

**LEGEND**

- North Saskatchewan River
- Watercourse
- Waterbody
- North Saskatchewan River Basin
- Cities & Towns
- County Boundaries

SOURCES:  
Basedata obtained from IHS Energy

**NORTH SASKATCHEWAN WATERSHED ALLIANCE  
OVERVIEW OF GROUNDWATER CONDITIONS**

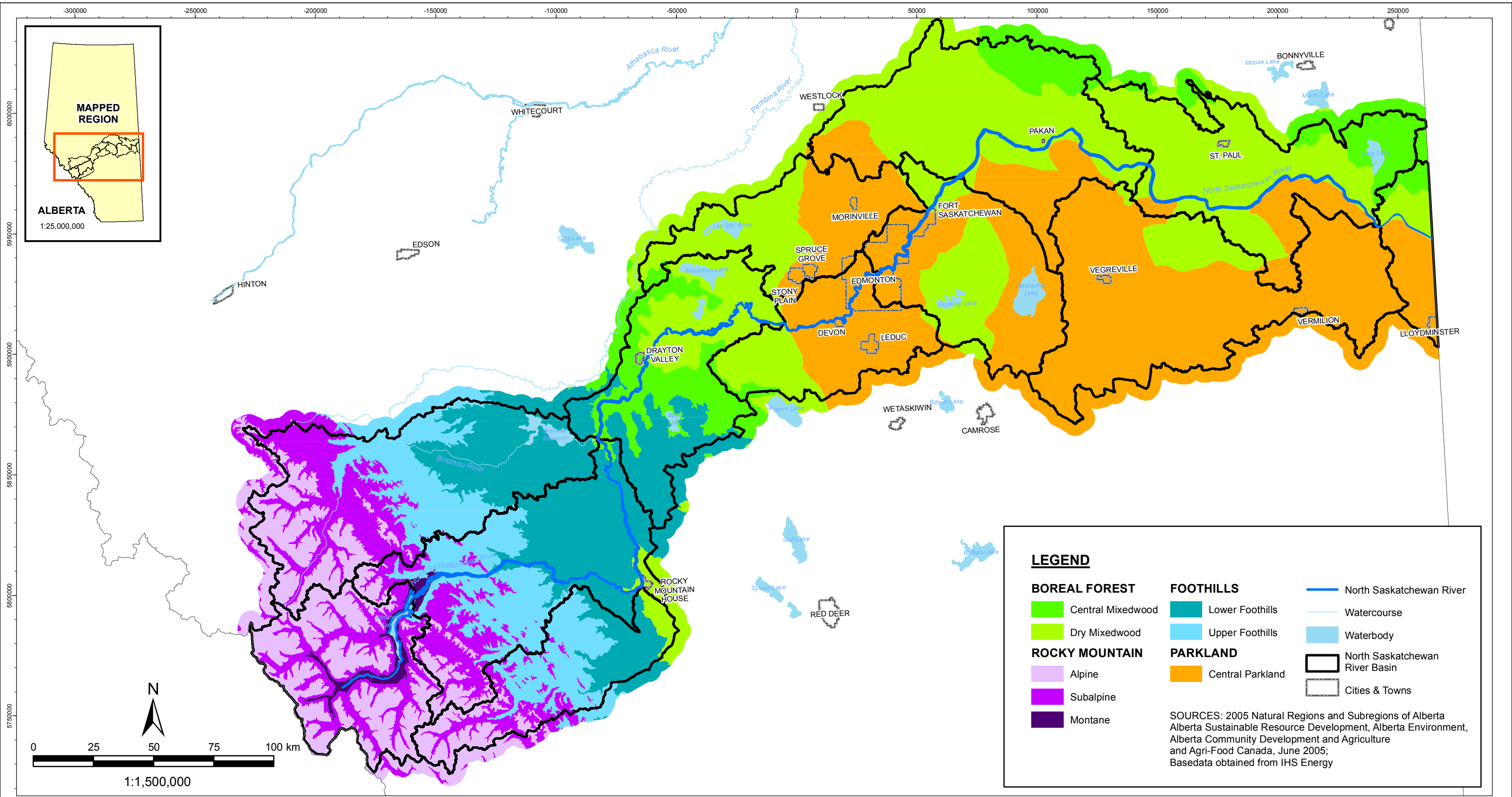
**WATERSHEDS OF THE NORTH SASKATCHEWAN RIVER BASIN**



|   |      |      |           |      |          |  |        |
|---|------|------|-----------|------|----------|--|--------|
| 09-JUN-09   | date | C.H. | edited by | J.L. | drawn by |  | app by |
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|                                     |                     |
|-------------------------------------|---------------------|
| PROJECT NUMBER:<br><b>E00088100</b> | FIGURE:<br><b>2</b> |
|-------------------------------------|---------------------|

FILE: Q:\E00088100\GIS\_NSW\WMD\Basemap.mxd Issued By: Edmonton GIS



**LEGEND**

|                       |                  |                                |
|-----------------------|------------------|--------------------------------|
| <b>BOREAL FOREST</b>  | <b>FOOTHILLS</b> | North Saskatchewan River       |
| Central Mixedwood     | Lower Foothills  | Watercourse                    |
| Dry Mixedwood         | Upper Foothills  | Waterbody                      |
| <b>ROCKY MOUNTAIN</b> | <b>PARKLAND</b>  | North Saskatchewan River Basin |
| Alpine                | Central Parkland | Cities & Towns                 |
| Subalpine             |                  |                                |
| Montane               |                  |                                |

SOURCES: 2005 Natural Regions and Subregions of Alberta  
 Alberta Sustainable Resource Development, Alberta Environment,  
 Alberta Community Development and Agriculture  
 and Agri-Food Canada, June 2005;  
 Basedata obtained from IHS Energy

**NORTH SASKATCHEWAN WATERSHED ALLIANCE  
 OVERVIEW OF GROUNDWATER CONDITIONS**

**NATURAL REGIONS AND SUBREGIONS**



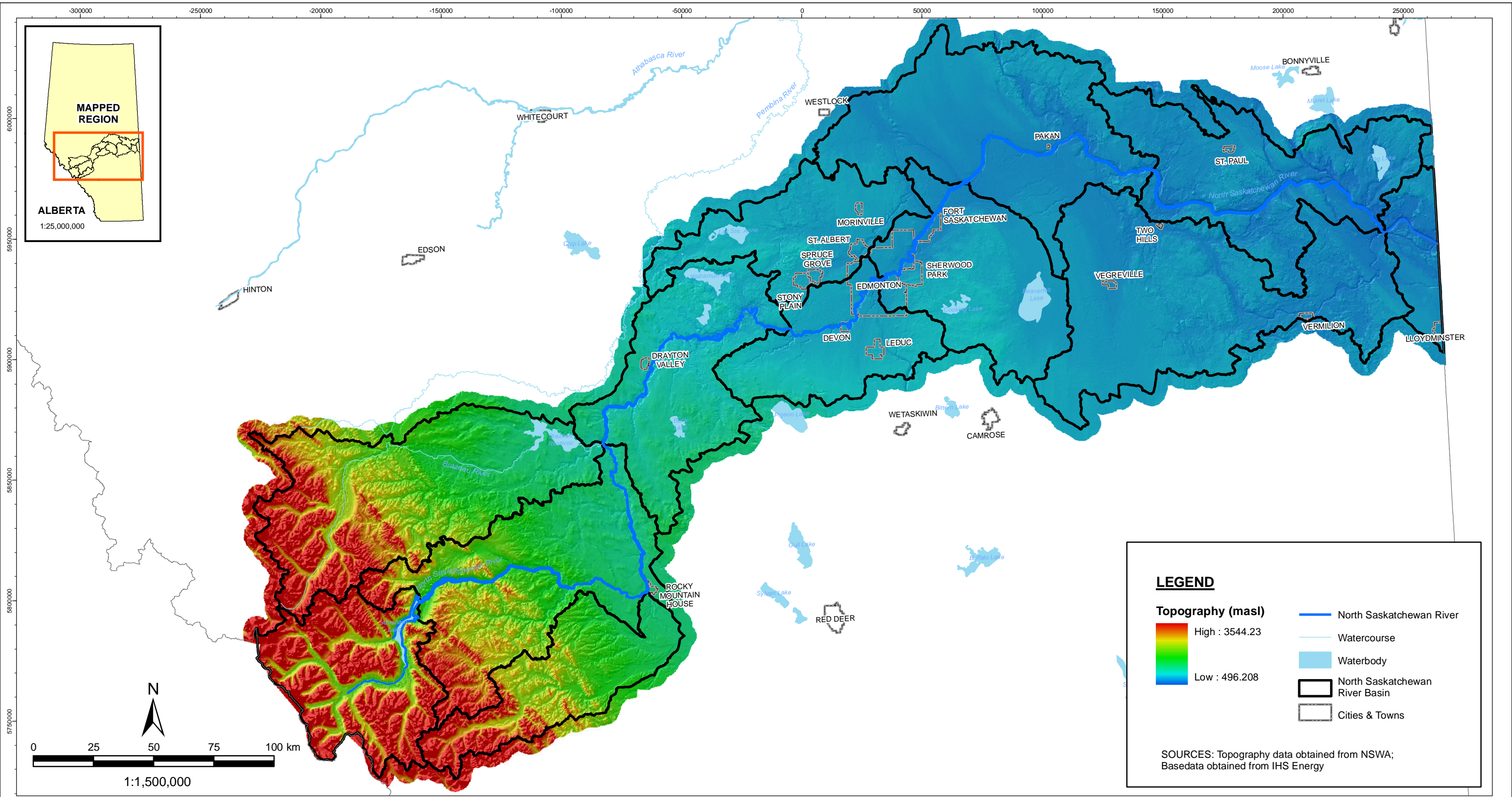
|           |      |      |           |      |          |  |        |
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| 26-MAR-09 | date | J.L. | edited by | J.L. | drawn by |  | app by |
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|                  |          |
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| PROJECT NUMBER:  | FIGURE:  |
| <b>E00088100</b> | <b>3</b> |

