CANADA-ONTARIO AGREEMENT (COA) RESPECTING THE GREAT LAKES BASIN ECOSYSTEM
CLIMATE CHANGE MONITORING REVIEW PROJECT:
Provincial Groundwater Monitoring Network (PGMN) and Stream Monitoring Network (PWQMN) Assessment

August 2010

FINAL REPORT

SENSITIVITY MAPPING AND LOCAL WATERSHED ASSESSMENTS FOR CLIMATE CHANGE DETECTION AND ADAPTATION MONITORING

APPENDICES

APPENDIX A – PREDICTED CLIMATE CHANGE IN ONTARIO (from MNR, 2009)

Table 1: Weather and Physical Element changes associated with Climate Change in Ontario	
Parameter	**Expected Change or Outcome**
Temperature	Increases in mean annual air temperature in all seasons, with high seasonal and regional variability, for example: • 0.7 to 3.1ºC for the 2020s } *range from 7 different climate models and six • 1.9 to 6.9ºC for the 2050s } storylines/emission scenarios • 2.1 to 12.7ºC for the 2080s } o Warming to be greatest in winter and spring o Warming to be greatest in northern and northwestern regions of the province Note: These projections are substantially higher than the projected global average increase of 1.8 to 4.0ºC provided by the Intergovernmental Panel on Climate Change 2007. For comparison, the Earth has warmed 0.74 +/- 0.2°C since 1906 to 2005 (IPCC 2007). (Mortsch et al. 2005, IPCC 2007)
Precipitation	Increases in total annual precipitation with high seasonal and regional variation, for example: • Northern sections of the province expected to experience greater increases than southern sections • Summer to be marked by possible water deficits as evaporation rates exceed precipitation increases (south and central regions expected to be most vulnerable) • Winter precipitation to include more rain events • Less snow accumulation province-wide (Mortsch et al. 2000, Lofgren et al. 2002, Kling et al. 2003, Mortsch et al. 2006)
Evaporation	Increases in evaporation and transpiration that are anticipated to exceed any precipitation increases resulting from: • Increases in air and water temperatures in all seasons • Lengthening of the growing season, with concurrent increases in plant productivity • Less winter ice coverage on lakes (Mortsch et al. 2000, Lofgren et al. 2002, Kling et al. 2003, Mortsch et al. 2006)
Extreme weather events	More extreme weather events, including more intense precipitation and increased occurrence of hot and dry spells are anticipated because: • More energy in the system to drive the circulation patterns • Warmer air means more available moisture within the system (Hengeveld 1998, Environment Canada 2005)
Ice cover /snowmelt	Significantly later freeze-up with earlier spring break-up Less spring snowmelt province-wide as rain events become more frequent in winter More melt of snow throughout the winter with warmer temperatures Less ice cover on the Great Lakes which could increase lake effect snowfall (Magnuson et al. 2000, Lofgren et al. 2002)

Table 2: Projected Effects of Climate Change on Water Bodies in Ontario	
Water body type	**Anticipated Effect**
Lakes (both Great and Inland)	▪ Most climate scenarios coupled with hydrologic models of the Great Lakes suggest lower mean water levels ▪ Higher degree of seasonal variability of water levels (greater fluctuations) ▪ Further shortening of the ice cover season and areal coverage ▪ Earlier spring freshet (Lofgren et al. 2002; Mortsch et al. 2000, 2003)
Streams	▪ Earlier and lower spring melt waters ▪ Increased duration of summer and early fall low flows ▪ Projected increase in more intense precipitation events that may trigger higher max flows and increased runoff ▪ Higher seasonal variability in runoff with larger 'flow' extremes ▪ Greater fluctuations in soil moisture, with increases of as much as 80% in winter and decreases of as much as 30% in summer and early fall (Mortsch et al. 2000, Bruce et al. 2002, Mortsch et al. 2003, Kling et al. 2003)
Groundwater	▪ A shorter overall snow season that will increase infiltration (recharge) events ▪ Lower overall water tables in late summer/early fall based on anticipated lower soil moisture (higher air temperatures and evaporation rates without compensating rainfall) ▪ Shallow (unconfined aquifers) will be more vulnerable to summer water fluctuations ▪ Changes to the amount and timing of baseflow to streams, lakes, and wetlands (Meisner et al. 1988, Changnon et al. 1988, Mortsch et al. 2000, Croley and Luukkonen 2003, Environment Canada 2004, de Loe and Berg 2006)

APPENDIX B-1 REFERENCE HYDROMETRIC BASIN NETWORK (RHBN) STATION AND WATERSHED ASSESSMENTS - GREAT LAKES BASIN

COA Climate Change Monitoring Review Project
Reference Basin Hydrometric Network (RHBN) Watersheds
PWQMN and PGMN Assessment

STATION NAME: Neebing R. Nr. Thunder Bay **RHBN NO.: 02AB008 (1942- pres.)**

Upstream Watershed Characteristics:
- 187 km2 drainage area; 71% forest, 4% urban, 24% range land; 1% tundra; <1% water; <1% barren land;
- Precambrian bedrock, Pleistocene till, glaciofluvial outwash deposits, glaciolacustrine deposits, organic deposits; 25% low porosity, 54% moderate, 20% high.

Suitability of RHBN Watershed for CC Detection:
- High discharge area (sand) around RHBN station; glacial till upstream
- Generally natural stable watershed land use area suitable for long term CC detection; monitor potential land cover changes using remote sensing as needed.

A. PWQMN ASSESSMENT:

Existing Station No.: 01010700202 (upstream; 1968-2008; 12 yr. missing data)

Rationale for use in CC:

– long record suitable for monitoring of trend in sand region; potential use in adaptation planning

Proposed New Station Location:

- new station recommended close to existing RHBN station on Neebing R. or move existing PWQMN station temporarily to RHBN station for calibration

Rationale for CC:

- Integrated ecosystem monitoring to detect changes in SW quality related to streamflow

B. PGMN ASSESSMENT:

Existing Stations: (1) 465-1 – 24.4m; (2) 467-1 – 60.1m (bedrock)

Rationale for use in CC:

- not applicable for CC detection due to lack of long term record, depth of wells and lack of connectivity to surface water monitoring stations

Proposed New Station Location:

- one shallow groundwater monitoring well nr. the RHBN station to relate trends in groundwater levels to baseflow / streamflow monitoring and climate

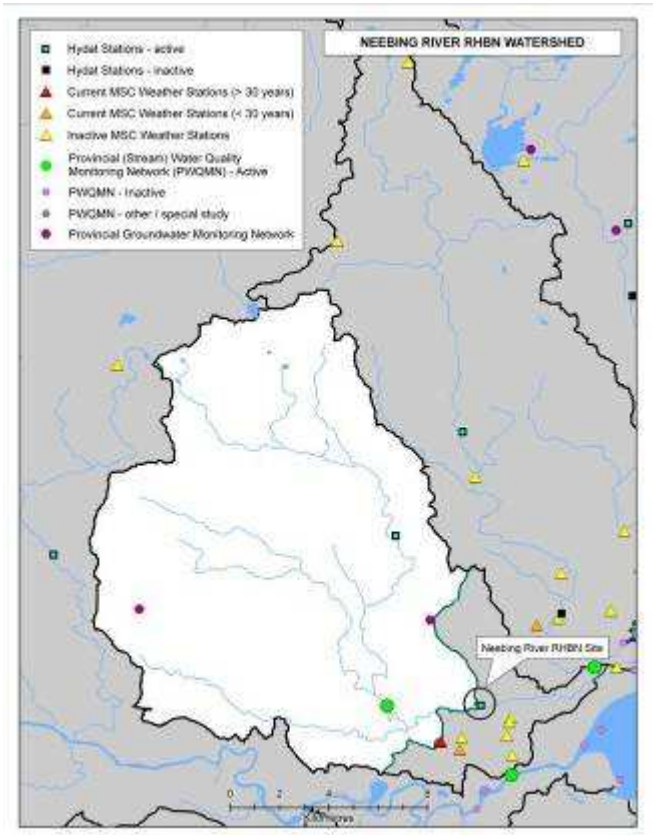
Rationale for CC:

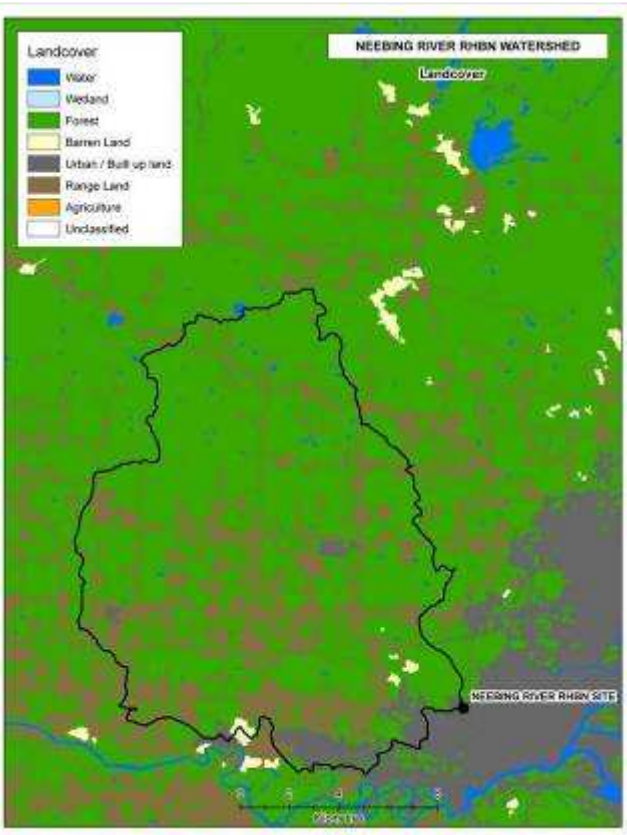
- new station in high discharge area for integrated monitoring; monitoring of baseflow contribution to surface water as impacted by climate
- suitable for CC detection monitoring and potential use in adaptation planning

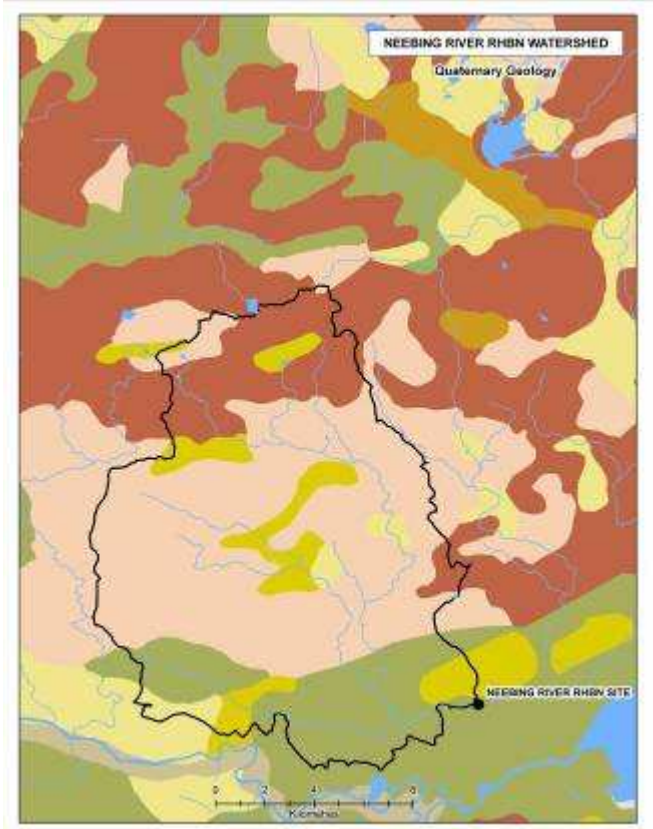
C. Other Monitoring Networks:

- one additional HYDAT station existing

- several climate stations exist in area of RHBN station (30 yrs.+ record)
- potential for one additional climate station upstream in watershed for hydrologic modeling







Baseflow index not available for Neebing River RHBN Watershed

COA Climate Change Monitoring Review Project
Reference Basin Hydrometric Network (RHBN) Watersheds
PWQMN and PGMN Assessment

STATION NAME: Goulais R. nr. Searchmount **RHBN NO.: 02BF002 (1967-pres.)**

Upstream Watershed Characteristics:
- 1160 sq.km; 93% forest, 6% water; 1% tundra
- Precambrian bedrock; Pleistocene till; glaciofluvial outwash deposits (sand and gravel in river valleys); fluvial and organic deposits;
- 87% low porosity; 13% high porosity.

Suitability of RHBN Watershed for CC Detection:
- Generally natural stable watershed land cover, unimpacted by human activity; suitable for long term CC detection; monitor land cover changes using remote sensing (eg. deforestation?) as needed.

A. PWQMN ASSESSMENT:

Existing Station No.: none existing: 3 inactive stations downstream of RHBN station

Rationale for use in CC:
- inactive stations not suitable because of d/s location and lack of recent record

Proposed New Station Location:
- new station recommended close to existing RHBN station

Rationale for CC:
- Integrated ecosystem monitoring to detect long term trends in SW quality related to streamflow

B. PGMN ASSESSMENT:

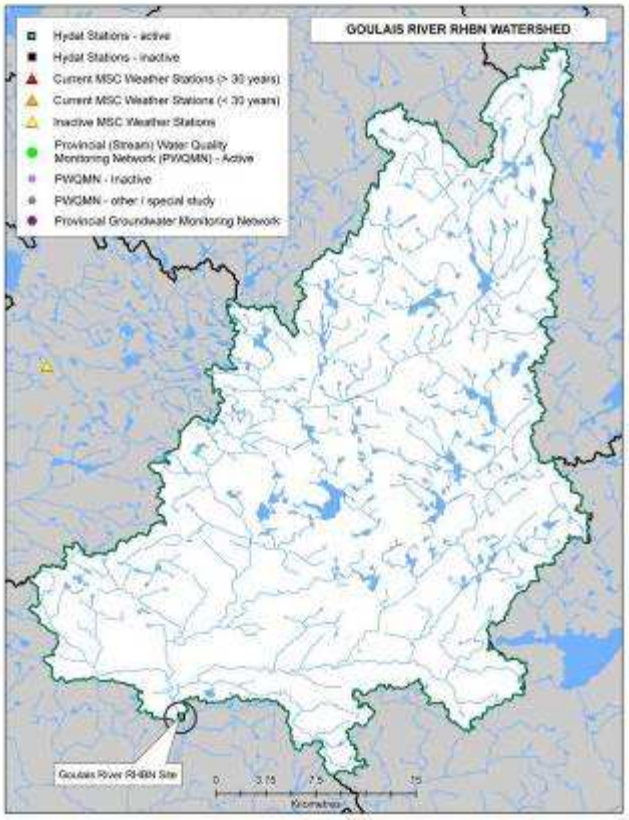
Existing Stations: none existing

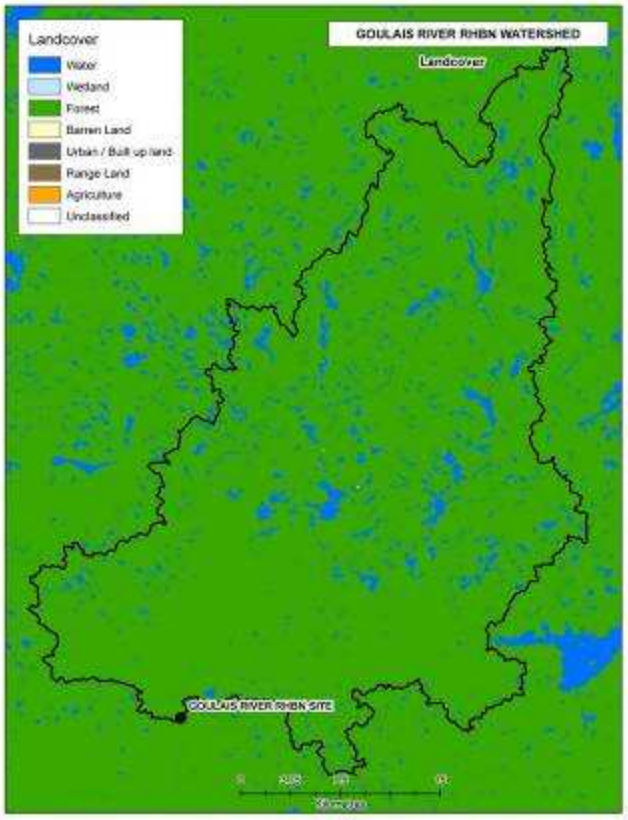
Rationale for use in CC:
NA

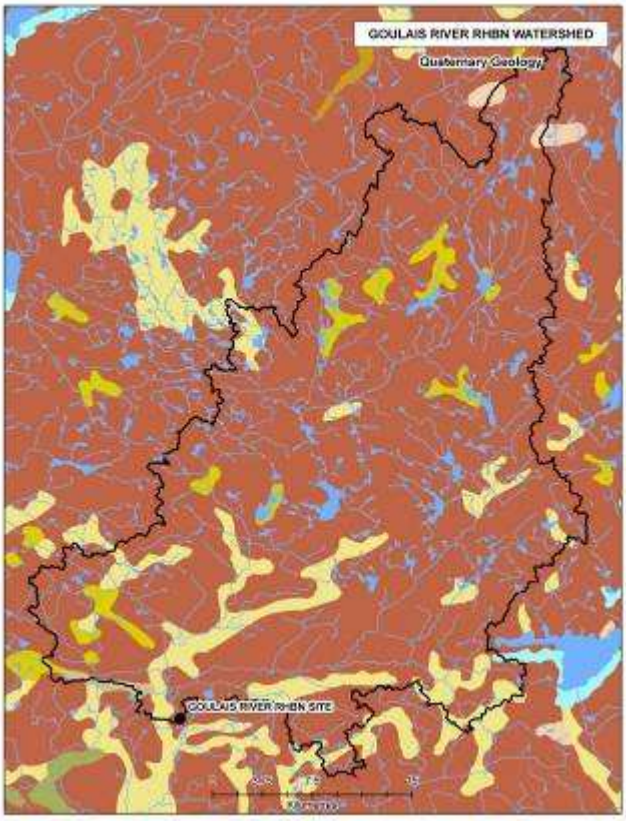
Proposed New Station Location:
None recommended due to unsuitable geology for use in GW/ SW integrated monitoring

Rationale for CC:
NA

C. Other Monitoring Networks:
- one additional active HYDAT station existing
- 2 MSC weather stations inactive; resurrect d/s station with long record (1914-1975) for use in integrated surface water / climate monitoring







Baseflow index not available for Goulais River RHBN Watershed

COA Climate Change Monitoring Review Project
Reference Basin Hydrometric Network (RHBN) Watersheds
PWQMN and PGMN Assessment

STATION NAME: Whitson R. at Val Caron **RHBN NO.: 02CF 008 (1960-pres.)**

Upstream Watershed Characteristics:
- 179km2; 4% water, 3% tundra, 46% forest, 27% barren land (eg. mine tailings); 4% urban, 17% range
- Precambrian bedrock, Pleistocene till, glaciofluvial ice contact deposits and outwash deposits, glaciolacustrine deposits, organic deposits;
- 55% low porosity, 44% high porosity.

