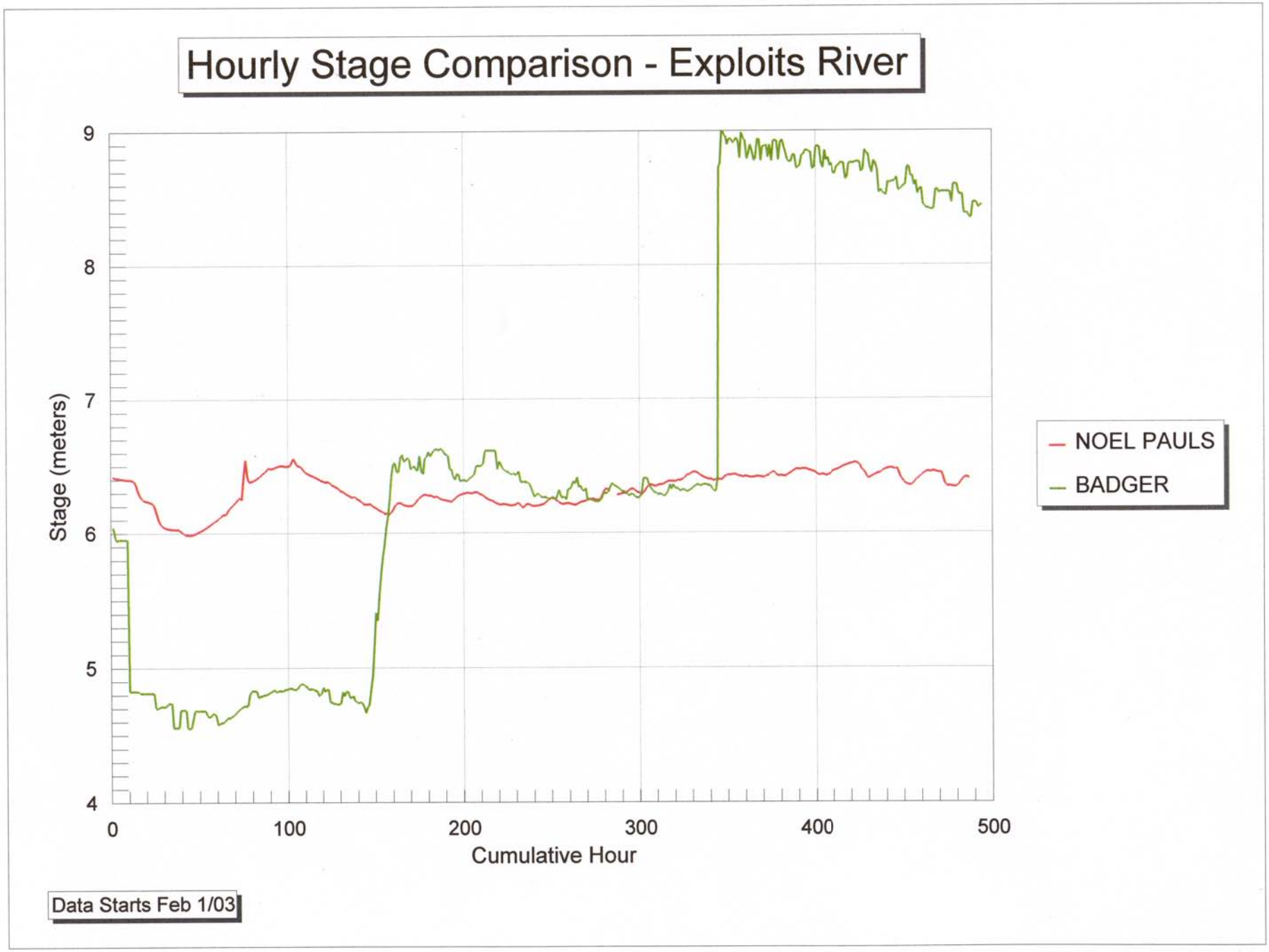

Figure 14 - Badger and Exploits River Water Levels

Photo 1 - Ice Movement - Badger Flood

The immense forces created by the ice movement caused ice from the Exploits River to be pushed up Badger Brook almost to the TCH bridge and up Little Red Indian Brook. See Photo 1.

