Plan is an ongoing adapted management process that works within the capacities and resources of all partners, and takes into account improvements in watershed science and the progress of management initiatives underway or completed.

Government of Alberta agencies have overarching roles and responsibilities that are defined by legislation, and are often the lead in the implementation of priority actions of watershed management plans. Partnership activities are essential for the effective implementation of watershed management plans, and communication between all partnerships on a regular basis is important to ensure that policy, planning and actions are integrated and supporting the achievement of shared outcomes.

The Oldman Watershed Council looks forward to working with committed and engaged stakeholders and watershed residents to address headwaters health over the coming years. Through community engagement, education, partnerships and shared goals, we will all become more effective stewards of this important source water/headwaters region of the Oldman watershed.

Oldman Headwaters Action Plan:
Definitions of key elements of the plan

Targets: the goal of each indicator of headwaters health (desired environmental condition)

Actions: initiatives that engage partnerships (within their mandates and capacity) in collaborative work that will help achieve the action goal.

Recommendations: advice to decision-makers for policy and regulatory changes that are foundational to achieving the actions.

Proposed Implementers: key stakeholders, agencies, and groups who have the mandate and capacity to achieve the actions, in whole or in part.

ACTION PLAN • Indicator 1: Presence and abundance of fish, especially native populations (an indicator of biodiversity and watershed integrity)

TARGET 1: Maintain current native and naturalized fish population integrity within the headwaters and explore opportunities to increase native fish populations in their current range.

Action	Target Area	Time-frame	Proposed Implementers (Lead Agency bolded)	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Link to Other Initiatives	Watershed Criteria addressed by the action	OWC Facilitate, Recommend, Action, Participate	Evaluation of Success	Progress
1. Complete a fine scale cumulative effects assessment of fish populations and habitat streams to: • determine where native and naturalized fish populations remain • monitor population trends over time • determine what impacts are contributing to declining populations. Ensure information of the assessment is clear and publicly accessible and offer opportunities for citizen science and stewardship action to support species persistence.	Headwaters	Ongoing	**Government of Alberta** Alberta Conservation Association Cows & Fish Trout Unlimited	*Source to Tap* community conversations identified research and information sharing is needed to determine impacts of practices, and focus stewardship efforts. *MD Pincher Creek Community Values Survey* rated erosion of ecosystems as undesirable. *Oldman Watershed Planning Priorities* identifies cumulative effects as a top risk to watershed health. *'What We Heard'* Headwaters Action Plan 2013-14: Public Review saw this indicator as a logical place to start, and that the public would identify with native fish species. Participants also saw the need for education and outreach related to fish species at risk.	Biodiversity and Ecosystems - Objective: Terrestrial and aquatic biodiversity are maintained; species at risk are recovered. (SSRP; 68) Headwaters - Objective: Headwaters in the region are managed to maintain recharge capabilities and support critical water quality, quantity and aquatic ecosystem requirements. (SSRP; 87) The aquatic environment and the water that people in the region rely on cannot be sustained unless headwaters are protected... collaboration and shared stewardship will be essential to achieving responsible management. (SSRP; 87) The South Saskatchewan Region Biodiversity Management Framework is a new approach to support cumulative effects management of important elements of biodiversity that are affected by land-uses in the region. (SSRP; 130) The framework will focus on key indicators that represent the broad range of biodiversity in the region. The indicators will reflect species, habitats and landscapes that sustain long-term ecosystem health (e.g., headwaters areas and existing intact native grasslands). (SSRP; 130) Objectives for biodiversity and healthy, functioning ecosystems will be incorporated to achieve multiple objectives. Watershed management and headwaters protection is the priority. Forests will be managed with this as the highest priority (including water storage, recharge and release functions). (SSRP; 58) Linear footprint disturbance will be minimized through linear footprint management planning for Green and White Area public land. Research and species recovery planning initiatives have shown that managing linear footprint... and motorized access are the most significant actions that can be taken to support biodiversity. There will be a focus on priority areas for the eastern slopes... including: key headwaters areas, areas of sensitive terrestrial and aquatic habitat and other areas of high biodiversity value including for connectivity.' (SSRP; 61)	Alberta Westslope Cutthroat Trout Recovery Plan - threat assessment identifies cumulative and synergistic effects on WSCT including: • Invasive species • Adverse effects on habitat • Consumptive use/ exploitation; • Stocking • Pollution • Climate change Bull Trout Conservation Management Plan 2012-2017 - limiting factors for bull trout distribution and abundance are: • Habitat fragmentation • Culvert (movement barriers) • Dams • Irrigation canals • Stream flow • Peak flow intensity • Roads • Groundwater flow • Sedimentation (water quality) • Stream temperature • Cumulative impacts Further research and inventory of bull trout populations, ecology, habitat requirements and impacts of industrial activities and non-native species is needed for management of this species.	Biodiversity Water quality Watershed integrity Water Levels and Flow	Facilitate Recommend Participate OWC can help by facilitating the education and communication on the results to the public.	Completion of an inventory and cumulative effects assessment of native fish populations and habitat in the headwaters. Reasons for declining populations are identified and mitigation measures are in place. Monitoring of populations continues. Information from the assessment is shared with stakeholders and the public; and citizen science and stewardship action is encouraged and supported.	Government of Alberta: 1. Westslope cutthroat trout and bull trout surveys are continuing in the headwaters. Not all sub-watersheds have been surveyed. Data will become available as surveys are completed. 2. Detailed land use assessment in westslope cutthroat trout watersheds is ongoing. Alberta Conservation Association is completing westslope cutthroat trout and bull trout population surveys in the Oldman headwaters. Shell Waterton - funding provided to Alberta Conservation Association to continue bull trout population and habitat studies in the headwaters. Trout Unlimited is involved in the Alberta Westslope Cutthroat Trout Recovery Plan.

ACTION PLAN • Indicator 1: Presence and abundance of fish, especially native populations (an indicator of biodiversity and watershed integrity), continued

TARGET 1: Maintain current native and naturalized fish population integrity within the headwaters and explore opportunities to increase native fish populations in their current range.

Action	Target Area	Time-frame	Proposed Implementers (Lead Agency bolded)	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Link to Other Initiatives	Watershed Criteria addressed by the action	OWC Facilitate, Recommend, Action, Participate	Evaluation of Success	Progress
2. Develop an education and outreach program to address: 1. importance of headwaters health and healthy trout streams 2. impacts on headwaters integrity caused by proliferation/intensity of use of linear disturbance 3. impacts of sedimentation in streams 4. importance of fish populations as an indicator of biodiversity/watershed integrity 5. encouragement of a stewardship ethic in motorized recreation users to safeguard headwaters health 6. how people can be part of the solution to headwaters concerns. The program should include: a) 'Adopt a Watershed Program' to engage people and groups to understand pressures and risks to their watershed; implement stewardship actions; and share information about their adopted watershed b) encouraging users to adopt practices that reduce sediment in streams c) a focus on youth and user groups.	Head-waters	2014-Ongoing	Oldman Watershed Council Government of Alberta Partnership Advisory Network members	*Source to Tap* community conversations identified education and awareness as a major need, especially for recreational users and youth, suggested focus on local place-based issues and BMPs and get people engaged with hands on activities outdoors. *Priorities for the Oldman Watershed: Promoting action to maintain and improve our watershed* identifies community engagement as the top priority of the Integrated Watershed Management Plan for the Oldman basin. *South Eastern Slopes Task Force:* emphasized recommendation for Gov't of Alberta to develop broad public education and awareness around appropriate use and conduct on public lands *'What We Heard'* Headwaters Action Plan 2013-14: Education was seen as a critical need. Understanding pressures and risks to headwaters health must be communicated to the public, and actions to maintain and protect headwaters health supported through awareness and education programming.	Education and awareness and delivery of compliance programs (including enforcement) to promote and support responsible land use and shared stewardship are essential to managing recreational activities to achieve environmental outcomes. Education promotes compliance by raising awareness, not only of the importance of environmental stewardship, but also of the regulatory requirements and potential consequences of not complying. (SSRP; 91) Education, awareness and compliance efforts will include the following: an 'on-the-ground' program, including seasonal outreach staff with field presence; responsible use messaging; continuing environmental literacy strategies; co-operative compliance programs, working with local governments and other agencies, during times of heavy demand during the recreation season; and support for programs promoting responsible use sponsored by the recreation community. (SSRP; 96).	Cows and Fish is working to improve riparian habitat around westslope cutthroat trout streams, and have provided workshops and citizen engagement opportunities to reclaim/replant riparian areas. Southern Rockies Watershed Project - showed wildfire causes major sedimentation; salvage logging after wildfire causes additional sedimentation in streams.	Biodiversity Water quality Watershed integrity	Facilitate Action	Awareness and education programs/ projects to foster a stewardship ethic for headwaters and source waters values are efficient and effective at reaching a broad recreation-user audience. Mitigation/restoration measures are clearly communicated and in place. Good stewardship practices are adopted by all users. Sediment loading monitoring is in place to measure how good stewardship practices are effective in decreasing sediment in streams. Sediment loads in streams decrease. Starting with one sub-watershed, the program will target adoption of 5 sub-watersheds over time.	OWC's Watershed Legacy Program provides resources for landowners to adopt beneficial management practices. Crowsnest Conservation Society - Maintaining and Restoring Crowsnest River Riparian Areas - community education project. Cows and Fish - Bioengineering and Riparian Restoration for westslope cutthroat trout - community hands-on restoration project. Pincher Creek Watershed Stewardship group - 'Blue Weed Blitz'. Drywood Yarrow Conservation Partnership - watershed stewardship programs. OWC working in partnership with ESRD to develop awareness and education messaging in alignment with shared objectives and regional planning initiatives.

