Environment and Climate Change Canada

Evaluation of the Weather Observations, Forecasts and Warnings (Sub-program 2.1.1)

Final Report

Audit and Evaluation Branch

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Canada

Report Clearance Steps

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Acronyms used in the report

ASTD	Atmospheric Science and Technology Directorate
BCP	Business Continuity Planning
CESI	Canadian Environmental Sustainability Indicators
CSB	Corporate Services Branch
DPS	Direct Program Spending
GEO	Group of Earth Observations
GEOSS	Global Earth Observation System of Systems
IMIT	Information Management / Information Technology
ISO	International Organization for Standardization
MEPIC	Meteorological and Environmental Predictions Innovation Centre
MSC	Meteorological Services Canada
NIRT	National Inquiry Response Team
NOAA	National Oceanic and Atmospheric Administration
PSPC	Pacific Storm Prediction Centre
PWPMC	Public Weather Program Management Committee
QMS	Quality Management System
SSC	Shared Services Canada
STB	Science and Technology Branch
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Science and Cultural Organization
WMO	World Meteorological Organization

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The Evaluation Project Team was led by Robert Tkaczyk, under the direction of the Environment and Climate Change Canada Evaluation Director, William Blois, and included Lindsay Comeau and Katheryne O'Connor.

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Executive Summary

Context

The Evaluation of the Weather Observations, Forecasts and Warnings Program addresses the issues of the program's relevance and performance (including effectiveness, efficiency and economy) from April 1, 2011 to June 30, 2014. The program represents 17.25% ($131.9M) of the department's 2014 direct program spending (DPS), including grants and contributions (G&Cs).

The Weather Observations, Forecasts and Warnings Program provides 24 hours per day, 365 days per year weather warnings, forecasts and information. Annually, the program collects millions of atmospheric and water observations and produces approximately 1.5 million weather forecasts and warnings to help Canadians to anticipate meteorological events in order to protect themselves and their property. The program is delivered by the Meteorological Services of Canada (MSC) through collaborations with Environment and Climate Change Canada's (ECCC) Science and Technology Branch (STB) and Corporate Services Branch (CSB) involving data, science, and information distribution in Canada and internationally. These activities depend on the telecommunication systems and supercomputing capacity managed by Shared Services Canada (SSC). Key collaborators include the media, all levels of government and academia in Canada, other national meteorological services, research and space agencies, and the United Nations World Meteorological Organization (WMO).

Findings and Conclusions

Relevance

There is an ongoing need for the provision of weather and environmental services to better manage the significant human and economic consequences stemming from severe weather events. The program is clearly aligned to government priorities related to the economy, public safety and the environment, and is also consistent with federal roles and responsibilities related to the *Department of the Environment Act*, the *Canadian Weather Modification Act*, the *Emergency Management Act*, as well as supporting Canada's international commitments under the *Convention of the World Meteorological Organization*.

Efficiency and Economy

The design of the program is appropriate, and the program continues its renewal agenda intended to improve weather services. The evaluation found the governance structure to be clear, appropriate and effective. The recent transition of IT resources to SSC has led to some issues with delays and the quality of products and services, though mitigation strategies are now in place to address them. Evidence also indicates that the program is undertaking activities and delivering products in an efficient manner. Challenges were, however, identified related to reporting burden (e.g., ISO certification reporting requirements), as well as delays in procurement.

Performance information is collected and reported, and is being used for decision-making. Although the program has a logic model and collects performance data, performance indicators and targets are either not identified for, or aligned to, most intended outcomes. In addition, the program's intended outcomes may not be fully reflected by the current logic model, as they focus more on satisfaction, awareness and

use of weather and environmental services rather than the impacts these services are expected to achieve.

Effectiveness

Data collected as part of the evaluation suggests the program is on track to achieve most of its outcomes. Key external factors influencing the achievement of outcomes were generally thought to concern evolving client expectations (e.g., social media), government-wide restructuring (e.g., SSC), and federal government policy related to communication.

Recommendation

The following recommendation is based on the findings and conclusions of the evaluation. The recommendation is directed to the Assistant Deputy Minister (ADM) of the MSC, as the senior departmental official responsible for the management of the Weather Observations, Forecasts and Warnings Program.

Recommendation #1: Develop and implement a performance measurement strategy for the Weather Observations, Forecasts and Warnings Program, including an updated logic model, the identification of performance indicators and targets for each intended outcome, and a performance reporting strategy.

Management Response

The ADM of the MSC agrees with the recommendations and has developed a management response that appropriately addresses each of the recommendations.

The full management response can be found in Section 6 of the report.

1.0 Introduction

This report presents the results of the Evaluation of the Weather Observations, Forecasts and Warnings Program which was conducted by Environment and Climate Change Canada's (ECCC) Evaluation Division, Audit and Evaluation Branch, in fiscal years 2014 and 2015. The evaluation was identified in the 2014 Departmental Risk-Based Audit and Evaluation Plan, which was approved by the Deputy Minister. The evaluation was conducted to meet a Treasury Board requirement related to the renewal of funding of the Government of Canada's weather and environmental monitoring and supercomputing infrastructure, as well as to meet the evaluation coverage requirements of the *Financial Administration Act* and the Treasury Board *Policy on Evaluation*, which require respectively that an evaluation of all grants and contributions (G&Cs) and direct program spending (DPS) be conducted at least once every five years. The program represents 17.25% ($131.9M) of the department's 2014 DPS, including G&Cs.