As noted above the flood waters reached a maximum elevation 100.5 metres at the gauge near the arena. This level is slightly above the 1:100 year flood level of 100.42 metres for the Main Street area that was determined in the 1985 report [1].

The temperatures on the days following the flood were very cold with high wind chill values. This combination caused the water in the town to freeze causing further damage and delaying clean up and repair operations.

The areal extent of the flooding was compared in the field with the areas shown on the flood risk map prepared for Badger based on the recommendations of the 1985 study[1]. The areas corresponded very closely with the areas predicted by the map. A Public Information version of the map in shown in Figure 15.

The extent of the damages is currently being assessed by the Department of Municipal and Provincial Affairs, Emergency Measures Division. As of March 14, of the 353 houses in Badger, 147 did not receive any damage, 68 received minor damage, 59 received major damage and 79 had yet to be inspected due to the ice conditions in the areas around these houses. It is likely that most of the 79 will have suffered major damage. The Town Council office and fire hall, the arena and various municipal services in the Town were also damaged. Many businesses were damaged and/or suffered losses of revenue.

In terms of the current flood risk zones, 63 houses were located in the 1:20 year flood zone and 140 were located in the 1:100 year zone.

In non monetary terms, the lives of everyone living in the Town was disrupted and for many, is still being disrupted and will be so for some time to come.

5. Flood Response

As noted earlier a state of emergency was declared on the morning of February 15, 2003 by the Town of Badger. The Emergency Measures Division (EMD) of the Department of Municipal and Provincial Affairs set up a command center and an Emergency Operations Committee (EOC) up at the Central Training Academy outside the flooded area in the Town of Badger to direct appropriate response.

The DOE was informed of the situation by EMD at approximately 11.30 AM. Staff of the Hydrologic Modelling (HM) Section and Water Investigation Sections (WI) were called back to the office to review the situation and modeling work and to forecast the ice generation. A decision was taken to dispatch a team to Badger. The managers of the WI and HM sections assembled a response kit and drove to Badger on February 16, 2003 and made their services available to the EOC.

