2017 Hurricane Season Flood Alert System
Final Report

Department of Municipal Affairs and Environment

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FINAL REPORT

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1 Flood Alerts Summary

The Wood Hurricane Season Flood Alert System (HSFAS) Product is the result of professionally trained meteorologists applying their full knowledge of atmospheric science to Newfoundland and Labrador's weather patterns and pairing that with existing trends, known observations, and weather prediction models. Examining maximum precipitation predictions from many different dynamic models allows forecasters to produce a better forecast of the maximum precipitation potential based on the strength of different models in handling the atmospheric physics of differing weather patterns.

From July 2017 to December 2017, 13 alerts were issued in total. These include one event where the Environment and Climate Change Canada (ECCC) data exceeded alert limits although those data have been determined to be erroneous. An excel spreadsheet of all the flood alerts issued has been provided to WRMD, and a summary of these alerts are below.

Table 1 Summary of Flood Alerts

Alert #	Site Name	Alert Issue Date	12-hourly Precipitation Forecast (mm)	24-hourly Precipitation Forecast (mm)
1	St. Lawrence (ST LAWRENCE)	2017-09-26 09:00	105	111
2	Corner Brook	2017-09-26 09:00	57	69
3	Deer Lake, Steady Brook	2017-09-27 09:00	55	60
4	St. Lawrence (ST LAWRENCE)	2017-09-27 09:00	95	110
5	Corner Brook	2017-09-27 09:00	58	66
6	Deer Lake, Steady Brook	2017-09-27 16:00	55	60
7	St. Lawrence (ST LAWRENCE)	2017-09-27 16:00	95	110
8	Whitbourne	2017-09-27 16:00	75	95
9	Corner Brook	2017-09-27 16:00	60	68
10	Whitbourne	2017-09-28 09:00	75	85
11	Whitbourne	2017-09-28 16:00	75	85
12	Wabush (WABUSH LAKE A)	2017-10-26 09:00	37	76
13	Churchill Falls	2017-12-22 10:00	8	10

Note:

Exceeded 12-Hourly 20-yr flood limit	Exceeded 24-Hourly 20-yr flood limit
Exceeded 12-Hourly 100-yr flood limit	Exceeded 24-Hourly 100-yr flood limit
WRMD or EC Exceeded flood limit	

The 2017 season represents a stark difference from the 2016 season. Alerts/events were much less numerous in 2017 (13) than in 2016 (114). This decrease in the number of alerts is a reflection of the summer/fall of 2017 being much drier than in 2016. The dryness was due to both a lack of tropical cyclones and their remnants reaching Newfoundland, as well as the general lack of moisture-laden low-pressure systems moving through the region. Instead, high pressure dominated over much of the Province during traditionally wet time periods. October is typically the wettest month of the year for most of the province yet in many places, including most of eastern and central Newfoundland, October 2017 was the driest on record. No alerts/precipitation events occurred in October this season, which is in contrast to previous seasons.

Nearly all 2017 alerts, except for one can be attributed, to a single event on September 27-28. That event triggered a total of 11 alerts across Newfoundland. In addition, an isolated alert was triggered in Wabush on October 26. Lastly, an Environment and Climate Change Canada station (Churchill Falls) triggered a false precipitation event alert on December 23.

Table 2 Monthly Analysis of Flood Alerts

Month	Total Alerts	12-hourly 20-yr alerts	12-hourly 100-yr alerts	24-hourly 20-yr alerts	24-hourly 100-yr alerts	Env. Can. & WRMD Obs.
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	11	11	0	0	0	0
October	1	0	0	0	1	0
November	0	0	0	0	0	0
December	1	0	0	0	0	1
Total:	13	11	0	0	1	1

The geographical spread of the alerts this season was large, spanning the entire province.

Table 3 Regional Analysis of Flood Alerts

Community	Region	Total Number of Alerts
Wabush	Labrador	1
Churchill Falls	Labrador	1
Corner Brook	Western	3

Community	Region	Total Number of Alerts
Deer Lake, Steady Brook	Western	2
Whitbourne	Eastern	3
St. Lawrence	Southern	3

From a geographic perspective, five (5) alerts were triggered for the Western region, three (3) alerts were issued for the Eastern Region, three (3) alerts were raised for the Southern Region, and two (2) alerts was issued for Labrador. With such a small sample size, there is no single geographic area that stands out for having been more excessively impacted by flooding than the others. Previous seasons that have shown more geographic and temporal variability in the alerts, proving that it is very difficult to predict far in advance what regions will have a challenging flood season.