2.0 Background or Context

2.1 Program Profile

The Weather Observations, Forecasts and Warnings Program provides 24 hours per day, 365 days per year weather warnings, forecasts and information with lead times ranging from minutes to weeks. Annually, the program collects millions of atmospheric and water observations and produces approximately 1.5 million weather forecasts and warnings. Information is disseminated primarily to enable Canadians to anticipate dangerous meteorological events in order to protect themselves and their property. There are also various additional benefits of accurate and timely forecasts related to the Canadian economy in such areas as agriculture, transportation, recreation and tourism. The program is delivered by the Meteorological Services of Canada (MSC) through collaborations with ECCC's Science and Technology Branch (STB) and Corporate Services Branch (CSB) involving data, science, and information distribution in Canada and internationally. These activities depend on the telecommunication systems and supercomputing capacity managed by Shared Services Canada. Key collaborators include the media, all levels of government and academia in Canada, other national meteorological services, research and space agencies, and the United Nations World Meteorological Organization (WMO).

2.2 Activities

The activities in this program area represent the MSC's core business, namely, the provision of the public weather program[1] including:

- Monitoring of weather conditions – year round, 24/7 operation of a national infrastructure of weather observing networks;
- Prediction and service - the real-time operational, year-round, 24/7 capacity of ECCC to assess and diagnose meteorological conditions that impact Canada;
- Atmospheric science to support the prediction process;

[1] This program does not include services to targeted users related to air navigation, marine navigation and military operations.

- Major projects to renew and re-engineer the monitoring infrastructure, as well as prediction and service delivery processes;
- Information management and information technology (IM/IT) to support the public weather program;
- Contributions to the WMO that support international collaboration in weather prediction; and
- Strategic policy and coordination of the weather program.

This is the largest single program in ECCC, accounting for three quarters of the MSC budget and involving all MSC Directorates, as well as STB and CSB. Beneficiaries of ECCC's public weather prediction services include the general public, other levels of government, and private sector organizations.

The MSC organizational structure includes 6 consolidated regional storm prediction centres,[2] each of which is supported by four key functions of the weather program: the Prediction Services Directorate, the Canadian Centre for Meteorological and Environmental Prediction, the Monitoring and Data Services Directorate, and the Policy, Planning and Partnerships Directorate.[3] The roles and responsibilities of these four MSC directorates in the delivery of this program are as follows:

- **Prediction Services Directorate** forecasts the changes in the atmospheric environment and the potential high impact meteorological situations or events regionally. It develops weather and related environmental services and information dissemination to meet the needs of Canadians (e.g., broadcast media partnerships, Weatheradio Canada, Weatheroffice website). The directorate generates the forecasts, warnings and alerts to inform all Canadians of impending high impact meteorological situations or events by tailoring the model predictions to the local situations. Finally, the Directorate promotes warning preparedness and adaptation to the risks posed by changes in the natural environment.
- **Canadian Centre for Meteorological and Environmental Prediction** leads the development of weather and related environmental prediction programs based on numerical models. The directorate includes the real-time operational, year-round, 24/7 modelling capacity to assess and diagnose meteorological conditions that impact Canadian territory, including its three coasts and navigable inland waters which is used as the foundation for the generation of MSC forecasts and warnings. The Directorate adapts and applies the numerical weather and environmental prediction models that are conceived with STB to the operation prediction of high impact events (e.g., storms and dispersion of harmful pollutants). Finally, the directorate leads the transfer of knowledge and technology from scientific research to forecast operations.
- **Monitoring and Data Services Directorate** ensures that meteorological, climatological, hydrometric and environmental data and information are collected and

[2] Storm prediction centres are located in Vancouver, Edmonton, Winnipeg, Downsview (Toronto), Montreal, and Dartmouth. There is also the Newfoundland and Labrador Weather Office located in Gander, which plays a similar role.

[3] As of April 1, 2014, MSC is operating under a new organizational structure. The re-organization, which focused primarily on revising roles and responsibilities and integrated key activities (i.e., prediction and service delivery) along key functional business lines (i.e., monitoring, forecasting/services, modeling/prediction system, and policy and planning), is intended to support delivery of the new investments and Signature Projects (discussed below) to modernize and revitalize Canada's weather services.

managed, allowing for environmental data to be available and usable for applications that better the life of Canadians. The directorate also has obligations relating to design and operation of complex networks, data standards, and quality assurance.

- **Policy, Planning and Partnerships Directorate** captures the evolving weather & environmental service needs of Canadians and integrating these into MSC's program planning and strategic directions, provides for increased focus on national and international partnerships, and facilitates the MSC transformation agenda through a dedicated Office of Transformation. The directorate also leads the development of policy, including Memoranda to Cabinet and Treasury Board Submissions. The directorate leads performance management, including the Quality Management System, registered to the International Organization for Standardization (ISO) 9001:2008 standard, which provides a framework to manage the weather and environmental services. Finally, the directorate coordinates Branch planning activities including Business Continuity Planning (BCP), which aims to mitigate risks in order to ensure continued delivery of critical services.

There are also a number of critical elements of the program conducted outside of MSC that are required to support the public weather program:

- **ECCC's Atmospheric Science and Technology Directorate (ASTD), STB** provides meteorological research and development (R&D) that supports the operations of the weather program, including assessments of new observing technologies, numerical weather and environmental prediction improvements, advancements in data assimilation techniques and research on cloud physics and severe weather. It also conducts research on water and air quality, climate and ice services.
- **ECCC's CSB** provides critical support of 24/7 mission critical systems and leadership in the development of new and unique applications that are critical to transforming meteorological services. In addition, CSB provides support for facilities management, and large and small scale procurement that are also essential in the transformation of weather services.
- **Shared Services Canada (SSC)** administers and maintains the supercomputer, as well as the IT network and related computer systems and software to support real-time weather and environmental observations, prediction and services. SSC also runs the telecommunications system upon which the weather program is dependent.

