Valued Component – Water Quantity (Final DRAFT)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to water quantity in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

× What are the baseline conditions with respect to water quantity?

~ In the Northwest Territories, baseline water quantity conditions depend mainly on physiographic characteristics of the region but are also influenced by latitude. There are three main physiographic regions and two large lakes, Great Bear Lake and Great Slave Lake, in the Northwest Territories. This results in a complex hydrologic picture.

Northern Cordillera. High-energy alpine streams characterize this region. Lakes and wetlands are not common in the cordillera region. Spring freshet, during the snowmelt period, generally results in peak stream flows. However, summer rainstorm events can also produce peak flows, especially if the storms trigger a rapid melt of late lying snow packs. Steep basin slopes and the lack of lake or wetland storage results in a rapid streamflow recession following the spring freshet or summer rainstorms. Low flows occur in late winter. In smaller and more northerly basins, winter low flows can drop to zero. The difference between summer high flows and winter low flows can be several orders of magnitude.

Interior Plains. Numerous lakes and wetland areas characterize this region. Lakes and wetlands provide a significant water storage component, which affects the streamflow regime. During the spring freshet period, the total winter precipitation (snow storage) is released in a few weeks, making the spring floods the most significant hydrological event. Summer rainfall events are attenuated by lake and wetland storage, although hydrographs vary considerably depending on the size, shape and drainage patterns of the basin. Streamflows recede throughout winter, but a baseflow is generally maintained by the lake and groundwater storage. The lowest streamflows occur just prior to spring break-up.

KEY MONITORING INDICATORS

Water Levels ***Ice Phenology***
Stream Flows

Precambrian Shield. This region is characterized by numerous small and large lakes, which are often connected by short turbulent streams. Spring freshet is the most significant hydrological event, but peak flows are generally moderated by storage in the many small to large lakes found in most basins. Runoff from summer rainfall events is also attenuated by lake storage. Lake storage tends to maintain baseflow over winter. Low flows occur just prior to spring breakup.

Great Bear and Great Slave Lakes have an enormous capacity to attenuate the flow variability of their tributaries, which results in relatively stable outflows throughout the year.

~ A network of 87 hydrometric stations currently monitors water levels and streamflows in the Northwest Territories. Of these stations, 16 are operated seasonally. A total of 20

stations are operated to provide a flow forecast on the Mackenzie River. There are historic data for another 50 sites from stations that were closed between 1991 and 2000. Baseline water quantity conditions can be expressed graphically and with descriptive statistics. For example, the mean annual discharge of the Mackenzie River into the Arctic Ocean is approximately 9100 m^3/s. Flood frequency analysis can be done for sites with long term records, i.e. greater than 30 years, to provide estimates of flood return periods.

× What are the trends observed in the hydrological regime in the NWT?

~ Water levels and streamflows are continually changing in response to hydro-climatic inputs and outputs (precipitation-evaporation, inflows-outflows, groundwater discharge-recharge). There is a large natural variability between inter-annual and inter-seasonal flows.

~ The timing and magnitude of streamflow peaks on the Slave River have been significantly altered by the Bennett Dam on the Peace River in northeastern British Columbia. During the initial filling of the Williston Reservoir from 1968 to 1971, there was a decrease in Great Slave Lake water levels and a corresponding decrease in the flow of the Mackenzie River. Current operations of the Bennett Dam have an effect that, although small, can be identified on the Mackenzie River and in the Mackenzie and Slave Delta channels.

~ Some trends have been identified in the hydrological regime of rivers in the Northwest Territories, including some cyclic trends between 1965 and 1998 in mean and maximum flows (Spence, 2002), linear trends over shorter time frames (Whitfield and Cannon, 2000), increasing winter flows and earlier spring freshets in the Liard basin (Burn, 2004). There are also the changes in the Slave River flow regime due to the operation of the Bennett Dam.

× Can the natural variability be determined?

~ Natural variability in water levels and stream flows are recorded at the existing water monitoring network stations. Long-term data, of 30 years or more, are required for statistical analysis of natural variability. Only a limited number of monitoring stations in the NWT have long-term records.

× Are there changes in the timing of freeze-up and break-up and can these be good indicators of climate change?

~ Changes in the timing of freeze-up and break-up (ice phenology) are not readily available in a single database. However, there may be information collected by community residents, in records from Hudson Bay Company trading posts, and through water quantity monitoring by the Water Survey of Canada. There is evidence that the timing of break up is changing (Burn, 2004; Marsh, 2002), but less definitive information is available on freeze up. There is a natural variation in the timing of freeze-up and break-up from year to year. This affects the length of the barge traffic season on the Liard and Mackenzie Rivers, and the duration of ice-bridge and ice-road travel. The transportation season is monitored by the GNWT Department of Transportation. Records of the transportation seasons could be used to determine trends of freeze-up and break-up. Caution must be used when interpreting the data because improved technology and increased effort affect the duration of the ice bridges and ice roads.

Valued Component – Water Quantity (Final DRAFT)

× **Have river-based travel patterns and routes changed as a result of levels and flows?**

~ It is unknown whether river-based travel patterns and routes have changed as a result of water levels and flows.

RECENT AND CURRENT MONITORING

Monitoring programs with respect to water quantity in the NWT are found below.

T Northwest Territories water quantity monitoring program includes 87 stations operated by the Water Survey of Canada, with funding from Environment Canada, Indian and Northern Affairs Canada, Northwest Territories Power Corporation and the Canadian Coast Guard. Monitoring began in 1938 but most stations were established in the 1960s and 1970s.