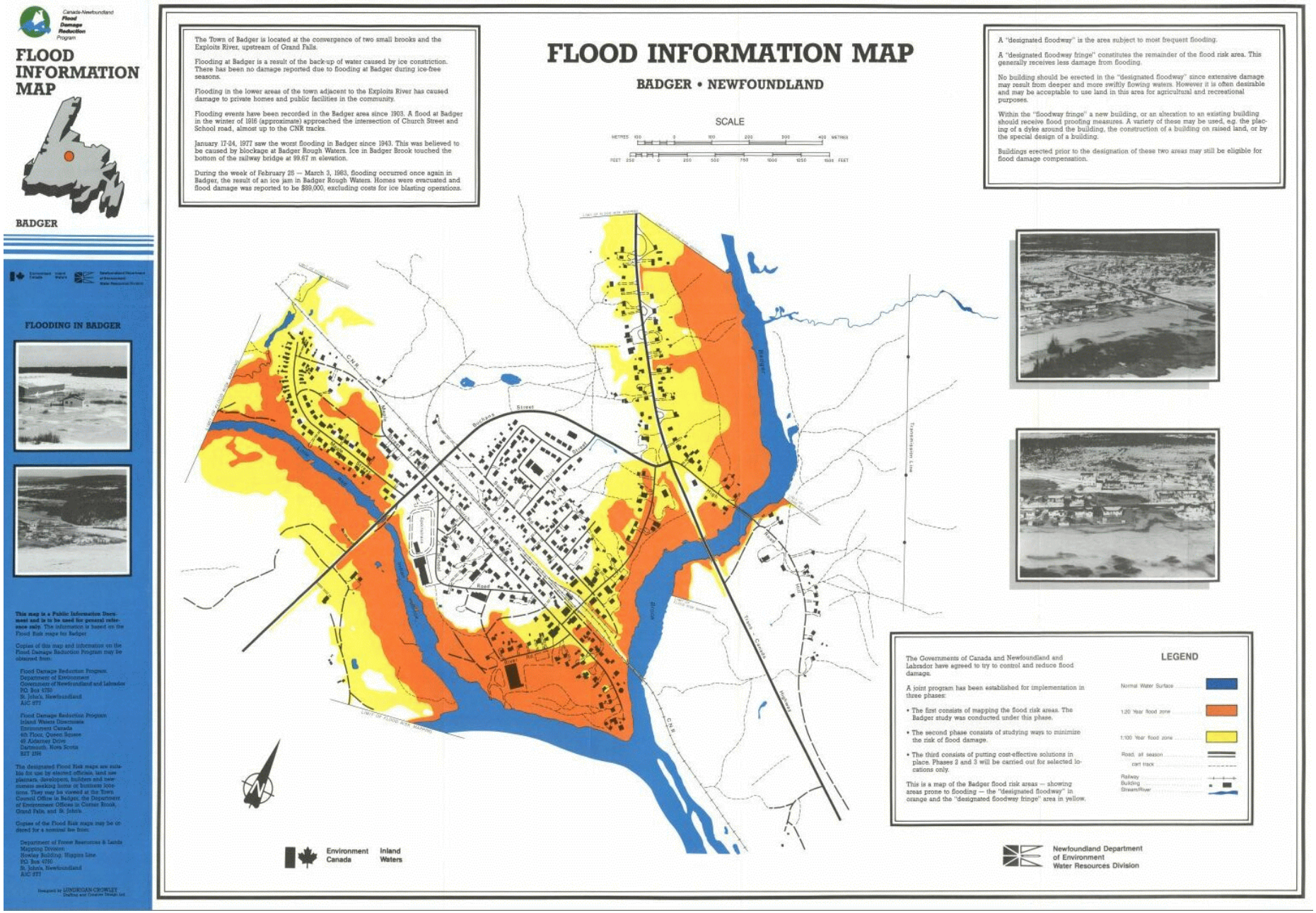

Figure 15 - Flood Risk Map

On the first day a download center was set up in the command office that allowed on call dialing into the water level station at Badger since the town's download computer was lost in the flood. A survey of the flooding was undertaken to delineate the extent of the flooding. The WRMD team also flew the river with town and Abitibi Consolidated Company of Canada officials to survey the situation and reported back to the EOC.

In the subsequent days the WRMD team fly twice a day to survey the river, reported to the EOC, helped evaluate various remedial measures, provided support to the ice clearing operation and provided expert opinion on other issues related to the water and ice conditions. The WRMD on the request of EOC also answered media enquires relating to the water levels.

On two occasions the water level station was secured by the WRMD team. On the first occasion due to ice movement the telephone wire to the station had to be extended and on the second occasion Water Survey of Canada (WSC) helped secure the station by removing ice from inside the station, removing ice from the instruments, relocating instruments within the station and by removing an extra nitrogen cylinder from the station.

The WSC team assisted the WRMD team to setup four temporary water level monitoring stations. The equipment was provided and installed by WSC. The temporary monitoring stations were installed to allow better observation of water levels and to provide advance warning of any significant change in conditions. The WRMD team downloaded data on a daily basis from these stations, analyzed them and presented the results to the EOC. The locations of the monitoring stations is shown in Figure 16. The station at 8 Mile was dismantled on March 27 after the ice shifted and pulled out the sensing line.

Continuous support was provided to the WRMD team in Badger by staff in the St. John's office. Ice forecasting was done twice a day in the St. John's office back on information gathered by the WRMD team in Badger. Data analysis support was also provided to the WRMD team and EOC in Badger.

The WRMD team was constantly in touch with ice experts to ensure that all possible remedial measures were being taken. On the recommendation of ice experts the WRMD started videotaping the ice conditions on a daily basis to provide a record for analysis of the flood.

Staff from the Community and Water and Wastewater (CWW) section were also available to assist the town and EOC in assessing, rehabilitating and securing the water supply and sewer systems. The situation was also reviewed by the Manager of the CWW section. The manager of the Groundwater section also assisted EMD by sampling the water supply and by aerially surveying the possible impact on the water supply recharge area. The Minister of the Department of Environment also visited Badger to ensure that all possible support was being provided by the DOE.