Other key program partners include international organizations (e.g. the United Nations WMO[4]) and Group on Earth Observations[5] (GEO)). Participation in these organizations is intended to enable Canada to benefit from global earth observations, science information and technologies developed by other countries (e.g., United States, China, Australia).

[4] The World Meteorological Organization (WMO) is a specialized agency of the United Nations (UN). It is the UN system's authoritative voice on the state and behaviour of the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources.

[5] The Group on Earth Observations (GEO) is a voluntary intergovernmental partnership of governments and international organizations, working to build a Global Earth Observation System of Systems (GEOSS). Eighty-eight countries, the European Commission, and over 60 international organizations, (such as the WMO, United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP), the UN Convention on Biodiversity, various space agencies, etc.) are active participants in GEO.

Signature Projects
Beginning in 2010, new and reallocated funds have focused on the development of 8 Signature Projects to revitalize and modernize the MSC, five[6] of which fall within the program being evaluated:

1. The Next Generation Weather Forecasting System project was launched to ensure that the MSC's prediction system meets the evolving needs of Canadians and takes advantage of ongoing advances in the field of meteorology. Public forecast services are being re-developed to enable access to more geographically precise information about environmental predictions (e.g., air, ice, water).
2. The Re-engineering the Weather Warning and Service Delivery System project is intended to improve the quality and reach of weather alerts, as well as provide better advice and support to users. MSC's vision is to quickly and clearly convey the potential impacts of approaching severe weather in time for people to properly assess the situation and take appropriate steps to reduce risks.
3. The Modern Day Monitoring Strategy project is intended to restore, sustain and modernize MSC's hydro-meteorological monitoring program, as well as help MSC meet national and international needs for weather, water, and climate information by modernizing and sustaining its core monitoring systems, creating collaborative, multi-participant observing networks, and improving the ability for partners to access data.
4. The High Performance Computing project is expected to more than double the capacity of the supercomputer (which is now the responsibility of SSC) currently used to process millions of weather observations from around the world, with an aim to ensuring that MSC's weather and environmental prediction systems can keep pace with the rapidly growing demand for more accurate and diversified services.
5. The Environmental Prediction Science project is expected to develop an integrated environmental prediction system to represent the physical, chemical, and biological characteristics of terrestrial and aquatic environments. The project expands the traditional use of numerical weather prediction models and includes more sophisticated approaches to address hydrology, the land-surface, urban environments, lakes, oceans, waves and ice. The system will integrate all available observations on the state of the environment based on results provided by MSC's numerical models.

2.3 Governance and Management

The Weather Observations, Forecasts and Warnings Program contributes to the department's strategic outcome: "Canadians are equipped to make informed decision on changing weather, water and climate conditions." Accountability for the program rests with the Assistant Deputy Minister (ADM), MSC; however, accountability for the delivery of the various activities rests with the four accountable Directors General (DGs) who are each responsible for their respective directorate (described under Section 2.2) within MSC.

Key program governance bodies include:

- The **DG Leads Committee** is the key horizontal committee which provides policy, planning, and performance advice to the three implicated ECCC ADMs (ADM MSC

[6] The other three Signature Projects relate to the METAREA initiative (under sub-program 2.2.2); Air Quality and Health Related Services (under sub-program 2.1.2); and Water and Climate Services (under sub-program 1.2.3 and 2.1.3).

(lead), ADM STB, and ADM CSB) related to the department's weather-related strategic outcome, including guidance and coordination of activities and addressing strategic policy issues.
- The Director-led **Public Weather Program Management Committee (PWPMC)** provides overall coordination and oversight specific to the Weather Observations, Forecasts and Warning Program to ensure the development of a consistent and collaborative approach to implementing program priorities and activities. The PWPMC is also an information sharing forum to bring forward issues related to the program and to identify synergies among internal partners.
- The **Meteorological and Environmental Predictions Innovation Committee (MEPIC)** was established to guide and align technology transfer between MSC and STB. It is chaired by the DG of the Canadian Centre for Meteorological and Environmental Prediction and the DG of ASTD and develops the strategic research and development priorities that are used to direct S&T activities to ensure they can support the weather program.

Other supporting and advisory committees include:
- The **Quality Management System (QMS) Steering Committee** provides senior management oversight and guidance for maintaining and strengthening the QMS. This committee also coordinates activities with SSC, as well as other key internal partners (e.g., STB, CSB).
- The **Business Continuity Planning (BCP) Steering Committee** sets the overall direction of the MSC BCP Program; ensures development, implementation and management of MSC BCP including regular testing; ensures appropriate critical support functions arrangements are in place; is responsible for on-going communications with staff; and participates in testing, exercises, training and awareness activities.
- The **MSC Information Management and Information Technology (IM-IT) Directors Committee** is the key horizontal committee which reviews and prioritizes all MSC IM-IT requirements and provides recommendations/advice to the DG Leads Committee. This Director committee is the key integrative forum for both the ongoing mission critical IM-IT requirements of MSC and the departmental planning process for IT resource allocation.

2.4 Resource Allocation

Table 1 below provides a summary of budget information by type of expenditure, while Table 2 below provides a summary of budget information by branch for the period from 2011-2012 to 2014-2015.

Budget 2011 provided $78.7M in funding to upgrade the parts of the monitoring network most critically in need of upgrades and that support the weather prediction process.[7] Building on this, Budget 2013 provided additional funding ($248M) beginning in 2013-14 (until 2022-23) to continue modernizing the monitoring infrastructure, including replacing the oldest radars and to modernize the weather and forecasting services (primarily

[7] Specifically, Budget 2011 provided funding to address the most immediate risks to the weather monitoring infrastructure and enable the continued ability to detect severe weather events. An additional $17.9M was provided to SSC for the extension of the supercomputing contract, which is now the responsibility of SSC since the fall 2011.

through the Signature Projects). These amounts are included in the budget amounts presented in the tables below.