FILE: Q:\E00088100\AgGIS\_NSWA\MXD\NaturalSubregions.mxd Issued By: Edmonton GIS





**LEGEND**

**Topography (masl)**  
 High : 3544.23  
 Low : 496.208

- North Saskatchewan River
- Watercourse
- Waterbody
- North Saskatchewan River Basin
- Cities & Towns

SOURCES: Topography data obtained from NSWA;  
 Basedata obtained from IHS Energy

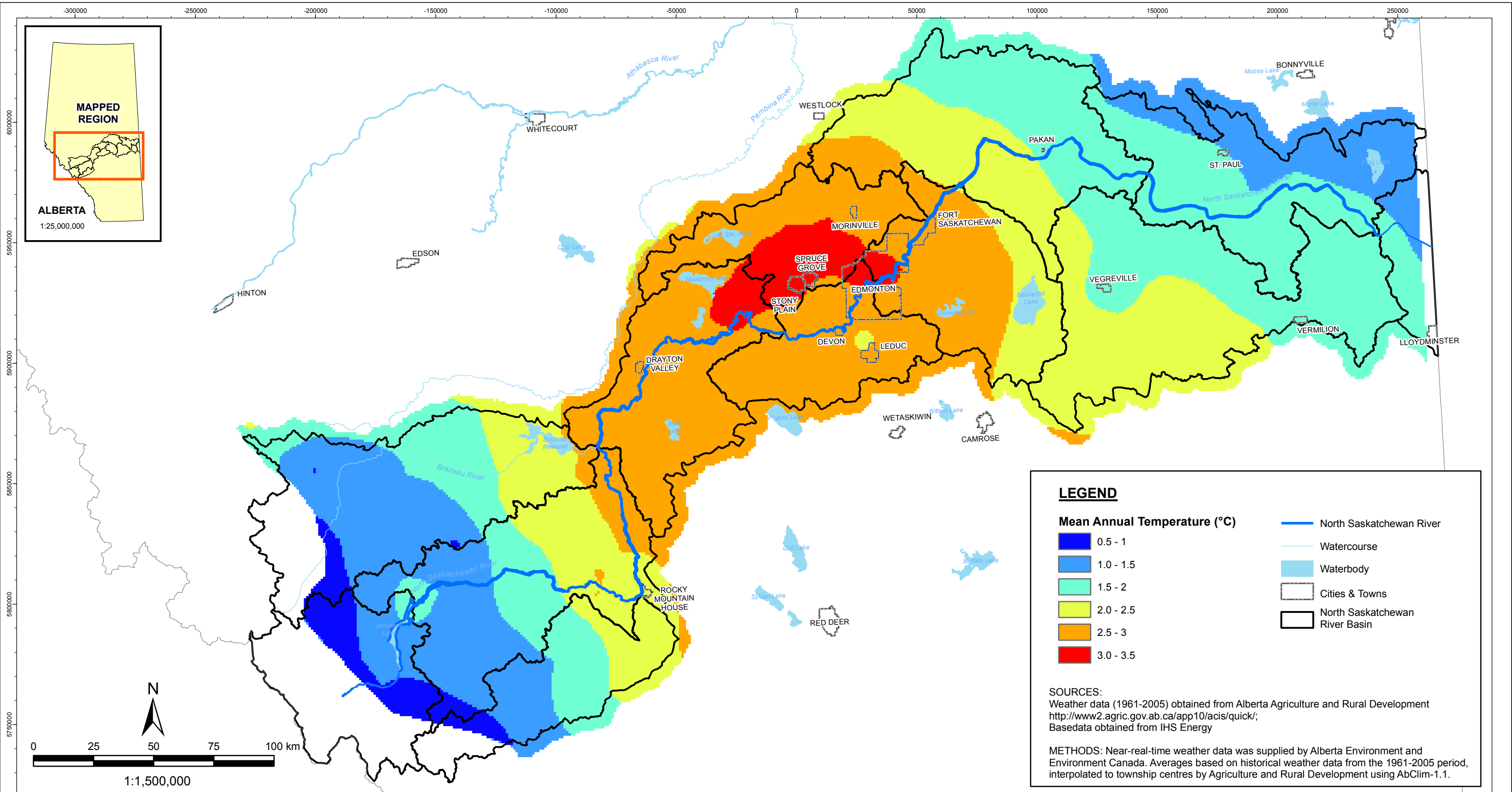
**NORTH SASKATCHEWAN WATERSHED ALLIANCE  
 OVERVIEW OF GROUNDWATER CONDITIONS**

**TOPOGRAPHY**

**WorleyParsons**  
 resources & energy

|   |                     |             |                          |             |                         |                       |
|---|---------------------|-------------|--------------------------|-------------|-------------------------|-----------------------|
| <b>09-JUN-09</b>  | <small>date</small> | <b>C.H.</b> | <small>edited by</small> | <b>J.L.</b> | <small>drawn by</small> | <small>app by</small> |
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|                                     |                     |
|-------------------------------------|---------------------|
| <b>PROJECT NUMBER:</b><br>E00088100 | <b>FIGURE:</b><br>4 |
|-------------------------------------|---------------------|



**LEGEND**

**Mean Annual Temperature (°C)**

- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2
- 2.0 - 2.5
- 2.5 - 3
- 3.0 - 3.5

- North Saskatchewan River
- Watercourse
- Waterbody
- Cities & Towns
- North Saskatchewan River Basin

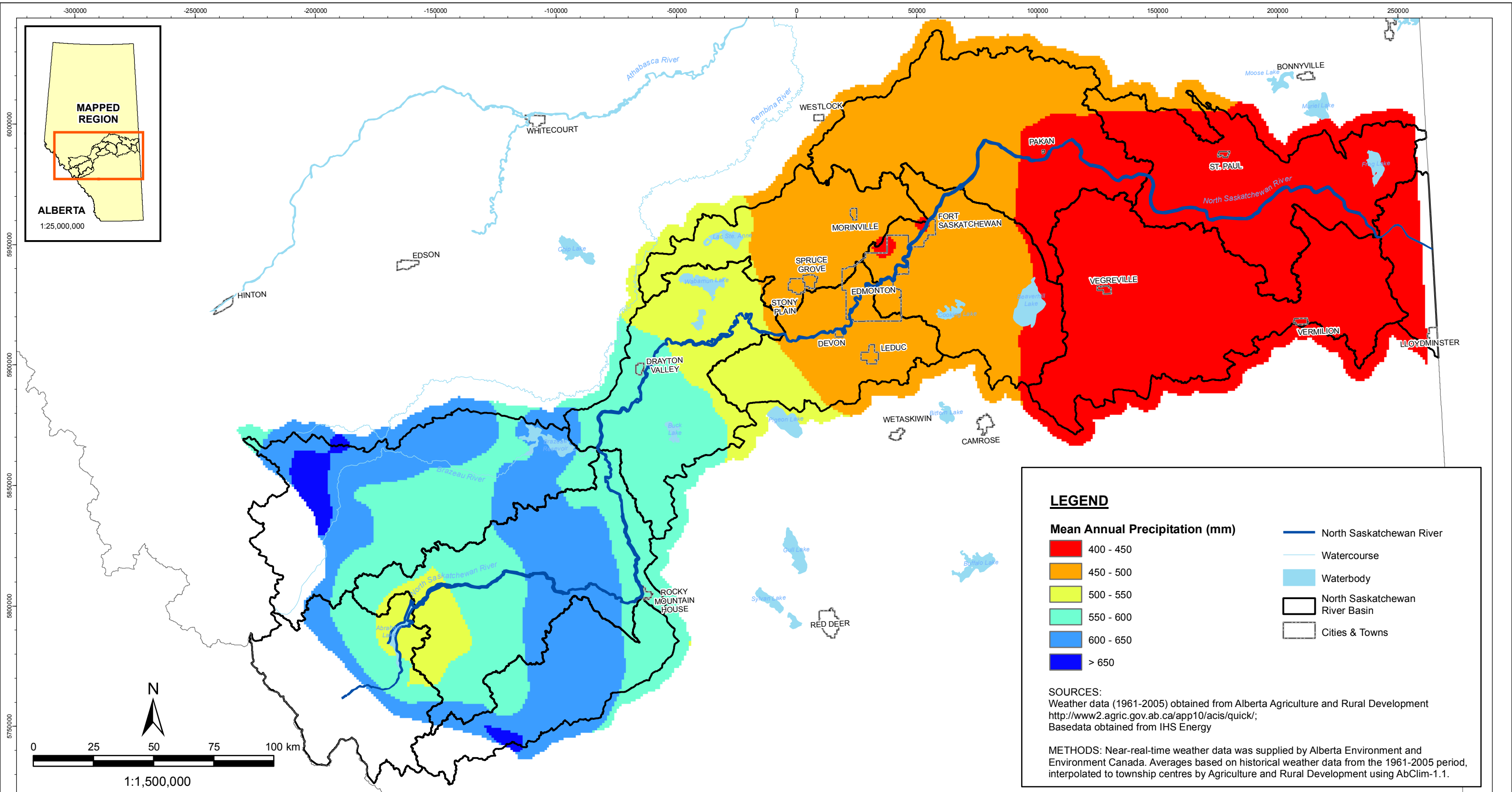
**SOURCES:**  
 Weather data (1961-2005) obtained from Alberta Agriculture and Rural Development <http://www2.agric.gov.ab.ca/app10/acis/quick/>;  
 Basedata obtained from IHS Energy