When the conditions had stabilized, regional staff from the WRMD took over the monitoring and videotaping of ice conditions, and downloading of data from the temporary water level stations. The data is being e-mailed to St. John's where it is analyzed and feedback is provided to EOC. Videos of the daily ice conditions are sent by courier to St. John's where they are reviewed.

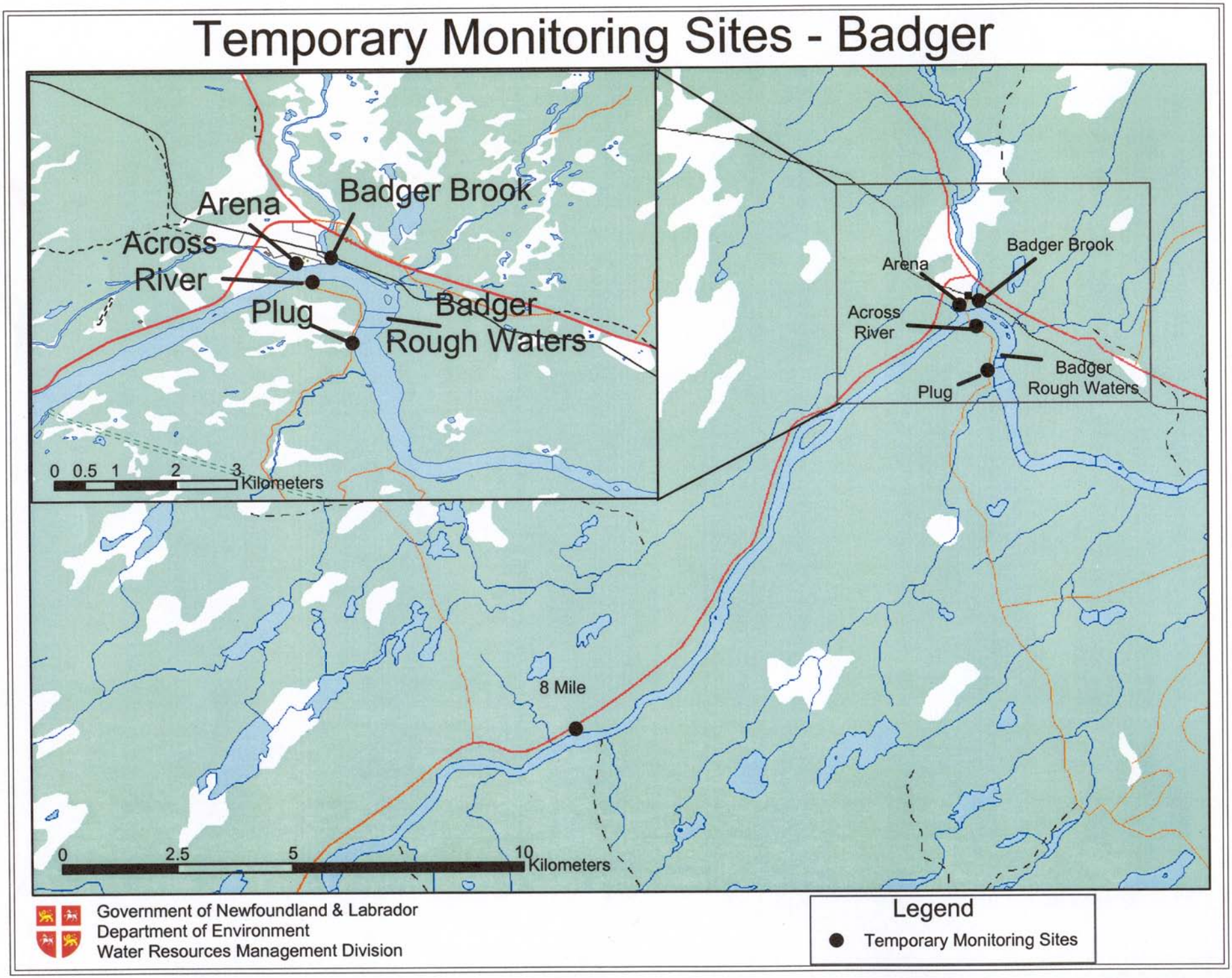

Figure 16 - Temporary Monitoring Stations

6. Current Situation

The water level on the Exploits has remained steady for the past few days at about 98.8 metres, about 1.7 metres below the maximum flood level. The recent warm weather has started to open leads above and below the main ice jam area but there has been no noticeable change in the area just below the ice jam to Three Mile Island.