ACTION PLAN • Indicator 1: Presence and abundance of fish, especially native populations (an indicator of biodiversity and watershed integrity), continued

TARGET 1: Maintain current native and naturalized fish population integrity within the headwaters and explore opportunities to increase native fish populations in their current range.

Action	Target Area	Time-frame	Proposed Implementers (Lead Agency bolded)	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Link to Other Initiatives	Watershed Criteria addressed by the action	OWC Facilitate, Recommend, Action, Participate	Evaluation of Success	Progress
3. Initiate a pilot restoration project in one sub-watershed to increase existing native and naturalized fish populations and improve water quality.	Dutch Creek and Hidden Creek - upper Oldman River watershed Potential for other sub-watershed stewardship action projects is open to stakeholders and the public.	2014-2015 (initiate)	OWC Partnership Advisory Network members Government of Alberta Fisheries and Oceans Canada (DFO)	*Source to Tap* community conversations identified restoration of degraded areas as a need. *MD Pincher Creek Community Values Survey* showed strong support for protecting water resources and environmental conservation. *'What We Heard'* Headwaters Action Plan 2013-14: Public Review saw this indicator as a logical place to start, and that the public would identify with native fish species. Participants also saw the need for education and outreach related to fish species at risk.	Biodiversity and Ecosystems – Objective: Terrestrial and aquatic biodiversity are maintained; species at risk are recovered. (SSRP; 68) The South Saskatchewan Region Biodiversity Management Framework is a new approach to support cumulative effects management of important elements of biodiversity that are affected by land-uses in the region. (SSRP; 130) The framework will focus on key indicators that represent the broad range of biodiversity in the region. The indicators will reflect species, habitats and landscapes that sustain long-term ecosystem health (e.g., headwaters areas and existing intact grasslands). (SSRP; 130) Research and species recovery planning initiatives have shown that managing linear footprint… and motorized access are the most significant actions that can be taken to support biodiversity. (SSRP; 61)	Cows and Fish - Bioengineering and Riparian Restoration for westslope cutthroat trout - community hands-on restoration project - knowledge and expertise resource. *Watershed Management Audit of Risks to Regional Water Supply as a Result of Forest Management* report (July 2012) identified old roads as a threat to water quality	Biodiversity Water quality Watershed integrity	Participate	Native fish populations increase and water quality improves. The project serves as a demonstration site to show how fish species at risk can be restored in the headwaters. Linear features and degraded riparian habitat are reclaimed.	Dutch Creek Pilot Project initiated in 2014 by the Headwaters Action Team. Cows & Fish riparian assessment and public education in Dutch Creek - 2015 Alberta Conservation Association trout population surveys - Dutch Creek, White Creek, Hidden Creek - 2015 Trout Unlimited, Cows & Fish and Alberta Conservation Association initiate riparian/native trout habitat restoration in Hidden Creek - 2015
4. Explore options for recreational user fees to fund enforcement, education and stewardship projects.	Crown Land	2014-2015 (initiate)	Environmental Law Centre	*Source to Tap* community conversations identified user pay model as desirable for all types of recreation, strong support for directing the funds to enforcement, education and local management. *Southeast Slopes Task Force* report supports user fees to cover costs of emergency services, policing and road maintenance. *'What We Heard'* Headwaters Action Plan 2013-14 - Public Review: significant support within communities for sustainable funding of enforcement needs.	Education and awareness and delivery of compliance programs (including enforcement) to promote and support responsible land use and shared stewardship are essential to managing recreational activities to achieve environmental outcomes. Education promotes compliance by raising awareness, not only of the importance of environmental stewardship, but also of the regulatory requirements and potential consequences of not complying. (SSRP; 91)	Alberta Off-Highway Vehicle Association proposal.	Biodiversity Water quality Watershed integrity	Participate	Options for collecting and using recreation user fees to fund enforcement, education and stewardship projects have been explored and shared with the Government of Alberta.	Environmental Law Centre has researched how other jurisdictions manage user fees to fund enforcement and stewardship education and action, and shared this information with the Government of Alberta.

ACTION PLAN • Indicator 1: Presence and abundance of fish, especially native populations (an indicator of biodiversity and watershed integrity), continued

TARGET 2: Restore native fish populations on selected streams* in the headwaters

Action	Target Area	Time-frame	Proposed Implementers (Lead Agency bolded)	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Link to Other Initiatives	Watershed Criteria addressed by the action	OWC Facilitate, Recommend, Action, Participate	Evaluation of Success	Progress
1. Develop a plan to restore native fish in key streams/sub-watersheds of their historic range. The plan will include: 1. identification of the best options of where to restore native fish and fisheries habitat, with input from GOA scientists, the public and stakeholders 2. determine what is needed to successfully restore habitat and repopulate native fish in top priority streams (e.g. land-use changes) 3. set timeframe for implementation of the plan.	To be prioritized	Initiate prioritization process - 2014	**Government of Alberta** Department of Fisheries and Oceans (DFO) Partnership Advisory Network members	*Values and Voices* community workshops identified fish and wildlife as an important value *MD Pincher Creek Community Values Survey* rated conservation and protection of water resources as a top priority.	Biodiversity and Ecosystems - Objective: Terrestrial and aquatic biodiversity are maintained; species at risk are recovered. (SSRP; 68) The South Saskatchewan Region Biodiversity Management Framework is a new approach to support cumulative effects management of important elements of biodiversity that are affected by land-uses in the region. (SSRP; 130) The framework will focus on key indicators that represent the broad range of biodiversity in the region. The indicators will reflect species, habitats and landscapes that sustain long-term ecosystem health (e.g., headwaters areas and existing intact grasslands). (SSRP; 130) Meeting the regional objectives for biodiversity will depend on using a range of management actions and approaches. The biodiversity management framework will describe actions that will be taken now. There will be some threshold values related to these management actions to provide clarity and help determine if biodiversity objectives are met. (SSRP; 130)	Westslope Cutthroat Trout Recovery Plan. Bull Trout Conservation Management Plan.	Biodiversity Water quality Watershed integrity	Recommend Participate	Identification and prioritization of stream/sub-watershed area restoration for BTR and/or WSCT is completed. Stream habitat/areas are maintained to safeguard current populations of native fish; native fish are re-populated in top priority habitat streams (e.g. native trout climate change refugia/strongholds).	Government of Alberta: Westslope cutthroat trout and bull trout surveys - identifying hydrologically significant areas in the headwaters (supportive of important population /spawning habitat)
2. Add mountain whitefish to list of native fish species to be considered in management planning and stewardship actions to ensure population persistence in the headwaters.	Headwaters	Ongoing	**Government of Alberta** Alberta Conservation Association Trout Unlimited	*'What We Heard'* Headwaters Action Plan Public Review: suggestion that all cold-water fish should be considered and included in stewardship actions for headwaters health.	The framework will focus on key indicators that represent the broad range of biodiversity in the region. The indicators will reflect the species, habitats and the landscapes that sustain long-term health. (SSRP; 130)		Biodiversity Watershed Integrity	Recommend	Mountain whitefish are included (where possible) in habitat restoration and population retention actions for fish species in the headwaters. Mountain whitefish are considered in land-use planning in the headwaters.	Government of Alberta is the lead on this process. A formal request for this action would be required and duly considered.

(*selected streams = streams with sufficient or restored habitat value for native fish; streams where native fish have been extirpated from their historic range)

ACTION PLAN • Indicator 1: Presence and abundance of fish, especially native populations (an indicator of biodiversity and watershed integrity), continued

TARGET 2: Restore native fish populations on selected streams* in the headwaters

Action	Target Area	Timeframe	Proposed Implementers (Lead Agency bolded)	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Link to Other Initiatives	Watershed Criteria addressed by the action	OWC Facilitate, Recommend, Action, Participate	Evaluation of Success	Progress
3. Reintroduce beavers into the headwaters area.	Headwaters sub-watersheds, only where feasible.	To be determined First step: review research on re-introduction of beavers for watershed health, and options for re-introduction in the headwaters area.	Cows and Fish Miistakis Institute	*Values and Voices* community workshops identified fish and wildlife as an important value. Miistakis Institute: *Leave It To Beavers* Project: beavers have traditionally played an important role in ecosystem health through the provision of healthy wetlands which also serve to hold high quality water in upper watershed areas for groundwater recharge and surface run-off. In a water-stressed landscape, such as southern Alberta, beavers could be used as an effective strategy to improve water quality and quantity. Beavers can be relocated to areas where they will provide natural engineering to improve water quantity and quality and provide a natural climate change adaptation strategy.	Objectives for biodiversity and healthy, functioning ecosystems will be incorporated to achieve multiple objectives. Watershed management and headwaters protection is the priority. Forests will be managed with this as the highest priority (including water storage, recharge and release functions). (SSRP; 58)	Cows and Fish Anne and Sandy Cross Conservation Area Calgary Science School and Miistakis Institute: Leave it to Beavers Project	Biodiversity Watershed integrity	Recommend Participate	The best options for re-introduction of beavers are assessed. A self-sustaining population of beavers in the headwaters contributes to water retention; watershed health. Information on the value of beavers for watershed health is shared with the greater watershed community.	Miistakis Institute of the Rockies, in partnership with the Anne and Sandy Cross Conservation Area, Calgary Science School and Cows and Fish are working on a beaver re-introduction project to determine the ecological benefits of beavers to watershed health. www.rockies.ca/beavers/

(*selected streams = streams with sufficient or restored habitat value for native fish; streams where native fish have been extirpated from their historic range)

RECOMMENDATIONS TO DECISION-MAKERS • Indicator 1: Presence and abundance of fish, especially native populations (an indicator of biodiversity and watershed integrity)

TARGET 1: Maintain current native and naturalized fish populations within the headwaters area and explore opportunities to increase native fish populations in their current range.

