Associated Environmental

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REPORT

Southern Alberta Land Trust Society

Oldman Watershed Priority Mapping




April 2018

Acknowledgements

This report was completed by Associated Environmental. We would like to thank Justin Thompson, Executive Director of the Southern Alberta Land Trust Society (SALTS), for his dedication to this project. The project was funded by the Watershed Resilience and Restoration Program (WRRP), under Alberta Environment and Parks (AEP).

Valuable input was obtained during and following the workshop conducted on October 30, 2017. The workshop participants and their organizations were as follows:

- Shannon Frank – Oldman River Watershed Council (OWC)
- Dr. Stefan Kienzle – University of Lethbridge Geography Department
- Oriano Castelli – Alberta Environment and Parks
- Kristi Stebanuk – Cows and Fish
- Kelsey Cartwright – Cows and Fish
- Suzanne Marechal – Independent GIS Consultant
- Gavin Scott – Oldman River Regional Services Commission (ORRSC)
- Shirley Pickering – Highwood Management Plan Public Advisory Committee

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1 Introduction

Associated Environmental (AEnv) partnered with the Southern Alberta Land Trust Society (SALTS) to produce this report and associated map products covering the Oldman River Watershed. The objective was to enable SALTS to target their conservation activities on critical lands to protect and maintain resilience to flood, drought and water quality degradation (watershed health). It was also to share the outputs of the project to empower other organizations working to do the same in the watershed. These priorities overlap with those of the Watershed Resilience and Restoration Program (WRRP), who funded this project.

This report describes the work that was completed through the following three phases:

- Develop a geographic information system (GIS) that is based on relevant and representative landscape data.
- Create maps identifying areas of high risk to watershed health.
- Conduct stakeholder outreach and refine map products, including identifying sub-basins of high priority protection.

The map products produced within the first three phases of work will be critical tools to be used in the next phase of work, which is centred on landowner engagement.

1.1 RATIONALE

The value of a parcel of land as it relates to slowing runoff, storing water and filtering water is a function of many factors including precipitation, proximity to waterbodies, streams and rivers, soil, vegetation and slope. Not all private land parcels are equal in terms of their importance to watershed health. The priority mapping previously completed by WRRP in Alberta was based on hydrologic unit code (HUC) 6 scale watersheds, yet the lands within a watershed have vastly different watershed health qualities. A higher resolution dataset is needed as SALTS protects private land based on legal land parcels. Similarly, organizations like Cows and Fish and the Oldman Watershed Council also partner with individual landowners so a higher resolution dataset is critical.

2 Method

The general approach followed the method described in Barten and Earnst (2004) and the Source Protection Handbook published by the Trust for Public Land and the American Water Works Association (TPL and AWWA, 2005).

The overall method involved the following six steps:

- **Step 1**: Select landscape layers for the GIS that are representative of potential watershed health.
- **Step 2**: Categorize the attributes of each landscape layer using a risk rating score of 1 to 4.
- **Step 3**: Overlay the landscape layers in the GIS and combine the scores to obtain an overall rating score for each polygon that is generated.
- **Step 4**: Classify overall rating scores into categories.
- **Step 5**: Adjust layers and conduct sensitivity trials to refine the final overlay.
- **Step 6**: Based on the detailed overlay data, produce sub-basin roll-ups, and high-resolution maps to target high priority conservation areas.

2.1 LANDSCAPE REPRESENTATION AND RATINGS

Seven landscape layers were identified to represent the effects of slowing runoff, storing water and filtering water. These were considered key water quantity and quality functions to maintain resilience to flood, drought and water quality degradation, thus maintaining watershed health. Table 1 identifies the landscape layers and summarizes their importance to watershed health.

Table 2-1
Landscape Layer Importance

Layer Name	Importance to Watershed Health
Precipitation	High surface runoff areas are the source of flood and (potentially) water quality degradation. Promoting infiltration and reducing runoff along linear disturbances in high precipitation areas can disproportionately reduce these effects.
Proximity to wetlands and lakes	Slow moving and high water-table areas moderate flows (attenuating downstream flood flows), provide water storage, are a source of baseflow, and promote water quality improvement through settlement and filtration (especially wetlands).
Proximity to watercourses	Watercourses, including their riparian areas, provide infiltration, filtration and flood conveyance. Reducing disturbance in proximity to watercourses also reduces the risk of siltation and other water quality impacts.
Aquifer vulnerability	Aquifers provide water storage and baseflow during low-flow periods and provide water filtration.
Land cover	The multiple processes/interactions between water and naturally vegetated areas (e.g., interception, absorption, transpiration, infiltration) have the effect of slowing surface flows, storing water and improving water quality.
Slope	Higher-slope areas exacerbate runoff issues, including erosion, by increasing runoff velocity (Dunne and Leopold 1983).
Surficial geology	Permeable soils and sub-soils facilitate infiltration, and are also more susceptible to erosion.

Each landscape layer was classified according to a risk rating with respect to watershed health, on a scale from 1 to 4 (final rating score and classifications are presented in Section 4.1).

The seven landscape layers were combined into a vector map having discrete polygons created by the intersections of each landscape layer. Several overlay versions were created by combining the rating scores and visualizing the overlays using the following method alternatives:

- Overlay combination (e.g., additive and multiplicative)
- Number of classifications (e.g., 4 to 8)
- Classification scheme (e.g., natural breaks and geometrical interval)

2.2 WORKSHOP

A stakeholder engagement workshop was conducted on October 30, 2017 in Lethbridge, AB, and included stakeholders from academia, non-governmental organizations and local agencies working on land conservation, planning and research in the Oldman River Watershed (see the Acknowledgements section for participant details). The purpose of the workshop was to obtain feedback on the suitability of the landscape layers and the appropriate datasets to represent the layers and on the draft overlay versions to improve the usability of the final map products to achieve common goals.

Key feedback that was obtained from the group related to the time period represented within the precipitation layer and its relevance compared to alternative data potentially available, the slope classifications, the representativeness of the wetlands layers, and the overlay classification colour scheme. Feedback on the quality and importance of each of the landscape layers was also obtained to determine relative weights to be used in the overlay process. The input from the workshop was fed back into Steps 1 through 5 in the development of the final map products (Section 4).

3 Data Sources

3.1 LANDSCAPE LAYERS

Table 2-1 lists the landscape layer data sources that were used, along with the data processing details and rationale related to each data source.