**METHODS:** Near-real-time weather data was supplied by Alberta Environment and Environment Canada. Averages based on historical weather data from the 1961-2005 period, interpolated to township centres by Agriculture and Rural Development using AbClim-1.1.

|   |                |   |        |
|---|----------------|---|--------|
| <b>Infrastructure &amp; Environment</b>   |                |   |        |
| <b>NORTH SASKATCHEWAN WATERSHED ALLIANCE<br/>OVERVIEW OF GROUNDWATER CONDITIONS</b>   |                | <b>WorleyParsons</b><br><small>resources &amp; energy</small> |        |
| <b>MEAN ANNUAL TEMPERATURE</b>  |                | <b>PROJECT NUMBER: E00088100</b>                              |        |
| 14-APR-09 date  | J.L. edited by | J.L. drawn by   | app by |
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FILE: Q:\E00088100\ArcGIS\_NSW\MapXDs\MeanAnnualTemp2.mxd Issued By: Edmonton GIS





**LEGEND**

**Mean Annual Precipitation (mm)**

- 400 - 450
- 450 - 500
- 500 - 550
- 550 - 600
- 600 - 650
- > 650

- North Saskatchewan River
- Watercourse
- Waterbody
- North Saskatchewan River Basin
- Cities & Towns

**SOURCES:**  
 Weather data (1961-2005) obtained from Alberta Agriculture and Rural Development  
<http://www2.agric.gov.ab.ca/app10/acis/quick/>;  
 Basedata obtained from IHS Energy

**METHODS:** Near-real-time weather data was supplied by Alberta Environment and Environment Canada. Averages based on historical weather data from the 1961-2005 period, interpolated to township centres by Agriculture and Rural Development using AbClim-1.1.

**NORTH SASKATCHEWAN WATERSHED ALLIANCE  
 OVERVIEW OF GROUNDWATER CONDITIONS**

**MEAN ANNUAL PRECIPITATION**



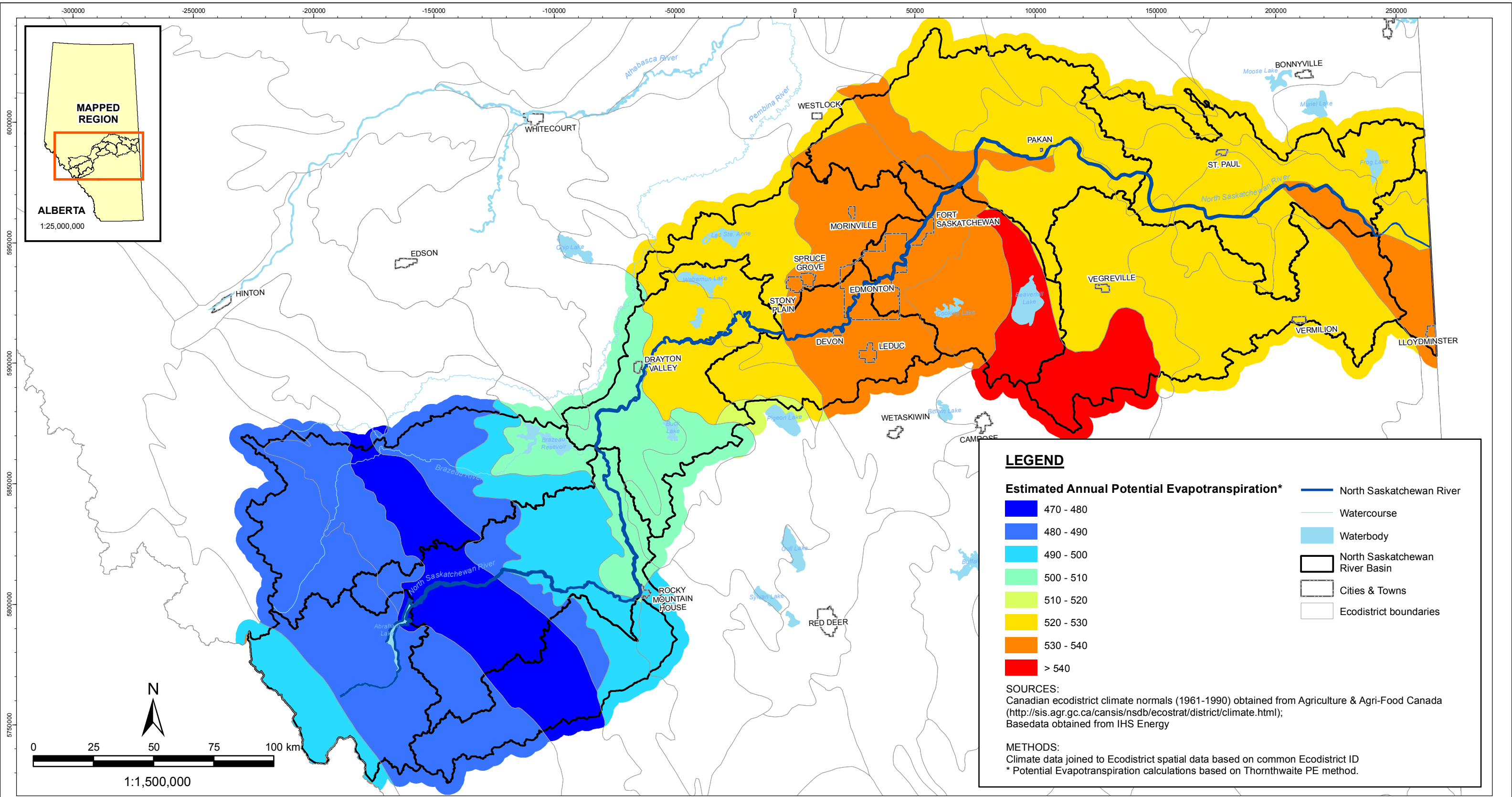
|                       |                       |                      |        |
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| <b>14-APR-09</b> date | <b>J.L.</b> edited by | <b>J.L.</b> drawn by | app by |
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|                 |         |
|-----------------|---------|
| PROJECT NUMBER: | FIGURE: |
|-----------------|---------|

**E00088100** **6**

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FILE: Q:\E00088100\ArgGIS\_NSW\MXD\MeanAnnualPrecip2.mxd Issued By: Edmonton GIS



**NORTH SASKATCHEWAN WATERSHED ALLIANCE  
 OVERVIEW OF GROUNDWATER CONDITIONS  
 ESTIMATED ANNUAL POTENTIAL EVAPOTRANSPIRATION**