Recommendations to Decision-makers	To Whom	Time-frame	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Watershed Criteria Addressed by the Recommendation	Evaluation of Success	Progress
1. Adopt the linear features density targets as determined in the Headwaters Action Plan (2013-14) into the South Saskatchewan Regional Plan. Linear features density targets are: 1. No net increase in linear features density in each sub-watershed of the Oldman headwaters 2. Set linear disturbance threshold of .15-0.2 km/km^2 in sub-watersheds where bull trout and westslope cutthroat trout currently exist* 3. Maintain negligible-low linear feature pressure/risk rating in sub-watersheds where it currently exists 4. Lower density of linear features in high priority 4th order watersheds by one pressure/ risk rating (e.g. high to moderate pressure/risk). (Reference: Oldman Headwater Indicator Project, version 2014.1)	Government of Alberta	SSRP 2014 - ongoing	18 organizations were involved in consensus decision-making process that set targets for density of linear features in the Oldman headwaters. *Source to Tap* community conversations identified a need to integrate watershed planning into the Land-use Framework, the need to focus land use planning on what the local community wants and needs. *'What We Heard'* Headwaters Action Plan Public Review - agreement from participants that linear features density thresholds should be set in the headwaters area; however, there were reservations that there may not be political will to accomplish this.	Integrated Management of Crown Land - Strategies: 3.2 Develop a linear footprint management plan for Green area and White area public land in the region... This plan will outline a system to minimize the extent, duration and rate of linear footprint development in order to meet the objectives established in this regional plan and the biodiversity management framework. For Green Area public lands, the linear footprint management plan will need to consider recreation management planning, species recovery plans such as Alberta's grizzly bear recovery plan and other initiatives including those led by partners such as Watershed Planning and Advisory Councils. (SSRP; 68-69)	Biodiversity Water quality Watershed integrity	The Government of Alberta integrates the Headwaters Action Plan 2013-14 linear features density targets and thresholds into implementation of the SSRP sub-regional plans. Linear features density targets threshold pressure/risk ratings in the Headwaters Action Plan 2013-14 determine the priorities for reclamation of linear features in select 4th order sub-watersheds, specifically watersheds with fisheries species at risk (e.g. westslope cutthroat trout and bull trout).	SSRP 2014-2024 - linear footprint management plan initiated; Headwaters Action Plan 2013-14 recommendations are considered. OWC/Headwaters Action Team 'Dutch Creek - Classification of Linear Features Project' completed and shared with SSRP sub-regional initiatives: Linear Footprint Management Plan and the Recreation Management Plan.
2. Develop Access Management Plans for the headwaters that will: 1. focus on watershed health as the first priority 2. clearly designate acceptable uses 3. manage the intensity/volume of use 4. recommend setting linear disturbance threshold .15-0.2 km/km2 in sub-watersheds with where bull trout and westslope cutthroat trout exist and level of linear disturbance is higher than this threshold value 5. for user groups, address displaced activities and recommend alternative locations that are not in high impact/ sensitive areas.	Government of Alberta	SSRP 2014 - ongoing	*Source to Tap* community conversations show support for water protection as the first priority on Crown lands, designated areas for protection and different types of recreational use to minimize conflict, limiting access in sensitive areas. *Southeast Slopes Task Force* report supports limiting access to reduce human footprint; alternatives must be provided. *Values and Voices* community workshops identified watershed health as the first priority. *MD Pincher Creek Community Values Survey* rated increased OHV use of Crown land as undesirable and rated protecting water resources as a top priority.	In the eastern slopes, there will be coordination of linear footprint management planning and recreation management planning, with combined governance and process, where they overlap such as in the Porcupine Hills and Livingstone areas. There will also be alignment with forest management planning, species recovery planning and other initiatives including those led by partners and stakeholders. (SSRP; 135)	Biodiversity Water quality Watershed integrity	Access Management Plans are developed and enforced to maintain and protect key watershed health parameters: water quality; fish species at risk; lower linear disturbance in critical areas; management of intensity of use. Linear features density targets of the Headwaters Action Plan 2013-14 will require reclamation of density of linear features in select 4th order watersheds (targeting linear disturbance threshold of 0.2 - .15 kms/kms2), specifically for sub-watersheds with fisheries species at risk: westslope cutthroat trout and bull trout.	SSRP 2014-2024 - Recreation Management Planning; South Saskatchewan Regional Trail System Plan initiated.

(*Reference: Valdal and Quinn; 2010. The threshold value 0.15-0.2 km/km^2 is related to road densities on erodible soils within riparian areas, 100 metres width, adjacent to streams. This threshold metric is also within the moderate to high risk road density range for bull trout in the Government of Alberta's guide to consistent reporting for Alberta's State of the Watershed Reports.)

RECOMMENDATIONS TO DECISION-MAKERS • Indicator 1: Presence and abundance of fish, especially native populations (an indicator of biodiversity and watershed integrity), continued

TARGET 1: Maintain current native and naturalized fish populations within the headwaters area and explore opportunities to increase native fish populations in their current range.

Recommendations to Decision-makers	To Whom	Time-frame	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Watershed Criteria Addressed by the Recommendation	Evaluation of Success	Progress
3. Increase enforcement of existing laws and policies related to recreational use in the headwaters.	Government of Alberta	Begin immediately, ongoing	*Source to Tap* community conversations identified increased enforcement of recreational use laws and policies as a major need. *Southeast Slopes Task Force* report supports increased enforcement. *MD Pincher Creek Community Values Survey* strongly supported increased enforcement. *'What We Heard'* Headwaters Action Plan - Public Review: The need for enforcement of motorized recreation use in the headwaters was a clear and consistent message at every public review meeting.	Education and awareness and delivery of compliance programs (including enforcement) to promote and support responsible land use and shared stewardship are essential to managing recreational activities to achieve environmental outcomes. Education promotes compliance by raising awareness, not only of the importance of environmental stewardship, but also of the regulatory requirements and potential consequences of not complying. (SSRP; 91) In conservation areas: where off-highway vehicle use is permitted in wildland parks...it will be managed to designated off-highway vehicle trails and areas.' (SSRP; 65) In the Green Area: 'while recreation management planning work is underway, current plans, mapping.... will continue...' until completion of new sub-regional plans. (SSRP;95) No new trails or routes or access may be developed without a management plan, trail plan or regulation. Off-highway vehicle use shall not occur in the beds and shores of permanent water bodies. (SSRP; 65)	Biodiversity Water quality Watershed integrity	Laws and regulations related to conservation, land-use and access are enforced by the Government of Alberta throughout the headwaters, and violations are reduced significantly over the long term due to increased awareness and education.	SSRP 2014-2024 - focus will be on education, voluntary compliance, and enforcement as required.
4. Develop a Recreation Management Plan for the Eastern Slopes (including the Oldman headwaters). The plan would include (but is not limited by): 1. retaining negligible-low linear feature pressure/risk rating in key sub-watersheds, including the South Castle and other headwaters sub-watersheds 2. development of motorized and non-motorized trail staging areas 3. monitoring and controlling intensity of use 4. limiting linear features to maintain and protect 'last of the best' watershed integrity values 5. referring to a current, successful access plan as an example for developing the recreation plan (e.g. Kananaskis Country) 6. meeting recreation needs of Albertans.	Government of Alberta		*Source to Tap* Community Conversations: Factors negatively affecting headwaters health: Recreation: Across the headwaters, recreation activities along and in water courses are affecting water quality. Impacts are particularly felt with: unregulated random camping, overuse of motorized vehicles such as ATV's and dirt bikes, back and front country campsites located along water courses, and boating on reservoirs. Participants noted that recreation use is the primary way that most people relate to the Oldman Basin headwaters area, and that overuse and abuse due to recreation uses is broadly recognized as a significant issue to be addressed. *Recreation Management a Priority:* The widespread effect of recreation activities on ecosystem integrity and water quality was the most commonly identified human use that negatively impacts the landscape. Recreation use of the headwaters is seen to be increasing in numbers and types of uses, and to be continually opening access in new areas. Recreation users, specifically organized recreation groups, also represent a tremendous opportunity for stewardship of the Oldman headwaters through promotion activities that involve education, monitoring, and compliance to/enforcement of regulations.	Comprehensive and integrated recreation management planning will build on existing access management plans and work done by stakeholders. This will support the creation of a sustainable recreation management system for public land...the system will include staging and camping areas, trail systems and access to the full network of recreation and tourism areas across the eastern slopes. (SSRP;94)	Watershed Integrity Biodiversity Water Quality	A Recreation Management Plan for the East Slopes (including the Oldman headwaters area) is developed and enforced. The South Castle sub-watershed is managed to retain the negligible-low pressure/risk rating for linear features. All highly impacted recreation areas in the headwaters region are managed to provide recreation needs for Albertans, but with a focus on water and watershed protection; no net increase in linear features; reduction in linear features in key-sub-watersheds with fisheries species at risk.	SSRP 2014-2024 - Recreation management and trail system planning is underway.

RECOMMENDATIONS TO DECISION-MAKERS • Indicator 1: Presence and abundance of fish, especially native populations (an indicator of biodiversity and watershed integrity), continued

TARGET 2: Restore native fish populations on selected streams* in the headwaters.