Table 3-1
Landscape Layer Data Summary

Layer Name	Data Sources	Processing Details and Rationale
Precipitation	Data obtained by the Regression on Independent Slopes Method (PRISM) Climate Group, University of Oregon.	Annual precipitation was averaged based on monthly precipitation normals for the period 1980-2010. The gridded data are based on an algorithm that transforms local climate time-series based on known physiographic relationships such as elevation, slope, and aspect.
Proximity to wetlands and lakes	Wetlands obtained from Alberta Merged Wetland Inventory (AMWI) – Alberta Environment and Sustainable Resource Development (AESRD).	The AMWI data depicts wetlands for the period 1998 to 2015, and is based on to the following major levels of the Canadian Wetland Classification System (CWCS): marsh, bog, fen, swamp and open (shallow) water. Buffer widths of 50 m were applied based on BC MOE (2014) guidelines, which are conservative compared to other jurisdictions.
	Lakes obtained from AltaLIS 1:20 000 Base Features Hydrography polygons.	The AltaLIS data includes reservoirs and overlaps the AMWI, especially for shallow open water. This ensured that all shallow wetlands were identified. Buffer widths of 50 m were applied based on BC MOE (2014) guidelines, which are conservative compared to other jurisdictions.
Proximity to watercourses	Streams mapped in the AltaLIS 1:20 000 Base Features Hydrographic Network.	AltaLIS data provides better resolution and appears to more accurately indicate location of streams (including canals and aqueducts) than other data sources. Buffer widths of 250 m were applied based on BC MOE (2014), which are conservative compared to other jurisdictions.
	Lotic riparian areas obtained from AESRD.	The data are derived from a digital elevation model (DEM) to identify critical wildlife habitat and potentially densely vegetated zones that provide stabilization against erosion.
	Flood hazard areas were obtained from Alberta Environment and Parks (AEP).	Flood hazard areas were delineated along streams and lakes using design flood levels established as part of limited flood hazard studies in and surrounding urban areas.

Layer Name	Data Sources	Processing Details and Rationale
Groundwater vulnerability	Groundwater vulnerability mapping for the South Saskatchewan region (SSR) by the Groundwater Policy Section, Water Policy Branch, Alberta Environment	Provides a high-level overview of the sensitivity of shallow groundwater quality to potential impacts by surface activities. The final groundwater vulnerability is ranked as low, medium, high and very high providing relative risk to groundwater quality from land-based activities. No reclassification was required. Two small data gap areas were filled.
Land cover	Grassland Vegetation Inventory (GVI) was obtained from AEP; Human footprint inventory was obtained from the Alberta Biodiversity Monitoring Institute (ABMI).	The GVI data were used as the primary data source; however, it contained some gaps in mountainous areas. The land cover obtained by ABMI, which was more detailed and comprised 11 different classes such as grassland, agriculture and developed land, was used to fill-in gaps in the GVI dataset and areas of anthropogenic activity. The classification was simplified to capture forest and other native vegetation, agricultural, and developed or low priority lands.
Slope	Slopes were derived based on the Canadian Digital Elevation Model (DEM) obtained from Natural Resources Canada (NRCan).	The 19 m resolution DEM calculated slope, which was classified according to an even distribution with one exception; areas of slope >30% were assumed as having low development risk.
Surficial geology	Surficial material data was obtained from Alberta surficial geology maps produced by the Alberta Geological Survey (AGS).	Surficial geology information indicates runoff generation and soil erodibility potentials. Classes were adapted from the erosion potential mapping criteria published by BC Ministry of Forests (1999).

For the purposes of this study, the proximity to wetlands and lakes, and proximity to watercourses layers were grouped as a single landscape layer named “proximity to water”. The grouping was intended to simplify the overlay process and provide better representation of the desired landscape features. For example, wetlands are typically not well identified and documented within AMWI and AltaLIS layers. Therefore, a more conservative interpretation of wetland distribution was achieved by combining these landscape layers.

In some instances, alternative landscape layers could have been selected to represent important processes to reach the same objective. For example, a water erosion potential layer is produced by the Alberta Water Erosion and Prediction Project (WEPP). However, this layer combines slope and soil texture, which are individually represented within the other landscape layers we selected. The GIS layer representations of the landscape layers were also selected based on data availability and completeness.

3.2 OTHER LAYERS

In addition to the landscape layers, municipal boundaries, roads and highways, and geographic feature labels such as those for streams and lakes, obtained from AltaLIS 1:20 000 Base Features, were added to the map products to facilitate user orientation when viewing the maps. The Map Book also contains key landscape information to facilitate engagement with landowners, as shown in Table 3-2.

Table 3-2
Map Book Data Sources

Layer Name	Data Source
Hydrological Unit Code (HUC) 10 watershed boundaries	Government of Alberta, Environment and Parks
Parks / Ecological Reserves	AltaLIS 1:20 000 Base Features
Grazing Leases	SALTS
First Nation Lands	AltaLIS 1:20 000 Base Features
Green Zone (i.e., forested portion of land owned by the Alberta Government)	AltaLIS 1:20 000 Base Features

4 Final Map Products

4.1 FINAL LANDSCAPE LAYERS AND OVERLAY

The final risk rating scores and associated classifications are detailed in Table 4-1. The six landscape layers were combined into a vector map having 413,574 discrete polygons created by the intersections of each layer.

Table 4-1
Risk Rating Scores and Classifications

Layer Name	Rating Score / Classification			
	4 Very High	3 High	2 Moderate	1 Low
Precipitation (mm/year)	850 - 2232	670 - 850	450 - 670	332 - 450
Proximity to water	Yes	-	-	No
Aquifer vulnerability	Very High	High	Moderate	Low

Layer Name	Rating Score / Classification			
	4 Very High	**3 High**	**2 Moderate**	**1 Low**
Land cover	Forest (all types), Grassland, Shrubland, Wetlands	None	Agriculture	Developed, Exposed Land, Rock/Rubble, Snow/Ice
Slope (%)	20 – 30	10 – 20	0 – 10	>30
Surficial geology	Lacustrine, Glacio-lacustrine, Eolian, Organic	Glaciofluvial, Fluvial	Moraine	Colluvium, Bedrock, Glaciers

Generally, areas with high-runoff potential coinciding with forest and other native vegetation on the landscape were designed to have a very high priority rating. The final landscape layers are found in **Appendix A**.

During the workshop, relative weights were assigned to each landscape layer, based on the group's consensus of the data quality and importance. For each layer, data quality was scored on a scale of 1 to 3, with 3 meaning highest data quality; importance was scored on a scale of 1 to 5, with 5 being the most important. The relative impacts for each layer were determined by summing the data quality and importance scores and dividing them by the total sum of scores (i.e., 41). Finally, the weights were calculated by assigning a relative impact of 15% to a neutral weight of 1 (Table 4-2).

Table 4-2
Relative Weights

	Abbreviation	Data Quality	Importance	Sum	Relative Impact	Weight
Precipitation (mm/year)	PR	3	3	6	15%	1
Proximity to water	WP	3	5	8	20%	1.33
Groundwater vulnerability	GV	2	2	4	10%	0.67
Land cover	LC	3	3	6	15%	1
Slope (%)	SL	3	3	6	15%	1
Surficial geology	SG	1	2	3	7%	0.5
Total				**41**	**100%**	-

The weights were applied in the multiplicative overlay of landscape layer risk rating scores for each unique polygon, as follows:

$$Risk\ Rating\ Score = PR \times (WP)^{1.33} \times (GV)^{0.67} \times (LC) \times (SL) \times (SG)^{0.5}$$

For each unique polygon, the possible total score ranged from zero to 1774. The overlay data was categorized into eight classes, based on the geometric interval classification method within ArcGIS. The final overlay results map is found in Figure 1.

4.2 MAP BOOK AND SUB-BASIN ROLL-UP

The Map Book was created to allow users to “zoom in” and view key areas of the Oldman River Watershed at a higher resolution. The Map Book includes 12 maps at approximately 1:180 000 scale, and each map includes an overlapping border of approximately 3.2 km. Areas located downstream from Lethbridge were not considered in this analysis, due to the lower overall rating scores in these areas, as well as the lack of HUC 10 sub-basin delineations. The map book of high-resolution maps, and other high-resolution maps may be found on-line at the following website: https://salts.land/publications/.