Daily briefings (seven days a week) with the forecasters at the Gander Weather Centre are continuing and will continue until the danger has passed. The forecasters prepare a specific forecast for the Badger-Exploits River basin. The major concern at this point is larger amounts of rainfall (>15 mm) and temperatures higher than zero for extended periods (>24 hours). The briefings should give three to four days warning of the approach of low pressure systems or mild weather.

Over flights by helicopter are still being carried out once or twice a week, or as conditions warrant, on the recommendation of the WRMD.

Outflows from Red Indian Lake are adjusted by Abitibti on a daily basis to maintain flows in the range of the post event freeze up flows. The goals in maintaining flows at this level are to maintain the stability of the ice cover, to ensure that the passages through the ice jam area are kept open and to lower the water level in Red Indian Lake provide storage. The storage will be used in the event of a rapid melt or rainfall event to store water and keep the flows on the Exploits River at Badger as close to the freeze up flows as possible. This course of action was taken on the advice of the WRMD.

7. Discussion

Antecedent weather condition were clearly a factor in the formation of the ice cover that preceded the flood. The temperatures and wind speed combined to produce high wind chill values and freezing degree days in the week preceding the flood. The milder temperatures prior to that caused the ice cover to progress and regress in reach of the river near Badger.

Precipitation was higher than the normal for February. The effect of this is not clear at this time.

Figure 17 shows the flows past Grand Falls, the releases from Red Indian Lake (not received at the writing of this report), the water levels at Badger and the Exploits River at Noel Pauls Brook for the period from February 1 to 8:00 am February 15. The shows the passage of the ice cover through Badger on February 7 and the small spike on February 3 is likely the time when the ice cover from Noel Pauls Brook broke up and moved downstream.

The flood forecasting model provided valuable information on the formation of a large volume of ice prior to the flood. However, this information was not used to issue a flood alert to the residents since all stake holders felt, based on previous recorded flood events at Badger, that there was a very low risk of flooding once the ice cover has advanced past Three Mile Island. Even if the