Recommendation	To Whom	Time-frame	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Watershed Criteria Addressed by the Recommendation	Evaluation of Success	Progress
1. The Government of Alberta will work diligently to ensure effective decision-making and regulatory action for watershed health.	Government of Alberta	Ongoing	*Source to Tap* Community Conversations on Headwaters Health and Stewardship in the Oldman River Basin: Major Discussion Themes: • Provincial Gov't support is recognized as being a positive factor through the policies and regulations that provide structure and tools for watershed planning and management in the Oldman headwaters area. However, in addressing regulatory and enforcement capacity, participants perceive that government agencies do not adequately recognize or acknowledge the ecological values of the watershed and develop policy based on community and watershed health. Further, participants are frustrated by their inability to have a local or regional voice heard in provincial decision-making regarding land and water issues.	Headwaters - Objective: Headwaters in the region are managed to maintain recharge capabilities and support critical water quality, quantity and aquatic ecosystem requirements. The aquatic environment and the water that people in the region rely on cannot be sustained unless headwaters are protected. The importance of headwaters has been recognized in the unique geography of the eastern slopes. Collaboration and shared stewardship will be essential to achieving responsible management. (SSRP; 87)	Watershed Integrity Biodiversity Surface Water Quality Water Levels and Flows	Government of Alberta is effective with decision-making and regulatory action that assists with maintaining and protecting headwaters integrity. From *Source to Tap* community conversations, success would come with a clear linkage between land use plan management /strategies and grassroots needs, values and actions. A line of sight is required between the Land Use Framework and Alberta's Water For Life Strategy through regional and municipal planning to grassroots stewardship. It is important to define conservation areas and stewardship opportunities under the SSRP and applicable legislation to manage and enforce accordingly. Enforcement is a clear government role and expectation.	SSRP 2014-2024 - water and watershed health is a priority.
2. Harmful stream channelization is avoided; current harmful channelization is removed or remediated.	Government of Alberta		*'What We Heard'* Headwaters Action Plan Public Review: Need to look at best practices when stream channelization cannot be avoided.	Mitigating impacts from flooding reduces risk to public safety, developments and infrastructure, provided environmental benefits and results in savings in tax dollars for post-flood recovery costs. This can be achieved through maintaining healthy, functional watersheds and through enhancements to the existing flood management systems used by both the Government of Alberta and municipalities. (SSRP; 78)	Watershed Integrity Biodiversity	Harmful channelization of streams is avoided; and current harmful channelization is removed or remediated. Alternatives to harmful stream channelization are fully explored and implemented to address flood mitigation and development needs. Alternatives include (but are not limited to) riparian setbacks and protection; floodplain and meander protection; development disallowed in flood hazard areas.	

(*selected streams = streams with sufficient or restored habitat value for native fish; streams where native fish have been extirpated from their historic range)

RECOMMENDATIONS TO DECISION-MAKERS • Indicator 1: Presence and abundance of fish, especially native populations (an indicator of biodiversity and watershed integrity), continued

TARGET 2: Restore native fish populations on selected streams* in the headwaters.

Recommendation	To Whom	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Watershed Criteria Addressed by the Recommendation	Evaluation of Success	Progress
3. Complete a fine scale analysis of linear disturbance in the Upper Oldman and Carbondale sub-watersheds, including criteria to establish a restoration plan to reduce linear disturbance to a lower pressure/risk rating (e.g high to moderate, or moderate to low) (Reference: density of linear features pressure/ risk ratings: Oldman Headwaters Indicators Report, 2014.1).	Government of Alberta	*Source to Tap* Community conversations: activities or factors perceived or known by local residents to affect headwaters health in a negative way included cumulative effects and linear disturbances. With increased population pressure and increased human use of the landscape in the Oldman headwaters, the cumulative effects of land uses (human activities) continues to intensify. In particular, participants see increased evidence of linear disturbances. *Westslope Cutthroat Trout Recovery Plan* - Detailed Threat Assessment: Forest harvest, linear disturbance, grazing, OVH recreational access, in-stream construction and municipal run-off were all listed as a high threat rating for westslope cutthroat trout recovery, especially in or upstream of spawning areas. Potential of high severity impact on small, isolated populations. (WSCT Recovery Plan; 16).	Linear footprint disturbance will be minimized through linear footprint management planning for Green and White Area public land. Research and species recovery planning initiatives have shown that managing linear footprint... and motorized access are the most significant actions that can be taken to support biodiversity. There will be a focus on priority areas for the eastern slopes... including: key headwaters areas, areas of sensitive terrestrial and aquatic habitat and other areas of high biodiversity value including for connectivity. (SSRP; 61)	Watershed Integrity Biodiversity Water Quality	An analysis of watershed restoration through lowering density of linear features in the Upper Oldman and Carbondale sub-watersheds is completed. Information is shared with the public and stakeholders. The criteria for restoration of linear disturbance to a lower risk rating is shared with the public and stakeholders.	SSRP 2014-2024 - linear footprint management plan initiated; Headwaters Action Plan 2013-14 recommendations are considered.
4. Angling regulations are amended to prevent stress or harm to native fish. (Regulatory changes may include closure of key reaches or sub-watersheds to angling; control of invasive species harmful to native fish.)	Government of Alberta	*Westslope Cutthroat Trout Recovery Plan* - Detailed Threat Assessment: Angling (legal harvest; catch and release), Incidental or accidental mortality through angling are considered low threats to WSCT recovery. Invasive species, however, pose various levels of threat to WSCT recovery: Rainbow trout - high threat Yellowstone cutthroat trout - medium threat Brook Trout - high threat Brown Trout - Medium threat	Biodiversity and Ecosystems – Objective: Terrestrial and aquatic biodiversity are maintained; species at risk are recovered.' (SSRP; 68)	Biodiversity	Regulation is updated to prevent stress or harm to native fish, including closure of some headwaters streams or stream reaches; and control of invasive species harmful to native fish (e.g.: rainbow trout; brook trout).	ESRD: Stewardship License Pilot Project - removal of non-native fish from stream reaches where they are invading and competing with native salmonids.
5. Restore native fish in prioritized streams where: 1. populations have been extirpated 2. habitat values for native fish are sufficient and/or have been restored 3. the threat of invasive species to native fish populations has been addressed.	Government of Alberta	*Alberta Westslope Cutthroat Trout Recovery Plan* identifies invasive species as a threat *Values and Voices* community workshops identified fish and wildlife as an important value *Priorities for the Oldman Watershed:* Promoting action to maintain and improve our watershed identifies aquatic invasive species as a primary concern to be addressed by an Integrated Watershed Management Plan	Biodiversity and Ecosystems – Objective: Terrestrial and aquatic biodiversity are maintained; species at risk are recovered.' (SSRP; 68)	Biodiversity Watershed Integrity	Selected streams within historic range are repopulated with self-sustaining populations of native fish. Streams prioritized for restoration of native fish would be where these species have been extirpated; where habitat values are sufficient or restored; and where invasive species threats are addressed to maintain and protect self-sustaining populations of native fish.	SSRP 2014-2024 - commitment to recovery plans for species at risk.

(*selected streams = streams with sufficient or restored habitat value for native fish; streams where native fish have been extirpated from their historic range)

ACTION PLAN • Indicator 2: Density of Linear Features

TARGET 1: In urban centres and major transportation corridors, no linear thresholds will be set; however, mitigation of the impact of linear features will be actively pursued.

Action	Target Area	Time-frame	Proposed Implementers (Lead Agency bolded)	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Link to Other Initiatives	Watershed Criteria addressed by the action	OWC Facilitate, Recommend, Action, Participate	Evaluation of Success	Progress
1. OWC will continue to build a good working relationship with local municipalities to strive for consistency in land-use planning that maintains and protects source water and headwaters integrity.	Municipalities that have jurisdiction in the Headwaters: MD Ranchlands Municipality of Crowsnest Pass MD Pincher Creek MD Willow Creek Cardston County	Immediate-ongoing	OWC and Municipalities	*Source To Tap:* Water as Priority of Public land management was viewed as a high political priority. Conservation and stewardship require a stronger value and role in land-use planning. Public input is critical regarding changes in land use planning and changes to status of by-laws. *South Eastern Slopes Task Force:* committed to land use planning of the east slopes to safeguard water quality and address environmental degradation from inappropriate recreation use. *'What We Heard'* Headwaters Action Plan Public Review: Limiting rural residential and urban sprawl was seen as a way that municipalities could help limit linear features. It was felt that there needs to be a municipal focus and intent to preserve precious landscapes. Municipalities must also have sufficient funds to reward conservation. Municipal planning could provide a strong means of minimizing linear density. All municipalities in the watershed should examine how they can help lower linear density through their planning regulations. Flood plain development should not be allowed.	Municipalities are expected to: - Utilize or incorporate measures which minimize or mitigate possible negative impacts on important water resources or risks to health, public safety and loss to property damage due to hazards associated with water. - Identify and consider values of significant water resources and other water features, such as ravines, valleys, riparian lands, stream corridors, lakeshores, wetlands and unique environmentally significant landscapes. - Determine appropriate land-use patterns in the vicinity of these significant water resources and other water features. - Consider local impacts as well as impacts on the entire watershed. - Consider a range of approaches to facilitate conservation, protection or restoration of water features, and protection of sensitive aquatic habitat. - Establish appropriate setbacks from waterbodies. - Use available guidance, where appropriate, for water and watershed planning initiatives in support of municipal planning. (SSRP; 110)	Pincher Creek Community Values Study: support for conserving and protecting water resources and protecting the natural environment were listed in the top 10 values.	Watershed Integrity Biodiversity Surface Water Quality Stream Levels and Flows	Facilitate Action	1. The OWC maintains a good working relationship with Municipalities. 2. The maintenance and protection of headwaters and source waters integrity, and the mitigation of impacts from linear disturbance and other cumulative impacts is addressed in municipal land-use plans.	OWC engagement with Municipal Councils in the Headwaters Action Plan process continues over time. Municipalities have indicated interest and have participated in the development of the Headwaters Action Plan 2013-14. Municipalities are represented on the Headwaters Action Plan Steering Committee to work on the implementation of priority actions, monitoring, evaluation and reporting of progress of the first iteration of the HAP.