We created a priority map to help target conservation initiatives within 74 sub-basins of the Oldman River Watershed. The map results were based on a roll-up of the overlay results, using the HUC 10 sub-basins and applying the following steps in each sub-basin:

- **Step 1**: Calculate the percentage area of the sub-basin that has a rating score of 5 to 8.
- **Step 2**: Classify the priority rating as follows if the percentage area calculated in Step 1 is:
  - >60% = 1
  - 47%-60% = 2
  - 33%-47% = 3
  - 20%-33% = 4
  - <20% = 5

The HUC 10 sub-basins considered within the roll-up analysis represented about 75% of the total area within the Oldman River Watershed. Out of the 74 sub-basins considered, the number of sub-basins that were rated as priority 1 and 2 was 22 and 17, respectively (Table 4-3). This represents approximately 40% of the sub-basins considered, in terms of both number and area. The priority sub-basins roll-up map is in Figure 2.

Table 4-3
Proportion of Priority Rated Areas as a Portion of the Sub-Basins Considered

Priority Rating	Number of Sub-Basins	Total Sub-Basins Area (km^2)	Proportion of Sub-Basins (%)
1	22	4207	21
2	17	3570	18
3	12	3326	17
4	7	2229	11
5	16	6554	33
Total	**74**	**19,885**	**100**

5 Summary

This report outlined the methods and map products developed to identify areas of high risk to watershed health in the Oldman River Watershed. The overlay results were used to create high-resolution maps and to roll-up the information at the HUC 10 sub-basin scale to target high priority conservation areas. The development of the map products described herein represents the outcome of the first three phases of this Project. In Phase 4, the map products will be used to facilitate landowner engagement.

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REPORT

Certification Page

This report presents our findings regarding the Southern Alberta Land Trust Society Oldman Watershed Priority Mapping.

Respectfully submitted,

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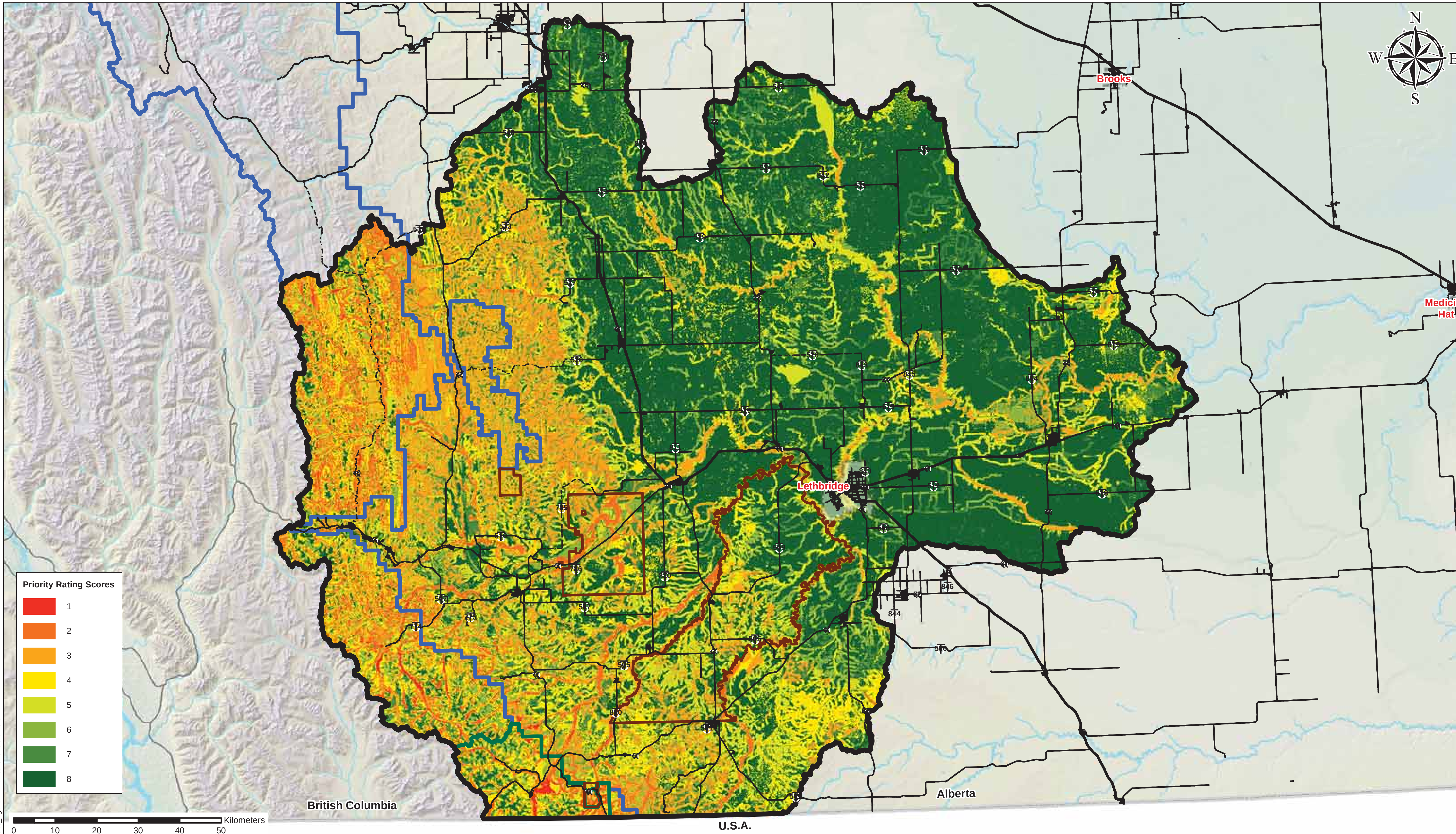
Figures



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Associated Environmental

SALTS southern alberta land trust society

Oldman River Watershed
City
First Nations Lands
National Parks
Green zone boundary
Provincial / International Boundary