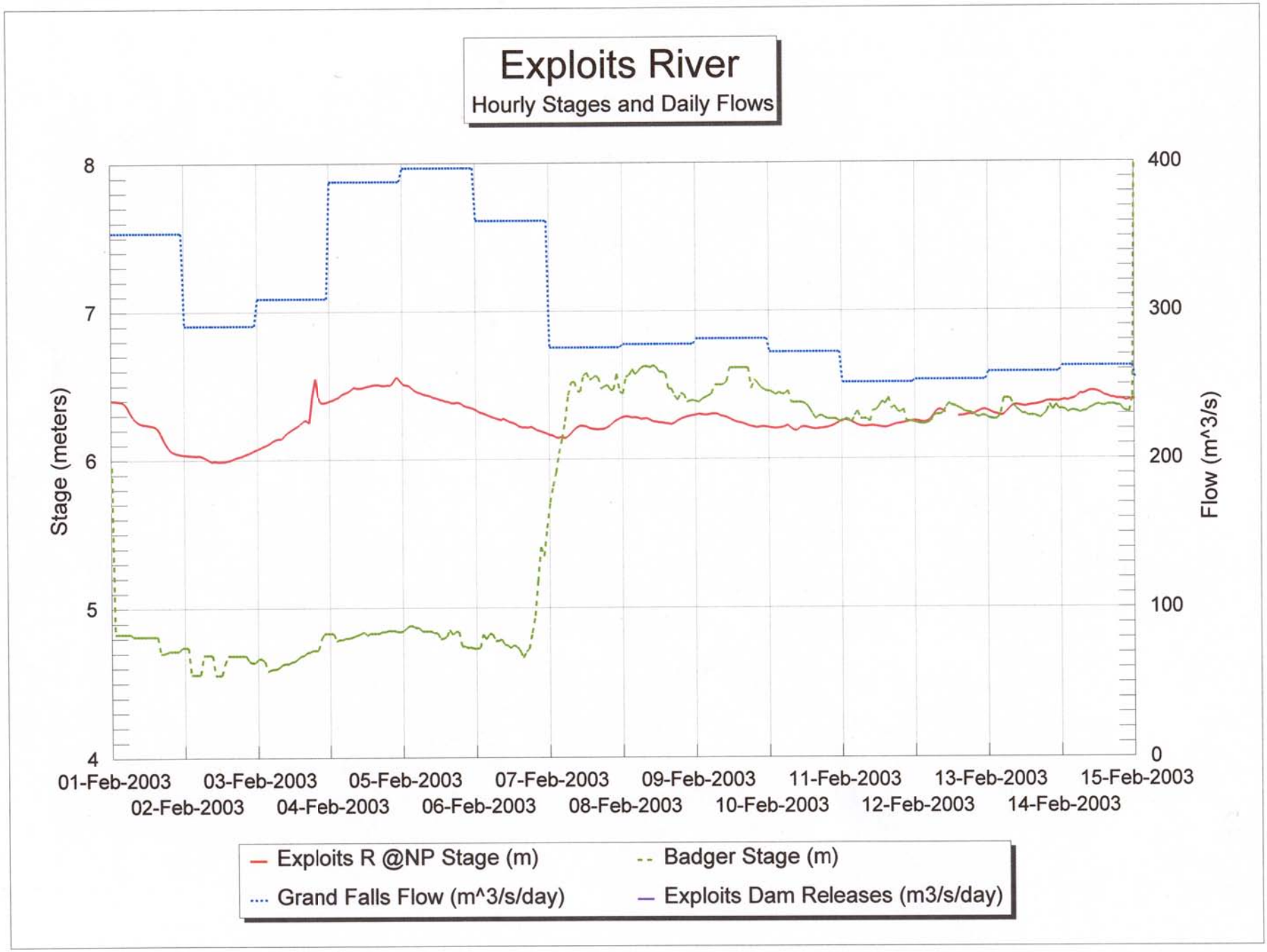

Figure 17 - Stage - Flow Comparison

flood forecast had been used to issue an alert, the past alert procedures, that were based on an assumption that a flood would develop over a period of six to eight hours, would have failed to alert the residents since the flood occurred in less than one hour.

This flood event also highlighted a number of shortcomings in the flood forecasting system. For modelling purposes, it is important to know the location of the ice front. However, this is difficult to know at all times since many river reaches are inaccessible. Ice observations are usually obtained from Abitibi and the Town. During the past two ice forecast seasons satellite images, when available, have been obtained over the Internet to assist in ice observation. A sample image is provided in Appendix C. The images are not high resolution, are not available in realtime, and cannot see through clouds. RADARSAT, a Canadian earth observation satellite, can see through clouds, can provide several images per day in realtime with a resolution of 6 metres. The reach of the Exploits River between Red Indian Lake and Grand Falls is up to three hundred metres wide and it should be able to accurately show the location of the ice front on a continuous basis using scheduled satellite images. In the past, there was a significant cost involved in obtaining these images, however, recently the images are available to the province at a reduced rate which makes this technology more cost effective.

Another limitation of the ice model is that the model does not simulate the regression of the ice front which happened a number of times during this season and has occurred in other seasons.

Air temperatures are fairly well represented in the region with four reporting stations. There are some weaknesses in the hydrological network as it relates to river ice generation and flood forecasting at Badger. Water temperature monitoring is lacking at Exploits Dam.

In order to manage the flood response and to provide early flood warning while water levels were still high after the event, it became necessary to install temporary water level gauges. This demonstrates the need for additional hydrometric stations within the basin.

The ground survey of the extent of flooding indicated that the flood risk mapping was very accurate. However, an initial evaluation of the flood damage indicates that some houses may have been constructed in the 1:20 flood zone. This is against the policy of the Canada-Newfoundland Flood Damage Reduction Program.

While this report does not attempt to investigate the mechanism that caused the shift in the ice cover which, in turn, caused the flooding, initial interviews with residents confirm that the ice cover progressed upstream of Badger at an unusually fast rate.

The response of the Town, particularly the Volunteer Fire Department, and the EMD was very well organized and professional.