ACTION PLAN • Indicator 2: Density of Linear Features (continued)

TARGET 1: In urban centres and major transportation corridors, no linear thresholds will be set; however, mitigation of the impact of linear features will be actively pursued.

Action	Target Area	Time-frame	Proposed Implementers (Lead Agency bolded)	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Link to Other Initiatives	Watershed Criteria addressed by the action	OWC Facilitate, Recommend, Action, Participate	Evaluation of Success	Progress
2. Take measures to reduce impacts by addressing connectivity for aquatic and terrestrial biodiversity in the headwaters area, and encourage/ support initiatives that improve connectivity across the Highway 3 corridor.	Headwaters	Ongoing	Government of Alberta Partnership Advisory Network members Alberta Transportation Foothills Stream Crossing Partnership Alberta Energy Regulator	*Source to Tap:* significant community recognition of a number of stewardship initiatives that benefit ecological values and contribute to headwaters health. *Grizzly Bear Recovery Plan:* Maintaining connectivity of habitat is necessary to maintain Grizzly Bear population persistence.	Connectivity of wildlife habitat across landscapes, within the region and across regions, is also an important factor in maintaining biodiversity. (SSRP; 57) Maintaining connectivity through the major Bow Valley and Crowsnest Pass corridors is important. Information gained from reports such as the Bow Corridor Ecosystem Advisory Group report, the 'Wildlife Corridor and Habitat Patch Guidelines for the Bow Valley - 2012', and the Highway 3 Transportation Corridor Project will contribute to developing transportation plans for maintaining wildlife connectivity in the region. (SSRP;57)	Grizzly Bear Recovery Plan Miistakis Institute: Road Watch in the Pass Project Westslope Cutthroat Trout Recovery Plan; Bull Trout Conservation Management Plan. Roadway Watercourse Crossing Remediation (Government of Alberta)	Biodiversity Watershed Integrity	Facilitate Action	Aquatic and terrestrial habitat connectivity issues are improved throughout the headwaters. Initiatives and projects that address connectivity for biodiversity values are encouraged and actively supported	Miistakis Institute - Road Watch in the Pass project - citizen science web-mapping of wildlife movement across Hwy 3. Further research is being completed as part of the Crown of the Continent Ecosystem - Crown Managers Partnership to determine critical wildlife crossing areas. (ie: "Protecting and Connecting Headwater Havens - Vital landscapes for vulnerable fish and wildlife - Southern Canadian Rockies of Alberta" John. L. Weaver, Wildlife Conservation Society Report No. 7, July 2013.)

ACTION PLAN • Indicator 2: Density of Linear Features (continued)

TARGET 2: Maintain negligible and low linear features density where it currently exists, and ensure no net gain of linear features in each sub-watershed.*

Action	Target Area	Time-frame	Proposed Implementers (Lead Agency bolded)	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Link to Other Initiatives	Watershed Criteria addressed by the action	OWC Facilitate, Recommend, Action, Participate	Evaluation of Success	Progress
1. Complete a 'Classification of Linear Features Project' which will include: 1. inventory and classification of linear features in key sub-watersheds of priority concern 2. analysis of reclamation priorities 3. linear features impacts on headwaters health 4. intensity of use monitoring program: collect data on the types and intensity of recreational use in the headwaters to better understand impacts on headwaters integrity, native fish, and water quality.	Key sub-watersheds of concern in the headwaters.	Initiate in 2014-15	Government of Alberta OWC Partnership Advisory Network Crown Managers Partnership	*Source To Tap:* linear features was not addressed specifically, however, community participants recognized management issues related to proliferation of roads and linear features - specifically by motorized recreation, and impacts on wildlife values. Source to Tap community conversations identified intensity of use data as lacking. Headwaters Action Plan 2013-14 - stakeholder group (Partnership Advisory Network) clearly stated the need for intensity of use data to maintain and protect key headwaters values. Headwaters Action Pla 2013-14: 18 organizations were involved in consensus decision-making process that set targets for density of linear features in the Oldman headwaters.	Linear footprint disturbance will be minimized through linear footprint management planning for Green and White Area public land. Research and species recovery planning initiatives have shown that managing linear footprint… and motorized access are the most significant actions that can be taken to support biodiversity. There will be a focus on priority areas for the eastern slopes... including: key headwaters areas, areas of sensitive terrestrial and aquatic habitat and other areas of high biodiversity value including for connectivity.' (SSRP; 61) Key Step - Inventory of land disturbance and usage such as: - current linear footprint categorized by type; - trails categorized by type and use and staging areas and campgrounds; - key areas of linear footprint for restoration; - viability of existing facilities and opportunities to enhance or reclaim, or; - compilation of local knowledge. (SSRP; 135)	Westslope Cutthroat Trout Recovery Plan and Bull Trout Conservation Management Plans cite high density linear disturbance as a threat to species persistence. Southern Foothills Study: Increase in access - increase in OHV use. Wildlife species reduced due to habitat fragmentation. Landscape Patterns Environmental Quality Analysis: provides metrics for density of roads in relationship to wildlife persistence and impacts on watershed health.	Watershed Integrity Biodiversity Surface Water Quality Stream Levels and Flows	Recommend Facilitate Action Participate	An inventory and classification of linear features in key sub-watersheds of concern is completed. An analysis of linear features classification to prioritize reclamation/roll-back and improve watershed integrity provides direction for linear feature reclamation priorities in sub-watersheds of concern. Intensity of recreation use is monitored and relationship to impacts on native fish populations are investigated. Incidence/location of infractions are monitored. Data is provided to support enforcement and adaptive watershed management	OWC and Partnership Advisory Network members, with assistance from SSRP planners, initiate a Linear Features Classification project in the Dutch Creek sub-watershed (2014-15).

(*Reference: Oldman Headwaters Indicator Project, 2014.1)

ACTION PLAN • Indicator 2: Density of Linear Features (continued)

TARGET 2: Maintain negligible and low linear features density where it currently exists, and ensure no net gain of linear features in each sub-watershed.*

Action	Target Area	Timeframe	Proposed Implementers (Lead Agency bolded)	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Link to Other Initiatives	Watershed Criteria addressed by the action	OWC Facilitate, Recommend, Action, Participate	Evaluation of Success	Progress
2. Engage in conversation with the public, stakeholders and the Government of Alberta to control access in South Castle watershed.	South Castle sub-watershed	Immediate. Provide input to the SSRP Recreation Management and access management initiatives. Participate in future access management planning for the South Castle sub-watershed.	Government of Alberta Partnership Advisory Network members NGOs Municipal Government	*Source to Tap* Community Conversations: Access management is needed - restoration of current footprint of logging and roads to below thresholds for water quality and biodiversity. Implementation and enforcement of current plans (e.g. Castle sub-watershed) requires commitment to enforcement. *'What We Heard'* Headwaters Action Plan Public Review: the Castle sub-watershed was recognized as having high integrity rating (Watershed Integrity Index - Headwaters Indicators Report) and needing attention for retention of key headwaters values.	There will be comprehensive and integrated recreation management planning in the Green Area. For some areas of public land, there are existing access management plans and planned trails (e.g., the Castle Access Management Plan (1992)). Recreation management planning will be expanded across the region building on existing plans, trail and access information and work done by stakeholders. (SSRP; 61) Objectives for biodiversity and healthy, functioning ecosystems will be incorporated to achieve multiple objectives. Watershed management and headwaters protection is the priority. Forests will be managed with this as the highest priority (including water storage, recharge and release functions). (SSRP; 58) Linear footprint disturbance will be minimized through linear footprint management planning for Green and White Area public land. Research and species recovery planning initiatives have shown that managing linear footprint…and motorized access are the most significant actions that can be taken to support biodiversity. There will be a focus on priority areas for the eastern slopes... including: key headwaters areas, areas of sensitive terrestrial and aquatic habitat and other areas of high biodiversity value including for connectivity. (SSRP; 61)	Bull Trout Conservation Recovery Plan - South Castle sub-watershed mapped as high risk for bull trout conservation. Density of roads a key threat to persistence. Near pure strain populations of westslope cutthroat trout populations are in the Castle River sub-watershed. Grizzly Bear Recovery Plan requires sound access management in critical habitat areas. The Castle sub-watershed is classified as a core area of high habitat value for grizzly bears.	Watershed Integrity Biodiversity Surface Water Quality	Action Recommend	Access in the South Castle sub-watershed is controlled to manage and protect source waters and headwaters integrity; protect key species at risk; and provide appropriate recreation access.	Castle Access Management Plan (requires enforcement action) SSRP - current Recreation and Access Management plans.