PROJECT NO.: 2017-8110
DATE: April 2018
DRAWN BY: BdJ

FIGURE 1 - OVERLAY RESULTS

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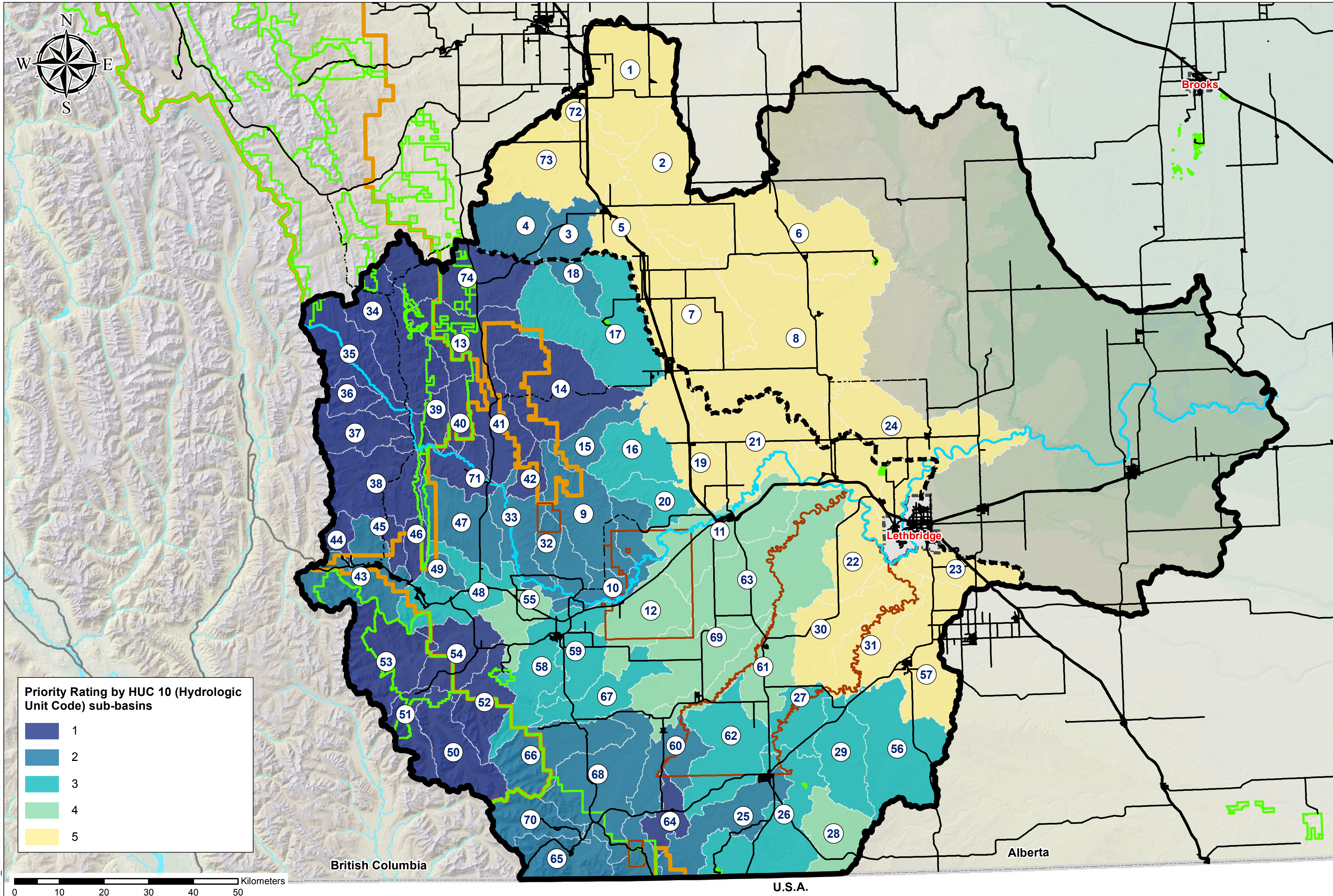
WRRP - Oldman Watershed Priority Mapping



Sub-basin ID	NAME
1	FRANK LAKE
2	LITTLE BOW RIVER ABOVE MOSQUITO CREEK
3	NANTON CREEK
4	UPPER MOSQUITO CREEK
5	LOWER MOSQUITO CREEK
6	UNNAMED ABOVE TRAVERS RESERVOIR
7	CLEAR LAKE
8	LITTLE BOW RIVER ABOVE TRAVERS RESERVOIR
9	BEAVER CREEK
10	UPPER OLDMAN BELOW OLDMAN RESERVOIR
11	MIDDLE OLDMAN BELOW OLDMAN RESERVOIR
12	CROWLODGE CREEK
13	SOUTH WILLOW CREEK
14	TROUT CREEK
15	MEADOW CREEK
16	KYISKAP CREEK
17	MIDDLE WILLOW CREEK
18	OXLEY CREEK
19	LOWER WILLOW CREEK
20	MUD LAKE
21	LETHBRIDGE NORTHERN HEADWORKS
22	PARK LAKE - OLDMAN RIVER
23	HENDERSON LAKE - OLDMAN RIVER
24	KEHO LAKE - OLDMAN RIVER
25	LEE CREEK
26	UPPER ST. MARY RIVER
27	ST. MARY RESERVOIR
28	ROLPH CREEK
29	PINEPOUND CREEK
30	UNNAMED - ST. MARY RIVER
31	LOWER ST. MARY RIVER
32	TENNESSEE CREEK
33	LOWER OLDMAN RIVER ABOVE RESERVOIR
34	LIVINGSTONE RIVER
35	UPPER OLDMAN RIVER ABOVE RESERVOIR
36	HIDDEN CREEK
37	DUTCH CREEK
38	RACEHORSE CREEK
39	CAMP CREEK
40	BOB CREEK
41	CALLUM CREEK
42	HEATH CREEK
43	UPPER CROWSNEST RIVER
44	ALLISON CREEK
45	BLAIRMORE CREEK
46	GOLD CREEK
47	TODD CREEK
48	LOWER CROWSNEST RIVER
49	ROCK CREEK
50	UPPER CASTLE RIVER
51	WEST CASTLE RIVER
52	MILL CREEK
53	CARBONDALE RIVER
54	MIDDLE CASTLE RIVER
55	LOWER CASTLE RIVER
56	UPPER POTHOLE CREEK
57	LOWER POTHOLE CREEK
58	PINCHER CREEK
59	INDIANFARM CREEK
60	UPPER BELLY RIVER
61	MIDDLE BELLY RIVER
62	LAYTON CREEK
63	LOWER BELLY RIVER
64	MIAMI CREEK
65	UPPER WATERTON RIVER
66	DRYWOOD CREEK
67	FOOTHILL CREEK
68	MIDDLE WATERTON RIVER
69	LOWER WATERTON RIVER
70	BLAKISTON CREEK
71	MIDDLE OLDMAN RIVER ABOVE RESERVOIR
72	UPPER LITTLE BOW RIVER
73	MIDDLE MOSQUITO CREEK
74	UPPER WILLOW CREEK

Associated Environmental

SALTS southern alberta land trust society

Oldman River Watershed
Watershed boundary (above Lethbridge)
City
First Nations Lands
Provincial / International Boundary
Green zone boundary
Parks / Ecological Reserves

Major Roads

Highway - divided
Highway - 4 lane undivided
Road - 2 lane undivided
Road - 2 lane gravel