Suitability of RHBN Watershed for CC Detection:
- High baseflow contribution in sand and gravel area
- potential influence from mine tailings areas

A. PWQMN ASSESSMENT:

Existing Station No.: 14002802802 (1970-1991) nr RHBN station

Rationale for use in CC:
Potential use for monitoring SW quality with SW flow; integrated monitoring

Proposed New Station Location:
NA

Rationale for CC:
Integrated ecosystem monitoring to detect long term trends in SW quality related to streamflow

B. PGMN ASSESSMENT:

Existing Stations: 454-1 in sand and gravel area further upstream in watershed

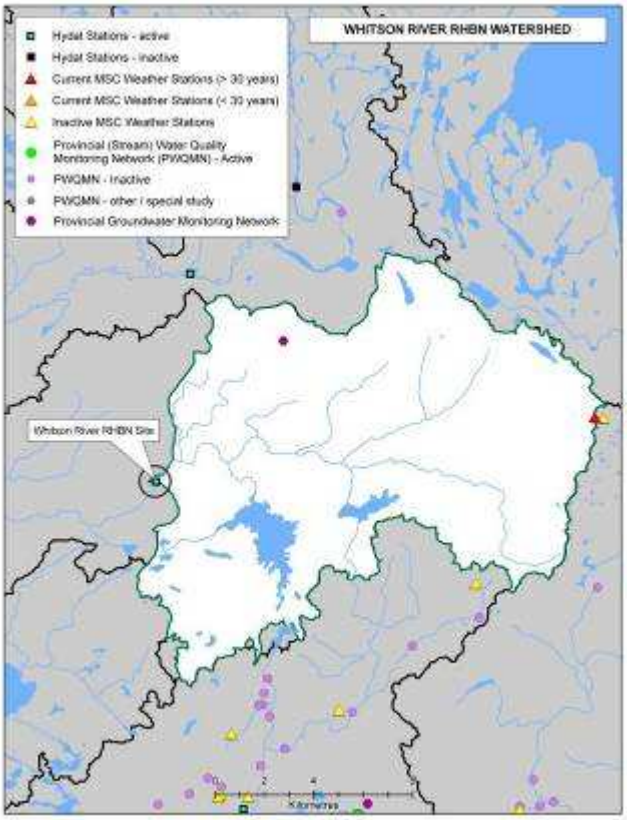
Rationale for use in CC:
NA

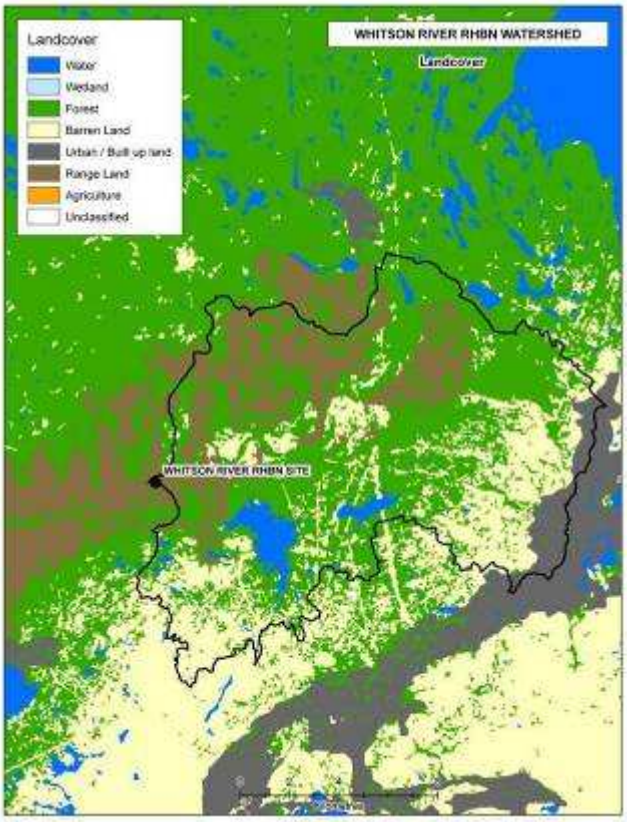
Proposed New Station Location:
Move existing station closer to RHBN site for integrated monitoring of SW/GW linkages

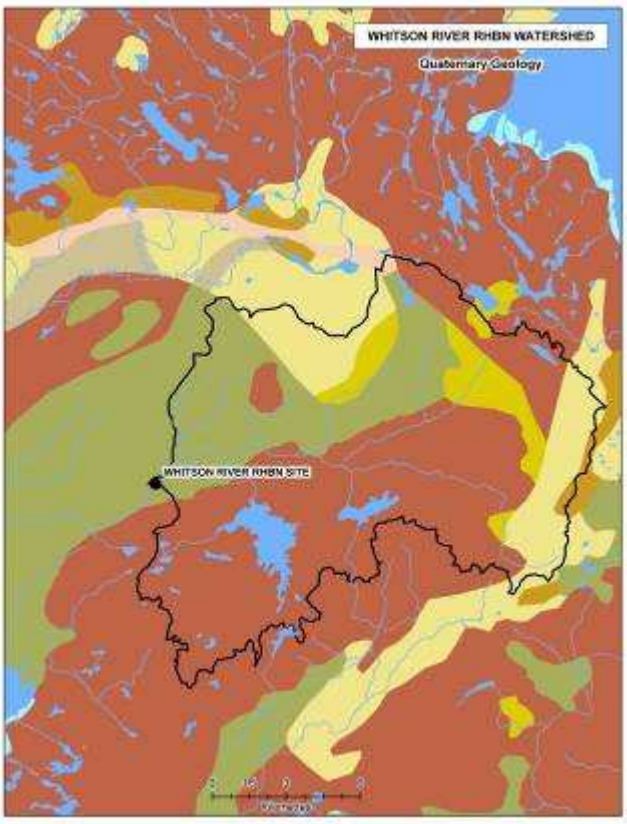
Rationale for CC:
Integrated ecosystem monitoring to link to SW monitoring and long term trends

C. Other Monitoring Networks:

- one long term active climate station located in headwaters (1953-2009) – retain for hydrology/climate watershed modeling







Baseflow index not available for Whitson River RHBN Watershed

COA Climate Change Monitoring Review Project
Reference Basin Hydrometric Network (RHBN) Watersheds
PWQMN and PGMN Assessment

STATION NAME: North Magnetewan R. nr. Burks Falls **RHBN NO.: 02EA005 (1915-pres.)**

Upstream Watershed Characteristics:
- 321km2; 7% water, 2% tundra, 90% forest, 1% range land
- Precambrian bedrock, Pleistocene till, glaciofluvial ice contact deposits and outwash deposits, glaciolacustrine deposits , organic deposits; coarse grained deposits along river course (sand and gravel)
- 58% low porosity, 22% mod., 19% high porosity.

Suitability of RHBN Watershed for CC Detection:
- High baseflow contribution in sand and gravel areas, high baseflow index
- suitable for long term trends in natural forest area watershed

A. PWQMN ASSESSMENT:

Existing Station No.: 03012400102 (d/s, 1968-1990)
Rationale for use in CC: NA / downstream location

Proposed New Station Location:
Near RHBN site

Rationale for CC:
-Integrated ecosystem monitoring to detect long term trends in SW quality related to streamflow
- monitoring impact of possible long term land use change (remote sensing)

B. PGMN ASSESSMENT:

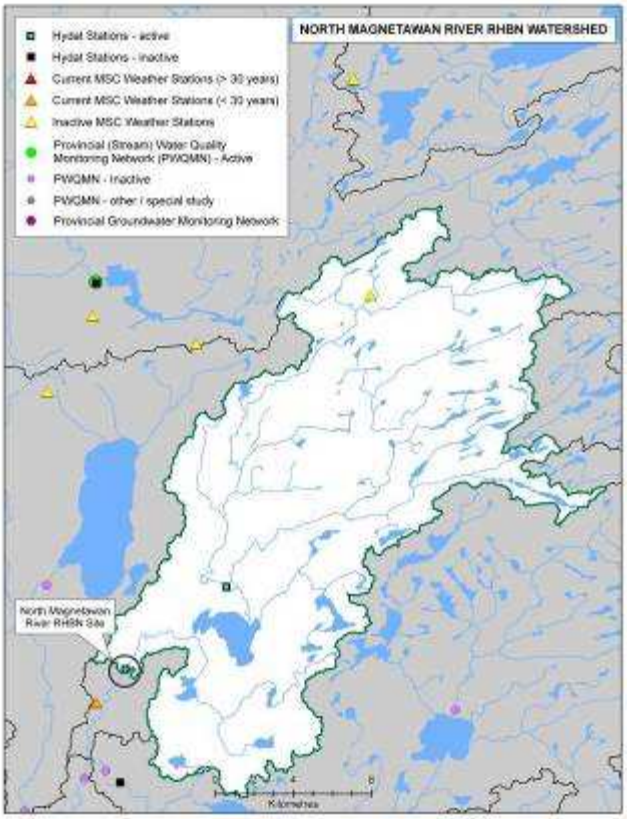
Existing Stations: NA, predominance of private wells in sand and gravel areas
Rationale for use in CC:
NA

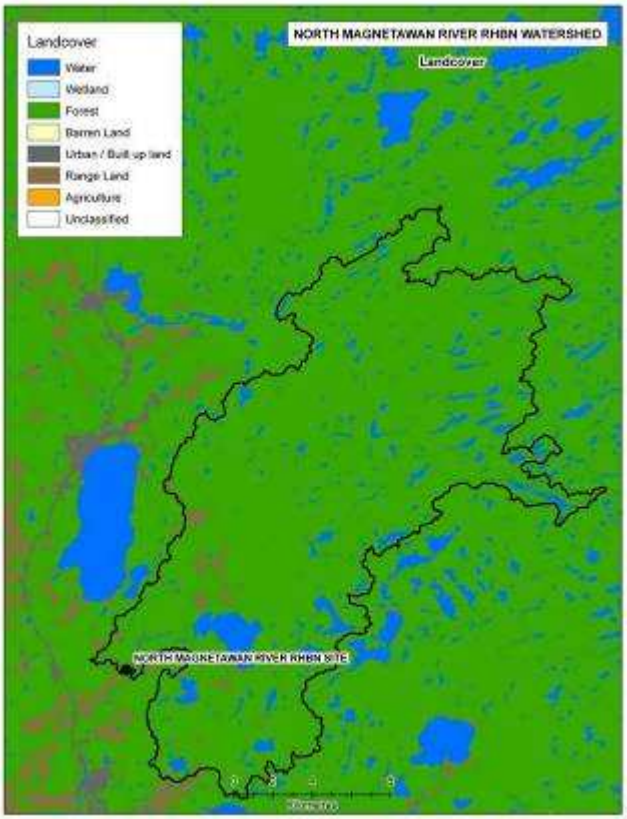
Proposed New Station Location: near RHBN station in glaciolacustrine deposit

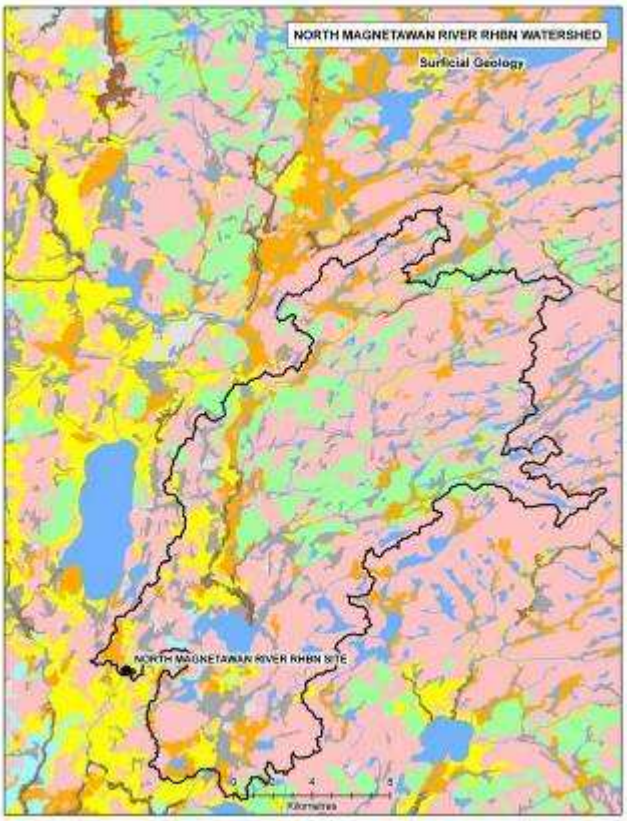
Rationale for CC:
- monitor groundwater levels rel to contribution to streamflow
- Integrated ecosystem monitoring to link to SW monitoring and groundwater long term trends

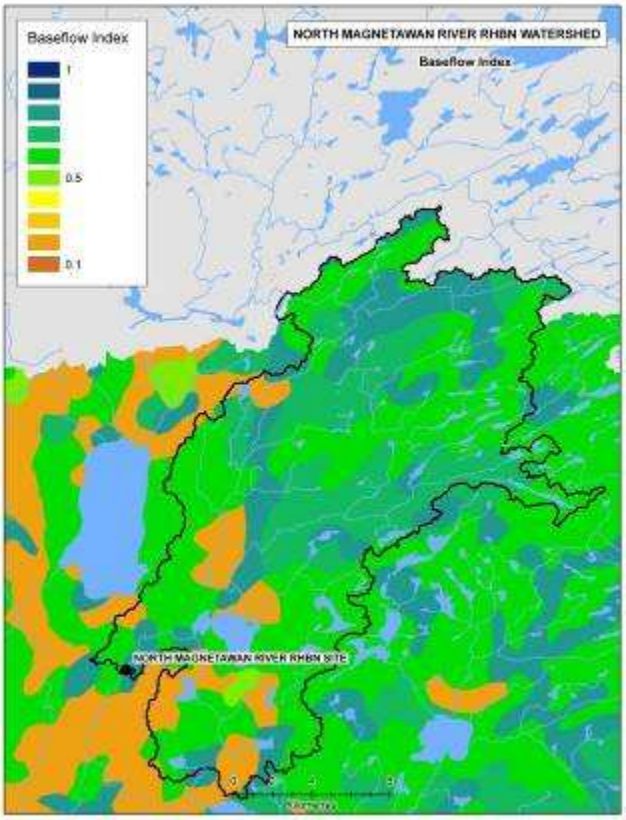
C. Other Monitoring Networks:

- one active climate station located d/s (2006-2009) – retain for hydrology/climate watershed modeling
- one active HYDAT station u/s nr. Pickerel Lake
- conduct periodic remote sensing to assess land use changes (potential for lumbering)


NORTH MAGNETAWAN RIVER RHBN WATERSHED
Hydat Stations - active
Hydat Stations - inactive
Current MSC Weather Stations (> 30 years)
Current MSC Weather Stations (< 30 years)
Inactive MSC Weather Stations
Provincial (Stream) Water Quality Monitoring Network (PWQMN) - Active
PWQMN - Inactive
PWQMN - other / special study
Provincial Groundwater Monitoring Network
North Magnetawan River RHBN Site
Kilometres


NORTH MAGNETAWAN RIVER RHBN WATERSHED
Landcover
Water
Wetland
Forest
Barren Land
Urban / Built up land
Range Land
Agriculture
Unclassified
NORTH MAGNETAWAN RIVER RHBN SITE


NORTH MAGNETAWAN RIVER RHBN WATERSHED
Surficial Geology
NORTH MAGNETAWAN RIVER RHBN SITE
Kilometres


Baseflow Index
NORTH MAGNETAWAN RIVER RHBN WATERSHED
Baseflow Index
1
0.5
0.1
NORTH MAGNETAWAN RIVER RHBN SITE

COA Climate Change Monitoring Review Project
Reference Basin Hydrometric Network (RHBN) Watersheds
PWQMN and PGMN Assessment

STATION NAME: Black R. nr. Washago **RHBN NO.: 02EC002 (1913-pres.)**

Upstream Watershed Characteristics:
- 1520km2; 8% water, 4%wetland, 1% tundra, 75% forest, 4% barren, 5% range land, 3% agriculture
- Precambrian bedrock, Paleozoic bedrock, Pleistocene till, glaciofluvial ice contact deposits and outwash deposits, glaciolacustrine deposits , organic deposits;
- 72% low porosity, 6% mod., 22% high porosity.