(*Reference: Oldman Headwaters Indicator Project, 2014.1)

ACTION PLAN • Indicator 2: Density of Linear Features (continued)

TARGET 2: Maintain negligible and low linear features density where it currently exists, and ensure no net gain of linear features in each sub-watershed.*

Action	Target Area	Time-frame	Proposed Implementers (Lead Agency bolded)	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Link to Other Initiatives	Watershed Criteria addressed by the action	OWC Facilitate, Recommend, Action, Participate	Evaluation of Success	Progress
3. Maintain the current low-negligible pressure/risk rating for density of linear features in headwaters sub-watersheds with high integrity rating (e.g. South Castle sub-watershed) (Reference: Watershed Integrity Index - Oldman Headwaters Indicator Project, 2014.1).	South Castle and other sub-watersheds currently at low-negligible risk rating for linear features in the headwaters.	Immediate - ongoing	Government of Alberta Partnership Advisory Network members	*Pincher Creek Community Values Assessment:* fragmentation of landscapes and clearcut logging were listed as an environmental concern. There were clear statements about the importance of maintaining healthy, functioning ecosystems conserving ecological diversity, sustaining wildlife and protecting water resources. Headwaters Action Plan 2013-14: 18 organizations were involved in consensus decision-making process that set targets for density of linear features in the Oldman headwaters.	Linear footprint management planning will be completed for Green Area and White Area public land. Priority Areas have been identified based on the following criteria...the criteria will be considered to identify further priority areas: - areas of important ecosystem function such as key headwaters areas, high value wetlands and riparian lands; - areas of sensitive terrestrial and aquatic habitat such as habitat of species at risk and habitat identified in provincial species recovery plans; - areas with high biodiversity value... areas experiencing higher pressures from development and areas experiencing significant off-highway vehicle use. (SSRP; 133) The aquatic environment and the water that people in the region rely on cannot be sustained unless headwaters are protected…collaboration and shared stewardship will be essential to achieving responsible management. (SSRP; 87).	Bull Trout Conservation Recovery Plan - South Castle sub-watershed mapped as high risk for bull trout conservation. Density of roads a key threat to persistence. Near pure strain populations of westslope cutthroat trout populations are in the Castle River sub-watershed. Grizzly Bear Recovery Plan requires sound access management in critical habitat areas. The Castle sub-watershed is classified as a core area of high habitat value for grizzly bears.	Watershed Integrity Biodiversity Water Quality	Recommend	The South Castle and other sub-watersheds in the headwaters remain at the low to negligible /pressure risk-rating for density of linear features.	SSRP 2014 - Linear Footprint Management Planning initiated.

(*Reference: Oldman Headwaters Indicator Project, 2014.1)

ACTION PLAN • Indicator 2: Density of Linear Features (continued)

TARGET 3: Decrease density of linear features where there is moderate to high pressure/risk rating in headwaters sub-watersheds.*

Action	Target Area	Time-frame	Proposed Implementers (Lead Agency bolded)	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Link to Other Initiatives	Watershed Criteria addressed by the action	OWC Facilitate, Recommend, Action, Participate	Evaluation of Success	Progress
1. Lower the density of linear features in sub-watersheds with moderate to high pressure/risk rating where high-value habitat for fish species at risk also exists (e.g. Lost Creek - Carbondale).	Initiate in all sub-watersheds with high-value habitat for bull trout and westslope cutthroat trout.	Initiate 2014-15, ongoing	Government of Alberta Partnership Advisory Network members NGOs	*Source to Tap* - Phase 1: participants see increased evidence of linear disturbance and cumulative effects of land use as negatively impacting the headwaters. Headwaters Action Plan: 18 organizations were involved in consensus decision-making process that set targets for density of linear features in the Oldman headwaters.	Biodiversity and Ecosystems – Objective: Terrestrial and aquatic biodiversity are maintained; species at risk are recovered. (SSRP; 68) Linear footprint disturbance will be minimized through linear footprint management planning for Green and White Area public land. Research and species recovery planning initiatives have shown that managing linear footprint... and motorized access are the most significant actions that can be taken to support biodiversity. There will be a focus on priority areas for the eastern slopes... including: key headwaters areas, areas of sensitive terrestrial and aquatic habitat and other areas of high biodiversity value including for connectivity. (SSRP; 61)	ESRD Fish and Wildlife: Reviews of land use proposals that could impact fish and fish habitat. Westslope Cutthroat Trout Recovery Plan and Bull Trout Conservation Management Plans cite high density linear disturbance as a threat to species persistence. Landscape Patterns Environmental Quality Analysis: provides metrics for density of roads in relationship to bull trout persistence and impacts on watershed health.	Watershed Integrity Biodiversity Surface Water Quality	Facilitate Recommend	Density of linear features is decreased in sub-watersheds with high value habitat for bull trout and westslope cutthroat trout.	SSRP Linear Footprint Management Planning initiated. SSRP Biodiversity Management Framework in place in 2015.
2. Develop and implement a plan to lower density of linear features in high priority 4th order watersheds that includes: 1. prioritization of sub-watersheds with high ecological value (e.g. connectivity requirements; aquatic and terrestrial habitat needs for species at risk) 2. mapping the intersection of high ecological value sub-watersheds with density of linear features and intensity of use to determine high priority areas for reclamation 3. selection of high priority sub-watershed(s) and reclamation of linear features to achieve a lower pressure/risk rating (e.g. high to moderate pressure risk).	High priority 4th order sub-watersheds in the headwaters.	Initiate 2014-15, ongoing.	Government of Alberta Partnership Advisory Network members	*Source to Tap* - Phase 1: participants see increased evidence of linear disturbance and cumulative effects of land use as negatively impacting the headwaters. *Pincher Creek Community Values Assessment:* Five of the 15 highest rated 'value statements' pertained to environmental conservation (protecting the natural environment within the MD, conserving and protecting water resources, practicing sustainable agriculture protecting the natural environment around the MD and maintaining natural wildlife and fish populations. Headwaters Action Plan 2013-14: 18 organizations were involved in consensus decision-making process that set targets for density of linear features in the Oldman headwaters .	Biodiversity and Ecosystems – Objective: Terrestrial and aquatic biodiversity are maintained; species at risk are recovered. (SSRP; 68) Planning for new nature-based tourism development such as recreation trails and associated amenities will address environmental concerns in particular near watercourses, wetlands, and lakes with fisheries vulnerable to increased human access. Trails in sensitive source water or ecological areas will be assessed and may be redesigned, relocated, closed or reclaimed. The objective is to have appropriate activities occurring in appropriate places. (SSRP; 94) Linear footprint disturbance will be minimized through linear footprint management planning for Green and White Area public land. There will be a focus on priority areas for the eastern slopes... including: key headwaters areas, areas of sensitive terrestrial and aquatic habitat and other areas of high biodiversity value including for connectivity. (SSRP; 61)	Landscape Patterns Environmental Quality Analysis: provides a review of metrics of linear disturbance impacts for key species of concern: grizzly bear; bull trout and the necessity to address connectivity for these species. Grizzly Bear Recovery Plan - core and secondary conservation areas of high habitat value overlap a significant number of 4th order sub-watersheds in the headwaters. Westslope Cutthroat Trout Recovery Plan and Bull Trout Conservation Management Plans cite high density linear disturbance as a threat to species persistence.	Watershed Integrity Biodiversity Surface Water Quality	Facilitate Recommend	High priority 4th order sub-watersheds are prioritized for ecological and watershed integrity values; linear features and intensity of use is overlaid priority sub-watersheds; reclamation is completed to reduce risk rating by one category (Reference risk ratings: Headwaters Indicators Report, Oct. 2013)	SSRP Linear Footprint Management Plan initiated. SSRP Biodiversity Management Framework - in place in 2015.

(*Reference: Oldman Headwaters Indicator Project, 2014.1)

ACTION PLAN • Indicator 2: Density of Linear Features (continued)

TARGET 3: Decrease density of linear features where there is moderate to high pressure/risk rating in headwaters sub-watersheds.*

Action	Target Area	Time-frame	Proposed Implementers (Lead Agency bolded)	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Link to Other Initiatives	Watershed Criteria addressed by the action	OWC Facilitate, Recommend, Action, Participate	Evaluation of Success	Progress
3. Review the Draft South Saskatchewan Regional Plan for consistency with headwaters targets and provide feedback on gaps and inconsistencies.	Headwaters	Ongoing	Partnership Advisory Network members OWC	*Source to Tap* Phase 2: Water is a priority for public land management. Conservation and stewardship require a stronger value and role in land use planning, and ongoing and meaningful public consultation in watershed management is called for.	The province will continue to work with municipalities and other stakeholders to build awareness, achieve effective watershed management and encourage protection of water resources and responsible development. A key partnership under the 'Water For Life' Strategy is with the Watershed Planning and Advisory Councils. They have demonstrated leadership in their contributions to watershed assessment and planning in the region and the Government of Alberta is committed to enhancing its relationship with them. (SSRP; 76)	Headwaters Action Plan Oldman Headwaters Indicators Report Source to Tap Community Conversations	Watershed Integrity Biodiversity Surface Water Quality Stream Levels and Flows	Facilitate Recommend Action	Feedback to the SSRP was provided by the Partnership Advisory Network members and the OWC to: 1. Highlight where the Headwaters Action Plan 2013-14(HAP) and the Draft SSRP are in alignment. 2. Where the HAP and the Draft SSRP are inconsistent - why the HAP is important to incorporate into the SSRP; and key points made on where to improve the SSRP outcomes in relation to headwaters and source water planning priorities.	Input from the Headwaters Action Plan was provided to the SSRP process. Feedback will continue to be provided through the implementation stages. Final SSRP was in effect as of September 1, 2014. Alignment between the SSRP and the HAP is outlined in the column 'Link to South Saskatchewan Regional Plan'
4. Update the Minister (Environment and Sustainable Resource Development) on the Headwaters Action Plan 2013-14.	Headwaters	Ongoing	Partnership Advisory Network members OWC	*Source to Tap* Phase 2: Water is a priority for public land management. Conservation and stewardship require a stronger value and role in land use planning, and ongoing and meaningful public consultation in watershed management is called for.	The province will continue to work with municipalities and other stakeholders to build awareness, achieve effective watershed management and encourage protection of water resources and responsible development. A key partnership under the 'Water For Life' Strategy is with the Watershed Planning and Advisory Councils. They have demonstrated leadership in their contributions to watershed assessment and planning in the region and the Government of Alberta is committed to enhancing its relationship with them. (SSRP; 76)	Headwaters Action Plan Oldman Headwaters Indicators Report Source to Tap Community Conversations	Watershed Integrity Biodiversity Surface Water Quality Stream Levels and Flows	Action	The Minister (Environment and Sustainable Resource Development) is updated on the progress of the Headwaters Action Plan 2013-14 implementation and integration with source waters and headwaters planning priorities.	