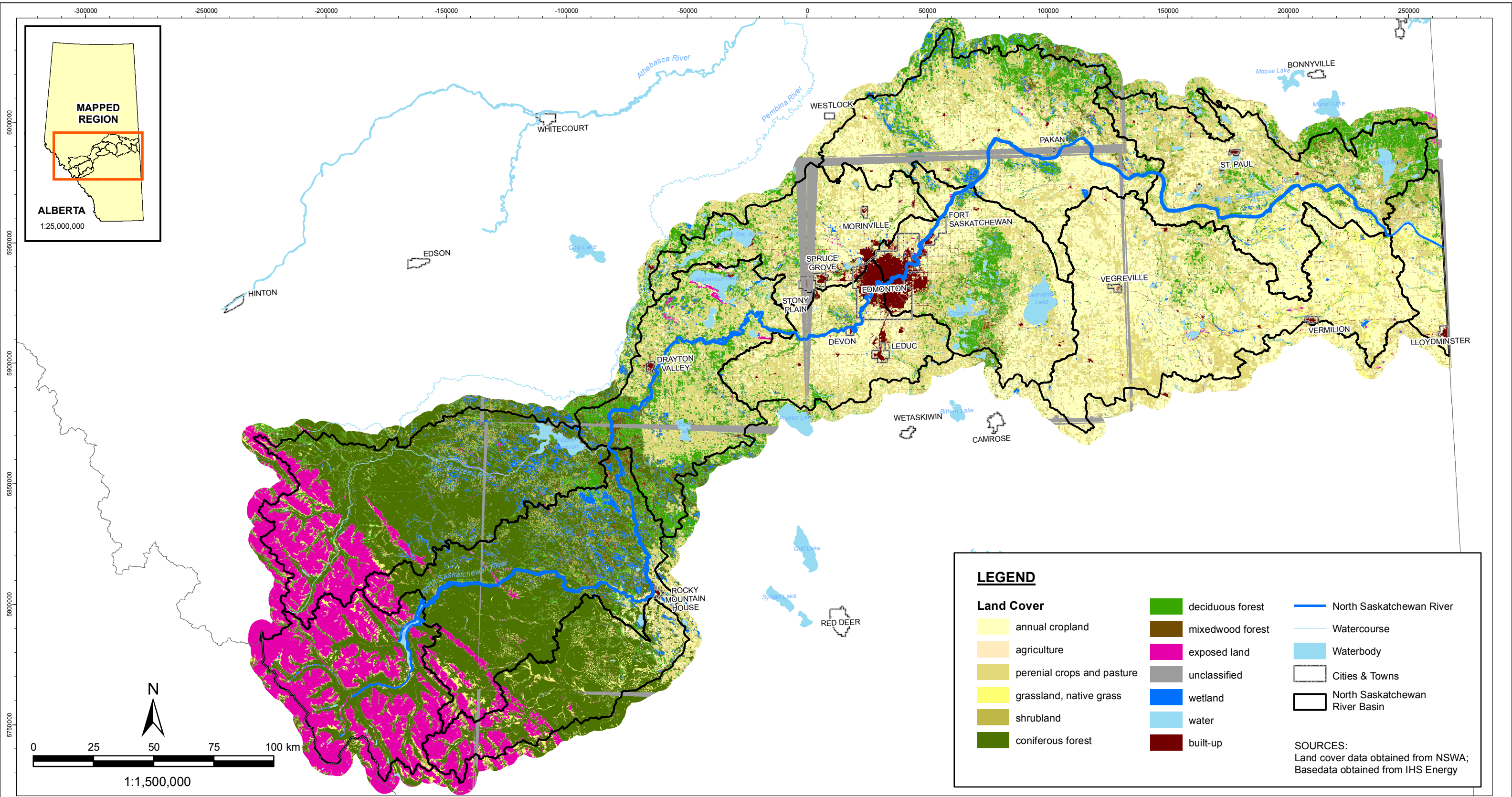


26-MAR-09 date J.L. edited by J.L. drawn by app by  
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PROJECT NUMBER: **E00088100** FIGURE: **7**

FILE: Q:\E00088100\ArgGIS\_NSWWMA\AnnualPotentialEvapotransfEcodistrict.mxd Issued By: Edmonton GIS





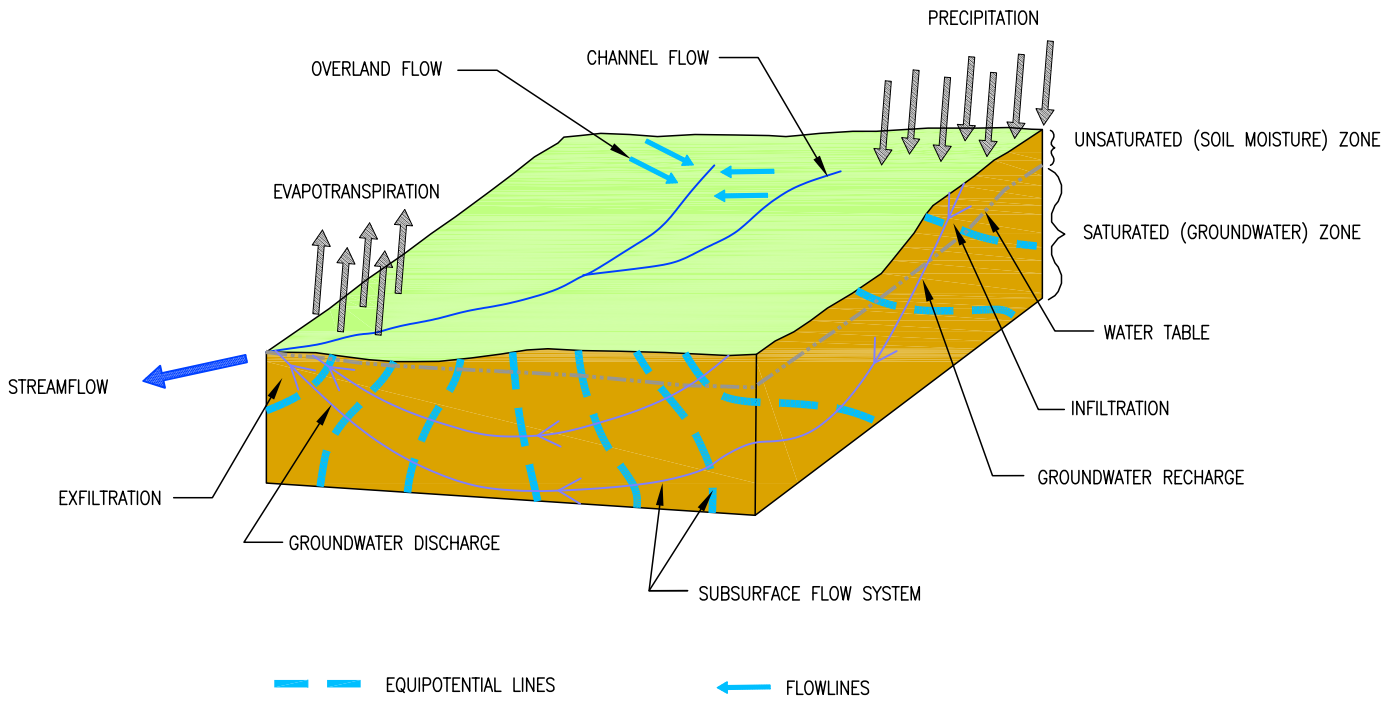
**LEGEND**

|                             |                  |                                |
|-----------------------------|------------------|--------------------------------|
| annual cropland             | deciduous forest | North Saskatchewan River       |
| agriculture                 | mixedwood forest | Watercourse                    |
| perennial crops and pasture | exposed land     | Waterbody                      |
| grassland, native grass     | unclassified     | Cities & Towns                 |
| shrubland                   | wetland          | North Saskatchewan River Basin |
| coniferous forest           | water            |                                |
|                             | built-up         |                                |

SOURCES:  
Land cover data obtained from NSWA;  
Basedata obtained from IHS Energy

|   |                       |  |        |
|---|-----------------------|--|--------|
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| <b>NORTH SASKATCHEWAN WATERSHED ALLIANCE<br/>OVERVIEW OF GROUNDWATER CONDITIONS</b>   |                       | <b>WorleyParsons</b><br>resources & energy |        |
| <b>LAND COVER</b>   |                       |  |        |
| <b>20-MAR-09</b> date   | <b>J.L.</b> edited by | <b>J.L.</b> drawn by                       | app by |
| PROJECT NUMBER:<br><b>E00088100</b>   |                       | FIGURE:<br><b>8</b>                        |        |
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SOURCE: FROM FREEZE AND CHERRY (1979) PAGE 3

Infrastructure & Environment

## NORTH SASKATCHEWAN RIVER BASIN OVERVIEW OF GROUNDWATER CONDITIONS

### CONCEPTUAL REPRESENTATION OF THE HYDROLOGIC CYCLE



**WorleyParsons**  
resources & energy

|           |      |      |           |      |          |  |        |
|-----------|------|------|-----------|------|----------|--|--------|
| 20-MAR-09 | date | J.Q. | edited by | L.F. | drawn by |  | app by |
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PROJECT NUMBER:

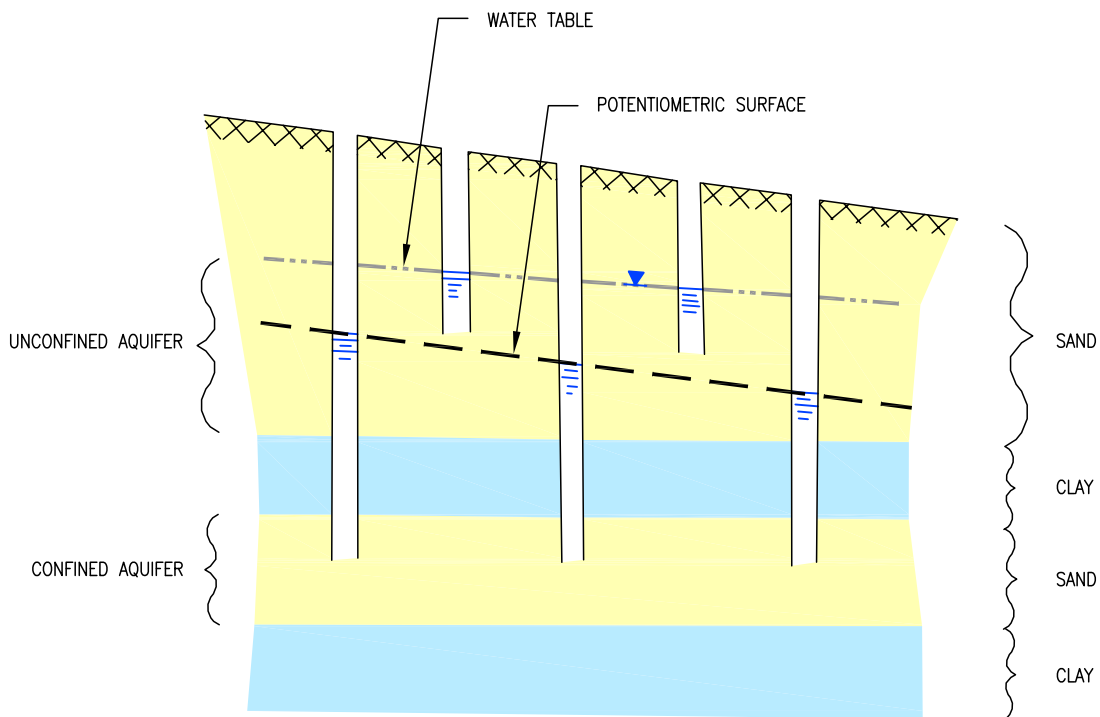
FIGURE:

**E00088100**

**9**

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SOURCE: FROM FREEZE AND CHERRY (1979) PAGE 48

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## NORTH SASKATCHEWAN WATERSHED ALLIANCE OVERVIEW OF GROUNDWATER CONDITIONS

### CONFINED AND UNCONFINED AQUIFERS



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23-MAR-09 date J.Q. edited by L.F. drawn by app by

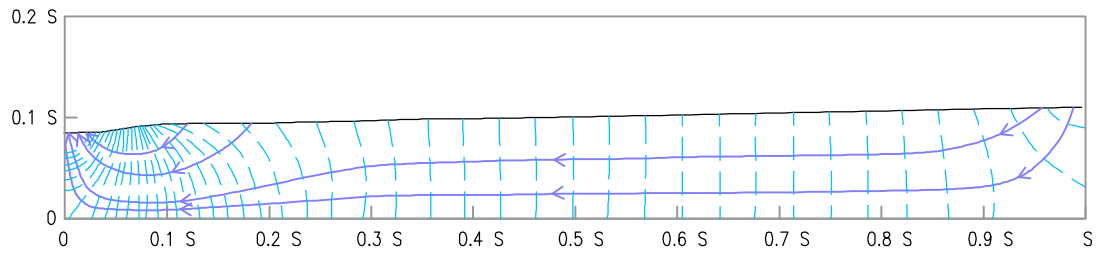
PROJECT NUMBER:

FIGURE:

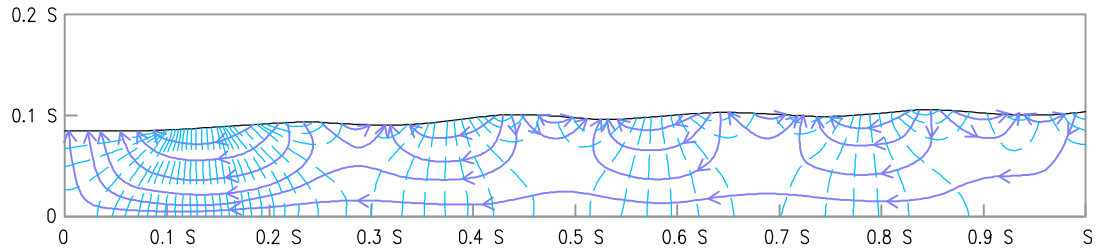
**E00088100**

**10**

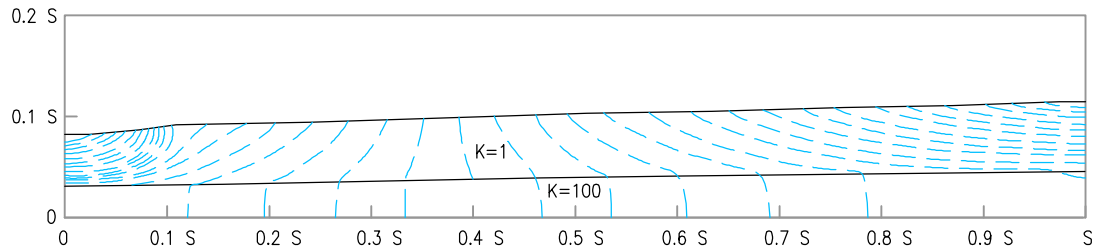
PREPARED SOLELY FOR THE USE OF OUR CLIENT AS SPECIFIED IN THE ACCOMPANYING REPORT. NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH WORLEYPARSONS HAS NOT ENTERED INTO A CONTRACT.



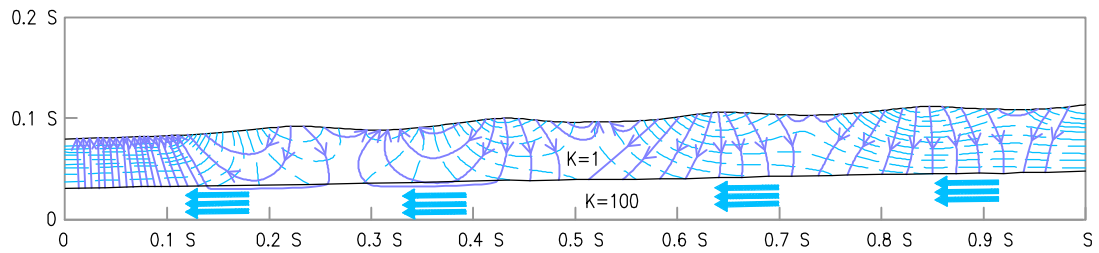
LACUSTRINE PLAIN



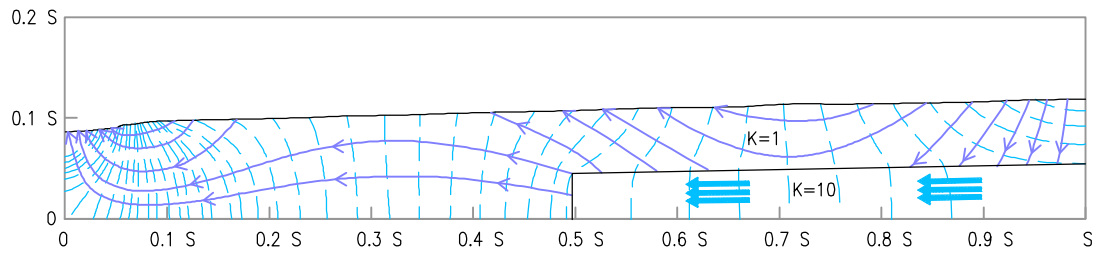
GLACIAL TERRAIN



BASAL AQUIFER



BASAL AQUIFER AND TOPOGRAPHY



GEOLOGY INDUCED DISCHARGE

SOURCE: FROM FREEZE AND CHERRY (1979) PAGES 196 AND 198

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**NORTH SASKATCHEWAN RIVER BASIN  
OVERVIEW OF GROUNDWATER CONDITIONS**

**EFFECTS OF TOPOGRAPHY AND GEOLOGY  
ON REGIONAL GROUNDWATER FLOW PATTERNS**



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| 20-MAR-09 | date | - | edited by | L.F. | drawn by | app by |
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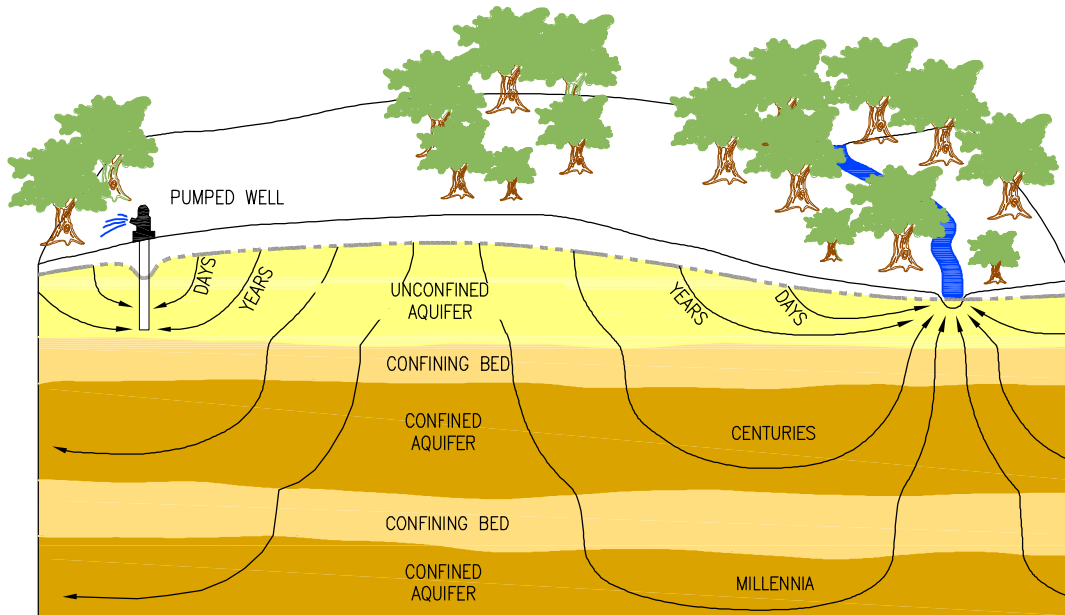
FIGURE:

**E00088100**

**11**

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SOURCE: FROM WINTER et al. (1999) PAGE 5

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**NORTH SASKATCHEWAN WATERSHED ALLIANCE  
OVERVIEW OF GROUNDWATER CONDITIONS**

**GROUNDWATER FLOW AND TRAVEL TIMES**



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|-----------|------|---|-----------|------|----------|--|--------|
| 26-MAR-09 | date | - | edited by | L.F. | drawn by |  | app by |
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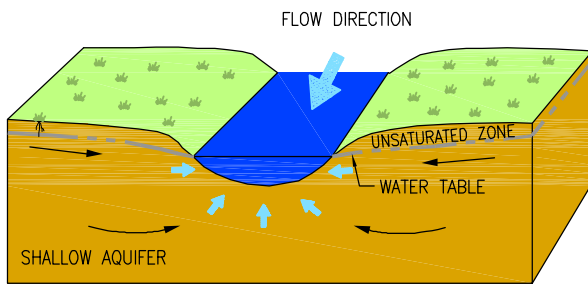
FIGURE:

**E00088100**

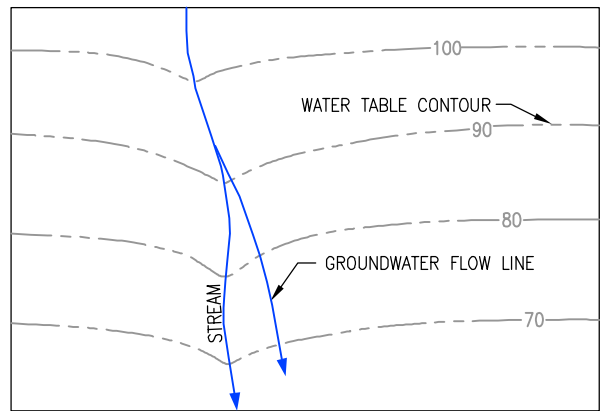
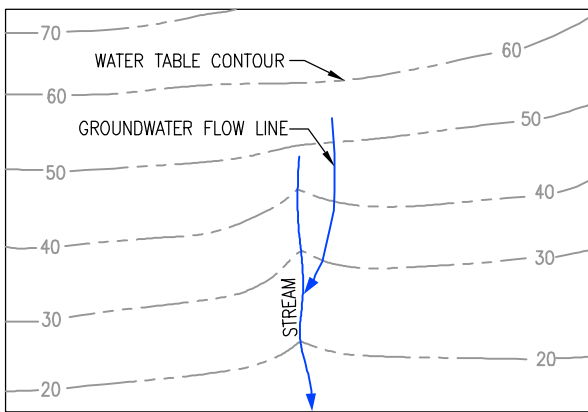
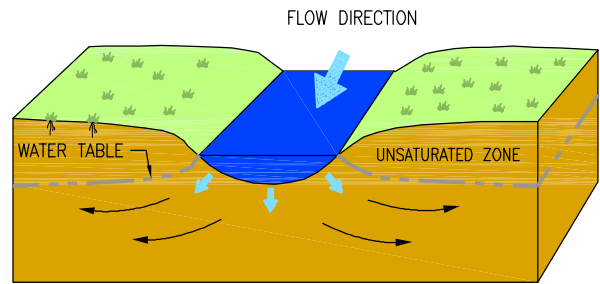
**12**

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### GAINING STREAM



### LOSING STREAM



SOURCE: FROM WINTER et al. (1999) PAGE 9

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## NORTH SASKATCHEWAN WATERSHED ALLIANCE OVERVIEW OF GROUNDWATER CONDITIONS

### INTERACTION OF GROUNDWATER AND STREAMS



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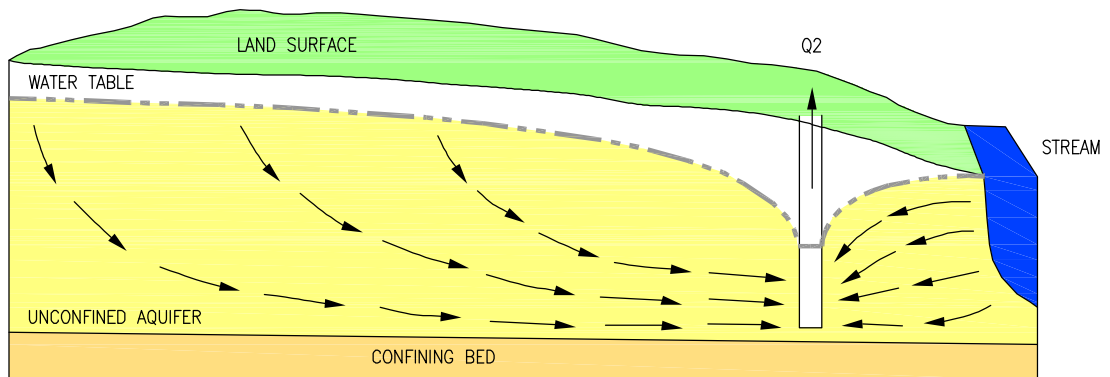
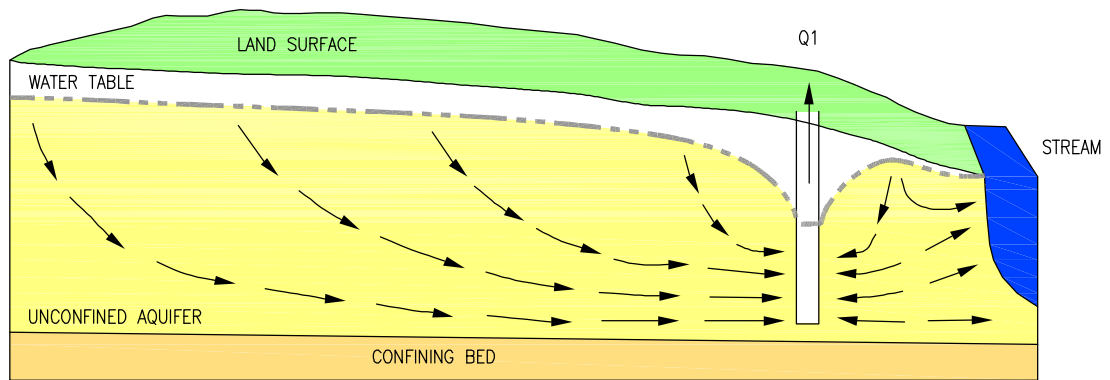
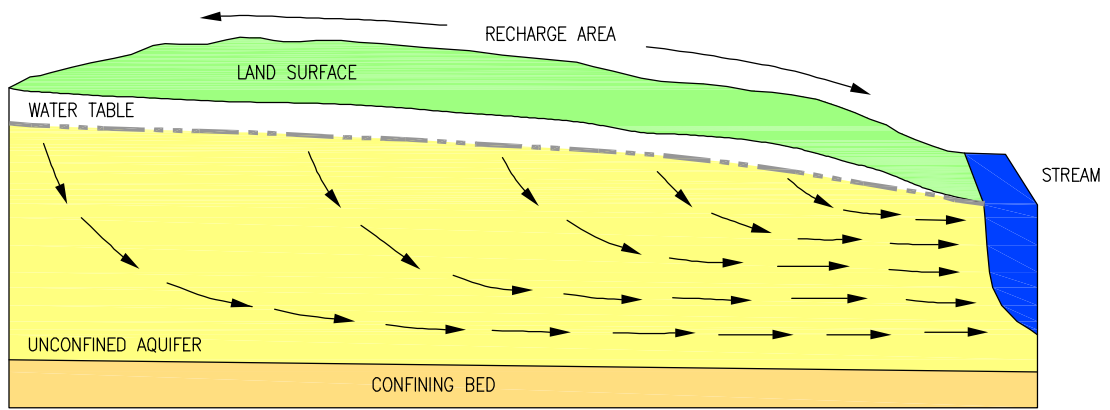
PROJECT NUMBER:

FIGURE:

**E00088100**

**13**

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SOURCE: FROM WINTER et al. (1999) PAGE 15