Table 1: Weather Observations, Forecasts and Warnings Budget 2011-12 to 2014-15

All Branches	Budget			
	2011-12	2012-13	2013-14	2014-15
Salary	$69,875,670	$64,890,161	$72,468,818	$75,089,233
O&M	$52,227,731	$35,936,125	$33,283,254	$35,398,151
Capital	$11,663,808	$13,590,091	$19,854,130	$19,523,337
G&Cs[8]	$3,356,955	$15,967,570[9]	$3,684,879	$4,191,491
VNR Salary	$405,165	$485,980	$426,163	$336,874
VNR O&M	$1,436,259	$3,892,358	$3,899,373	$4,101,349
Grand Total	**$138,965,588**	**$134,762,285**	**$133,616,617**	**$138,640,435**

Source: ECCC's financial system.

Table 2: Distribution of Weather Observations, Forecasts and Warnings Budget by Branch – 2011-12 to 2014-15

Branch	Budget			
	2011-12	2012-13	2013-14	2014-15
Meteorological Services Canada	$87,256,267	$109,555,254	$105,115,184	$112,187,066
Corporate Services Branch	$36,067,501[10]	$13,330,976	$13,982,554	$13,989,751
Science and Technology Branch	$15,641,820	$11,876,055	$14,518,878	$12,463,618
Grand Total	**$138,965,588**	**$134,762,285**	**$133,616,617**	**$138,640,435**

Source: ECCC's financial system.

2.5 Expected Results

The logic model for the Weather Observations, Forecasts and Warnings Program is presented in Annex 2. The expected outcomes used to assess the performance of the program are presented below:

Immediate outcomes

- Users are satisfied with the accuracy, timeliness, geographic precision, reliability and access of EC's public weather and environmental services

[8] Includes assessed contributions to the WMO and G&Cs under the umbrella contribution program "Weather and Environmental Services for Canadians."
[9] The G&C figure for 2012-13 includes two projects funded through the Fast-Start Financing Initiative with a value of approximately $12.6M. Under the Copenhagen Accord, Canada delivered a total of $1.2 billion in new and additional fast-start financing, targeting three priority areas: (1) adaptation by the poorest and the most vulnerable countries; (2) clean energy; and (3) forests and agriculture.
[10] This includes IT-related resources, which were transferred to SSC upon its creation in 2012.

- Continued access to meteorological data from other countries
- Meteorological research addresses issues affecting Canadian interests and priorities

Intermediate outcome
- Understanding EC's weather and environmental products

Final outcome
- Use of EC's weather and environmental services [to make sound decisions which contribute to mitigating negative environmental, economic, social and health impacts][11]

3.0 Evaluation Design

3.1 Evaluation Scope

In accordance with the 2009 Treasury Board *Policy on Evaluation*, the evaluation addresses the issues of relevance and performance (including effectiveness, efficiency and economy) of the Weather Observations, Forecasts and Warnings Program.

The evaluation covered the period from April 1, 2011 to March 31, 2015 and includes all components of the program.

3.2 Evaluation Approach and Methodology

The methodological approach and level of effort for this evaluation were determined using a risk-based approach. The following data collection methodologies were developed to adequately address the evaluation issues and questions. Evidence gathered was then used to develop overall findings and conclusions.

Document Review

The document review involved reviewing key secondary materials to capture documented evidence related to the core evaluation issues. Key documents were gathered, listed in an inventory and then each document was assessed in terms of its contribution to each of the evaluation questions and corresponding indicators. A document review template was used to organize the review and capture the information. Documents included: descriptive program information on priorities, governance structure and processes; Government of Canada and Departmental publications (e.g., Speech from the Throne, Departmental Performance Reports); and other internal financial, performance and administrative documents.

This data collection method addressed all evaluation questions.[12]

[11] The evaluation added the text in brackets to the final outcome in order to explore different dimensions of the impact of using ECCC's weather and environmental services. Please refer to Section 3.3 for more details.

[12] Evaluation issues examined are identified in Annex 1.

Key Informant Interviews
In total, 38 key informant interviews were conducted in person or by telephone, to gather detailed information related to the evaluation questions and issues. Interviews were conducted either by telephone or in-person using a semi-structured interview guide tailored to the specific respondent group. All relevant stakeholder perspectives were considered, including through interviews with: program staff and management (n=15); internal ECCC partners and stakeholders (n=3); federal partners and stakeholders (n=4); provincial/territorial stakeholders (n=8); industry/media stakeholders (n=4); and international stakeholders (n=4).

The evaluation methodology provided a balance of internal and external perspectives on the program's performance, as approximately 60% of interviewees were not directly accountable for the program's delivery and approximately 53% were external to the Department.

This data collection method addressed evaluation questions 1, 4, 5, 6, 7 and 8.

Literature Review
A review of literature, including grey and published literature sources, was conducted on a key selection of the most relevant texts, including documents about comparable programs in similar jurisdictions and other relevant studies (e.g., related to the ongoing need for the program). About 10-15 key sources (articles) were reviewed. A total of 3 key informant interviews were also conducted to fill in gaps and clarify various aspects of the public weather programs in their respective countries.

A review template was used to gather and record the information. The information was then organized in a matrix by evaluation issue, such that the evidence from the various sources could be easily compiled for the analysis stage.

This data collection method addressed evaluation questions 4 and 6.