(*Reference: Oldman Headwaters Indicator Project, 2014.1)

RECOMMENDATIONS TO DECISION-MAKERS • Indicator 2: Density of Linear Features

Recommendation	To Whom	Timeframe	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Watershed Criteria Addressed by the Recommendation	Evaluation of Success	Progress
1. Develop policy to ensure there will be no net increase in density of linear features in the Oldman headwaters sub-watersheds.	Government of Alberta Municipal Governments	Provide policy input to the SSRP process. (Spring 2014).	*Source to Tap* - Phase 1: participants see increased evidence of linear disturbance and cumulative effects of land use as negatively impacting the headwaters. *Headwaters Action Plan 2013-14*: 18 organizations were involved in consensus decision-making process that set targets for density of linear features in the Oldman headwaters. *Pincher Creek Community Values Assessment:* Five of the 15 highest rated 'value statements' pertained to environmental conservation (protecting the natural environment within the MD, conserving and protecting water resources, practicing sustainable agriculture protecting the natural environment around the MD and maintaining natural wildlife and fish populations.) *Westslope Cutthroat Trout Recovery Plan, Bull Trout Conservation Management Plan and Grizzly Bear Recovery Plan* all list proliferation of linear features and access issues as threats to species persistence.	Through regional planning, as well as other initiatives, Alberta is shifting to a more effective and efficient management system that considers the cumulative effects of all activities and improves integration across the economic, environmental and social pillars. (SSRP; 2) Linear footprint disturbance will be minimized through linear footprint management planning for Green and White Area public land. There will be a focus on priority areas for the eastern slopes…including: key headwaters areas, areas of sensitive terrestrial and aquatic habitat and other areas of high biodiversity value including for connectivity. (SSRP; 61) Conservation areas will be managed to minimize or prevent new land disturbance. (SSRP; 64)	Watershed Integrity Biodiversity Surface Water Quality	The SSRP includes a policy for no net gain of linear features in the Oldman headwaters.	SSRP 2014-2024 - Linear Footprint Management Planning is initiated.
2. Permits for construction of roads or other linear disturbance should include timeframe for active use and date for decommission and reclamation.	Government of Alberta Municipal Governments		*Westslope Cutthroat Trout Recovery Plan, Bull Trout Conservation Management Plan and Grizzly Bear Recovery Plan* all list proliferation of linear features and access issues as threats to species persistence.	There will be enhanced management of land disturbance. Linear footprint disturbance will be minimized through linear footprint management planning. (SSRP; 61) This plan will outline a system to minimize the extent, duration and rate of linear footprint development in order to meet the objectives established in this regional plan and biodiversity management framework. (SSRP; 69)	Watershed Integrity Biodiversity Surface Water Quality	All permits for new roads or other linear features include a timeframe for active use and a date for decommission and reclamation	SSRP 2014-2024 - Linear Footprint Management Planning is initiated.

ACTION PLAN • Indicator 3: Aquatic Invasive Species

TARGET: Keep these aquatic invasive species out of the Oldman watershed (zebra mussels, quagga mussels and eurasian watermilfoil).

Action	Target Area	Time-frame	Proposed Implementers (Lead Agency bolded)	Support from Community	Link to South Saskatchewan Regional Plan (SSRP)	Link to Other Initiatives	Watershed Criteria addressed by the action	OWC Facilitate, Recommend, Action, Participate	Evaluation of Success	Progress
1. Assist Government of Alberta with the awareness and education program ("Stop Aquatic Hitchhikers") for stakeholders and the public on how to prevent these aquatic invasive species from entering Alberta.	Headwaters	Immediate - ongoing	**Government of Alberta** Partnership Advisory Network members Alberta Lake Management Society Interested citizens	There is a significant gap in public and stakeholder awareness of zebra mussels, quagga mussels, and eurasion watermilfoil.	Continue to work with other government agencies, other levels of government, landholders, non-government organization, industry, the research community and other partners within and outside the province to manage risk associated with invasive species. (SSRP; 71)	Government of Alberta Crown Manager's Partnership Alberta Lakes Management Society	Watershed Integrity Biodiversity Water Quality	Facilitate Recommend Action	Public awareness and education programs on aquatic invasive species prevention is provided to the greater watershed community. Monitoring for aquatic invasive species is in place at boat launches at select headwaters lakes.	The Crown Manager's Partnership and Government of Alberta have initiated the "Stop Aquatic Hitchhikers" program (2013-2014).
2. Assist with monitoring for these aquatic invasive species through a citizen-science monitoring program that is active at specified boat launch areas on headwaters lakes and reservoirs.	Headwaters	Spring 2014 - ongoing	OWC Government of Alberta Partnership Advisory Network members Alberta Lake Management Society Interested citizens	Ongoing monitoring for the presence of aquatic invasive species is needed - early warning of this significant threat to aquatic ecosystem health and water-use infrastructure.	Continue to work with other government agencies, other levels of government, landholders, non-government organization, industry, the research community and other partners within and outside the province to manage risk associated with invasive species. (SSRP; 71)	Government of Alberta Crown Manager's Partnership Alberta Lakes Management Society	Watershed Integrity Biodiversity Water Quality	Facilitate Recommend Action	Monitoring for aquatic invasive species is in place at boat launches at select headwaters lakes.	Government of Alberta and the Alberta Lakes Management Society are prepared to assist local stewardship groups and individuals to implement aquatic invasive species monitoring programs.
3. Government of Alberta's response strategy if these aquatic invasive species are found in Alberta will be shared, and action taken where the OWC and others can add effectiveness and help with the strategy.	Headwaters	Immediate - ongoing	**Government of Alberta** OWC Partnership Advisory Network members	Invasive species are recognized as a problem in the headwaters *(Source to Tap; Chief Mt Cumulative Effects Study; Southern Foothills Study; OWC Vision, Risk Analysis and Priority Reports)*. Aquatic invasive species of greatest concern (zebra mussels, quagga mussels, eurasian watermilfoil) were not specifically mentioned in *Source to Tap* community conversations. This is a significant gap in public awareness and knowledge.	Aquatic invasive species are of concern to maintain healthy aquatic ecosystems. The current focus is on preventing the establishment of the three most noxious aquatic invasive species: zebra mussels; quagga mussels and Eurasian water-milfoil. In addition to aquatic ecosystem impacts, there are high economic costs associated with affected water infrastructure. The Government of Alberta is committed to continued prevention and control work with multi-jurisdictional organizations such as the Crown Managers Partnership (Crown of the Continent) (SSRP: 80).	Government of Alberta Crown Manager's Partnership Alberta Lakes Management Society	Watershed Integrity Biodiversity Water Quality	Facilitate Recommend Action	Aquatic invasive species are kept out of Alberta.	The Crown Manager's Partnership and Government of Alberta have initiated the "Stop Aquatic Hitchhikers" program (2013-2014).

APPENDIX A
Statement of Concern

Spray Lake Sawmills

305 Griffin Road W
Cochrane, Alberta T4C 2C4
Phone (403) 932-2234
Fax (403) 932-6675

March 26, 2014

Connie Simmons,
Planning Manager
Oldman Watershed Council
100, 5401 – 1st Avenue South
Lethbridge, Alberta
T1J 4V6

Re: Headwaters Action Plan, Statement of Concern

Dear Connie,

This letter is a "statement of concern" by Spray Lake Sawmills (SLS) in regards to several headwaters health indicators, targets, recommendations, and proposed actions within the Oldman Watershed Council's (OWC) Headwaters Action Plan (HAP). This letter is also follow up to objections that I voiced at the Headwaters Action Plan draft review that was held in Cowley, Alberta on November 20th, 2013 as well as the HAP Introductory meeting in Pincher Creek on January 31st, 2014.

SLS has specific concerns with the following headwaters health indicators, targets, recommendations, and proposed actions:

1. Indicator 1, Presence and abundance of Trout, especially native populations:
   - SLS is very concerned with the use of native fish "presence / absence" and abundance as a surrogate indicator for water quality. There are many other attainable, measurable, and repeatable parameters that are better indicators of water quality.

2. Indicator 1, Recommendations to Decision Makers for Target 1: Maintain current native fish population integrity within the headwaters area and explore opportunities to increase populations in their current range.
   - SLS is concerned with the proposed action of setting a threshold for lineal disturbance at 0.2 – 0.15 km/km^2 in sub-watersheds where BLTR and WS CTTR currently exist. The threshold is too low and restrictive for the development of temporary access in designated multiple use areas. This standard is not supported in the Oldman Watershed Headwaters Indicators Project Report either. The report suggests that fourth order watersheds remain in the low risk category when road densities remain below 0.5 km/km^2 and are within the moderate risk category when road densities remain below 0.87 km/km^2.

- SLS fully supports the maintenance of current native fish populations and their habitat integrity within the headwaters area. It is a pillar of sustainable forest management. Nevertheless, SLS believes that the OWC is beyond its management mandate to attempt to manage fish populations in the headwaters area. Managing fish populations and their distribution is the mandate of the Province through the Department of Environment and Sustainable Resource Development (AESRD). SLS maintains that the OWC should focus primarily on water quality and quantity utilizing proven, measurable, and repeatable scientific parameters.