2 Verification of Alerts

The flood alerts were verified on a monthly basis using three data sources/methods to compare with the forecasted values: ECCC rain gauge data, WRMD rain gauge data, and qualitative community-based reports. However, there remain some significant challenges with verification. Rainfall has very high spatial variability, meaning that stations only a few kilometres apart may record vastly different values. Nearby gauge comparison is a limited verification method due to the intense variability of precipitation over the changing terrain.

Also, due to the risk involved with missed alerts, the forecasting approach that was implemented represents a worst-case scenario. The forecast is essentially the highest possible rainfall based on the current conditions as opposed to the most likely scenario rainfall. Every season, by design, there are a large number of alerts issued that are not required. As such, any issued alert will generally overestimate what is observed, creating a large number of alerts that will not verify. The system was designed in this manner to avoid missing an alert as the consequence for missed alerts are very serious for the people and resources involved.

For the 2017 season, validation was not possible for 6 of the 12 valid alerts because there were no nearby gauges to provide a comparison. The remaining six (6) alerts were for communities that have WRMD gauges within 10 kilometers, so Wood was able to quantify whether any of those alerts were warranted. The available data indicated that all six (6) of the verifiable alerts issued were not required and were over-forecasted.

2.1 Community Based Flood Reports

Wood worked with Fire & Emergency Services – NL (FES-NL) this season, with monthly calls to discuss the alerts. The concept was to create a qualitative field verification measurement that could further validate the statistical methods. Following a forecasted flood event, the intention was for local officials to classify the event as having no, minor, or catastrophic flooding and these eyewitness reports would be noted on the monthly verification. In the absence of community accounts, local newspapers were scanned to verify

the alerts qualitatively.

2.2 Potential Missed Alerts

During the September 28-29 event where alerts had been issued for Eastern, Southern, and Western Newfoundland, flooding was also reported in local newspapers for several communities in central Newfoundland including Burlington, Hare Bay, Greenspond, Fogo Island, Harry's Harbour, Beachside, Croque, and Gander. Specifically, damage to roadways and infrastructure leading to these communities and associated repair work was reported. The alert system had issued alerts for areas in Eastern and Western Newfoundland (i.e., Corner Brook, Deer Lake, Steady Brook, Whitbourne, and St. Lawrence) but not for Central Newfoundland. Gauge data from Central Newfoundland was analyzed to determine if an alert should have been triggered. Ultimately it was determined that the rainfall recorded in Central Newfoundland during this period did not cross any of the alert thresholds.

Due to missing data (i.e., for St. Anthony or La Scie) and lack of geographically-relevant gauges (Comfort Cove, Glovertown, and St. Albans), it is not possible to verify whether observed rainfall amounts for those sites exceeded the forecasted amounts. However, useful data was available for Gander and Bishops Falls, as illustrated in the below table.

Table 4 Potential Missed Alerts

Community	Nearby Flood Report	Issue Date	12-hour Precip Forecast	24-hour Precip Forecast	EC Observed (Sep 28-29 Combined)	WRMD Observed (Sep 28-29 Combined)	Conclusion
St. Anthony	Croque	28-Sep-17	28	30	11.8 on Sep. 28, missing data for Sep. 29	N/A	N/A
La Scie	Routes 391, 392, 413	28-Sep-17	38	39	Missing data for Sep. 28, 8.9 mm on Sep. 29	N/A	N/A
Bishops Falls	Route 350, 352, 364 391	28-Sep-17	33	34	N/A	7.5 mm	Amount less than forecasted
Comfort Cove	Routes 333, 346,	28-Sep-17	32	33	N/A	N/A	N/A
Gander	Gander	28-Sep-17	33	34	23 mm	N/A	Forecast was good
Glovertown	Routes 320, 330	28-Sep-17	35	35	N/A	N/A	N/A
St. Albans	Routes 361, 364	28-Sep-17	43	50	N/A	N/A	N/A

Community	Nearby Flood Report	Issue Date	12-hour Precip Forecast	24-hour Precip Forecast	EC Observed (Sep 28-29 Combined)	WRMD Observed (Sep 28-29 Combined)	Conclusion
Wabush	None	27-Oct-17	37	76	35	N/A	Amount less than forecasted

For Gander, the EC-measured amount of 23 mm is below the 12-hour precipitation forecast of 33 mm but within reasonable limits. For Bishops Falls, the observed amount was significantly less than forecasted, supporting the concept that the Central Newfoundland flooding could not have been flagged by the alert system alone.