G&C File Review
A review of a sample of 28 out of a total of 52 program G&Cs project files was completed to examine project activities, outputs, outcomes and lessons learned in more depth. All relevant project documentation within each file was reviewed, including the funding application, contribution agreement, progress reports, and final reports. To be broadly representative of G&Cs activity during the time period, the sample was selected to ensure it reflected a range of project values, fiscal years, types of activity (e.g., international initiative/membership, research, training), and types of funding recipient (e.g., academic institution, international organization). To ensure the file review was structured and captured all the information from the project files pertinent to the evaluation, a data capture template was created.

This data collection method addressed evaluation questions 4, 6, 7 and 8.

Case Studies
Case studies, as an evaluation methodology, combine various sources of information to provide illustrations and examples of selected activities or components of a program. Two case studies were undertaken as part of the evaluation. The first examined the

Pacific Storm Prediction Centre (PSPC), located in Vancouver, British Columbia with the objective to obtain a regional perspective on emerging weather issues, as well as regional challenges related to providing weather and environmental services. The second case study examined the emerging issue of impact-based forecasting[13] with the objective to gain a better understanding of the advantages and challenges of this new approach, as well as the activities that are underway within MSC that focus on impact-based forecasting. Data collection for each case study involved a review of relevant documents and key informant interviews (n=3-4 for each case study). Case study interviews were in addition to the key informant interviews described above.

This data collection method addressed evaluation questions 4, 6 and 8.

3.3 Limitations

No significant methodological limitations were identified as part of the evaluation. The evaluation was able to gather all required documentation and interview all key stakeholders, as part of the document review, file review, literature review, key informant interviews and case studies. Although a survey of users was not undertaken, the evaluation was able to rely on public opinion research (POR) conducted on behalf of the program by independent public opinion and market research firms.

4.0 Findings

This section presents the findings of this evaluation by evaluation issue (relevance and performance) and by the related evaluation questions. For each evaluation question, a rating is provided based on a judgment of the evaluation findings. The rating statements and their significance are outlined below in **Table 3**. A summary of ratings for the evaluation issues and questions is presented in **Annex 1.**

Table 3: Definitions of Standard Rating Statements

Statement	Definition
Acceptable	The program has demonstrated that it has met the expectations with respect to the issue area.
Opportunity for Improvement	The program has demonstrated that it has made adequate progress to meet the expectations with respect to the issue area, but continued improvement can still be made.
Attention Required	The program has not demonstrated that it has made adequate progress to meet the expectations with respect to the issue area and attention is needed on a priority basis.
Not applicable	There is no expectation that the program would have addressed the evaluation issue.

[13] According to WMO Guidelines, the fundamental distinction between a general weather warning and an impact-based warning is the consideration of the vulnerability of human people, livelihood and property to the hydro-meteorological hazard in question. Migrating to an impact-based paradigm involves a number of complex factors. For example, a heat warning under a general weather warning framework is triggered by a value exceeding a certain combination of temperature and relative humidity. In an impact-based warning framework, the issuance of a heat warning is driven not only by physical measurements, but also in consideration of the locations and timing of the weather event if these affect human vulnerabilities.

Unable to assess	Insufficient evidence is available to support a rating.

4.1 Relevance

Continued Need for Program

Evaluation Issue: Relevance	Rating
1. Is there a continued need to provide weather observations, forecasts and warnings?	Acceptable

There is a continued environmental and societal need for the provision of weather observations, forecasts and warnings. Given that severe weather, noted to be increasing, has significant human and economic consequences, information regarding what weather is anticipated to occur is important for related planning, decision-making and mitigation of the negative effects.

- Available documentation and literature indicates that severe weather activity is increasing in Canada and globally. Weather events such as floods, storms and droughts that used to happen once every 40 years are now happening once every six years in some regions in the country.[14] Canada is predicted to experience an increase in average temperatures of 0.5 to 2 degrees Celsius by 2020 and 2 to 4 degrees Celsius by 2050.[15] Higher summer and spring temperature are linked to increased heat and humidex advisories, as well as heavy rain and snowfall.[16]

- Severe weather has significant human and economic consequences.
  - According to data contained in the Canadian Disaster Database, maintained by Public Safety Canada, between 2011 and 2015 there were a total of 46 significant meteorological-related disasters in Canada, which amounted to approximately $5.9B in damages, and required the evacuation of over 150,000 people.[17]
  - According to the Insurance Bureau of Canada, the economic cost of the Southern Alberta and Toronto floods in June and July of 2013 were estimated to be around $7 billion and insurance companies paid out approximately $3.2 billion.[18] Government expenditures related to severe weather events also increased 280% in the first six months of 2013-2014.[19]
  - Southern Alberta flooding the month of July 2013 showed approximately 5.1 million hours of work lost, resulting in $485 million of lost economic output by the private sector, even when accounting for the additional work from relief efforts.[20]

[14] The Institute for Catastrophic Loss Reduction for Insurance Bureau of Canada Telling the Weather Story, 2012. http://assets.ibc.ca/Documents/Studies/McBean_Report.pdf.
[15] Feltmate, B., & Thistlethwaite, J. (2013). *Climate Change Adaptation: A Priorities Plan for Canada.* University of Waterloo.
[16] *Ibid.*
[17] Canadian Disaster Database, maintained by Public Safety Canada: http://www.publicsafety.gc.ca/cnt/rsrcs/cndn-dsstr-dtbs/index-eng.aspx.
[18] Reports from Abroad, Resilience to Extreme Weather: a Canadian Perspective. The Royal Society of Canada, the Academics of Arts, Humanities and Sciences of Canada. http://www.rsc.ca/en/report-from-abroad-resilience-to-extreme-weather
[19] *Ibid.*
[20] Impact of Southern Alberta Flooding on Hours Worked and GDP, Alberta Government, September 6, 2013.