Suitability of RHBN Watershed for CC Detection:
Stable land use suitable for CC detection monitoring; shallow groundwater regime suitable for long term monitoring of CC impact

A. PWQMN ASSESSMENT:

Existing Station No.: 03007703102 (1977-1993) nr RHBN station
Rationale for use in CC:

Proposed New Station Location:
Reactivate former station nr. RHBN station

Rationale for CC:
-Integrated ecosystem monitoring to detect long term trends in SW quality related to streamflow

B. PGMN ASSESSMENT:

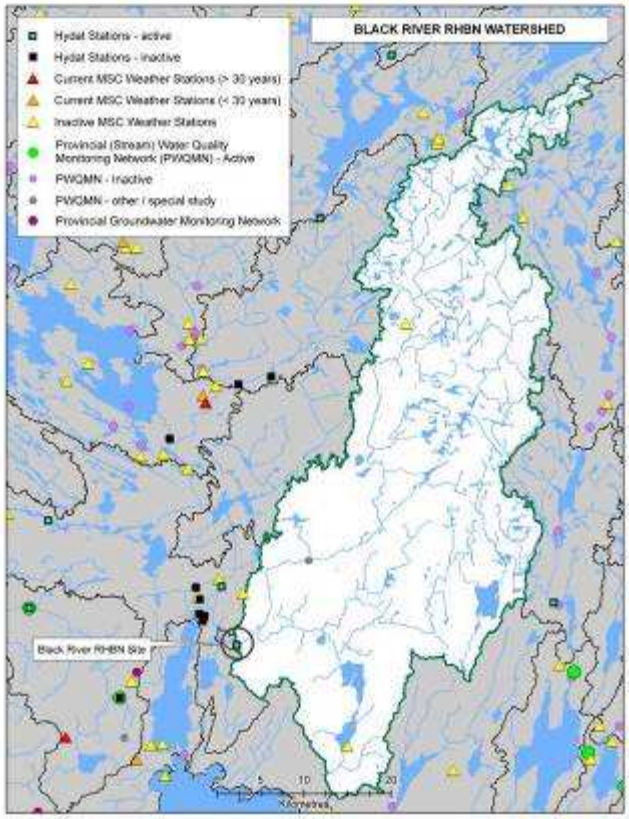
Existing Stations: NA
Rationale for use in CC:
NA

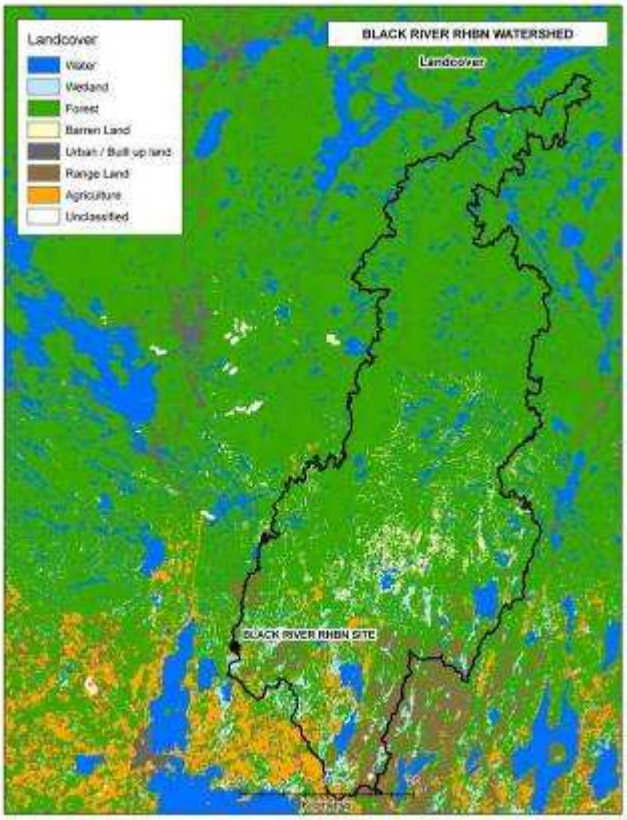
Proposed New Station Location: one shallow well near RHBN station

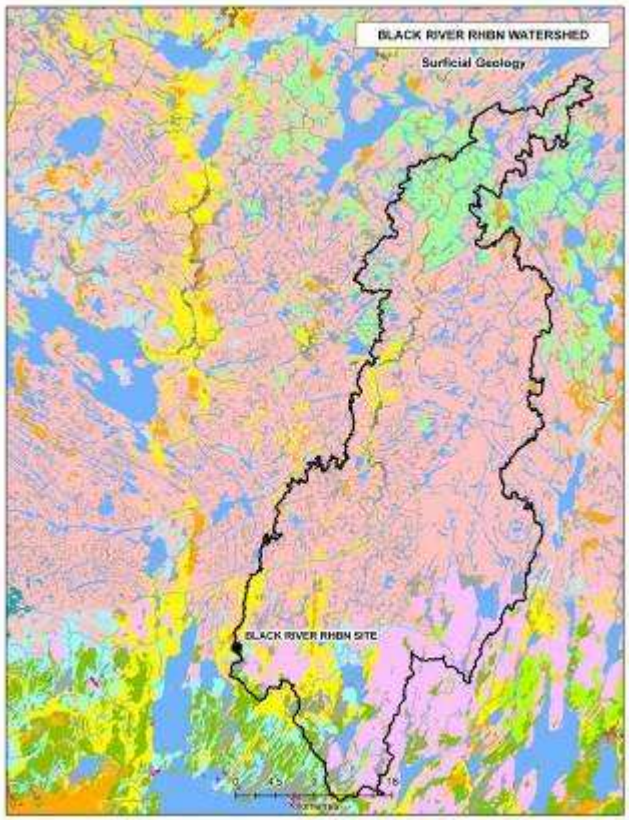
Rationale for CC:
- high baseflow index in region of RHBN station location
- monitor groundwater levels rel to contribution to streamflow
- Integrated ecosystem monitoring to link to SW monitoring and groundwater long term trends

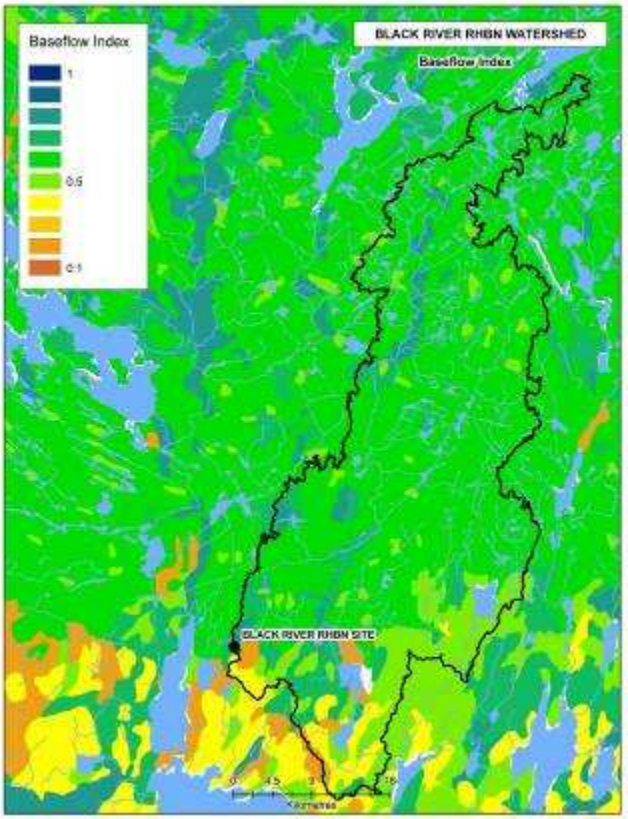
C. Other Monitoring Networks:

- retain two existing MSC stations upstream in watershed for model calibration
- existing streamflow monitoring at the RHBN station adequate for CC detection


BLACK RIVER RHBN WATERSHED
Hydat Stations - active
Hydat Stations - inactive
Current MSC Weather Stations (> 30 years)
Current MSC Weather Stations (< 30 years)
Inactive MSC Weather Stations
Provincial (Stream) Water Quality Monitoring Network (PWQMN) - Active
PWQMN - Inactive
PWQMN - other / special study
Provincial Groundwater Monitoring Network
Black River RHBN Site
Kilometres


BLACK RIVER RHBN WATERSHED
Landcover
Landcover
Water
Wetland
Forest
Barren Land
Urban / Built up land
Range Land
Agriculture
Unclassified
BLACK RIVER RHBN SITE


BLACK RIVER RHBN WATERSHED
Surficial Geology
BLACK RIVER RHBN SITE


BLACK RIVER RHBN WATERSHED
Baseflow Index
Baseflow Index
1
0.5
0.1
BLACK RIVER RHBN SITE

COA Climate Change Monitoring Review Project
Reference Basin Hydrometric Network (RHBN) Watersheds
PWQMN and PGMN Assessment

STATION NAME: Sydenham R. nr. Owen Sound **RHBN NO.: 02FB007 (1915-pres.)**

Upstream Watershed Characteristics:
- 181 km2; 5%wetland, 39% forest, 13% range land, 42% agriculture
- Paleozoic bedrock, Pleistocene Elma and St.Joseph till, glaciofluvial ice contact deposits and glaciolacustrine deposits , organic deposits;
- 23% low porosity, 61% mod., 16% high porosity.

Suitability of RHBN Watershed for CC Detection:
- questionable use for CC detection due to high agriculture and potential for land use change , affecting streamflow and water quality; potential for climate change adaptation monitoring in selected subwatersheds

A. PWQMN ASSESSMENT:

Existing Station No.: 03001600302 (1975-2008/ present?) at RHBN station

Rationale for use in CC:
- Retain station for long term monitoring of trends related to changes in agriculture, forestry
- potential linkage with CC adaptation monitoring ; integrated SW flow and water quality

Proposed New Station Location:
na

Rationale for CC:
na

B. PGMN ASSESSMENT:

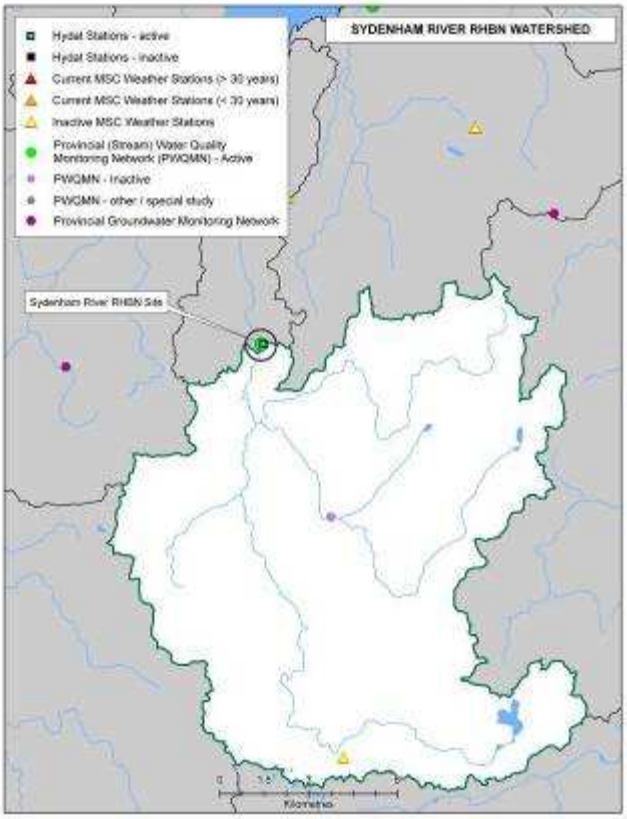
Existing Stations: NA

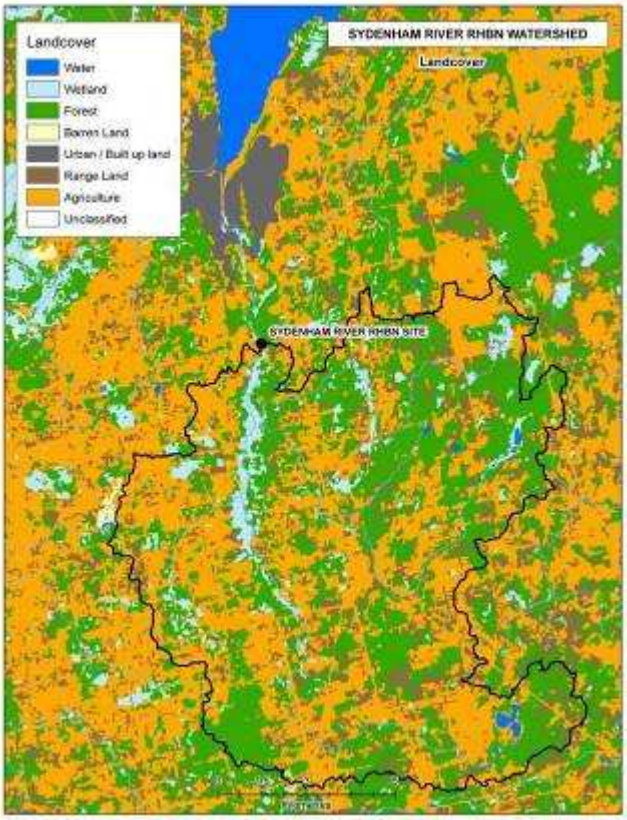
Rationale for use in CC:
NA

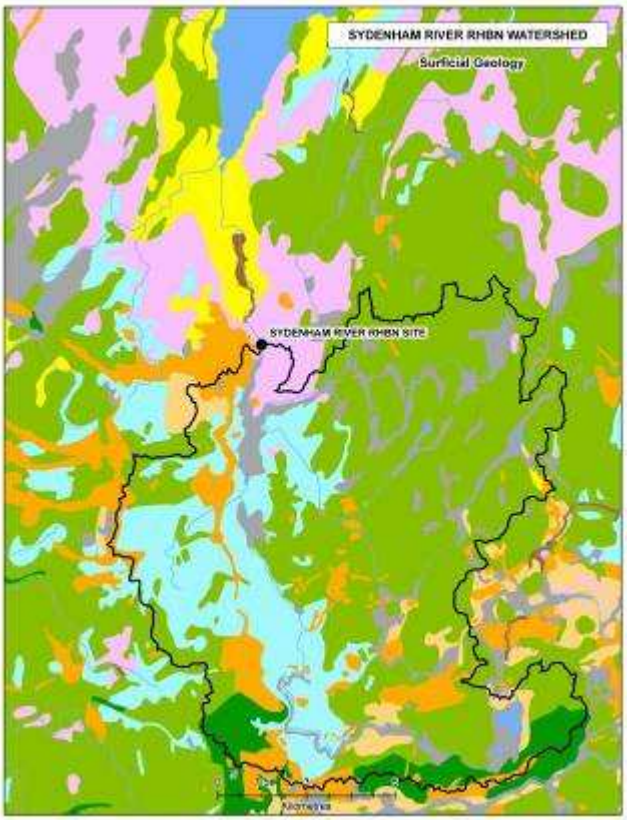
Proposed New Station Location: one shallow well near RHBN station in sandplain connected to stream

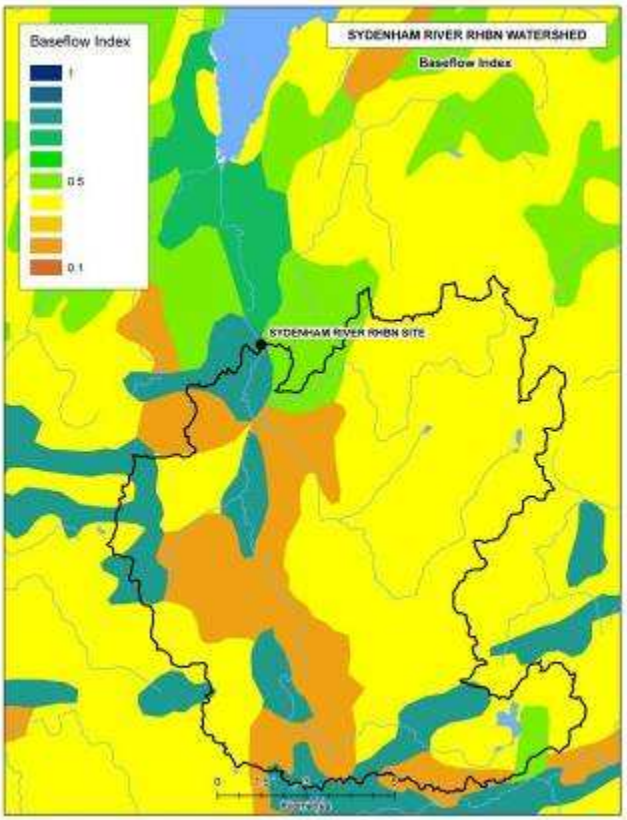
Rationale for CC:
- high groundwater discharge area
- monitor groundwater levels rel. to contribution to streamflow
- Integrated ecosystem monitoring for GW/SW interaction

C. Other Monitoring Networks:
- retain existing MSC station in headwaters
- existing streamflow monitoring at the RHBN station adequate for CC detection


SYDENHAM RIVER RHBN WATERSHED
Hydat Stations - active
Hydat Stations - inactive
Current MSC Weather Stations (> 30 years)
Current MSC Weather Stations (< 30 years)
Inactive MSC Weather Stations
Provincial (Stream) Water Quality Monitoring Network (PWQMN) - Active
PWQMN - Inactive
PWQMN - other / special study
Provincial Groundwater Monitoring Network
Sydenham River RHBN Site
Kilometers


SYDENHAM RIVER RHBN WATERSHED
Landcover
Landcover
Water
Wetland
Forest
Barren Land
Urban / Built up land
Range Land
Agriculture
Unclassified
SYDENHAM RIVER RHBN SITE


SYDENHAM RIVER RHBN WATERSHED
Surficial Geology
SYDENHAM RIVER RHBN SITE
Kilometers


SYDENHAM RIVER RHBN WATERSHED
Baseflow Index
Baseflow Index
1
0.5
0.1
SYDENHAM RIVER RHBN SITE

COA Climate Change Monitoring Review Project
Reference Basin Hydrometric Network (RHBN) Watersheds
PWQMN and PGMN Assessment

STATION NAME: Saugeen R. nr. Port Elgin **RHBN NO.: 02FC001 (1911-pres.)**

Upstream Watershed Characteristics:
- 3960 km2; 3%wetland, 26% forest, 10% range land, 61% agriculture
- Pleistocene till, glaciofluvial ice contact deposits and glaciolacustrine deposits , fluvial and recent organic deposits;
- 20% low porosity, 38% mod., 42% high porosity.