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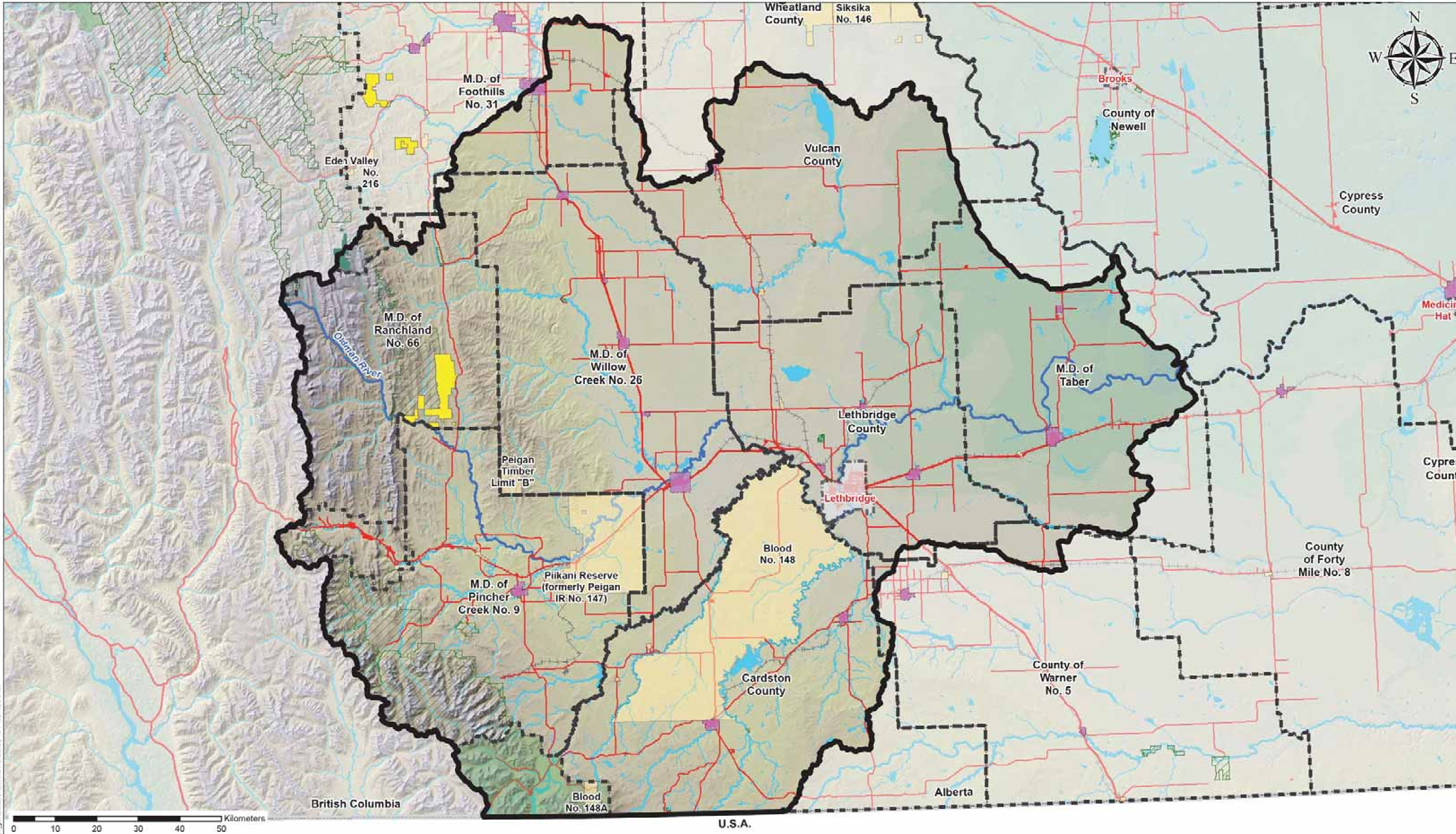
DATE: April 2018
DRAWN BY: BdJ

FIGURE 2 - PRIORITY SUB-BASINS

Southern Alberta Land Trust Society

WRRP - Oldman Watershed Priority Mapping

Appendix A – Landscape Layers



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Associated Environmental

Oldman River Watershed	Village
City	Municipal District
Town	Indian reserve
Heritage rangeland	National Park
Ecological reserve	Provincial / International Boundary
Provincial Park	

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FIGURE A1 - JURISDICTIONS

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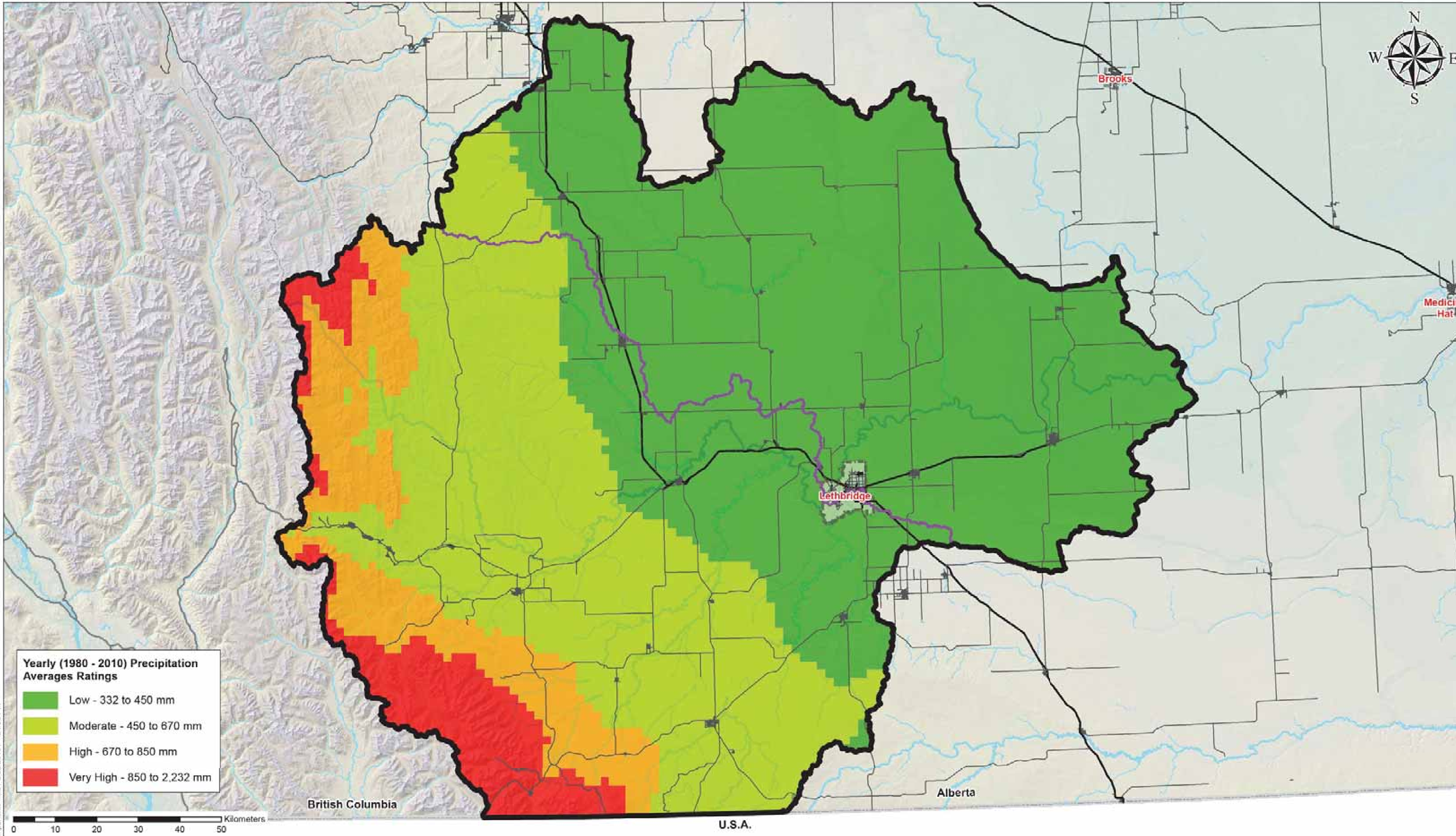
WRRP - Oldman Watershed Priority Mapping