- Improving weather and climate forecasting not only decreases the cost of weather- and climate-related damages on society, but also provides better information to the public.[21] Early warnings of weather hazards are useful to take timely action to protect lives and property and are a basic component of any disaster risk reduction strategy. A 2011 study on the cost and benefits of Early Warning Systems indicated that warning systems not only allow optimum time for action, but also help to refine a priori the decisions which need to be made when the warnings are issued.[22]

- All international stakeholders interviewed for the evaluation feel that there is a continued need for Canada's contribution and involvement in international meteorological organizations, including contributing and exchanging data globally to support forecasting internationally.

- Although ECCC is technically the only weather service in Canada with the mandate to issue warnings, most external stakeholders see similarities among Canadian weather information providers. However, most indicated that ECCC's forecasts were more accurate and that other sources were simply complementary to what ECCC provides. A few interviewees also noted that some services use ECCC observational data.

Alignment with Federal Government Priorities

Evaluation Issue: Relevance	Rating
2. Are the Weather Observations, Forecasts and Warnings Program aligned with federal government priorities?	Acceptable

Evidence indicates that the program is aligned with federal government priorities related to the economy, public safety, and the environment.

- Documentary evidence indicates that ECCC's weather and environmental services are consistent with federal priorities, such as those related to the economy, public safety, and the environment.
  - Canada's Economic Action Plan 2011, under 'Protecting Canada's Natural Environment, Improving Canada's Weather Services' states that "Accurate and timely forecasts and warnings are critical to the functioning of the Canadian economy, where businesses in many industries, including agriculture, tourism, transportation and forestry, are directly affected by weather conditions."[23] Budget 2011 provides $96.6 million over five years to improve Canada's weather services.
  - Similarly, in Canada's Economic Action Plan 2013, under 'Strengthening Canada's Meteorological Services', $248 million over five years was allocated to revitalize Canada's weather services to provide up-to date information about the

[21] Ray. A. Williamson, H.R. Hertzfeld and J. Cordes., the Socio-Economic Value of Improved Weather and Climate Information. Space Policy Institute. The George Washington University - Washington, DC 20052, December 2002
[22] Rogers. D and V. Tsirkunov., Global Assessment Report on Disaster Risk Reduction: Cost and Benefits of Early warning Systems 2010.
[23] http://actionplan.gc.ca/en/initiative/strengthening-canadas-meteorological-services.

weather which is vital for protecting the health, safety, security and economic well-being of individuals and communities.[24]

- One of the targets of Canada's 2013 Federal Sustainable Development Strategy is to mitigate the impacts of, or prevent, environmental disasters, incidents and emergencies which includes providing "environmental and/or other information to reduce the risk of, and advice in response to, the occurrence of events such as polluting incidents, wildlife disease events or severe weather and other significant hydro-meteorological events as applicable."[25]

Consistency with Federal Roles and Responsibilities

Evaluation Issue: Relevance	Rating
3. Are the Weather Observations, Forecasts and Warnings Program consistent with federal/departmental roles and responsibilities?	Acceptable

The program is consistent with federal/departmental roles and responsibilities related to the provision of weather and environmental services as outlined in relevant legislation. The program also supports Canada's commitments under the Convention of the World Meteorological Organization.

- ECCC's Weather Observations, Forecasts and Warnings program is consistent with departmental roles and responsibilities, as described by the *Department of the Environment Act*, which states that the powers, duties and functions of the Minister of the Environment extend to matters such as meteorology.
- In addition, the program supports the *Weather Modification Information Act*, which includes any activity intended to change the atmosphere in order to artificially influence weather conditions. The *Weather Modification Information Act* allows the federal government to set requirements for reporting such activities.
- The program also supports the *Emergency Management Act* through the provision of weather forecasts and warnings, atmospheric and hydrologic trajectory and dispersion modeling, and other hydro-meteorological related services (e.g., ice and iceberg charts). ECCC is the lead department related to the Environment Emergency Support Function under the Act, which encompasses the provision of environmental information and advice in response to emergencies related to severe weather and other significant hydro-meteorological events.[26]
- In the international arena, the program supports Canada's commitments as a member country under the *Convention of the World Meteorological Organization*. Canada has been a member of WMO since 1950 and the ADM, MSC currently serves as president of the organization.

[24] http://www.budget.gc.ca/2013/doc/plan/chap3-3-eng.html.
[25] Environment Canada. Planning for a Sustainable Future: A Federal Sustainable Development Strategy for Canada. Pg. 66.
[26] http://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/mrgnc-rspns-pln/index-eng.aspx.

4.2 Performance – Economy and Efficiency

Program Design

Evaluation Issue: Performance - Efficiency & Economy	Rating
4. Is the design of the Weather Observations, Forecasts and Warnings Program appropriate for achieving its intended outcomes?	Acceptable

The design of the program is appropriate, and the program continues its renewal agenda intended to improve weather services. Evidence also indicates that activities are underway to support impact-based forecasting.

- MSC delivers weather and environmental services through integrated functions of environmental monitoring, science, operations, services and policy. MSC maintains a Canada-wide observation network to monitor changes in the weather, climate, water, ice and air quality and to obtain the data which is the foundation of weather and environmental prediction.