Suitability of RHBN Watershed for CC Detection:
- large drainage area with multiple land use; questionable use for CC detection due to high agriculture and potential for land use change affecting streamflow and water quality; potential for climate change adaptation monitoring in selected subwatersheds

A. PWQMN ASSESSMENT:

Existing Station No.: 08012303080 (1975-2003) nr. RHBN station; several others u/s

Rationale for use in CC:
- strong u/s influence from various land uses; therefore questionable for CC detection
- select stations in stable subwatersheds potentially useful for CC adaptation planning and monitoring of long term trends related to land use

Proposed New Station Location:
NA

Rationale for CC:
- too many anthropogenic effects on stream water quality

B. PGMN ASSESSMENT:

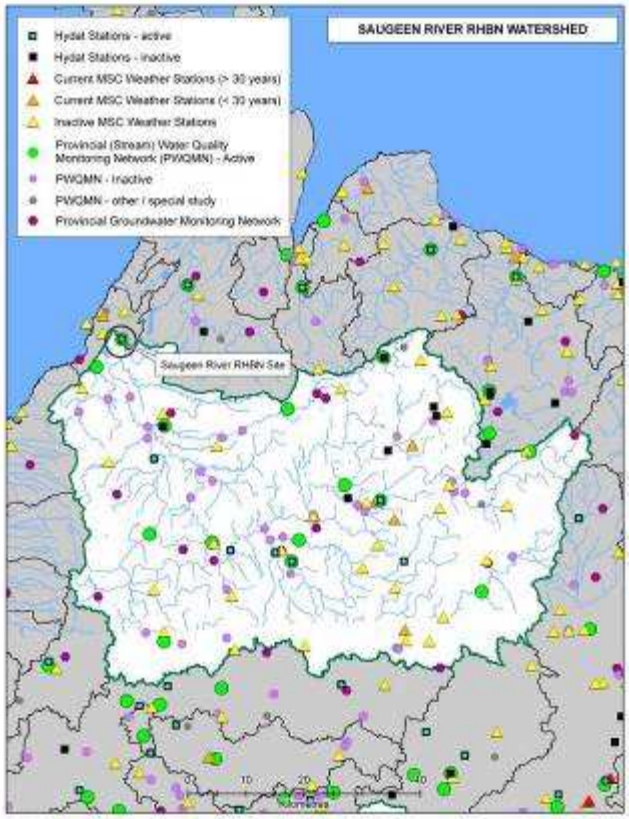
Existing Stations: 11 monitoring wells in watershed

Rationale for use in CC:
- select shallow wells in subwatersheds with specific land use potentially suitable for climate change adaptation monitoring
- Integrated ecosystem monitoring for GW/SW interaction for CC adaptation planning

Proposed New Station Location:
NA

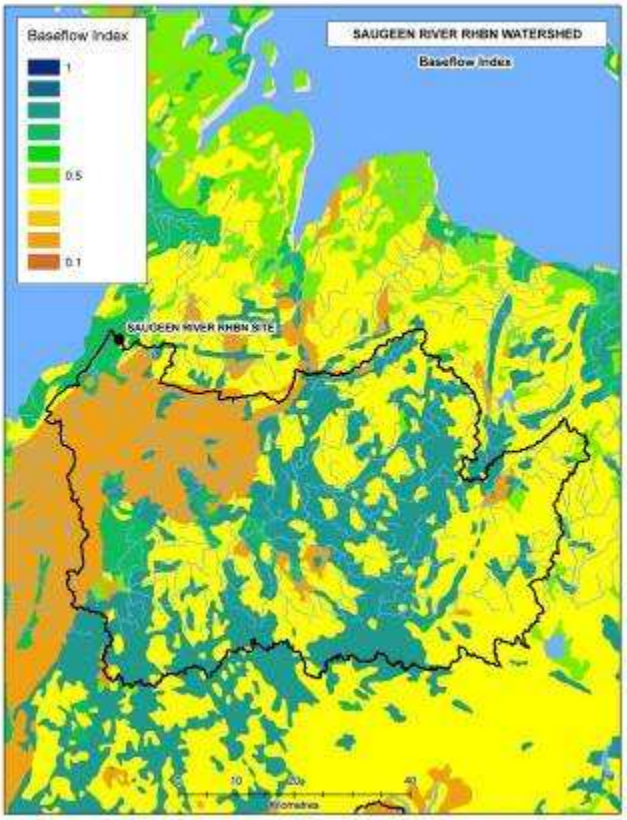
Rationale for CC:
NA

C. Other Monitoring Networks:
- numerous MSC weather stations, historic and current in watershed
- several HYDAT stations in watershed; suitable for CC adaptation planning


SAUGEEN RIVER RHBN WATERSHED
Hydat Stations - active
Hydat Stations - inactive
Current MSC Weather Stations (> 30 years)
Current MSC Weather Stations (< 30 years)
Inactive MSC Weather Stations
Provincial (Stream) Water Quality Monitoring Network (PWQMN) - Active
PWQMN - Inactive
PWQMN - other / special study
Provincial Groundwater Monitoring Network
Saugeen River RHBN Site
Kilometres


SAUGEEN RIVER RHBN WATERSHED
Landcover
Landcover
Water
Wetland
Forest
Barren Land
Urban / Built up land
Range Land
Agriculture
Unclassified
SAUGEEN RIVER RHBN SITE
Kilometres


SAUGEEN RIVER RHBN WATERSHED
Surficial Geology
SAUGEEN RIVER RHBN SITE
Kilometres


SAUGEEN RIVER RHBN WATERSHED
Baseflow Index
Baseflow Index
1
0.5
0.1
SAUGEEN RIVER RHBN SITE
Kilometres

COA Climate Change Monitoring Review Project
Reference Basin Hydrometric Network (RHBN) Watersheds
PWQMN and PGMN Assessment

STATION NAME: Nith River nr. Canning **RHBN NO.: 02GA010 (1913-pres.)**

Upstream Watershed Characteristics:
- 1030 km2; 1%wetland, 11% forest, 2% range land, 86% agriculture
- mainly Pleistocene till, glaciofluvial ice contact deposits and outwash deposits, glaciolacustrine deposits , fluvial and recent organic deposits;
- 39% low porosity, 28% mod., 33% high porosity.

Suitability of RHBN Watershed for CC Detection:
- large drainage area with major agr. land use; questionable limited use for CC detection due to high agriculture and potential for land use change affecting streamflow and water quality; good potential for climate change adaptation monitoring due to likely change in agr. practice needed to adapt to CC.

A. PWQMN ASSESSMENT:

Existing Station No.: 16018408002 (1975-1978) u/s nr. RHBN station, one station (16018400902 – 1964-2008) below RHBN station

Rationale for use in CC:
- major agriculture basin suitable for use as representative basin for CC detection (assuming no change in land use) or CC adaptation planning and monitoring of resulting stream water quality changes

Proposed New Station Location:
NA

Rationale for CC:
NA

B. PGMN ASSESSMENT:

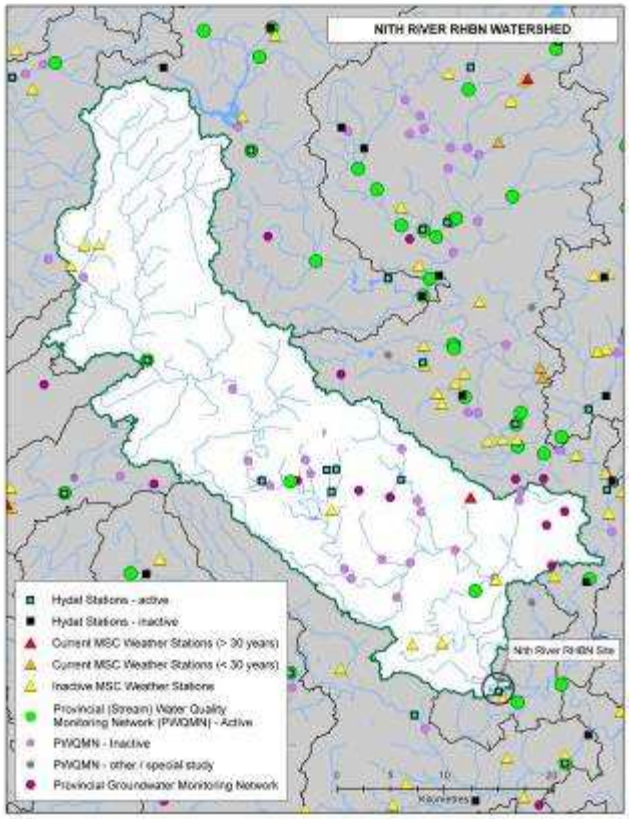
Existing Stations: 6 monitoring wells in watershed

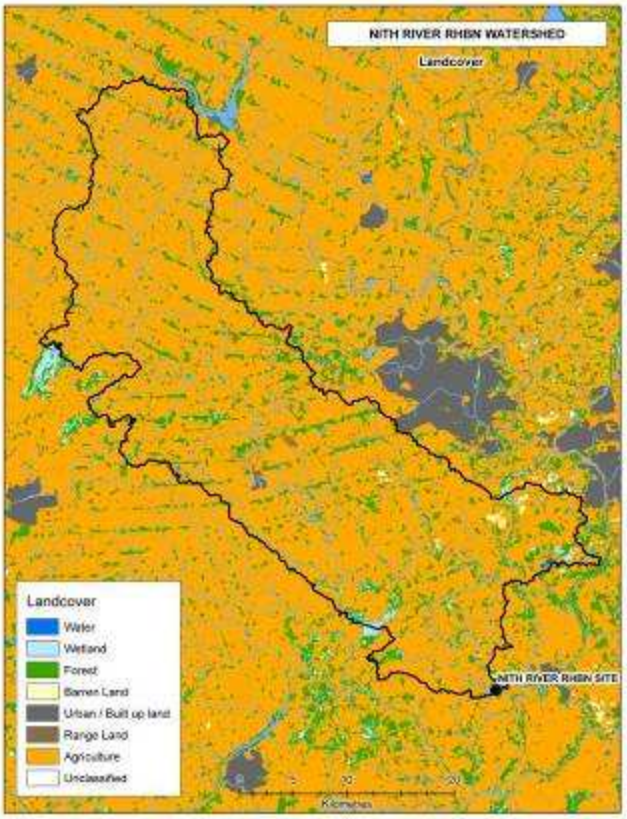
Rationale for use in CC:
- No. 306 good candidate for CC detection / adaptation monitoring depending on changing land use in agriculture area; 13.7m well located in sand overburden area with high baseflow index u/s of RHBN station
- relate to RHBN station streamflow to groundwater levels and baseflow contribution

Proposed New Station Location:
NA

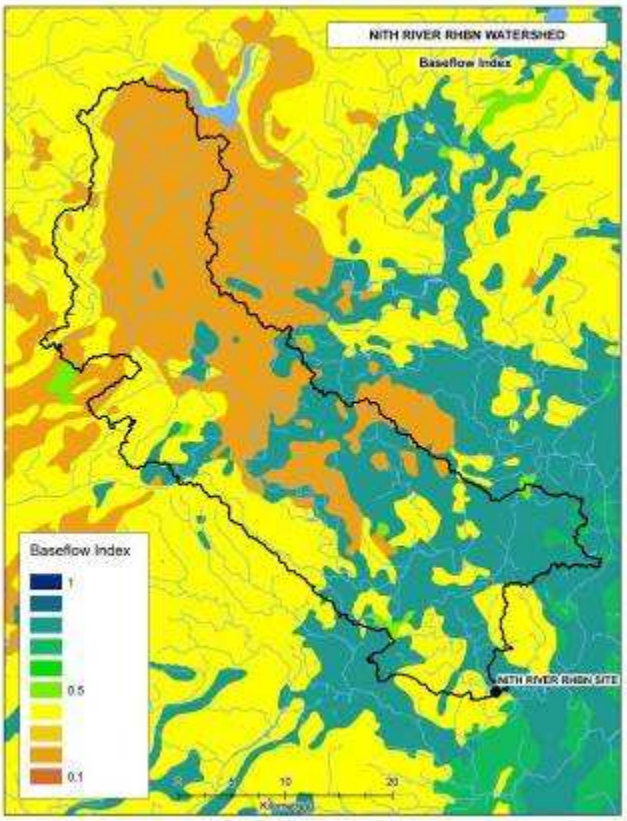
Rationale for CC:
NA

C. Other Monitoring Networks:
- several MSC weather stations in basin; ensure continuation of one long term monitoring station at RHBN and one u/s for use in integrated watershed ecosystem monitoring and modelling
- use periodic remote sensing to assess land use changes related to CC


NITH RIVER RHBN WATERSHED
Hydat Stations - active
Hydat Stations - inactive
Current MSC Weather Stations (> 30 years)
Current MSC Weather Stations (< 30 years)
Inactive MSC Weather Stations
Provincial (Stream) Water Quality Monitoring Network (PWQMN) - Active
PWQMN - Inactive
PWQMN - other / special study
Provincial Groundwater Monitoring Network
Nith River RHBN Site
Kilometres


NITH RIVER RHBN WATERSHED
Landcover
Landcover
Water
Wetland
Forest
Barren Land
Urban / Built up land
Range Land
Agriculture
Unclassified
NITH RIVER RHBN SITE
Kilometres


NITH RIVER RHBN WATERSHED
Surficial Geology
NITH RIVER RHBN SITE


NITH RIVER RHBN WATERSHED
Baseflow Index
Baseflow Index
1
0.5
0.1
NITH RIVER RHBN SITE

COA Climate Change Monitoring Review Project
Reference Basin Hydrometric Network (RHBN) Watersheds
PWQMN and PGMN Assessment

STATION NAME: Skootamatta R. nr. Actinolite **RHBN NO.: 02HL004 (1913-pres.)**

Upstream Watershed Characteristics:
- 712 km2; 8% water, 2% wetland, 3% tundra, 80% forest, 6% barren, 1% range land,
- Precambrian bedrock, pleistocene till, glaciofluvial ice contact deposits and outwash deposits, glaciolacustrine deposits, organic deposits;
- 86% low porosity, 1% mod., 13% high porosity.

Suitability of RHBN Watershed for CC Detection:
- large drainage area with major forest land cover on bedrock; stable land use suitable for CC detection to assess impact on surface water and contribution of groundwater to streamflow in lower part of watershed.

A. PWQMN ASSESSMENT:

Existing Station No.: active station 17002600902 at RHBN station (1966-pres.)