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**NORTH SASKATCHEWAN WATERSHED ALLIANCE  
OVERVIEW OF GROUNDWATER CONDITIONS  
EFFECT OF GROUNDWATER WITHDRAWAL ON SURFACE WATER**



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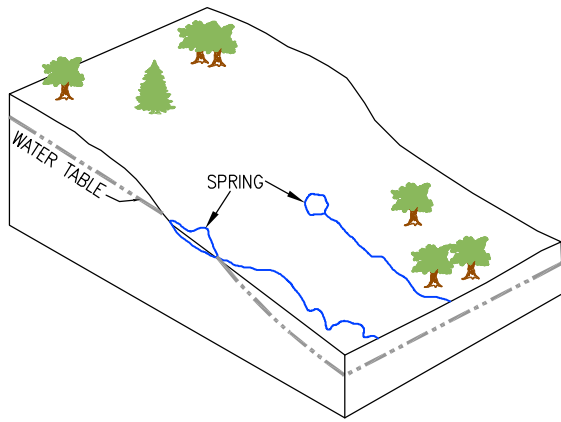
FIGURE:

**E00088100**

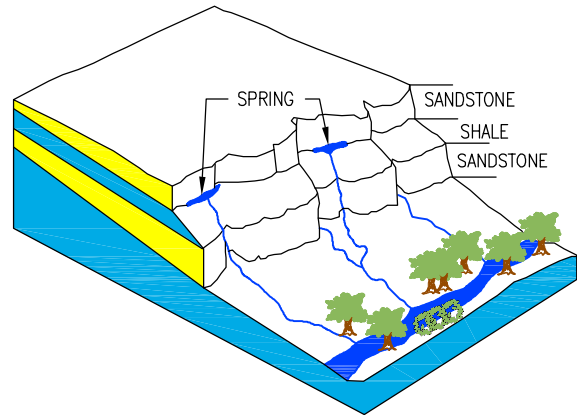
**14**

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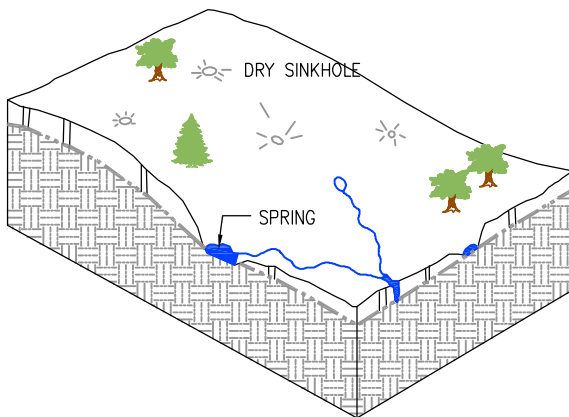




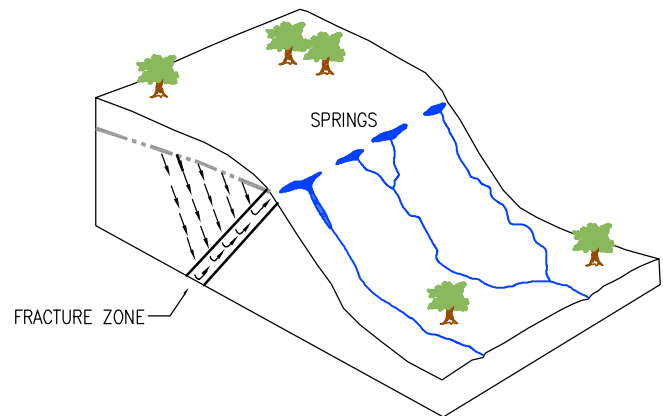
**DEPRESSION SPRING**



**CONTACT SPRING**



**SINKHOLE SPRING**



**FRACTURE SPRING**

SOURCE: FROM FETTER (2001) PAGE 207

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**NORTH SASKATCHEWAN WATERSHED ALLIANCE  
OVERVIEW OF GROUNDWATER CONDITIONS**

**TYPES OF SPRINGS**



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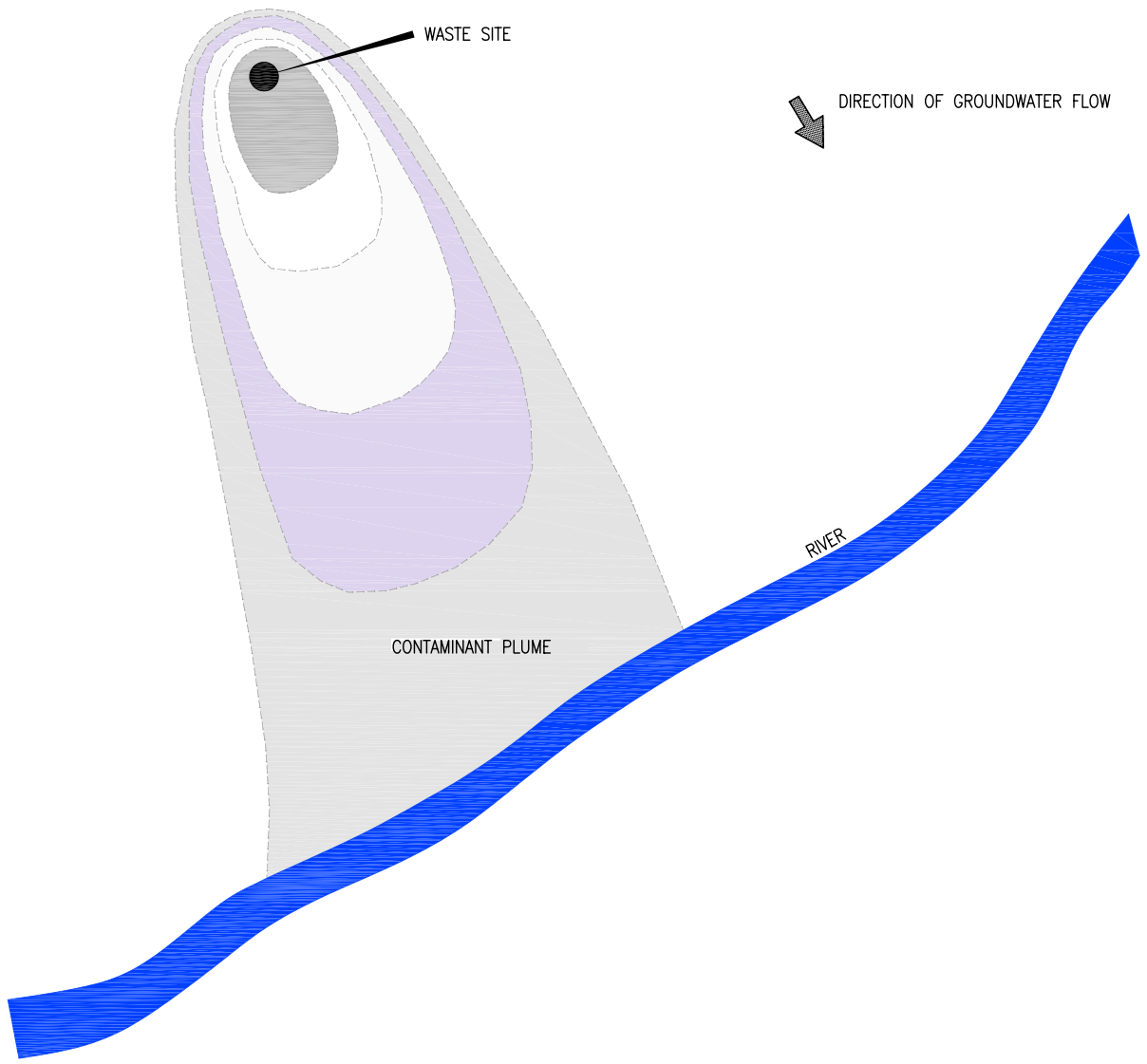
PROJECT NUMBER:

FIGURE:

**E00088100**

**15**

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SOURCE: FROM FETTER (2001) PAGE 207

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**NORTH SASKATCHEWAN WATERSHED ALLIANCE  
OVERVIEW OF GROUNDWATER CONDITIONS**