- Most internal interviewees indicated that the program is optimally designed and is broadly implemented as planned. A majority of internal interviewees, as well as documentary evidence, also indicated that the nature and level of investments in priority areas such as the Signature Projects are generally appropriate and on-track.
  - Most interviewees noted that the components of the current program design (i.e., monitoring, prediction, and service delivery) are necessary for achieving the program's objectives. As well, MSC has developed a 10-year investment plan in these three components on a scale necessary for a sustainable platform. A few interviewees also indicated that although the program design, including the recent restructuring of the organization, is thought to be optimal, it will take time to determine the overall success of the renewal agenda.
  - Documentary evidence suggests a number of ways in which the program is adjusting its design and exploring new models to improve performance. Current renewal efforts include: five Signature Projects related to the Weather Observations, Forecasts and Warnings program; MSC's internal re-organization; MSC's 2013-16 People Plan;[27] and new investments for overall capital infrastructure renewal and modernization (stemming from Budget 2011 and 2013 commitments). In addition, MSC introduced a new Service Strategy in 2015, which is intended to guide program decision making at all levels by providing clarity on the service goals of the weather and environmental services programs.

- Accurate and timely weather forecasts are increasingly considered a necessary, but not the only prerequisite to prevent or mitigate human weather-related casualties, damage to and loss of property, and economic disruption. Impact-based forecasting represents a paradigm shift in service delivery. This paradigm shift requires that

[27] A vital focus of the plan is to ensure that the MSC, as the center of Canada's meteorological expertise, continues to attract and retain a competent, highly skilled, and specialized workforce that is committed to continuous learning.

national meteorological services engage with partners to understand their needs, decision-making processes and vulnerabilities. In this way, they are better able to predict the impacts of weather-events, thus better equipping users to take appropriate steps to mitigate negative consequences.

- At ECCC, several activities are underway that support an impact-based forecasting approach. The approach is relatively new, however, and few studies exist on promising practices or the effectiveness of impact-based forecasting in supporting decision-making.
  - The warning system for high-impact weather is undergoing a major overhaul under the Re-engineering the Weather Warning and Service Delivery System Signature Project, intended to improve the quality and reach of weather alerts, as well as provide better decision-making advice and support to users. As part of this project, in November 2013, the Pacific and Quebec regions undertook the V-Nix[28] pilot project. The pilot project goals were to understand how meteorological information influences decisions related to selected activities; to understand audience-specific information needs for improved decision making; and to understand the range of potential consequences of weather events in different economic sectors. According to a report on the pilot, by connecting with users, establishing relationships and increasing our awareness, V-Nix demonstrably helped clients make better decisions.

- Twice each year (in January and June) a QMS External Surveillance Audit is conducted. Furthermore, each year, internal QMS audits are conducted of specific QMS processes (e.g., prediction, services, monitoring, R&D projects) at selected locations (between 6 and 19 in the years examined by the evaluation). Corrective and preventive actions and opportunities for improvement are documented.

Program Governance

Evaluation Issue: Performance - Efficiency & Economy	Rating
5. To what extent is the governance structure clear, appropriate and effective for achieving expected results?	Acceptable

Overall, the program's governance structure is clear, appropriate and effective. Recent restructuring has led to some issues related to IT resources, though mitigation strategies are now in place to address them.

- Representatives from CSB, STB and SSC participate in the horizontal DG Leads Committee, as well as various other horizontal committees that have been established where all three branches participate to ensure collaboration takes place. These include the PWPMC, the MEPIC, the MSC IM-IT Directors Committee, the QMS Steering Committee, as well as the BCP Steering Committee.[29]

- A majority of internal interviewees feel that, overall, program governance is clear, appropriate and effective.

[28] This is an amalgamation of the Vigilance pilot project in Quebec and the Phoenix pilot project in the West and North Region.
[29] These committees were described earlier in Section 2.3.

  - Several internal interviewees noted the senior level DG Leads Committee that includes representatives from all functional areas within the program, as well as from MSC internal and external partners (STB, CSB and SSC) as an effective forum.
  - A few interviewees also noted that the recent restructuring of the organization is still in the process of implementation and has led to some growing pains (e.g., budget allocations, clarity of revised roles and responsibilities). These issues have been mitigated by the formal committee structures, the strong historical relationships among individuals who moved on to other organizations as part of recent and previous restructuring initiatives (e.g., STB, CSB, SSC), as well as the long-standing service delivered by the program.
  - Several internal interviewees also indicated the need to pay attention to the implementation of changes across the four function-based directorates as part of the recent reorganization, and ensure effective working relationships are in place. The cross-cutting boards (committees) were noted to be particularly important to permit and reinforce cross-functional interaction and to remain sensitive to regional weather-related information needs (e.g., avalanche information for British Columbia (B.C.)).

- Internal program interviewees were generally positive when asked about the issue of collaboration amongst the three ECCC branches involved in the delivery of the weather service (i.e., MSC, STB, CSB). Several respondents noted that there were established processes and a strong governance structure in place among the three branches to facilitate discussion and collaboration, as well as knowledge transfer.
  - For their part, representatives of ECCC partner branches feel they are sufficiently and appropriately engaged by the program to contribute and collaborate in an effective manner. Partners mentioned the benefit of the long-standing relationships with MSC, specifically the fact that many individuals within the ECCC partner branches had formerly worked in MSC. A portfolio manager within CSB is also dedicated to each departmental branch (including MSC) and coordinates requests for support from the branch.