Rationale for use in CC:
- major forest area basin suitable for use as representative basin for CC impact on streamwater quality as it relates to streamflow

Proposed New Station Location:
NA

Rationale for CC:
NA

B. PGMN ASSESSMENT:

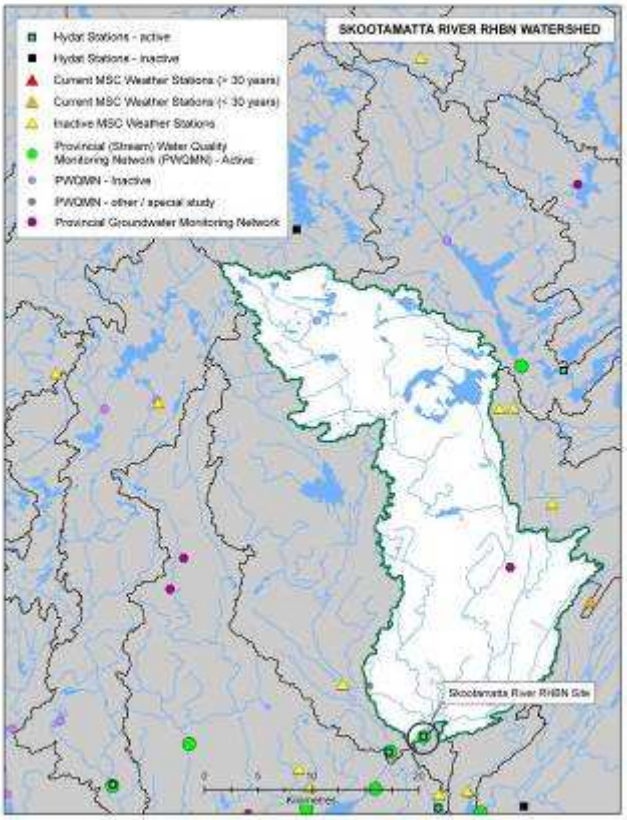
Existing Stations: existing monitoring well 131-1 upstream of RHBN station (65m deep in high baseflow discharge area along stream channel; Canadian Shield)

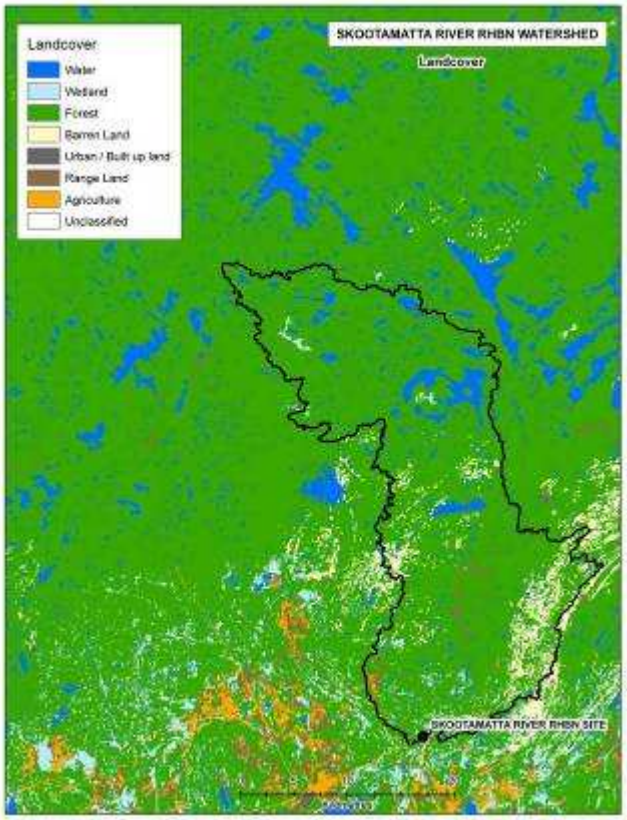
Rationale for use in CC:
- existing monitoring well to be further investigated to assess suitability for monitoring CC gw levels in high discharge area ie. relate to RHBN station streamflow to groundwater levels and baseflow contribution

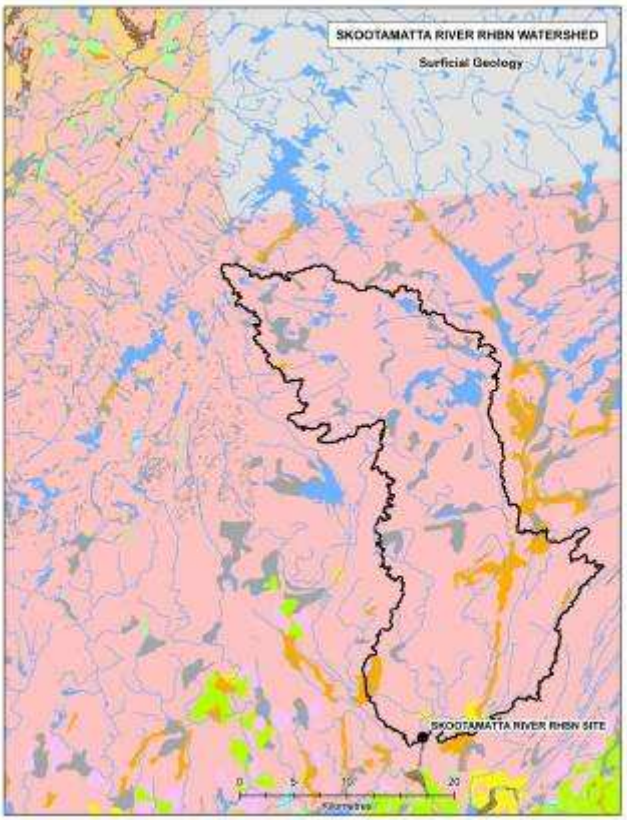
Proposed New Station Location:
Potential for new shallow well near RHBN station in high discharge area;

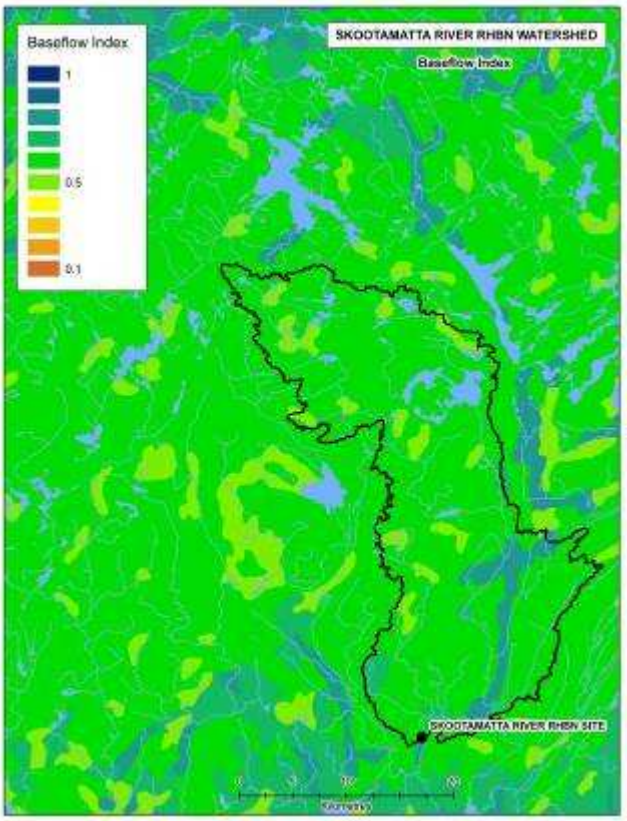
Rationale for CC:
- monitoring of GW / SW linkages in high discharge sand and gravel area along stream; potential long term impact of CC

C. Other Monitoring Networks:
- several MSC weather stations outside the watershed boundary; eg. one nr. the eastern boundary suitable for use in climate / hydrology models and CC monitoring


SKOOTAMATTA RIVER RHBN WATERSHED
Hydat Stations - active
Hydat Stations - inactive
Current MSC Weather Stations (> 30 years)
Current MSC Weather Stations (< 30 years)
Inactive MSC Weather Stations
Provincial (Stream) Water Quality Monitoring Network (PWQMN) - Active
PWQMN - Inactive
PWQMN - other / special study
Provincial Groundwater Monitoring Network
Skootamatta River RHBN Site
Kilometres


SKOOTAMATTA RIVER RHBN WATERSHED
Landcover
Landcover
Water
Wetland
Forest
Barren Land
Urban / Built up land
Range Land
Agriculture
Unclassified
SKOOTAMATTA RIVER RHBN SITE


SKOOTAMATTA RIVER RHBN WATERSHED
Surficial Geology
SKOOTAMATTA RIVER RHBN SITE
Kilometres


SKOOTAMATTA RIVER RHBN WATERSHED
Baseflow Index
Baseflow Index
1
0.5
0.1
SKOOTAMATTA RIVER RHBN SITE
Kilometres

COA Climate Change Monitoring Review Project
Reference Basin Hydrometric Network (RHBN) Watersheds
PWQMN and PGMN Assessment

STATION NAME: Blanche R. above Englehart **RHBN NO.: 02JC008 (1968-pres.)**

Upstream Watershed Characteristics:
- 1780 km2; 5% water, 1% wetland, 1% tundra, 89% forest, 1% barren, 2% range land, 1% urban
- Precambrian bedrock, pleistocene till, glaciofluvial ice contact deposits and outwash deposits, glaciolacustrine deposits (silt and clay) around stream area, recent fluvial and organic deposits;
- 80% low porosity, 2% mod., 18% high porosity.

Suitability of RHBN Watershed for CC Detection:
- large drainage area with major forest land cover on bedrock; stable land use suitable for CC detection to assess impact on surface water flow and water quality.

A. PWQMN ASSESSMENT:

Existing Station No.: no active stations; 5 inactive stations u/s in watershed

Rationale for use in CC:

Proposed New Station Location:
One station near existing RHBN station

Rationale for CC:
- Assess CC impact on stream water quality as dictated by streamflow and forest land cover
- long term trend monitoring ; integrated with flow

B. PGMN ASSESSMENT:

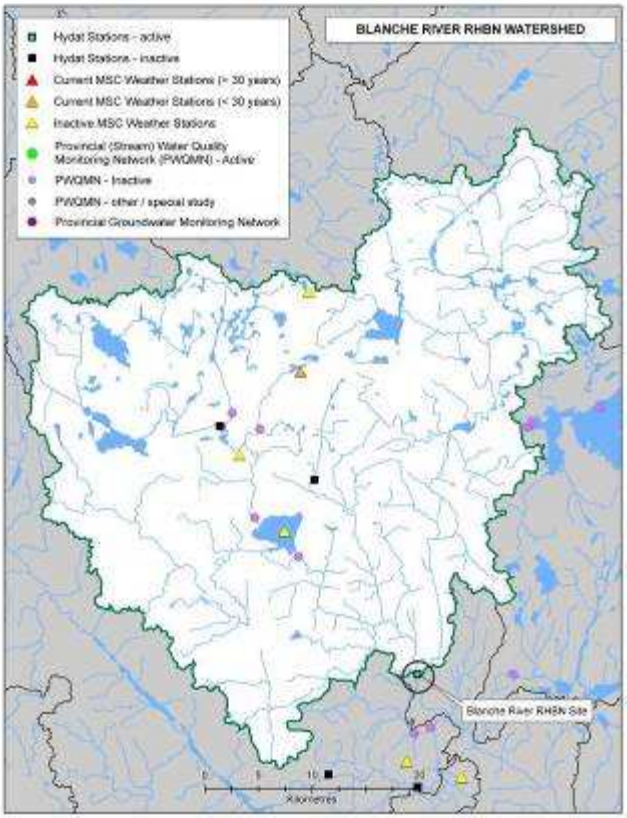
Existing Station: NA

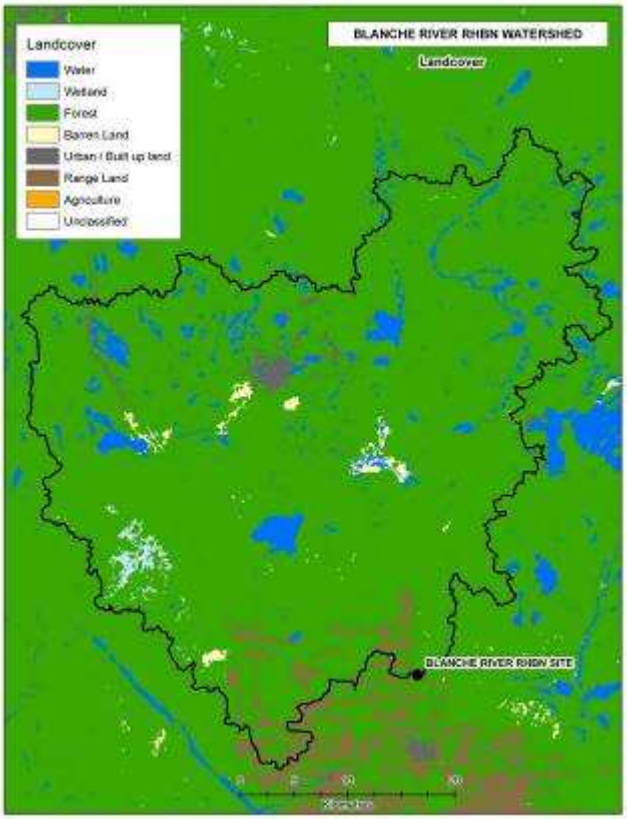
Rationale for use in CC:
NA

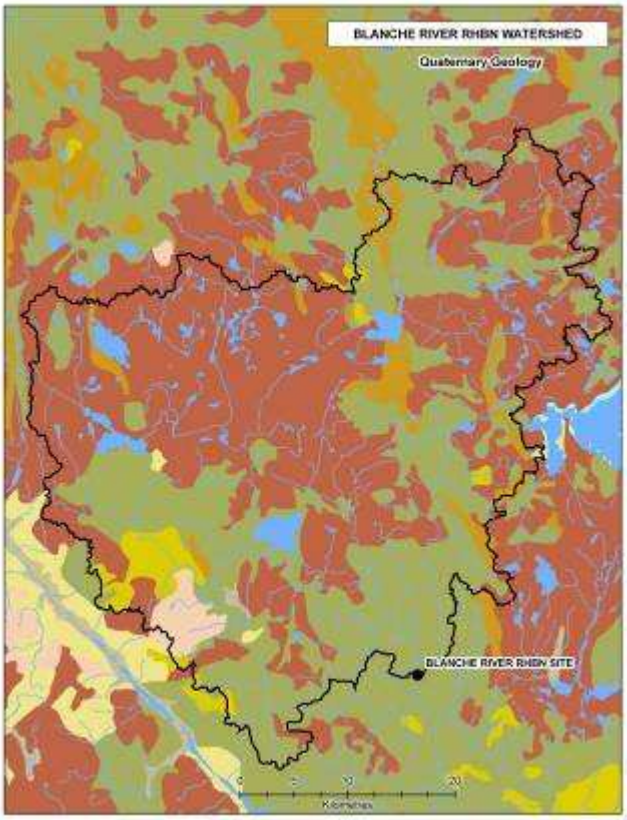
Proposed New Station Location:
NA

Rationale for CC:
- monitoring of SW / GW linkage not warranted due to primarily silt and clay deposits near streams; primarily a surface water systems with minimal groundwater discharge

C. Other Monitoring Networks:
- one MSC station operating; retain for CC monitoring and hydrology/ climate modeling of a primarily surface water system in a forest cover watershed on bedrock.
- 2 inactive HYDAT stations u/s for historic record supplement to RHBN station







Baseflow index not available for Blanche River RHBN Watershed

COA Climate Change Monitoring Review Project
Reference Basin Hydrometric Network (RHBN) Watersheds
PWQMN and PGMN Assessment

STATION NAME: Petawawa R. nr. Petawawa **RHBN NO.: 02KB001 (1905-pres.)**

Upstream Watershed Characteristics:
- 4120 km2; 10% water, 2% tundra, 88% forest, 1% barren, 2% range land, 1% urban
- Precambrian bedrock, pleistocene till, glaciofluvial ice contact deposits and outwash deposits along Ottawa R. valley, recent organic deposits;
- 49% low porosity, 21% mod., 30% high porosity.

Suitability of RHBN Watershed for CC Detection:
- large drainage area with majority in forest land cover and standing water; assumed stable land cover suitable for CC detection to assess impact on surface water flow and water quality on a watershed basis.

A. PWQMN ASSESSMENT:

Existing Station No.: 18493002002 (1968-2000); d/s (confirm) of RHBN station

Rationale for use in CC:

Proposed New Station Location:
Move station to RHBN station for data integration for flow / water quality

Rationale for CC:
- Assess CC impact on stream water quality as dictated by streamflow and forest land cover
- long term trend monitoring ; integrated with flow; consider 5 yr baseline study