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Associated Environmental

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DATE:	March 2018
DRAWN BY:	BdJ

FIGURE A2 - PRECIPITATION (MM/YEAR)

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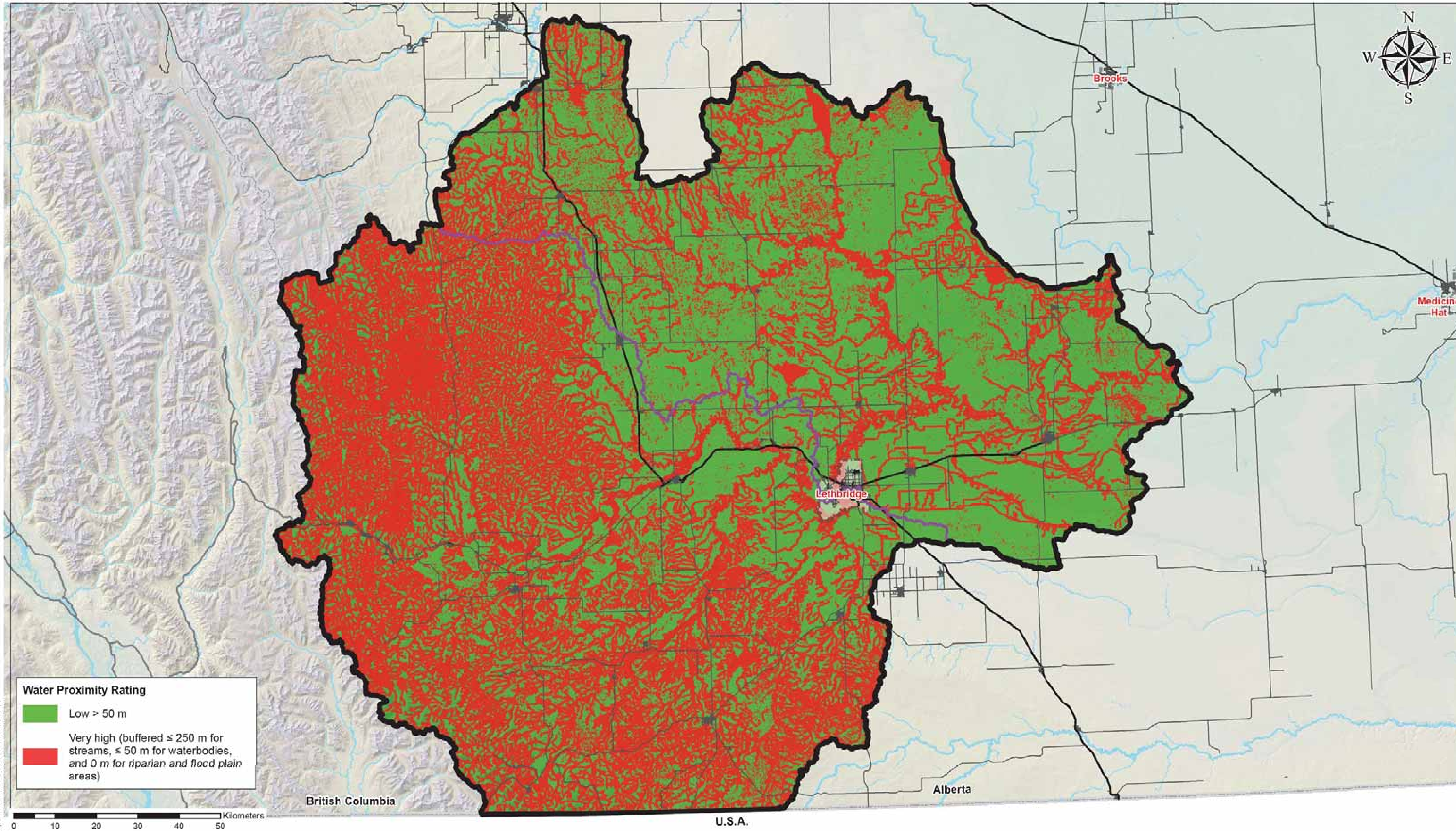
WRRP - Oldman Watershed Priority Mapping



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Associated Environmental

Oldman River Watershed

Lethbridge intake watershed

City

Provincial / International Boundary

Major Roads

Highway - divided

Highway - 4 lane undivided

Road - 2 lane undivided

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FIGURE A3 - PROXIMITY TO WATER

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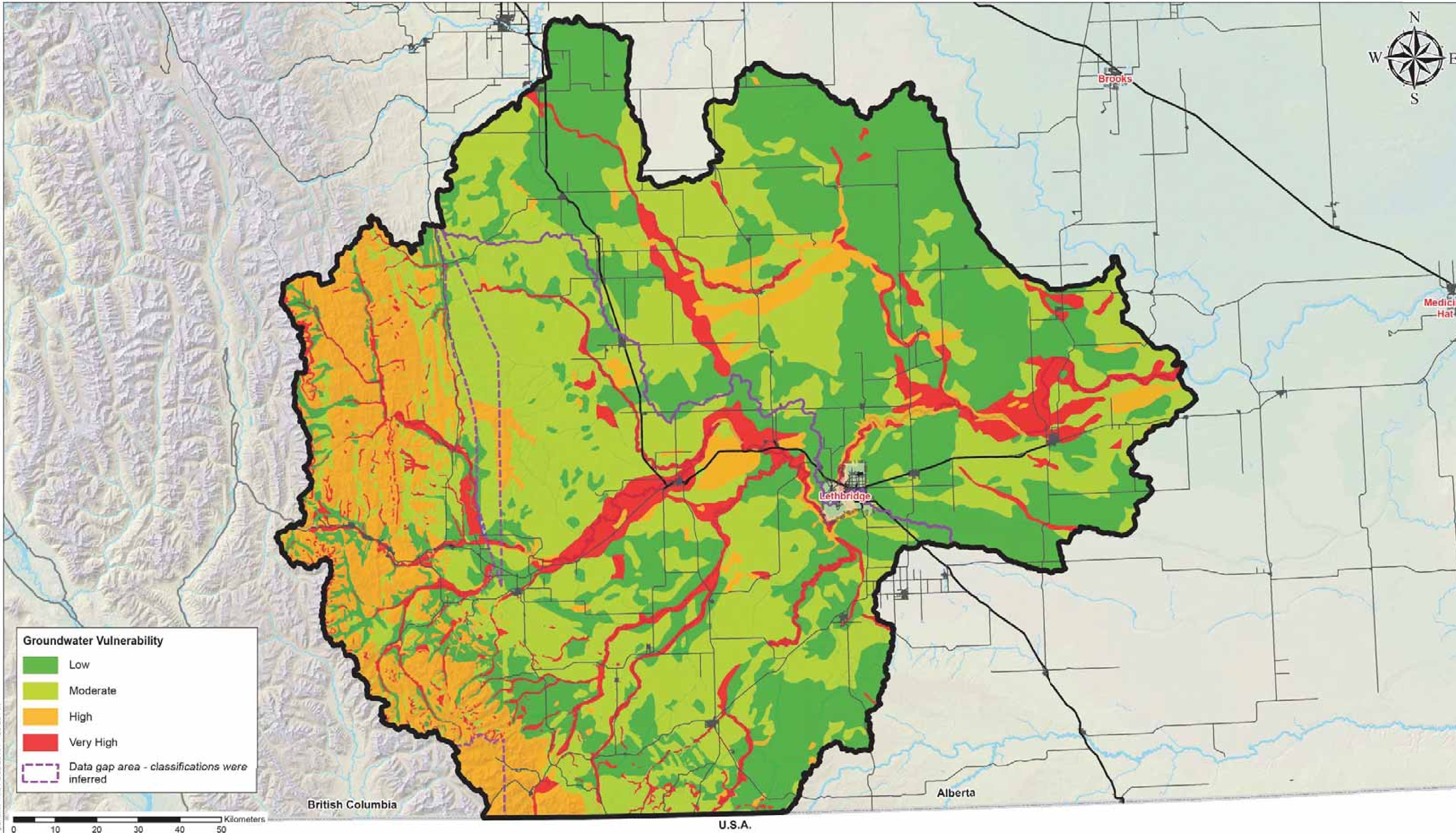
WRRP - Oldman Watershed Priority Mapping