Given that flooding resulted from generally small amounts of observed rainfall, several possible factors may have contributed to the reported flooding:

1. One factor is that the rainfall was highly variable spatially, resulting in large totals in some areas but not others. This is supported by the below radar image from September 28th that show discrete thunderstorm-like clusters of precipitation tracking across central Newfoundland.

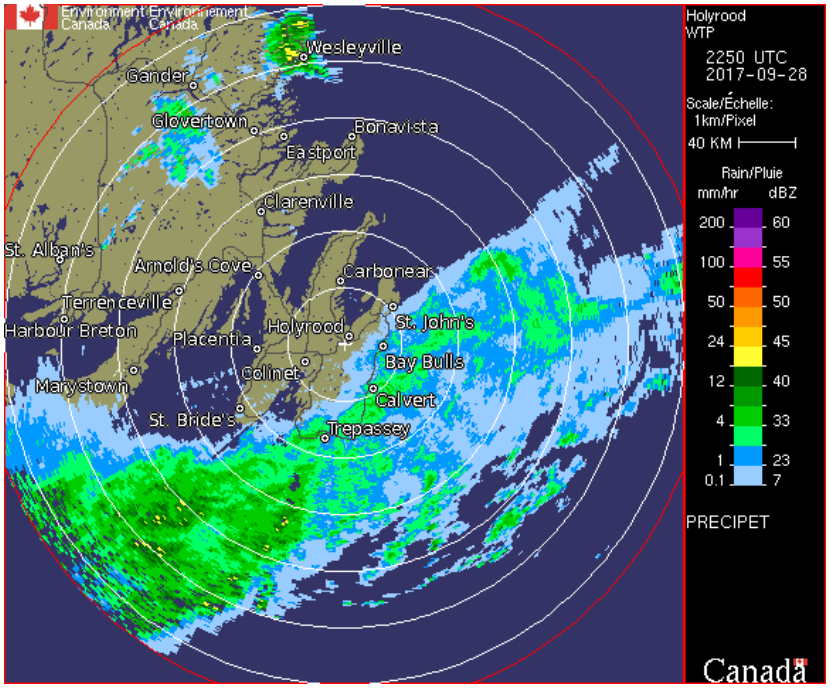

Figure 1 Holyrood Radar Image, Sep. 28, 2017

2. Another contributing factor could be the timing of this event during the height of autumn: leaves and other fallen debris often block and limit storm drainage infrastructure. When drains are obstructed, even precipitation well below the flooding thresholds can cause damage that is, at its

core, non-meteorological in origin.

3. Lastly, existing groundwater levels play a large role in determining whether a less substantial rainfall will be accommodated by the saturated soil or if it will cause major damage to a community.

In conclusion, available gauge data from Central Newfoundland indicated a small amount of rainfall during this period, not enough to have triggered the alert system on its own. Other contributing factors such groundwater levels and autumn-related debris probably exacerbated the situation to cause the flooding.

Regarding the alert-level rainfall that was reported at Churchill Falls on December 23, there is strong evidence that this observation is erroneous. The ECCC data show an observed 169 mm of rain on that day, but the maximum observed temperature on that day was -21.0 C, meaning any precipitation that would have occurred would have been snow. This may have been a typo or glitch in the ECCC observation database since rain is physically impossible at temperatures that far below zero.

2.3 Climate Normals

Airport reports of rainfall across NL were examined to determine how the 2017 HSFAS season compared to the climatological normals. 2017 months are colour-coded in red if they were substantially above normal and blue if they were substantially below normal.