B. PGMN ASSESSMENT:

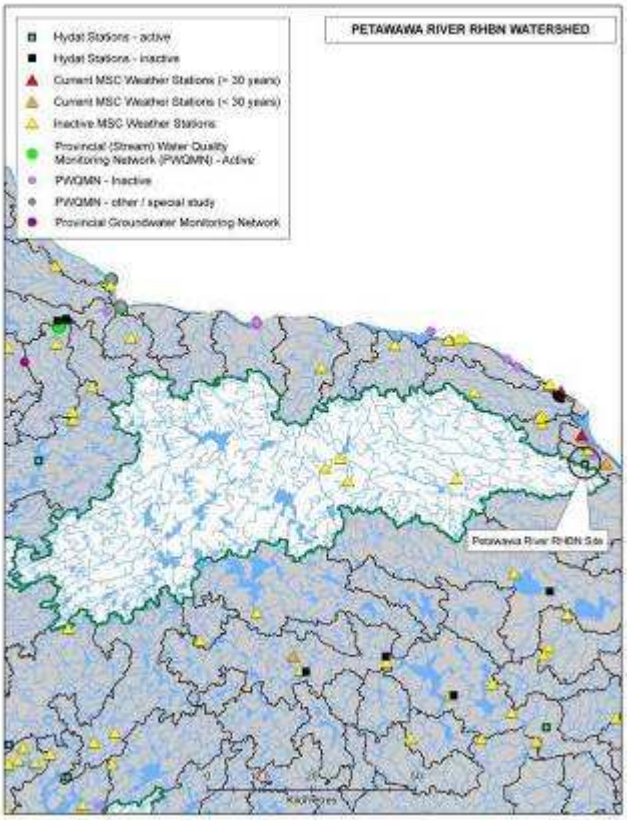
Existing Station: NA

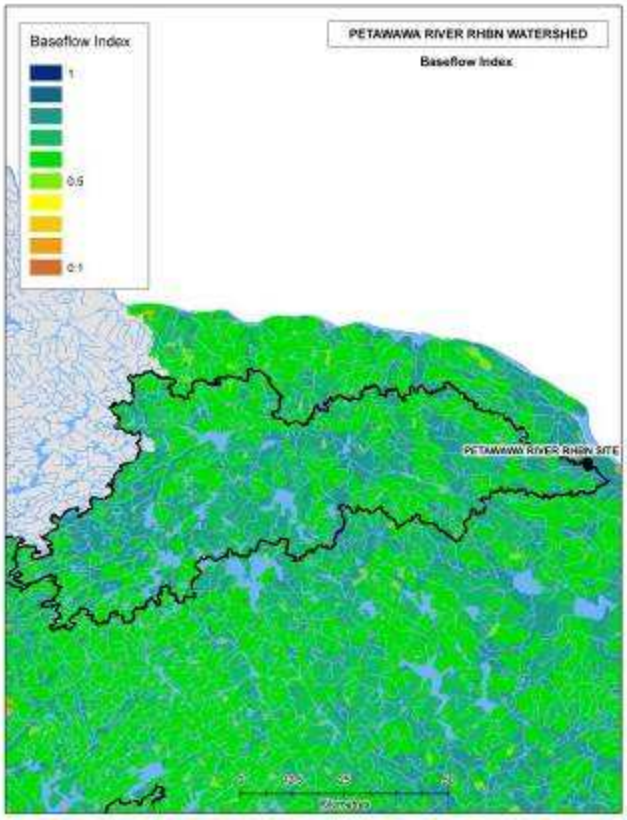
Rationale for use in CC:
NA

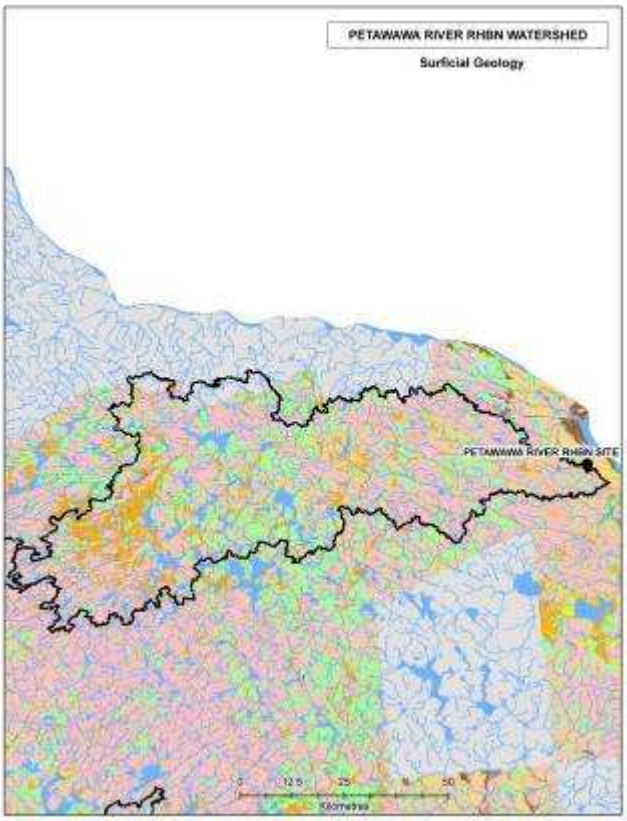
Proposed New Station Location:
NA

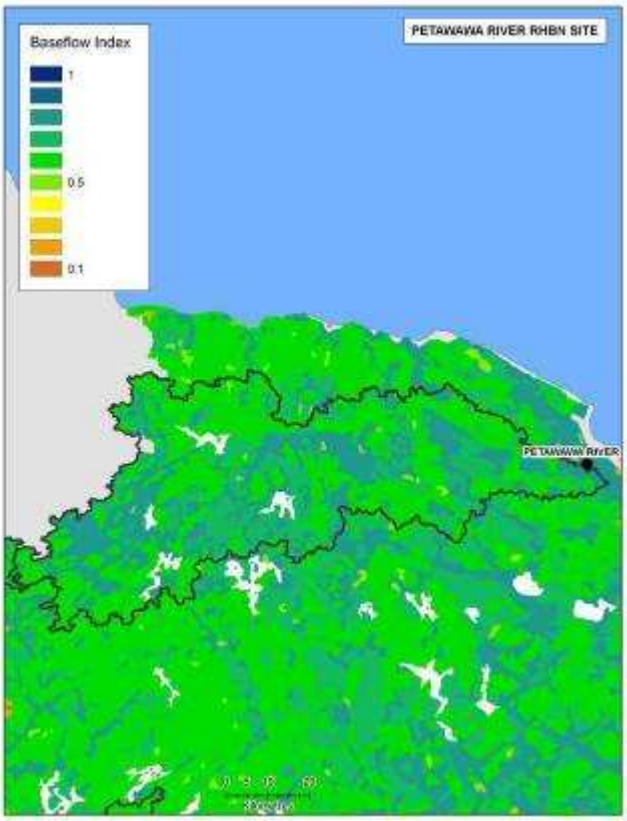
Rationale for CC:
- monitoring of GW levels for CC not suitable due to large watershed, predominantly bedrock, with mainly surface water drainage ie. no significant gw contribution to streamflow evident

C. Other Monitoring Networks:
- several climate stations in watershed, one active climate station d/s – retain
- one active MSC station with 40yrs of record at Can. Forces Base – retain
- 2 inactive HYDAT stations at Chalk R. / historic supplement to RHBN station
- Chalk R. AECL – 1960-pres.


PETAWAWA RIVER RHBN WATERSHED
Hydat Stations - active
Hydat Stations - inactive
Current MSC Weather Stations (> 30 years)
Current MSC Weather Stations (< 30 years)
Inactive MSC Weather Stations
Provincial (Stream) Water Quality Monitoring Network (PWQMN) - Active
PWQMN - Inactive
PWQMN - other / special study
Provincial Groundwater Monitoring Network
Petawawa River RHBN Site
Kilometres


Baseflow Index
1
0.5
0.1
PETAWAWA RIVER RHBN WATERSHED
Baseflow Index
PETAWAWA RIVER RHBN SITE
Kilometres


PETAWAWA RIVER RHBN WATERSHED
Surficial Geology
PETAWAWA RIVER RHBN SITE
Kilometres


Baseflow Index
1
0.5
0.1
PETAWAWA RIVER RHBN SITE
PETAWAWA RIVER
Kilometres

COA Climate Change Monitoring Review Project
Reference Basin Hydrometric Network (RHBN) Watersheds
PWQMN and PGMN Assessment

STATION NAME: S. Nation R. at Spencerville **RHBN NO.: 02LB007 (1946-pres.)**

Upstream Watershed Characteristics:
- 246 km2; 45% forest, 16% wetland, 21% range land, 17% agriculture
- Paleozoic bedrock, pleistocene till, glaciofluvial ice contact deposits, glaciomarine and marine deposits , recent organic deposits;
- 24% low porosity, 4% mod., 72% high porosity.

Suitability of RHBN Watershed for CC Detection:
- intermixed land use complicates climate change detection; potential use for CC adaptation monitoring / eg. impact of agr. land use on water quality.; High sensitivity rating

A. PWQMN ASSESSMENT:

Existing Station No.: 18207015002 u/s (1995-pres);

Rationale for use in CC:
Too far u/s for application

Proposed New Station Location:
Move station to RHBN station for data integration for flow / water quality monitoring; or establish new station; consult with Cons. Authority for feasibility

Rationale for CC:
- potential for streamflow / water quality monitoring in a mixed land use watershed with potential for adaptation

B. PGMN ASSESSMENT:

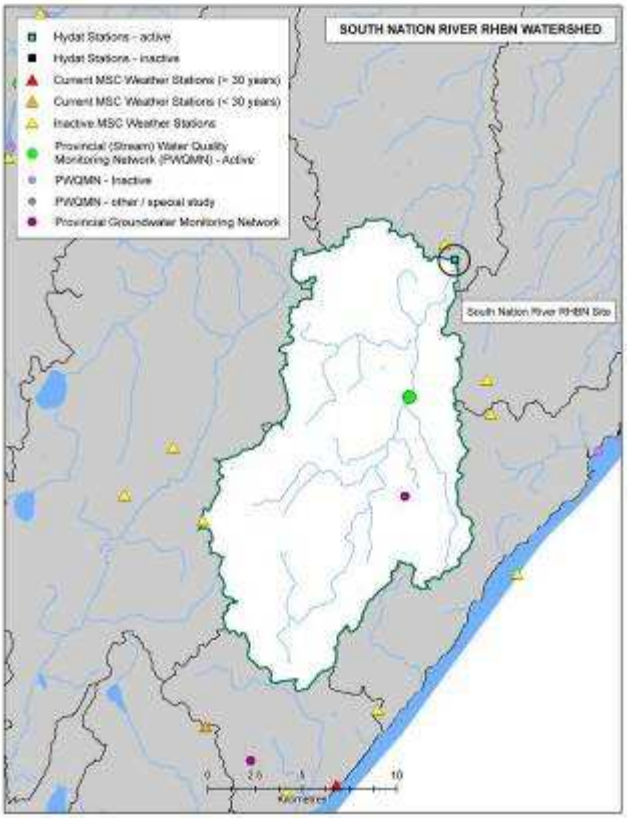
Existing Station: 96-1 u/s in watershed

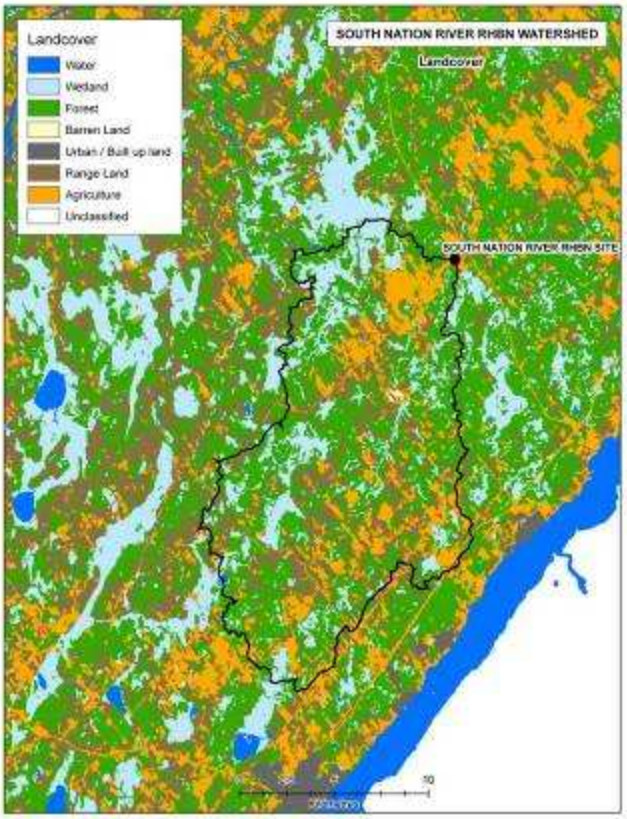
Rationale for use in CC:
tbd /

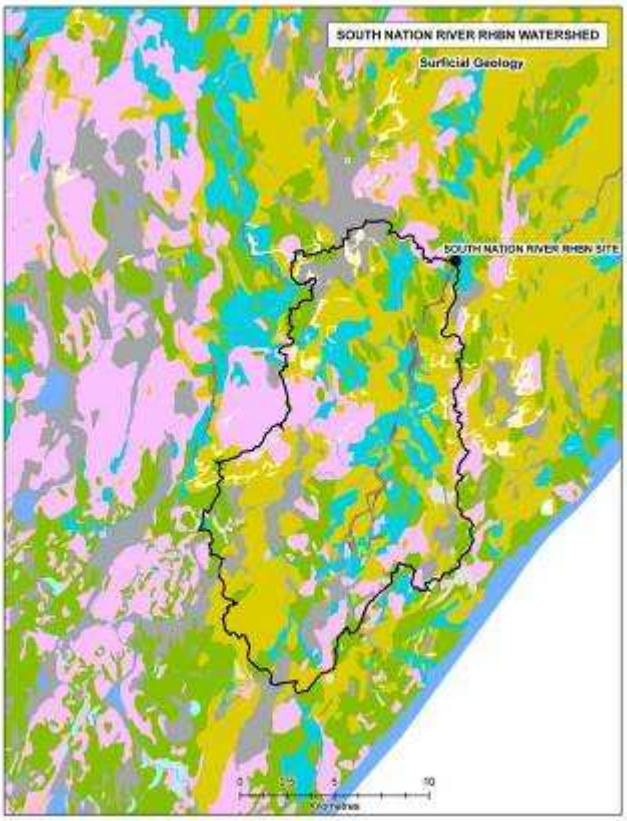
Proposed New Station Location:
Tbd /

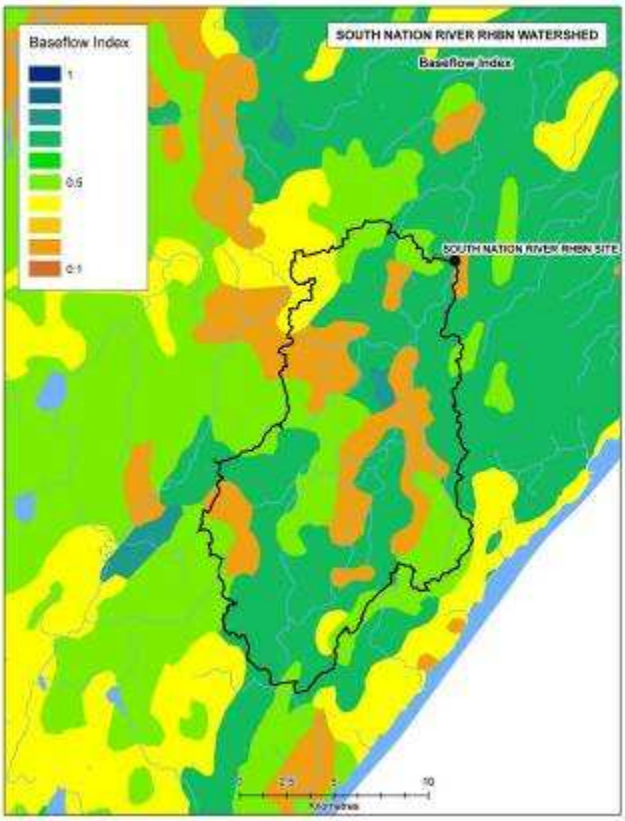
Rationale for CC:
Tbd /

C. Other Monitoring Networks:
- one active climate station u/s outside the watershed (Brockville) – retain
- one inactive climate station nr. RHBN (52-59) (Spencerville) – historic supplementary use
- consider periodic land use change monitoring (eg. remote sensing) to complement long term integrated surface water monitoring.


SOUTH NATION RIVER RHBN WATERSHED
Hydat Stations - active
Hydat Stations - inactive
Current MSC Weather Stations (> 30 years)
Current MSC Weather Stations (< 30 years)
Inactive MSC Weather Stations
Provincial (Stream) Water Quality Monitoring Network (PWQMN) - Active
PWQMN - Inactive
PWQMN - other / special study
Provincial Groundwater Monitoring Network
South Nation River RHBN Site
Kilometres


SOUTH NATION RIVER RHBN WATERSHED
Landcover
Water
Wetland
Forest
Barren Land
Urban / Built up land
Range Land
Agriculture
Unclassified
SOUTH NATION RIVER RHBN SITE


SOUTH NATION RIVER RHBN WATERSHED
Surficial Geology
SOUTH NATION RIVER RHBN SITE
Kilometres


SOUTH NATION RIVER RHBN WATERSHED
Baseflow Index
1
0.5
0.1
SOUTH NATION RIVER RHBN SITE
Kilometres


Surficial Geology
1: Precambrian bedrock
2: Precambrian bedrock-drift complex
2a: Mainly till veneer
2b: Mainly stratified veneer
3: Paleozoic bedrock
4: Paleozoic bedrock-drift complex
4a: Mainly till veneer
4b: Mainly stratified veneer
5: Undifferentiated till
5a: Shield-derived silty to sandy till
5b: Stone-poor, carbonate-derived silty to sandy till
5c: Stony, carbonate-derived silty to sandy till
5d: Glaciolacustrine-derived silty to clayey till
5e: Undifferentiated older till and stratified sediment
6: Ice-contact stratified deposits
6a: In moraines, kames, eskers and crevasse fills
6b: In subaquatic fans
7: Glaciofluvial deposits
7a: Sandy deposits
7b: Gravelly deposits
8: Fine-textured glaciolacustrine deposits
8a: Massive-well laminated
8b: Interbedded flow till, rainout deposits and silt and clay
9: Coarse-textured glaciolacustrine deposits
9a: Deltaic deposits
9b: Littoral-foreshore deposits
9c: Foreshore-basinal deposits
10: Fine-textured glaciomarine deposits
10a: Massive-well laminated
10b: Interbedded flow till, rainout deposits and silt and clay
11: Coarse-textured glaciomarine deposits
11a: Deltaic deposits
11b: Littoral-foreshore deposits
11c: Foreshore-basinal deposits
12: Older alluvial deposits
13: Fine-textured lacustrine deposits
14: Coarse-textured lacustrine deposits
14a: Deltaic deposits
14b: Littoral-foreshore deposits
14c: Foreshore-basinal deposits
15: Fine-textured marine deposits
16: Coarse-textured marine deposits
16a: Deltaic deposits
16b: Littoral-foreshore deposits


Quaternary Geology
Bedrock
Catfish Creek Till
Dunkeld Till
Elma Till
Fluvial deposits
Glaciofluvial ice-contact deposits
Glaciofluvial outwash deposits
Glaciolacustrine deposits
Glaciomarine and marine deposits
Halton Till
Kettleby Till
Lacustrine deposits
Lake
Maryhill Till
Mornington Till
Newmarket Till
Organic deposits
Port Stanley Till
Rannoch Till
St. Joseph Till
Stratford Till
Tavistock Till
Till
Wartburg Till
Wentworth Till

APPENDIX B-2

REFERENCE HYDROMETRIC BASIN NETWORK (RHBN) STATION AND WATERSHED ASSESSMENTS – FAR NORTH

COA Climate Change Monitoring Review Project
Reference Basin Hydrometric Network (RHBN) Watersheds outside the Great Lakes Basin / Far North
PWQMN and PGMN Assessment

STATION NAME:	Pipestone R. at Karl Lake	**RHBN NO.:** 04DA001 (1966-pres.)
	Cat R. below Wesleyan Lake	**RHBN No.:** 04GA002 (1970-pres.)
	Ogoki R. above Whiteclay Lake	**RHBN No.:** 04GB004 (1971-pres.)
	Nagagami R. at Hwy 11	**RHBN No.:** 04JC002 (1950-pres.)
	Kwataboahegan R. nr. mouth	**RHBN No.:** 04KA001 (1967-pres.)
	Missinaibi R. at Mattice	**RHBN No.:** 04LJ001 (1920-pres.)
	North French R. nr. mouth	**RHBN No.:** 04MF001 (1966-pres.)
	Turtle R. nr. Mine Centre	**RHBN No.:** 05BP014 (1914-pres.)
	Lake 239 Outlet nr. Kenora	**RHBN No.:** 05PD023 (1970-pres.)