Subsets include:

- Northwest Territories reference hydrometric basin network (since 1965) (water flow rates, water quantity, ice phenology)

- Mackenzie Delta water level, flow and hydrometric data monitoring (includes a modeling component)

T Northwest Territories evaporation/ water balance studies are ongoing at certain abandoned mine sites for water management purposes. Study sites are located at Salmita/Tundra mine in the upper Lockhart River basin, Colomac mine in the Snare River basin, Silver Bear Mine sites in the Camsell River basin, Discovery Mine in the Yellowknife River basin and Pocket Lake on the Giant mine site near Yellowknife (Indian and Northern Affairs Canada).

T The Global Energy and Water Cycle Experiment (GEWEX) was initiated in major watersheds around the globe in the early 1990s to improve understanding and modeling of high latitude water and energy cycles that play a key role in the global climate system. Between 1992 and 2004, Canada's Mackenzie GEWEX Study (MAGS) focused on improving the ability to assess changes to Canadian water resources (primarily the water and energy cycles of the Mackenzie River) that arise from climate variability and anthropogenic climate change. A series of large-scale hydrological and related land-atmosphere studies in the Mackenzie Basin provided information on the role of high latitude hydrological and meteorological processes in the global climate system, as one of 7 regional experiments in different parts of the world. For further details see http://www.usask.ca/geography/MAGS.

T **I**mproved **P**rocesses and **P**arameterisation for **P**rediction in Cold Regions (IP3) is a research network recently funded ($2.5 million) by the **Canadian Foundation for Climate and Atmospheric Sciences** (CFCAS) that will operate from 2006-2010. It is headquartered at the University of Saskatchewan. **IP3** is a Canada-wide research network devoted to an improved understanding of surface water and weather systems in cold regions, particularly in Canada's Rocky Mountains and western Arctic regions. **IP3** is targeted towards: a) Understanding the key climate system processes relating to the hydrometeorology of cold regions; b) Parameterising land surface hydrology processes that control the coupled atmospheric-hydrological system in cold regions; c) Validating and improving models for weather, water and climate systems leading to better prediction and simulation of related atmospheric impacts on water resources and surface climates in cold regions. www.usask.ca/ip3/index.html

T Water balance studies at Lower Carp Lake and in the Snare River basin were initiated in 1997 as part of the Mackenzie GEWEX study. Additional MAGS studies include hydrological research in Baker Creek watershed (Yellowknife area) (Environment Canada), and ice jam studies at Hay River (University of Alberta, Indian and Northern Affairs Canada). MAGS researchers also studied evaporation from Great Slave Lake (GSL) from 1997–2003, from smaller lakes in the Yellowknife area from 2000–2003 and extended GSL lake/energy balance investigations to Great Bear Lake in 2004-2006.

T Forest fire effects on microclimate at Tibbitt Lake have continued every year since the large fire occurred in the area in 1998 (Indian and Northern Affairs Canada).

T A dendrochronological sampling and analysis project was initiated in 1999. This project correlates standardized tree ring widths with streamflow and precipitation records. Hydrological records have been extended to the late 1600s with these proxy data methods. Sampling has been done in several locations, including the Yellowknife area, along the Mackenzie Highway, in the South Nahanni Watershed, the East Arm (Great Slave Lake) watershed, the Mackenzie River Delta and the Great Bear Lake watershed. (Indian and Northern Affairs Canada, Environment Canada, Carleton University, University of Regina).

T Northern Rivers Ecosystem Initiative (NREI) is a follow-up to the Northern River Basins Study (NRBS). The Ministers agreed with the direction of the NRBS recommendations and committed to focus their efforts in the areas of pollution prevention, science-based ecological management, resolving contaminant and nutrient issues,
endocrine disruption, long-range transport of atmospheric pollutants and continuing environmental research in northern rivers. NREI is working with industry, Aboriginal peoples, academia, communities and others to address the recommendations from the NRBS. The main partners are Environment Canada, the Government of the Northwest Territories and the Government of Alberta. Other key partners are Indian and Northern Affairs Canada, Health Canada and Alberta Health.

GAPS AND RECOMMENDATIONS FOR MONITORING

A partial list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

⎦ Water quantity monitoring for baseline data in areas with no development.

⎦ Small basin hydrology in the Liard basin related to oil and gas development.

⎦ Small basin hydrology in the Lockhart and Coppermine basins (subarctic shield and southern arctic) related to diamond mine developments.

⎦ Annual record at hydrometric stations in the Mackenzie Mountains.

⎦ Long-term water quantity monitoring data for detection of trends.

Recommendations

⎦An enhanced and coordinated program for water monitoring, including flow/level stations and weather data collection, will improve ⎥ Re-open some gauging stations closed between 1991 and 2000 and returning selected seasonal stations to annual operations.

⎦Establish a nested monitoring sub-network, with coordinated multi-scale research efforts that lead to improved understanding of hydrological processes and incorporation of this knowledge into predictive models (see Spence *et al*. (2005)).

⎦ Perform detailed data analyses to separate natural versus artificial changes in the Slave and Mackenzie Rivers resulting from operations of the Bennett Dam in BC.

⎦ Continue dendrochronology reconstructions of climate and streamflow data to extend records back into the late 1600s.

⎦ Document traditional knowledge of changes in river-based travel patterns and routes, and freeze-up and break-up dates (ice phenology) from community representatives, Dene Elders, staff of barge transportation companies, and members of the Canadian Coast Guard.

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