3. Indicator 2, Density of Lineal Features:
   - Indicator 2 has three targets identified. Two of these targets are of concern to SLS. I would also expect that they would be of concern to any company, group, or organization that is interested in or relies upon access within the headwaters region of the Oldman Watershed. The two targets that are of concern to Spray Lake Sawmills specifically are:
     - Target 2: Maintain negligible and low lineal features density where it currently exists; ensure no net increase of lineal features in each sub-watershed.
     - Target 3: Decrease density of lineal features where there is moderate to high risk rating in the headwaters.

Spray Lake Sawmills wishes to provide the Oldman Watershed Council with the following suggestions so that the aforementioned targets may be refined or clarified so that they can be practically implemented.

1. Indicator 1, Presence and abundance of Trout, especially native populations:
   - The "presence / absence" and abundance of native fish, as surrogate indicators of water quality are not supported by proven science and do not follow the OWC "Headwaters Indicators Project – Final Report". The aforementioned report lists the following measureable indicators for surface water quality as:
     - Nutrients (nitrogen, phosphorous)
     - Trace metals (Mercury, aluminum, iron, vanadium)
     - Base chemistry (dissolved oxygen, total suspended solids (TSS))
     - Major elements (sulfate, chlorine, sodium)
     - Organics (pesticides, organochlorine pesticides)
   - In addition, benthic invertebrates are also recognized as a reliable, repeatable, measureable indicator of water quality. The presence of fish is influenced by many factors other than water quality (ie. climate, water temperature, natural and non-natural barriers, sport fishing pressure, catch and release mortality, and competition with non-native fish species among others) making it a very poor indicator of water quality. Further to that, the OWC "Headwaters Indicators Project – Final Report" classes the water quality in the forest reserve portion of the Oldman River Watershed as very good to excellent. The reduction in pure strain West Slope Cutthroat Trout (WS CTTR) and Bull Trout (BLTR) numbers has very little to do with the current water quality of the Oldman River Watershed and far more to do with hybridization, competition from introduced fish species and over-fishing.

- The identified "data gap" in regards to benthic invertebrate populations and distribution should be identified as a high priority action in the HAP and appropriately addressed so that it falls in line with the "Headwaters Indicators Project – Final Report" as well as the draft South Saskatchewan Regional Plan (SSRP).
- The OWC HAP should be consistent with the SSRP draft plan which has also proposed measureable indicators of water quality all consistent with those from the OWC "Headwaters Indicators Project – Final Report".

2. Indicator 1, Recommendations to Decision Makers for Target 1:
   - Set a threshold for lineal disturbance for roads of up to 0.5 km/km^2 in sub-watersheds where BLTR and pure strain WS CTTR currently exist without special approval.
   - Allow for densities of all lineal features of up to 3.0 km/km^2 in sub-watersheds where temporary roads (ie. 5 years or less) are proposed and BLTR and pure strain WS CTTR currently exist with special approval / conditions from AESRD.

3. Indicator 2, Density of Lineal Features:
   - These targets are too vague in their intent and leave too much open to interpretation by both proponents and opponents to access development. They may also prove to be short-sighted and incompatible with approved land use activities that are permitted through the South Saskatchewan Regional Plan (SSRP).
   - The term lineal feature needs to be defined in much more detail. Lineal features should also be grouped in logical use categories, life expectancy, and current status of use. Descriptors and physical characteristics also need to be clearly defined for each lineal feature use category.
   - If the current targets were to be adopted into regulation, access development of any type could be significantly limited, denied, and / or cost prohibitive depending on which sub-watershed it is proposed within. Moreover, development of access, whether it be permanent or temporary could be severely inhibited or prohibited, even if it is deemed necessary and / or desirable and compatible with approved land uses. Criteria for responsible access development need to be part of the HAP.
   - Finally, calculation of the current lineal features density should not include temporary access structures that have been permanently deactivated or have naturally become inactive. Further to that, proposed or active temporary access structures should not be viewed as an increase to the lineal feature density, provided that their life expectancy is ≤5 years.

I look forward to working with the Oldman Watershed Council on the Headwaters Action Plan so that it achieves a high level of success, in a manner that permits responsible resource development and land use. Please feel free to contact me at <contact information removed> should you have any comments or concerns.

Sincerely,
<Original signed by>

Wade Aebli, RPFT
C5 Woodlands Supervisor

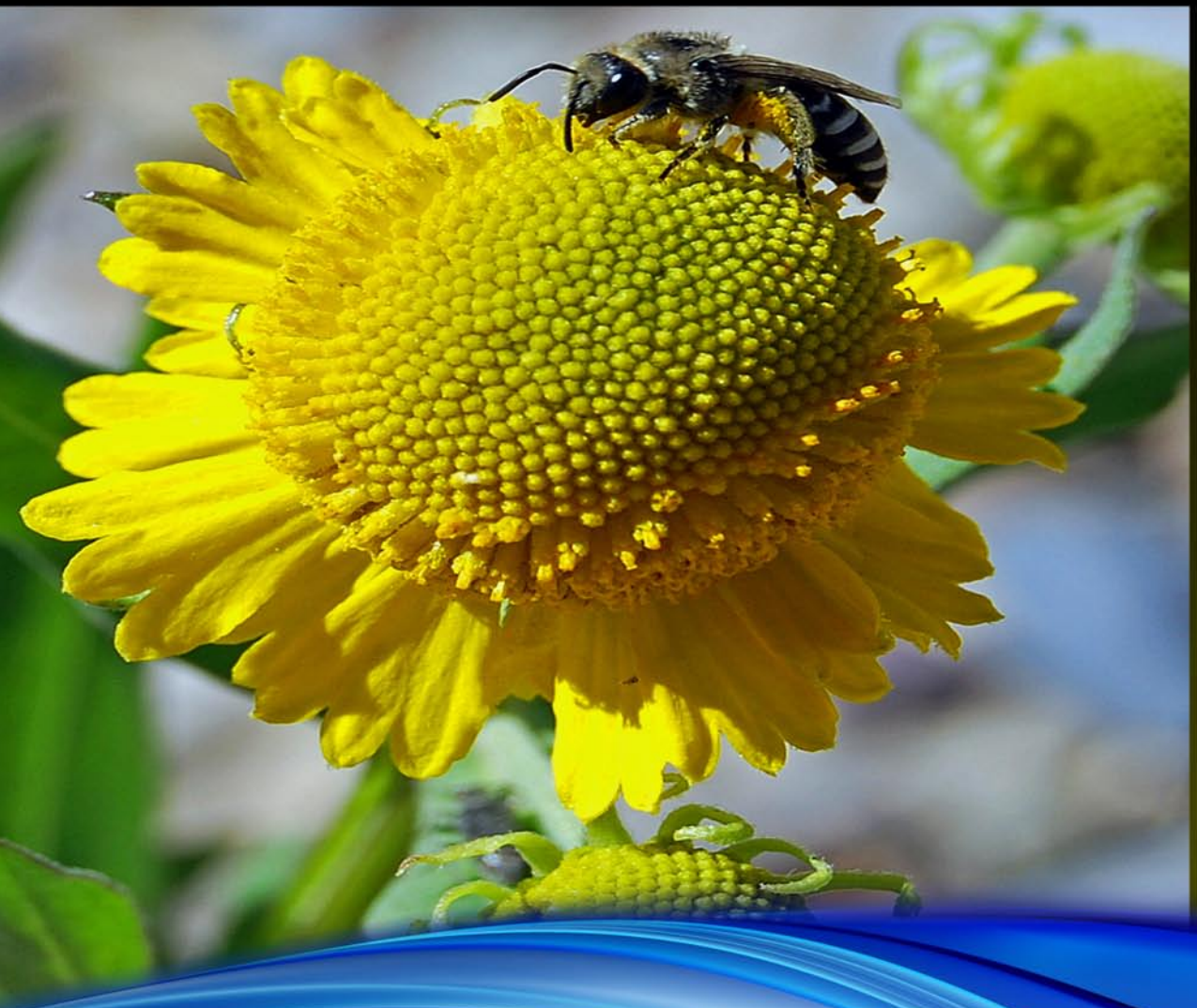
Website: www.spraylakesawmills.com Email: info@spraylakesawmills.com

APPENDIX B
OWC Response

OLDMAN WATERSHED COUNCIL
Response to Statement of Concern, Spray Lake Sawmill

The Oldman Watershed Council would like to thank Wade Aebli, C5 Woodlands Supervisor, Spray Lake Sawmills (SLS), for outlining the concerns SLS has with the Headwaters Action Plan's (HAP) targets, recommendations and proposed actions in a Statement of Concern, dated March 26, 2014. The OWC has taken these recommendations into consideration and will continue to work with SLS on the Headwaters Action Team (HAT), which is collaborating on implementation of the HAP. The OWC values all stakeholder input and as such, will take all input into consideration in the future implementation of the HAP and the Integrated Watershed Management Plan (IWMP) in order to ensure a healthy and resilient watershed for future generations.

In addition, a letter addressing the specifics in the Statement of Concern was sent to Wade Aebli on November 26, 2014.



Our vision is a healthy, resilient watershed where people, wildlife and habitat thrive.

The Oldman Watershed Council, or OWC, is a community-based, not-for-profit that works with everyone to find practical solutions to environmental challenges that impact us all. People depend on a healthy watershed to provide economic, social and cultural benefits. Everything in the watershed is connected, so we need to work together to make trade-offs, solve problems, plan for the future, and safeguard our quality of life.

It takes time and effort to work collaboratively, but the OWC is building a new way of managing our collective impacts on water and land - where we can all do our part, work together and keep in mind the long term benefits of a healthy watershed.

We believe it's worth the investment.

OLDMAN WATERSHED COUNCIL

www.oldmanwatershed.ca

Photo credits
Front: Rochelle Coffey
Above (L-R): Ruth Christie, Jollin Charest, Karen Armstrong