Upstream Watershed Characteristics:
- mainly forest cover (>80%), 10-20% water, minor wetlands and tundra;
- interconnected lakes and wetlands; groundwater close to surface
- mainly Precambrian bedrock; Pleistocene till; glaciofluvial ice contact and outwash deposits, glaciolacustrine deposits, recent fluvial and organic deposits;
- 70-90% low porosity, 5% mod., 15-20% high porosity.

Suitability of RHBN Watershed for CC Detection:
- large drainage basins with predominant stable forest cover and interconnected lake systems
- no surficial geology and baseflow contribution maps available but largely influenced by surface drainage and runoff
- suitable for climate change detection monitoring on a long term basis, integrated monitoring with climate and stream water quality, groundwater monitoring where suitable.
- Set up integrated monitoring networks for climate/hydrology watershed model calibration and prediction of long term impact of climate change.
- need to recognize MNR planning phase for Far North (population 28,000) coordination with other agencies needed
- use remote sensing to monitor potential long term changes in land cover

A. PWQMN ASSESSMENT:
Existing Station No.: none active; some historic sampling conducted, eg. 1983
Rationale for use in CC:

Proposed New Station Location:

- stream water quality sampling recommended at existing RHBN stations to define baseline conditions (dictated by land cover and vegetation); eg. 5-6 samples for one year; go back 10 yrs later to detect changes; consider historic changes in long term flow regimes as guide ;
- locate stream water sampling stations at same location as RHBN station / data integration for flow / water quality monitoring;

Rationale for CC:
- potential for streamflow / water quality monitoring in several stable forest land use watersheds unimpacted by land use changes or water use / demands

B. PGMN ASSESSMENT:
Existing Station: none active
Rationale for use in CC:

Proposed New Station Location:

Rationale for CC:
- more detailed information on local groundwater conditions / geology necessary to define use of PGMN for CC detection or SW / GW linkages in the Far North watersheds

C. Other Monitoring Networks:
- further assessment to be conducted on existing climate stations in the watersheds
- recommend suitable climate monitoring stations to be continued / activated in conjunction with RHBN stations and future PWQMN/PGMN monitoring.
- recommend integrated monitoring stations for improved climate / hydrology modeling and prediction of climate change impacts

APPENDIX C: SENSITIVITY RATINGS FOR TERTIARY AND QUATERNARY WATERSHEDS IN ONTARIO

CONSERVATION AUTHORITY	QUATERNARY	TENTATIVE NAME	LOW WATER LEVEL	STREAM WATER QUALITY (N & P)	WATER USE	SHALLOW WELL VULN.	BASEFLOW	OVERALL SENSITIVTY VALUE
Ausable Bayfield	2FF-02	Jericho - Mud - Decker Creeks - Lower Ausable R.	3	2	1	1	3	10
	2FF-03	Upper Ausable R.	3	3	1	1	3	11
	2FF-04	Parkhill Cr.	3	3	1	2	3	12
	2FF-05	Little Ausable R.	3	2	1	1	3	10
	2FF-06	Zurich Beach	3	N/A	1	2	3	N/A
	2FF-07	Bayfield R.	3	3	1	2	3	12
	2FF-08	Bannockburn R.	3	N/A	1	2	3	N/A
Grand	2GA-01	Upper Grand R.	3	2	2	1	2	10
	2GA-02	Nith R.	3	2	2	1	2	10
	2GA-03	Galt Cr.	3	N/A	2	1	1	N/A
	2GA-04	Speed R.	3	2	2	1	1	9
	2GA-05	Eramosa R.	3	1	2	1	1	8
	2GA-06	Conestoga R.	3	2	2	1	3	11
	2GB-01	Lower Grand R.	3	3	3	1	3	13
	2GB-02	McKenzie Cr.	3	3	3	1	3	13
	2GB-03	Big Cr.	3	N/A	3	1	3	N/A
	2GB-04	Fairchild Cr.	3	3	3	1	2	12
	2GB-05	Horner Cr.	3	2	3	1	2	11
Kettle Creek	2GC-02	Kettle Cr.	3	3	3	2	3	14
Catfish Creek	2GC-03	Catfish Cr.	3	3	3	1	3	13
	2GC-04	Big Otter -Silver Creeks	3	3	3	1	2	12
Long Point	2GC-01		3	N/A	3	1	3	N/A
	2GC-05	Little Otter - Clear Creeks	3	N/A	3	1	1	N/A
	2GC-07	Dedrich -Young Creeks	3	N/A	3	1	1	N/A
	2GC-08	Big Cr.	3	2	3	1	1	10
	2GC-09	Lynn R.	3	2	3	1	2	11
	2GC-10	Wardell's Cr.	3	N/A	3	1	3	N/A
	2GC-11	Nanticoke Cr.	3	3	3	1	3	13
	2GC-12	Sandusk Cr.	3	N/A	3	1	3	N/A
Essex	2GH-01	Pike Cr.- St. Clair Beach	2	N/A	2	N/A	3	N/A
	2GH-02	Ruscon R.	2	3	2	1	3	11
	2GH-03	Belle R.	2	N/A	2	1	3	N/A
	2GH-04	Upper Detroit R.	2	3	2	2	3	12
	2GH-05	Canard Cr.	2	3	2	1	3	11
	2GH-06	Lower Detroit R. - Big Cr.	2	N/A	2	1	3	N/A

	2GH-07	Oxley - Seacliffe Beaches	2	3	2	1	3	11
	2GH-08	Point Pelee	2	3	2	1	2	10
	2GH-09	Hillman Cr. - Wheatley Beach	2	3	2	N/A	3	N/A
Niagara	2HA-01	Red Hill - Forty mile Creeks	2	N/A	3	1	3	N/A
	2HA-02	Twenty Mile Cr.	2	3	3	1	3	12
	2HA-03	Sixteen Mile - Fifteen Mile Creeks	2	N/A	3	2	3	N/A
	2HA-04	Twelve Mile Cr.	2	2	3	1	3	11
	2HA-05	Lower Welland Canal	2	1	3	1	3	10
	2HA-06	Lower Niagara R. - Four Mile - Six Mile Creeks	2	3	3	1	3	12
	2HA-07	Welland R.	2	3	3	1	3	12
	2HA-08	Upper Niagara R.	2	N/A	3	1	3	N/A
	2GC-13	Sandusk Cr.	3	N/A	3	1	3	N/A
Hamilton	2HB-06	Hamilton Harbour	3	3	2	1	3	12
	2HB-07	Spencer Cr	3	2	2	1	1	9
Quinte - Prince Edward Region	2HE-01	S. Quinte Shore	3	N/A	2	1	2	N/A
	2HE-02		3	3	2	1	3	12
	2HE-03	Demorestville Cr.	3	2	2	1	2	10
	2HE-04		3	2	2	1	2	10
	2HE-05	Yeo Cr.	3	2	2	1	2	10
	2HE-06	Picton Bay	3	2	2	1	2	10
	2HE-07	Black R.	3	1	2	1	2	9
	2HE-08	S. Shore Adolphus Reach - Cressy Pt.	3	3	2	1	3	12
	2HE-09	Hubbs - Pleasant Bay Creeks	3	2	2	1	2	10
	2HE-10		3	N/A	2	1	2	N/A
	2HE-11	Point Petre - South Bay Shore	3	N/A	2	1	2	N/A
Quinte - Moira	2HL-02	Lower Moira R.	3	1	1	1	1	7
	2HL-03	Parks Cr.	3	N/A	1	1	1	N/A
	2HL-04	Claire R.	3	1	1	1	1	7
	2HL-05	Skootamatta R.	3	1	1	2	1	8
	2HL-06	Black R.	3	1	1	2	2	9
	2HL-07	Upper Moira R.	3	1	1	1	1	7
	2HM-01	Blessington Cr.	3	N/A	2	1	3	N/A
Quinte - Napanee	2HM-02	Salmon R.	3	1	2	1	1	8
	2HM-03	Napanee R.	3	1	2	1	2	9
	2HM-10	Marysville - Sucker C	3	N/A	2	1	3	N/A
Cataraqui	2HM-04	Little - Big Creeks	3	1	2	1	3	10
	2HM-05	Loyst Cr.	3	N/A	2	1	3	N/A
	2HM-06	Milihaven Cr.	3	2	2	1	2	10
	2HM-07	Collin's Cr.	3	3	2	1	3	12
	2HM-08	Cataraqui Cr.	3	2	2	1	3	11
	2MA-05	Upper St. Lawrence Shore	3	N/A	3	1	3	N/A

	2MA-06	Rideau Canal - Cataraqui R.	3	2	3	1	2	11
	2MA-07	Milburn Cr.	3	N/A	3	1	2	N/A
	2MA-08	Gananoque R.	3	2	3	1	2	11
	2MA-09	Wiltse Cr	3	N/A	3	1	3	N/A
	2MB-01	St Lawrence R.	3	N/A	2	1	3	N/A
	2MB-02	La Rue Cr.	3	N/A	2	2	3	N/A
	2MB-03	Vones Cr. - St. Lawrence N. Shore	3	3	2	1	2	11
	2MB-04	Butlers Cr. - St. Lawrence N. Shore	3	2	2	1	2	10
South Nation	2LB-04	South Nation R.	3	3	2	1	3	12
	2LB-05	Scotch R.	3	3	2	1	3	12
	2LB-06	Bear Br.	3	N/A	2	1	2	N/A
	2LB-07	Castor R.	3	2	2	1	3	11
	2LB-08	Payne R.	3	N/A	2	1	3	N/A
	2LB-09	Black Cr.	3	N/A	2	1	1	N/A
	2MB-05	Lemmons - Smades - Bradleys Creeks	3	N/A	2	1	1	N/A
	2MB-06	Hilliards - Flanq Creeks	3	N/A	2	1	3	N/A
Central Lake Ontario	2HC-11	Lynde - Pringle Creeks	2	1	1	1	3	8
	2HD-04	Tooley -Bowmanville Soper Creeks	3	1	1	1	2	8
	2HD-03	Oshawa -Harmony Creeks	3	2	1	1	3	10
Credit	2HB-02	Credit R. - Cooksville Cr.	1	2	2	1	1	7
Crowe	2HK-11	Deer R.	3	N/A	1	2	1	N/A
	2HK-10	Dickey Cr.	3	N/A	1	2	2	N/A
	2HK-09	Beaver Cr.	3	N/A	1	1	2	N/A
	2HK-07	Crowe R.	3	N/A	1	1	1	N/A
	2HK-08	North R.	3	N/A	1	2	2	N/A
Ganaraska	2HD-01	Gage Cr.	2	1	1	1	3	8
	2HD-07	Cobourq Br.	2	1	1	1	2	7
	2HD-06	Ganaraska R.	2	1	1	1	1	6
	2HD-05	Britain Creeks	2	1	1	1	2	7
GreySauble	2FB-08	Indian Br.	3	N/A	1	1	2	N/A
	2FB-02	Pottawatomi R.	3	1	1	1	2	8
	2FB-07	Beaver R.	3	1	1	1	2	8
	2FB-05	Waterton - Johnston Creeks	3	N/A	1	1	3	N/A
	2FB-06	Bighead R.	3	1	1	1	3	9
	2FB-03	Sydenham R.	3	1	1	1	3	9
	2FA-01	Colpoys Cr. - Gleason Br.	3	N/A	1	2	2	N/A
	2FB-01	Indian Cr.	3	N/A	1	1	2	N/A

	2FA-12	Sucker Cr.	3	N/A	1	2	2	N/A
	2FA-11	Rankin R.	3	N/A	1	1	2	N/A
	2FA-10	Sauble R.	3	1	1	1	2	8
	2FA-09		3	N/A	1	N/A	1	N/A
	2FA-02	Melville Sound Shore	3	N/A	1	2	2	N/A
	2FB-04	Telfer - Keefer Creeks	3	1	1	1	3	9
Halton	2HB-01	Burlington Creeks	3	N/A	2	2	3	N/A
	2HB-03	Oakville - Morrison - Joshua Creeks.	3	1	2	1	3	10
	2HB-04	Bronte - McCraney Creeks	3	2	2	1	2	10
	2HB-05	Grindstone Cr.	3	3	2	1	2	11
Kawartha	2HF-01	Fenelon R.	3	1	1	1	2	8
	2HG-06	East Cross Cr.	3	N/A	1	1	2	N/A
	2HG-05	Mariposa Br.	3	1	1	1	3	9
	2HG-03	Nonquan R.	3	2	1	1	1	8
	2HG-02	Lake Scugog	3	2	1	1	2	9
	2HH-10	Nogies Cr.	3	N/A	1	1	1	N/A
	2HG-01		3	N/A	1	1	3	N/A
	2HF-03	Corbeau Cr.	3	N/A	1	1	1	N/A
	2HH-03	Sturgeon L.	3	1	1	1	2	8
	2HF-02	Rosedale R.	3	1	1	1	2	8
	2HH-05	Emily Cr.	3	N/A	1	1	2	N/A
	2HH-01	Pigeon R.	3	N/A	1	1	2	N/A
Lake Simcoe	2EC-10	Thorah Cr.	3	N/A	1	1	1	N/A
	2EC-08	Kempenfelt Bay	3	1	1	1	1	7
	2EC-07	Alcona Beach	3	N/A	1	1	1	N/A
	2EC-06	Maskinonge R.	3	3	1	1	1	9
	2EC-05	Beaverton R.	3	1	1	1	2	8
	2EC-04	Pefferlaw Br.	3	2	1	1	1	8
	2EC-03	Black R.	3	2	1	1	1	8
	2EC-02	Holland R.	3	3	1	1	1	9
	2EC-01	Schomberg R.	3	3	1	1	2	10
Lower Thames	2GE-02	Big Cr.	2	3	1		3	N/A
	2GE-03	Jeanette Cr.	2	N/A	1		3	N/A
	2GE-04	McGregor Cr.	2	3	1	1	3	10
	2GE-01	Lower Thames - Tremblay Cr - St. Clair Beach	2	3	1	1	2	9
	2GF-01	Renwick - Erie Beach	2	N/A	1	2	2	N/A
	2GF-02	Flat Cr. - Rondeau	2	N/A	1	1	3	N/A
	2GF-03	Morpeth - Palmyra Beach	2	N/A	1	1	3	N/A

	2GF-04	Brock's Cr. - Clearville - Dutton Beach	2	3	1	1	3	10
	2GF-05	Tyrconnel Beach	2	3	1	2	3	11
	2GF-06	Talbot Cr	2	N/A	1	2	3	N/A
Lower Trent	2HK-03	Salt Cr.	2	N/A	1	1	1	N/A
	2HK-04	Percy Cr.	2	1	1	1	1	6
	2HD-02	Popham Bay	2	N/A	1	1	1	N/A
	2HK-02	Cold Cr.	2	1	1	1	1	6
	2HJ-02	Rice L.	3	1	1	1	2	8
	2HK-06	Squire C r.	2	N/A	1	1	2	N/A
	2HK-01	Trent R.	2	1	1	1	2	7
	2HK-05	Rawdon C r.	2	N/A	1	1	1	N/A
Maitland	2FE-02	Maitland R.	2	2	1	1	2	8
	2FD-06	Lucknow R.	2	1	1	1	2	7
	2FE-04	Middle Maitland R.	2	2	1	2	3	10
	2FD-05	Kerrys - Griffins Creeks	2	N/A	1		3	N/A
	2FD-07	Boundary - Allans Creeks	2	N/A	1		3	N/A
	2FE-01	Gully Cr.	2	N/A	1	2	3	N/A
	2FE-03	Maitland R.	2	2	1	1	2	8
	2FD-04	Eighteen Mile R.	2	N/A	1		3	N/A
	2FE-05		2	2	1	1	2	8
Mississippi	2KF-03	Carp R.	3	2	1	1	3	10
	2KF-01	Lac Deschenes	3	1	1	1	3	9
	2KF-05	Indian R.	3	N/A	1	1	2	N/A
	2KF-02	Constance Cr.	3	N/A	1	1	3	N/A
	2KF-06	Clyde R.	3	1	1	1	1	7
	2KF-07	Fall R.	3	1	1	1	2	8
	2KF-08	Gull Cr.	3	N/A	1	2	2	N/A
	2KF-09	Buckshot Cr.	3	N/A	1	1	2	N/A
	2KF-04	Lower Mississippi R.	3	1	1	1	2	8
Nottawasaga	2ED-10	Pretty R.	3	1	1	1	1	7
	2ED-15	Innisfil Cr.	3	2	1	2	1	9
	2ED-14	Willow Cr.	3	2	1	1	1	8
	2ED-13	Boyne R.	3	2	1	1	1	8
	2ED-12	Pine R.	3	1	1	1	1	7
	2ED-11	Mad R.	3	2	1	1	1	8
	2ED-09	Nottawasaga R.	3	2	1	1	1	8
Otonabee	2HJ-03	Indian R.	3	1	1	1	2	8
	2HJ-01	Otonabee R.	3	1	1	1	2	8
	2HJ-04	Ouse R.	3	1	1	1	1	7
Raisin	2MC-10	Lake St. Francis	1	N/A	2	1	3	N/A