Table 5 Monthly Rainfall Totals (in millimetres) compared to climate normals

Location	Jul 2017	Jul Norm	Aug 2017	Aug Norm	Sep 2017	Sep Norm	Oct 2017	Oct Norm	Nov 2017	Nov Norm	Dec 2017	Dec Norm
St. John's	101.5	91.6	141.4	100.0	264.2	129.6	37.2	153.7	110.0	124.8	148.2	102.9
Gander	82.4	95.4	113.8	104.2	136.4	114.7	27.4	102.3	69.6	75.2	39.4	48.9
Deer Lake	40.2	95.1	84.0	109.6	155.2	99.9	86.0	84.9	71.6	60.2	23.5	27.6
Goose Bay	109.0	121.3	120.0	99.3	122.4	90.6	29.4	63.3	23.6	22.7	1.4	6.6

July experienced average rainfall except in Deer Lake where it was below average. August was also average at every location except in St. John's where it was above average. September was very wet across the Province thanks to a very active hurricane season impacting the Caribbean and Gulf of Mexico and a favourable weather pattern that provided persistent transport of hurricane moisture to NL despite the fact that the actual hurricanes tracked far away from Newfoundland and Labrador. October was starkly different from September in that it was the driest, or one of the driest, months on record for many parts of the province, mainly thanks to a quiet hurricane season and high pressure over the North Atlantic. October's record-breaking dry spell led to overall dry conditions since October is more typically the wettest month of the year. November and December were generally average for most areas.

2.4 Summary

This year, through the use of the Weather Web Portal, the raw Esri Shapefiles and the data services the forecast details were available to a larger audience. It would benefit WRMD to solicit feedback from the users of the service to determine the effectiveness of the current data distribution formats. Feedback

from the users can then be taken into consideration for enhancements to the services. It is also recommended to consider adding the WRMD rain gauge data to these data services thus providing users with another source of near real-time validation of an ongoing event.

3 Lessons Learned

This season stands out as an anomaly, with so few flood alerts compared to previous seasons. As individual seasons continue to depart further from climate normals, customized alerting services such as this become more critical. Record-breaking dry or wet spells emphasize the growing importance of nowcasting and advanced weather monitoring, on a very local scale.

Another issue brought to the forefront this season was that falling precipitation is only one part of flood risk analysis. The in-depth analysis of the Central region during the rainfall that triggered alerts elsewhere across the Island highlighted the other factors that can turn a small amount of rain into a massive flooding problem. Future services could include more collaboration and integration between the weather forecast products and the other contributing factors that WRMD reviews before issuing a community alert. It is essential to keep evolving the service over time as technology advances and as the needs of the impacted communities change.

As we have stressed over the past several seasons, there is a dramatic need to fill the gaps in the available monitoring networks. Using only the ECCC and WRMD gauge data limits our ability to verify the forecasts in some areas. Many communities require additional measurements, access, and/or studies. Without adequate instrumentation for measuring precipitation, it can be almost impossible to know for certain in high terrain areas whether the forecasted precipitation was accurate. Attempts have been made to fill these gaps through community-based flood reports and use of local media sources to try to corroborate sparse gauge data.

More accurate monitoring solutions have been developed in recent years, and with increasing communication options across the Province, with the expansion of cellular coverage, it may be the time to revisit additional investment in quantitative measuring equipment. To advance the service, additional rain gauges should be installed, particularly in the regions that have generated significant alerts in the past, and access must be obtained for other gauge networks in use across the Province by commercial/private agencies. In this year's case, and in most cases over the past few years, these subjective reports only generate more false alarms and ultimately do not uncover missed alerts hence we recommend discontinuing this practice.

4 Conclusion

It would be highly beneficial to pursue additional improvements to the data sources:

1. Additional rain gauges could be installed, particularly in the regions that generated significant alerts.
2. Access could be obtained for other rain gauge networks in use across the Province, and the existing Department of Transportation Road Weather Information System monitoring network could add rain gauges to their existing stations.

3. Flood Risk Mapping Studies could be considered for the communities that triggered alerts based on Intensity-Duration-Frequency (IDF) curves.

Without the implementation of several of these recommendations, it will remain difficult to verify the flood alerts in some regions accurately.

5 Closure

We trust that this report meets your needs. Please do not hesitate to contact the undersigned if you have any questions or comments regarding the hurricane season outlook.

Yours sincerely,

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