SALTS southern alberta land trust society

Associated Environmental

Oldman River Watershed

Lethbridge intake watershed

City

Provincial / International Boundary

Major Roads

Highway - divided

Highway - 4 lane undivided

Road - 2 lane undivided

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DATE: March 2018

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FIGURE A4 - AQUIFER VULNERABILITY

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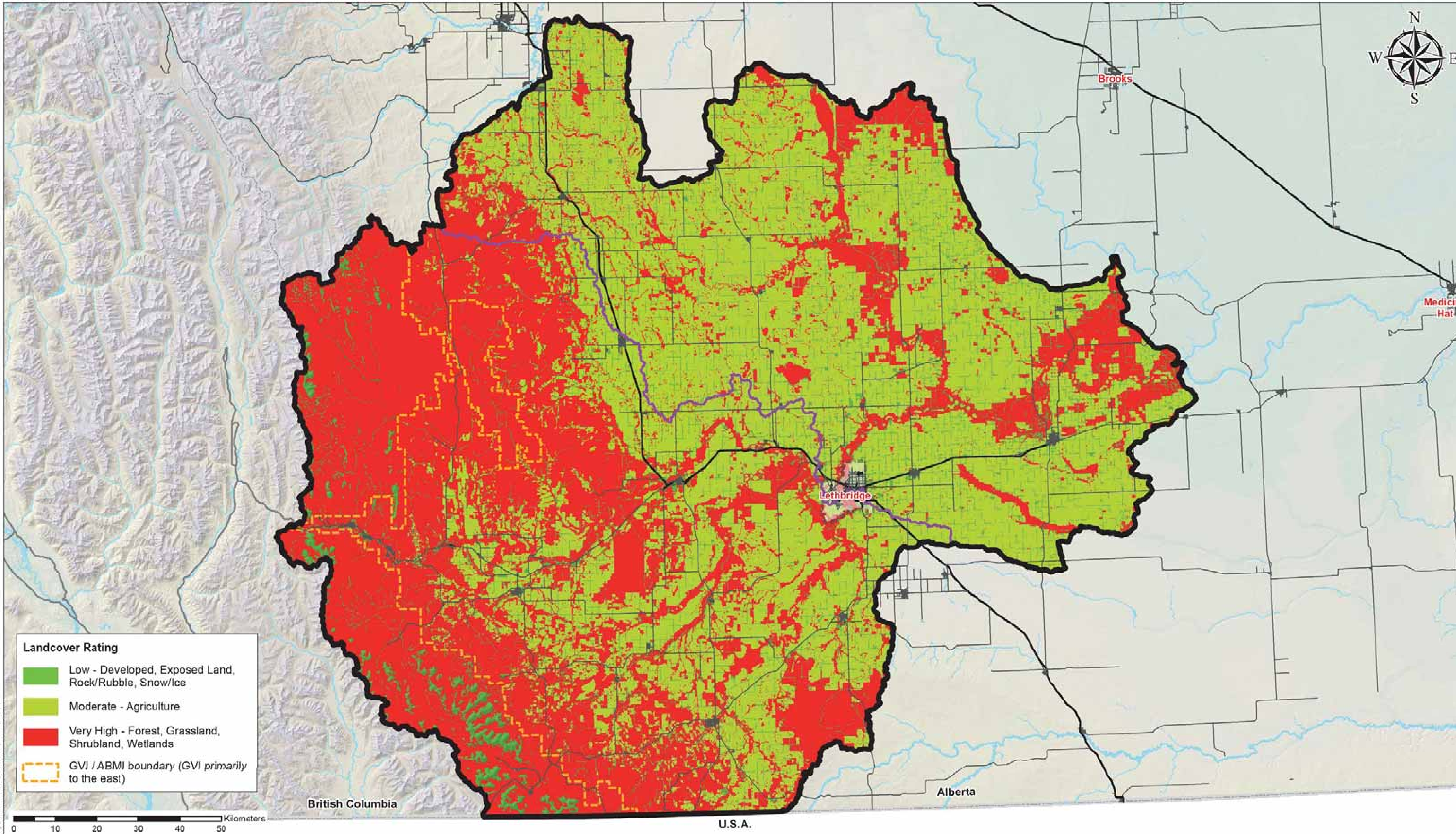
WRRP - Oldman Watershed Priority Mapping