**TRANSPORT OF CONTAMINATION BY GROUNDWATER FLOW**



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|           |      |   |           |      |          |  |        |
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| 20-MAR-09 | date | - | edited by | L.F. | drawn by |  | app by |
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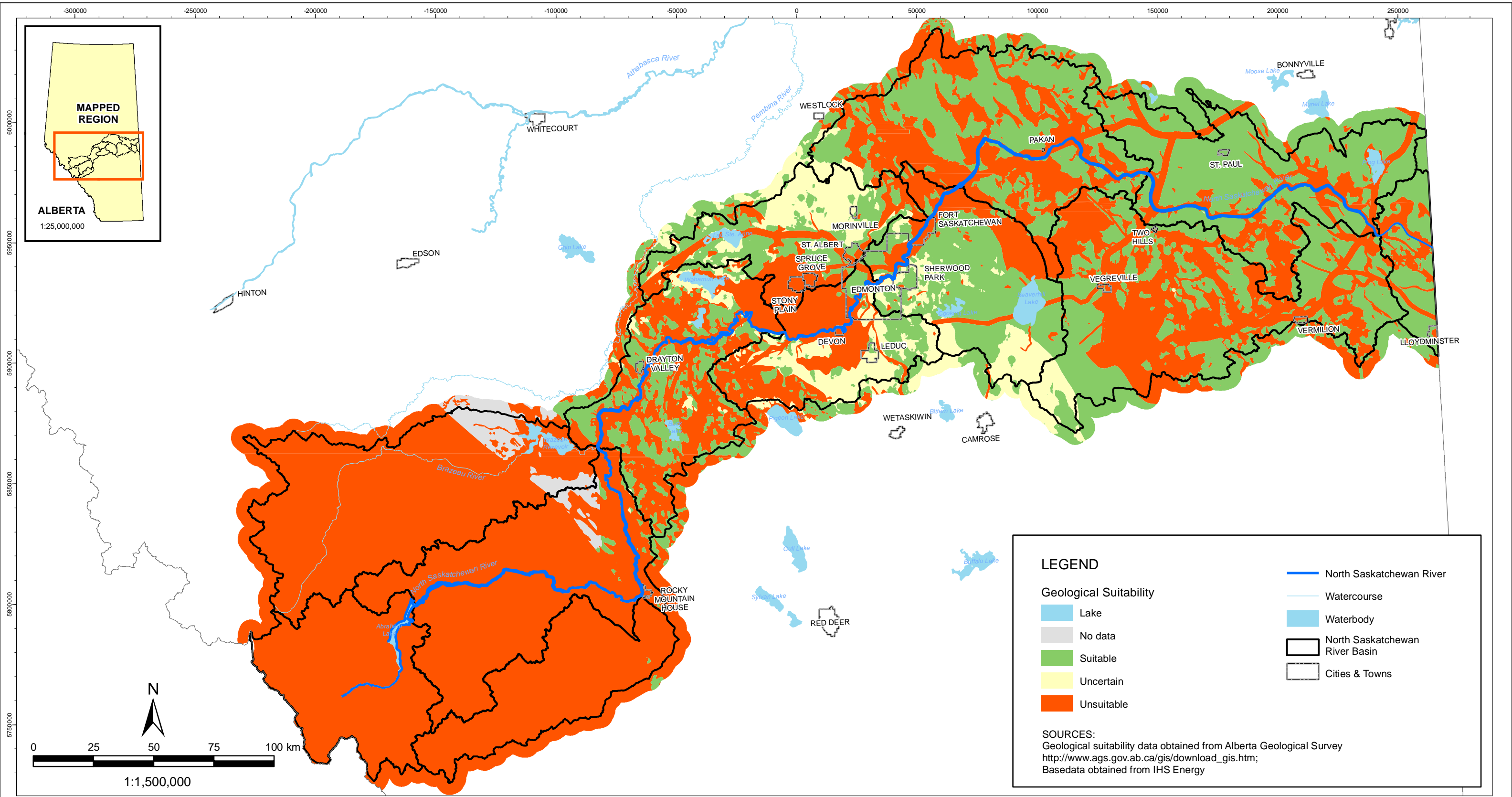
PROJECT NUMBER:

FIGURE:

**E00088100**

**16**

PREPARED SOLELY FOR THE USE OF OUR CLIENT AS SPECIFIED IN THE ACCOMPANYING REPORT. NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH WORLEYPARSONS HAS NOT ENTERED INTO A CONTRACT.



**LEGEND**

**Geological Suitability**

- Lake
- No data
- Suitable
- Uncertain
- Unsuitable

- North Saskatchewan River
- Watercourse
- Waterbody
- North Saskatchewan River Basin
- Cities & Towns

**SOURCES:**  
 Geological suitability data obtained from Alberta Geological Survey  
[http://www.ags.gov.ab.ca/gis/download\\_gis.htm](http://www.ags.gov.ab.ca/gis/download_gis.htm);  
 Basedata obtained from IHS Energy

**NORTH SASKATCHEWAN WATERSHED ALLIANCE  
 OVERVIEW OF GROUNDWATER CONDITIONS  
 NATURAL SUITABILITY OF GEOLOGICAL SETTING  
 FOR WASTE MANAGEMENT**



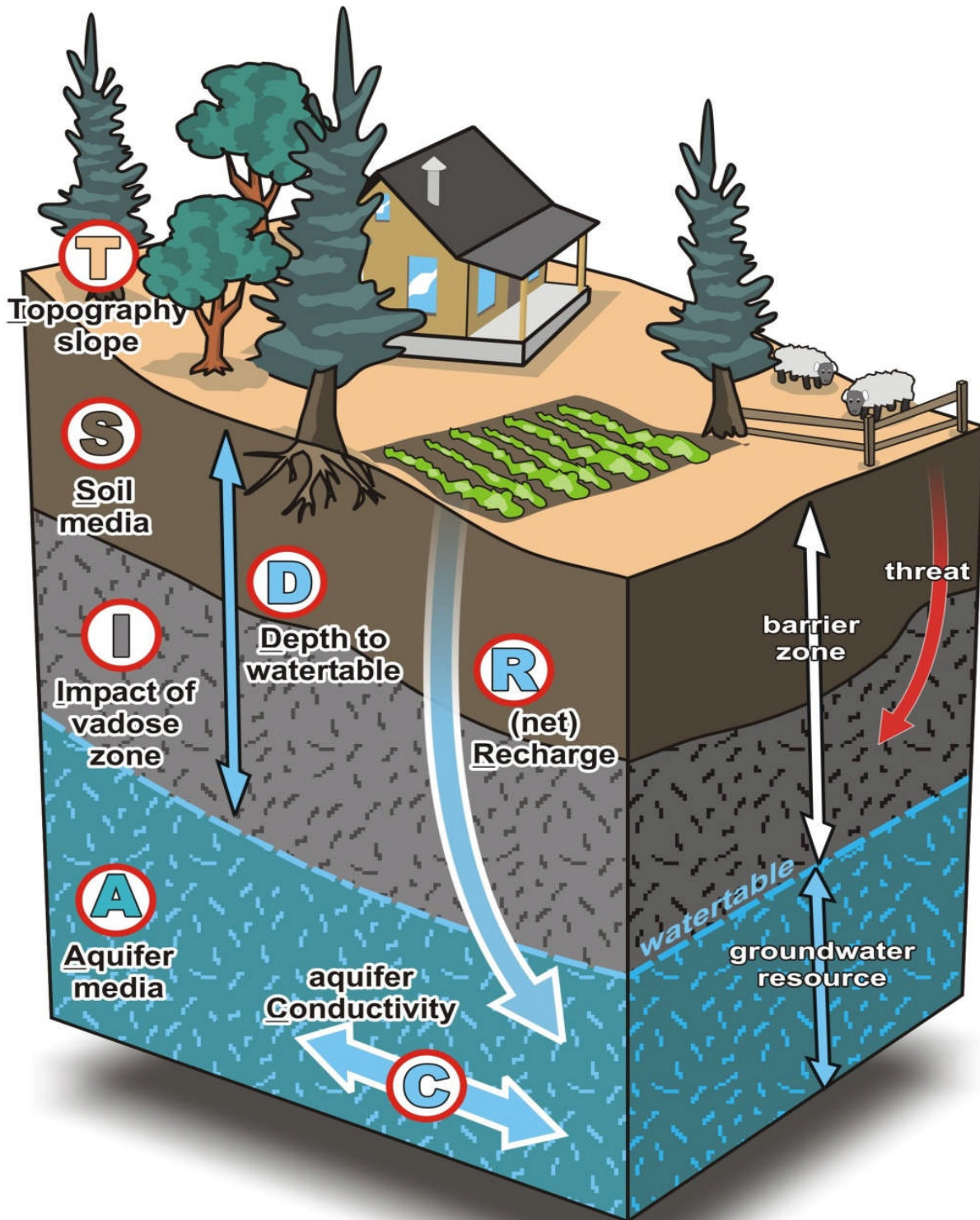
|           |      |      |           |      |          |  |        |
|-----------|------|------|-----------|------|----------|--|--------|
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|                  |           |
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| PROJECT NUMBER:  | FIGURE:   |
| <b>E00088100</b> | <b>17</b> |

FILE: Q:\E00088100\AgGIS\_NSWA\MXD\NaturalSuitability\GeoSetting.mxd Issued By: Edmonton GIS





SOURCE: COURTESY OF B. TURNER, AND R. FRANKLIN (GSC).  
 MODIFIED BY C. MÉDARD DE CHARDON (SFU)

**NORTH SASKATCHEWAN WATERSHED ALLIANCE  
 OVERVIEW OF GROUNDWATER CONDITIONS**

**DRASTIC METHOD OF EVALUATING GROUNDWATER VULNERABILITY**



**WorleyParsons**  
 resources & energy

20-MAR-09 date L.F. edited by J.Q. drawn by app by

PROJECT NUMBER:

FIGURE:

**E00088100**

**18**

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