Proposed Flood Warning System - Badger

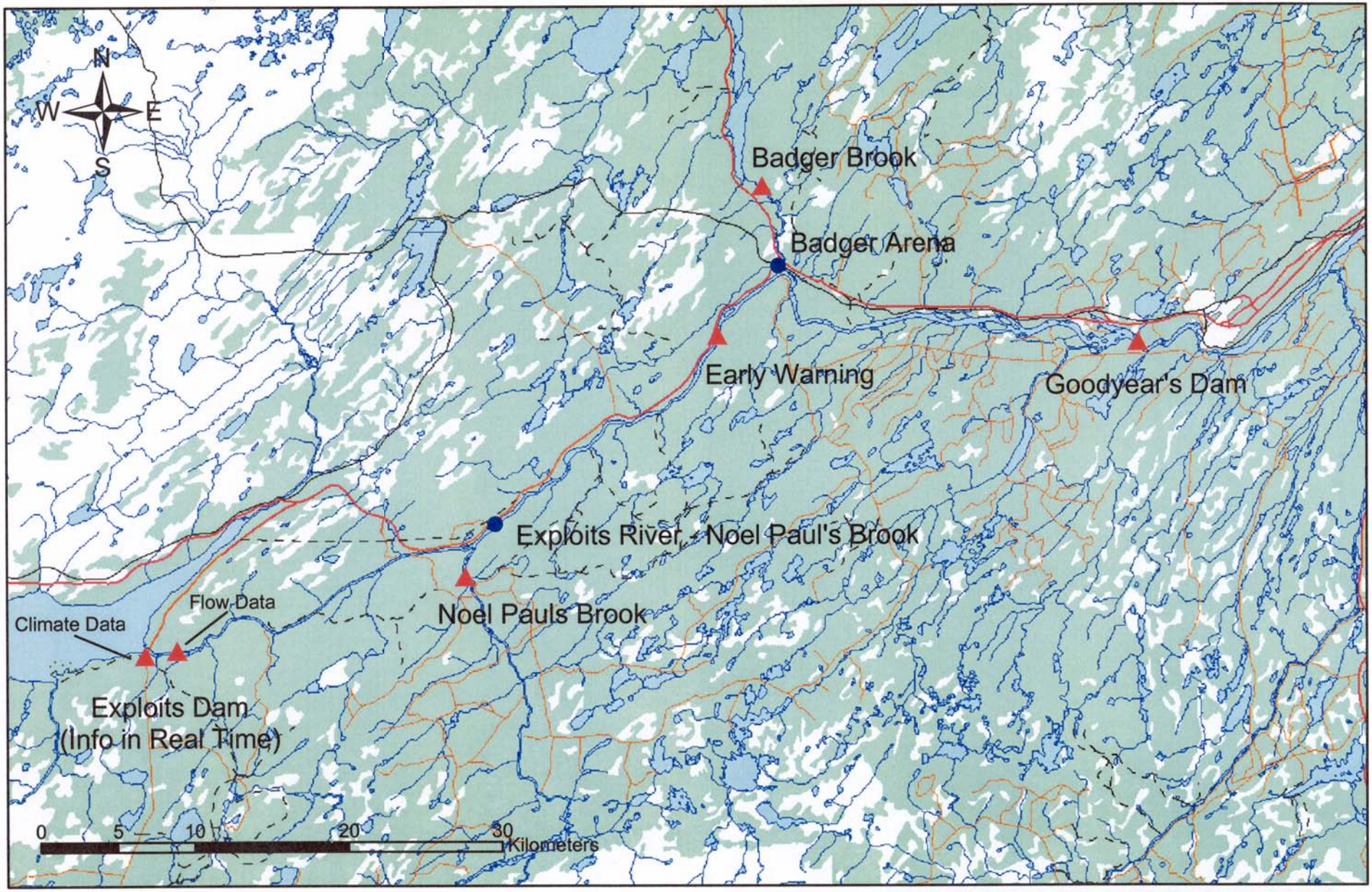

Figure 18 - Proposed Flood Warning System

Government of Newfoundland & Labrador
Department of Environment
Water Resources Management Division

Legend

● Existing Monitoring Sites ▲ New Monitoring Sites