Associated Environmental

SALTS southern alberta land trust society

Oldman River Watershed

Lethbridge intake watershed

City

Provincial / International Boundary

Major Roads

Highway - divided

Highway - 4 lane undivided

Road - 2 lane undivided

PROJECT NO.: 2017-8110

DATE: March 2018

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FIGURE A5 - LAND COVER

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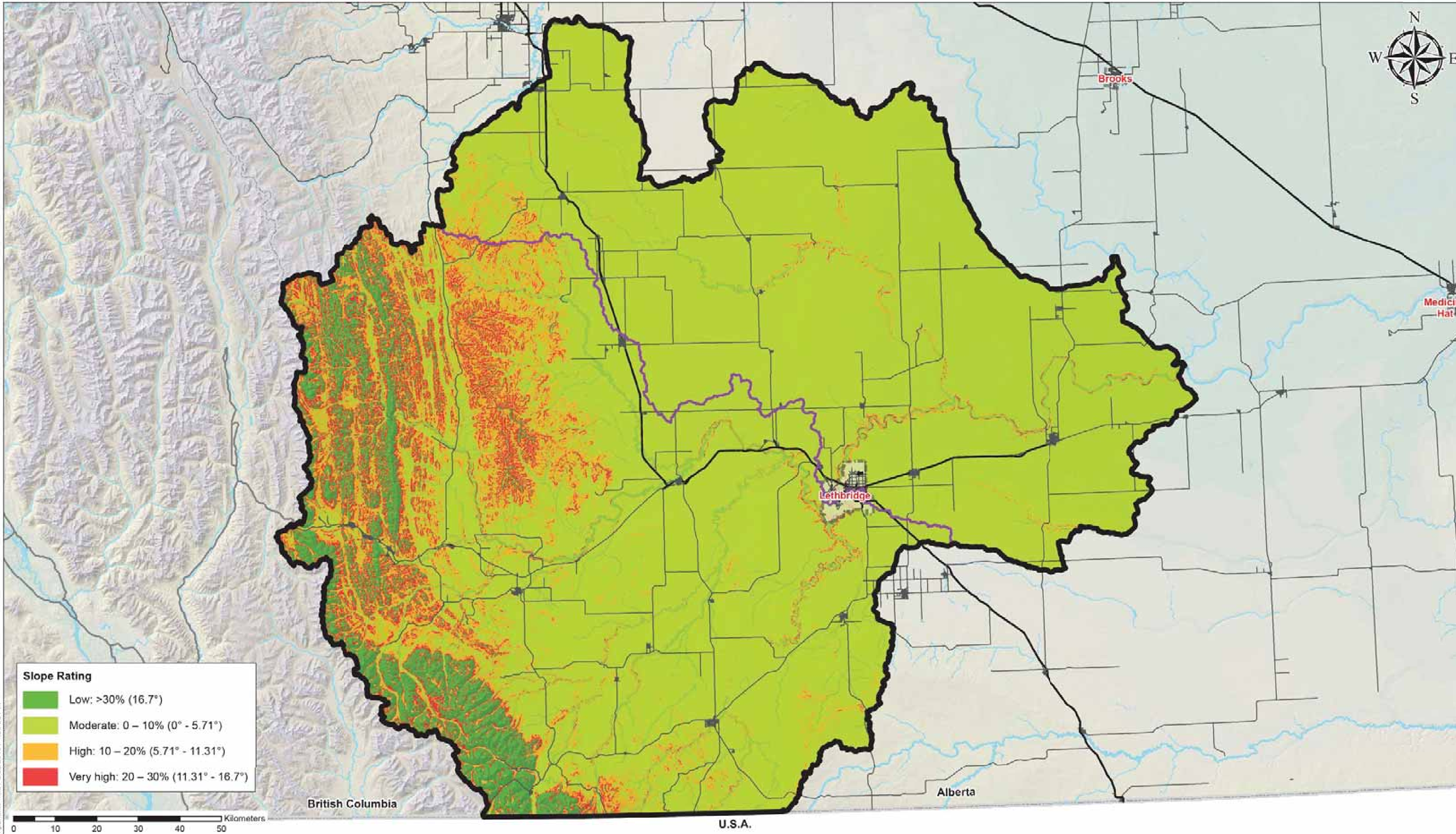
WRRP - Oldman Watershed Priority Mapping



Associated Environmental

SALTS southern alberta land trust society

Oldman River Watershed

Lethbridge intake watershed

City

Provincial / International Boundary

Major Roads

Highway - divided

Highway - 4 lane undivided

Road - 2 lane undivided

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FIGURE A6 - SLOPE (%)

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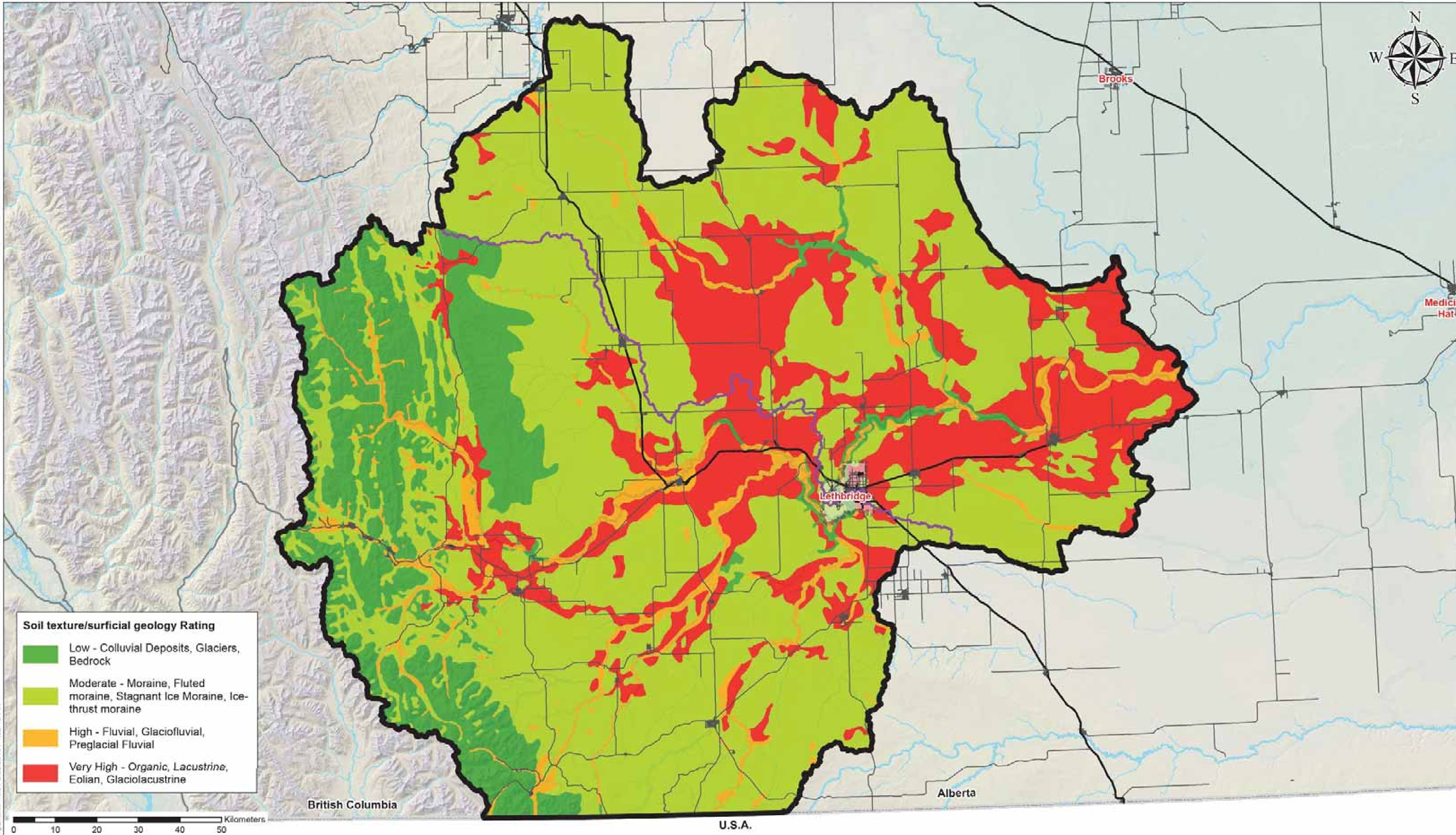
WRRP - Oldman Watershed Priority Mapping



Associated Environmental

SALTS southern alberta land trust society

Oldman River Watershed

Lethbridge intake watershed

City

Provincial / International Boundary

Major Roads

Highway - divided

Highway - 4 lane undivided

Road - 2 lane undivided

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DATE:	March 2018
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FIGURE A7 - SURFICIAL GEOLOGY

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WRRP - Oldman Watershed Priority Mapping