	2MC-12	Lake St. Lawrence	1	N/A	2	1	3	N/A
	2MC-04	Riviere Delisle	1	2	2	2	3	10
	2MC-06	Riviere Au Baudet	1	2	2	1	3	9
	2MC-07	Wood - Gunn -Sutherland - Wesley -Finney Creeks	1	N/A	2	1	1	N/A
	2MC-09	Raisin R.	1	2	2	1	3	9
	2LA-08	Lower Tay R. - Tay Canal	2	1	2	1	2	8
	2LA-06	Irish - Otter Creeks	2	N/A	2	1	2	N/A
	2LA-01	Ottawa R.	2	N/A	2		3	N/A
	2LA-09	Grant Cr.	2	N/A	2	2	2	N/A
Rideau	2LA-07	Upper Rideau R.	2	N/A	2	1	2	N/A
	2LA-05	Kemptville Cr.	2	1	2	1	2	8
	2LA-04	Steven Cr.	2	N/A	2	1	3	N/A
	2LA-03	Jock R.	2	2	2	1	3	10
	2LA-02		2	2	2	1	3	10
	2LA-10	Upper Tay R.	2	1	2	1	2	8
	2FC-01	Saugeen R.	2	1	1	1	2	7
	2FD-02	Penetangore R.	2	1	1	1	3	8
	2FC-07	Snake Cr.	2	N/A	1	1	3	N/A
	2FC-03	S. Saugeen R.	2	1	1	1	2	7
	2FC-04	Mill Cr.	2	1	1	1	3	8
	2FC-05	Willow Cr.	2	N/A	1		3	N/A
	2FC-06	Teeswater R.	2	1	1	1	2	7
Saugeen	2FC-08	Deer Cr.	2	N/A	1	1	3	N/A
	2FC-09	Styx R.	2	N/A	1	1	1	N/A
	2FC-10	Rocky Saugeen R.	2	1	1	1	1	6
	2FC-11	Beatty Saugeen R.	2	1	1	2	1	7
	2FD-01	Li ttle Sauble R. - Underwood - Tiverton - Andrew Creeks	2	N/A	1	1	3	N/A
	2FD-03	Pine R. - Clark Cr.	2	1	1	1	3	8
	2FC-12	Meux R.	2	N/A	1	1	2	N/A
	2GG-02	Lower St. Clair - LowerSydenham Rivers	2	2	1	2	2	9
	2GG-03	Boyle Drain	2	N/A	1	1	2	N/A
St Clair	2FF-01	Waddel l - Perch - Errol - Aberarder - Highland - Hickory - Shashawandah Cr	2	N/A	1	1	3	N/A
	2GG-04	Little Bear Cr.	2	N/A	1		2	N/A
	2GG-01	Upper St. Clair R.	2	N/A	1	1	3	N/A
	2GG-05	E. Sydenham R.	2	3	1	1	3	10

	2GG-06	N. Sydenham R.	2	3	1	2	3	11
	2GG-07	Bear Cr.	2	3	1	1	3	10
Toronto	2HC-12	Pickering Cr	2	N/A	1	1	3	N/A
	2HC-10	Duffins Cr.	2	1	1	1	3	8
	2HC-04	Humber R.	2	2	1	2	2	9
	HC-08	Highland Cr. - Scarboro Shore	2	N/A	1	1	3	N/A
	2HC-07	Don R. - East Toronto Beach	2	3	1	1	3	10
	2HC-06	Garrison - Taddle Creeks	2	N/A	1		1	N/A
	2HC-05	East Humber R.	2	N/A	1	1	3	N/A
	2HC-01	Etobicoke Cr.	2	2	1	2	3	10
	2HC-02	Mimico Cr.	2	2	1	2	3	10
	2HC-03	W. Humber R.	2	3	1	2	3	11
	2HC-09	Rouge R. - Petticoat Cr.	2	2	1	1	3	9
Upper Thames	2GE-05		3	2	1	1	3	10
	2GD-05	N. Thames Cr.	3	2	1	1	3	10
	2FF-05	Little Ausable R.	3	2	1	1	3	10
	2GD-01	Upper Thames R.	3	3	1	1	2	10
	2GD-04	Reynolds Cr.	3	3	1	1	2	10
	2GD-06	Medway R.	3	N/A	1	1	3	N/A
	2GD-07	Fish Cr.	3	2	1	2	3	11
	2GD-08	Trout Cr.	3	3	1	1	3	11
	2GD-09		3	3	1	1	3	11
	2GE-06	Dingman Cr.	3	3	1	2	2	11
	2GD-11		3	N/A	1	1	3	N/A
	2GD-10		3	2	1	1	3	10

N/A – insufficient data

Sensitivity Ratings:

H: 12-14

M: 9-11

L: 6-8

Notes: Quaternary Watersheds were manually assigned to Conservation Authorities using GIS. Quaternary wateshed boundaries did not always fall entirely within a CA boundary. This table may contain errors and/or omissions

APPENDIX D: GUIDE FOR ASSESSMENT OF PGMN AND PWQMN STATIONS ON A WATERSHED SCALE

COA Phase II - Guide for Assessment of PGMN and PWQMN in High Priority Watersheds

The following is an outline of the general process to be followed in the assessment of the PGMN and PWQMN in High Priority Watersheds (previously selected on the basis of the integrated sensitivity rating and climate vulnerability:

For each quaternary watershed:

1. Compile map overlays (preferably GIS, provincial or watershed scale as available) for the following watershed characteristics (*note these may be available from MOE, MNR or the local SPP Committee Watershed Characterization project):*
   - land use (natural areas incl. wetlands, forest areas; sensitive and protected areas; urban, agricultural)
   - surface geology
   - physiography
   - shallow wells
   - sensitive, protected areas, eg. wetlands
   - areas of groundwater discharge or baseflow contribution
   - surface water quality (N,P)
   - PGMN, PWQMN station locations and period of record
   - RHBN, Climate Ref. stations and periods of record

2. Using the Provincial GIS layers for CC sensitivity factors recently prepared (COA project 2009) or other recent watershed mapping prepared by Source Protection Planning Committees, identify the factors most sensitive in the respective watershed; for use as guidance in assessing intensity for groundwater and surface water monitoring network stations. The potential sensitivity factors are:
   - water use / water demand
   - potential low water (drought) condition
   - groundwater discharge / baseflow
   - water quality
   - shallow groundwater supplies

3. Use the documentation previously prepared to show the potential impact of CC on the surface water and groundwater resources in Ontario (see tables 3, 4, 5 below). This information provides the guidance for assessing the suitability / adequacy of the PGMN and PWQMN for use in detection or adaptation.

4. Use the guidelines prepared for the spatial and temporal monitoring needs for the three levels of Sensitivity Ratings (HML) assigned for each quaternary watershed in the province. Use the guidelines to assess the PGMN and the PWQMN monitoring networks in the high priority watersheds selected. (*see Table 1).*

5. Fill in the Assessment Table (Table 2) for documentation of the assessment of the individual PGMN and PWQMN stations in the H priority watersheds; examining their suitability for:
   - monitoring the ecosystem function related to effects of climate change
   - use in the development and calibration of climate / hydrology models
   - potential use in an integrated monitoring system

6. Consider recommendations for modification of the existing networks or additional priority PGMN and PWQMN stations where needed, for use in Climate Change Detection and Adaptation monitoring

7. Consider additional recommendations for modification or new monitoring stations for streamflow, climate stations, etc., complementary or integrated with the PGMN or PWQMN.

Table 1. Guidelines for PGMN and PWQMN Climate Change Adaptation and Detection Monitoring in H M L Priority Watersheds

Mon. Network	**HIGH Sensitivity Monitoring Need**	**MED. Sensitivity Monitoring Need**	**LOW Sensitivity Monitoring Need**
PGMN - shallow wells for water supply (water table conditions) // *CC Adaptation*	Daily water levels /real time; select representative wells for long term monitoring	Weekly water levels in representative areas; increase frequency with drought conditions	Seasonal water levels in representative areas
PGMN – shallow wells in areas connected to surface water discharge // *CC Adaptation*	Daily water levels /real time; hourly during severe events eg. drought; integrate with streamflow and climate monitoring (for ecosystem linkage and modeling)	Daily water levels at representative stations for long term trend monitoring related to streamflow	NA
PGMN – shallow wells in natural areas connected to surface water // *CC Detection*	Weekly water levels at select natural areas that can be linked to RHBN stations with climate monitoring; long term monitoring	NA	NA
PGMN – confined shallow aquifer in natural areas // *CC Detection*	Monthly water levels at select natural areas in RHBN watersheds with climate monitoring; long term monitoring	NA	NA
PWQMN – *CC Adaptation*	Monthly sampling at each major land use region and sensitive area; daily sampling during severe events; hourly where needed for ecosystem function modeling; incl. temp., DO, N, P;	Monitor each major land use region; weekly sampling; detect seasonal changes; incl. temp.,DO, N, P.	Monitor at the outlet of each tertiary watershed for long term monitoring; monthly sampling incl. temp., DO, N, P.
PWQMN – *CC Detection*	Weekly sampling at select natural areas that can be linked to RHBN stations; incl. temp., DO, N, P.; monthly sampling in Northern Ontario RHBN watersheds	NA	NA

Table 2. COA CC Monitoring Network Assessment Table

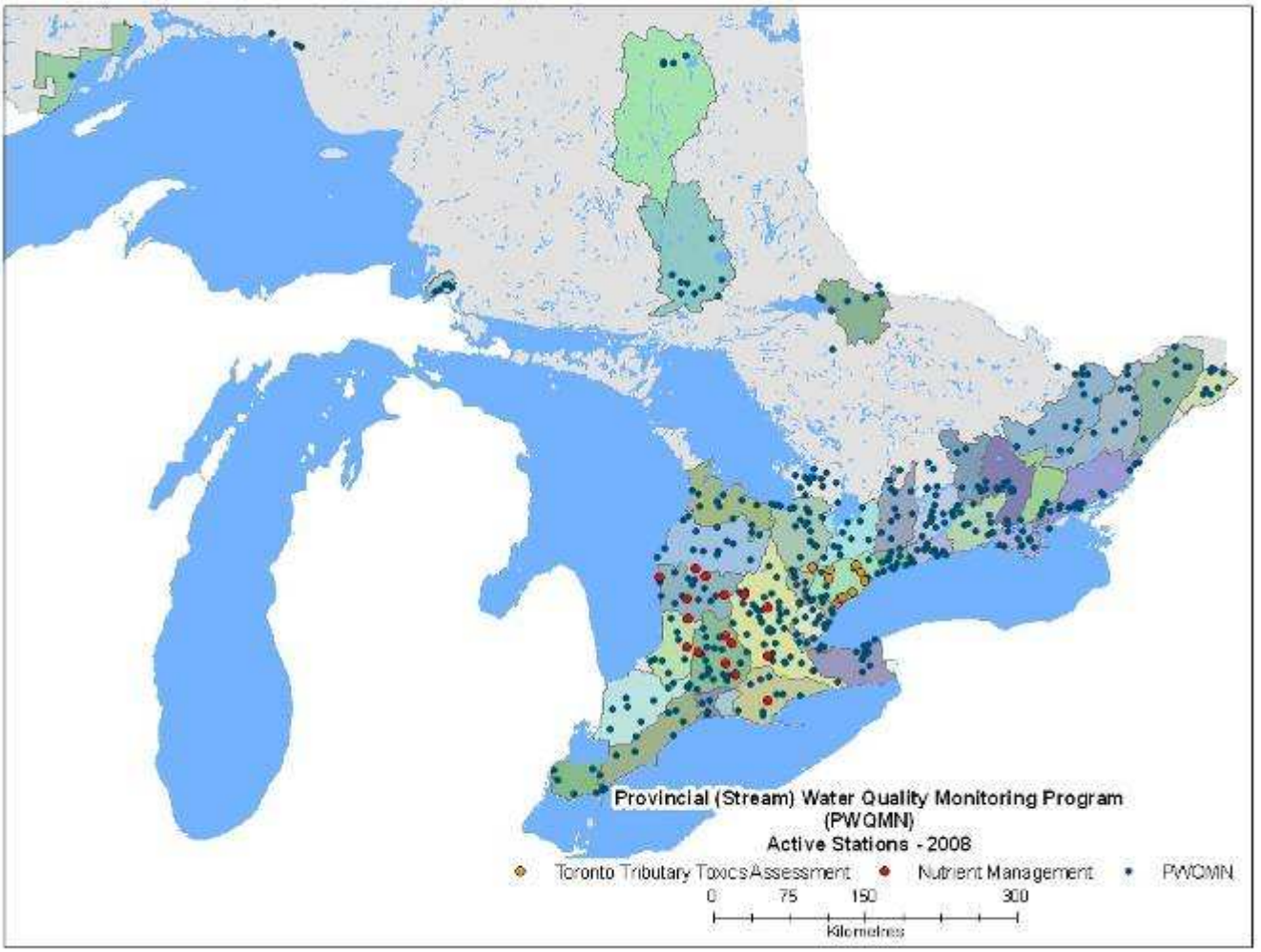
Quaternary Watershed:
Sensitivity Level (HML):

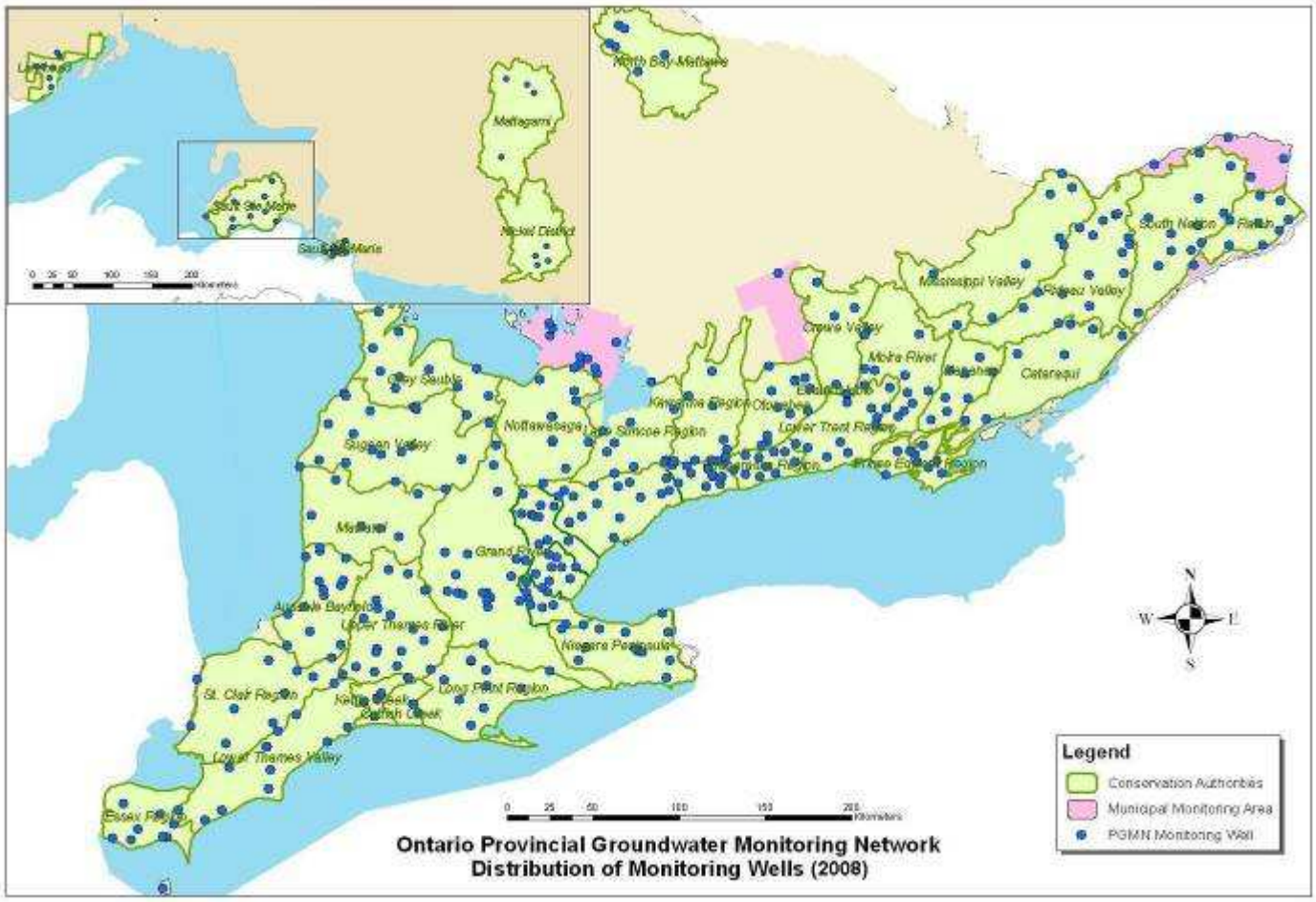
Tertiary Watershed:
Climate Vulnerability Level (HML):
Prepared by:
Conservation Authority:

Network and Station No., Location	**Current Monitoring Strategy:** ***(frequency, parameters)***	**Climate Change Application:** ***Detection, Adaptation; Ecosystem Monitoring (specify); Modelling***	**Recommendation:** ***(modification, deletion, addition***)

APPENDIX E

MAPS OF STATIONS FOR THE PROVINCIAL STREAM WATER QUALITY MONITORING NETWORK (PWQMN) AND THE PROVINCIAL GROUNDWATER MONITORING NETWORK (PGMN)




Ontario Provincial Groundwater Monitoring Network
Distribution of Monitoring Wells (2008)
Legend
Conservation Authorities
Municipal Monitoring Area
PGMN Monitoring Well
N
W
E
S
Mattagami
Mississippi Valley
Ottawa Valley
Moira River
Cataraqui
Nottawasaga
Lake Simcoe Region
Saugeen Valley
Maitland
Grand River
Lower Thames River
Niagara Peninsula
St. Clair Region
Long Point Region
Lower Thames Valley
Essex Region
0 25 50 100 150 200 Kilometers