- In 2012, a SSC IT Service Level Agreement was developed for MSC, which identifies specialized IT services provided by SSC required for MSC to fulfil its mandate. SSC coordinates activities related to MSC with the QMS Steering Committee (as they are part of the QMS certification).
  - With respect to the relationship with external partners (e.g., SSC), MSC interviewees noted the significant inefficiencies created for the program with the creation of SSC and the transfer of control of IT resources. Specifically, while support of SSC is seen as being adequate by some, especially as it pertains to supercomputing, this is largely owing to the presence of former MSC employees with SSC that are knowledgeable about and sensitive to the needs of the program. Others characterize the collaboration with SSC as uneven or poor, citing a lack of responsiveness and understanding of MSC needs, leading to delays and quality issues for products and services. Decision-making about services was mentioned not to be working well in some instances, although it is unclear if this continues to be an issue (e.g., the transfer of authority to pay the bill for the telecommunications lines to SSC resulted in one instance where

service from some weather stations was cut off as the bill was not paid on time).[30]

- A review of documentation showed that MSC has a formal QMS in place and has been certified to ISO standard. The QMS identifies the accountability of each DG with respect to their functional role, including the key contributors from STB, CSB and SSC, who are part of the certification.

Program Efficiency and Economy

Evaluation Issue: Performance - Efficiency & Economy	Rating
6. Are the Weather Observations, Forecasts and Warnings Program undertaking specific activities and delivering products at the lowest possible cost? How could the efficiency of the program's activities be improved? Are there alternative, more economical ways of delivering program outputs?	Acceptable

International comparisons with other weather services suggest that the program is undertaking activities and delivering products in an efficient manner. The low variance (2-3%) between budget amount and actual expenditures suggests that the program is being managed well. Challenges identified by key informants related to reporting burden, as well as delays in procurement.

- In general, internal key informants characterized the activities of the Weather program as being delivered in a largely efficient and cost-effective manner, with many key informants noting that Canada compares favourably to international benchmarks in terms of cost (e.g., more highly automated observing network, fewer meteorologists).
  - A review of the literature revealed that MSC appears to be economical, having comparable costs per gross domestic product and population in comparison to other jurisdictions (i.e., United States, United Kingdom and Australia), and the lowest delivery costs per area.

- When reflecting on factors that detract from the efficiency of the program, internal interviewees most often mentioned inefficiencies related to reporting burden (e.g., ISO certification reporting requirements), as well as delays in procurement.
- A few internal interviewees also indicated challenges inherent in managing the new investments. Specifically, these interviewees feel that project management of the additional investments that have been made in monitoring capital infrastructure has been weak because it is not adequately resourced and is being carried out on top of individuals' existing duties, though it is unclear what the consequences have been. A few internal interviewees suggested that one effective project management tool to address the project management issues is the Prince 2 tool, which was used for other MSC projects (e.g., METAREAs).

[30] OAG is presently completing an audit of SSC, scheduled to be tabled in fall 2015, examining the governance, client agreements, financial reporting and IT Security in place at SSC, and the integration of selected department resources. ECCC was consulted on the audit as an SSC partner.

- A review of available literature reveals a range of program models used by national governments which vary primarily according to the share of costs borne by government and the private sector. [31] Although information is not available on which delivery model delivers outcomes at the lowest cost, in each case the public weather services (distinct from services to targeted users such as aviation, defence, and marine) were fully funded by the national government.

- Table 4 below presents the budget and actual expenditures for the Weather Observations, Forecasts and Warnings program for the period 2011-12 and 2014-15. Although the analysis of financial data in not a major indicator of program efficiency, and should be examined in the context of other indicators of efficiency, it does provide some evidence regarding the extent to which a program is well managed. In this case, actual expenditures were within 2-3% of budget amounts for the program over this period, which suggests that the program is being managed well.
- The only significant variances between budgets and actual expenditures related to capital investments, primarily in monitoring infrastructure, in each of 2012-13 ($3,145,135), 2013-14 ($4,521,134) and 2014-15 ($4,310,984). Senior management confirmed that a decision was taken to carry forward capital funding,[32] in order to capitalize on technological investments anticipated in future years. [33]

Table 4: Weather Observations, Forecasts and Warnings Program Budget and Actual Expenditures for the Period 2011-12 to 2014-15 (in 000's)

	Budget $	Actuals $	Budget $	Actuals $	Budget $	Actuals $	Budget $	Actuals $
	2011-2012	2011-2012	2012-2013	2012-2013	2013-2014	2013-2014	2014-2015	2014-2015
MSC								
Salary	$49,680	$51,245	$52,642	$52,996	$59,242	$59,630	$60,882	$61,407
O&M	$25,735	$29,231	$30,689	$28,824	$26,740	$28,404	$28,930	$29,632
Capital	$7,987	$7,217	$9,319	$6,174	$14,873	$10,352	$17,267	$12,956
G&Cs	$2,977	$2,954	$15,638	$15,585	$3,312	$3,313	$3,893	$3,891
VNR Salary	$119	$115	$339	$268	$171	$189	$115	$113
VNR O&M	$758	$811	$927	$871	$777	$723	$1,101	$1,064
Total	**$87,256**	**$91,571**	**$109,555**	**$104,717**	**$105,115**	**$102,611**	**$112,187**	**$109,064**
Variance	-$4,315	(-4.9%)	$4,838	(4.4%)	$2,504	(2.4%)	*$3,123*	(2.3%)

[31] The United States places a strong emphasis on working with and supporting private sector weather/climate service providers, while the United Kingdom uses a commercial model, and operates its weather service primarily on a cost-recovery basis. The weather services in Australia and Canada share the most similarities having some level of cost recovery for programs outside the public weather service to help cover overall program costs.

[32] ECCC Financial records indicate that $4.2M was carried forward from 2012-13 to 2013-14, $3.7M was carried forward from 2013-14 to 2014-15, and approximately $6M was carried forward from 2014-15 to 2015-16.

[33] As per TBS guidance on determining Capital Budget Carry Forward (http://publiservice.tbs-sct.gc.ca/ems-sgd/publi/cbcf-rdbc/instr-direc-eng.asp), to promote efficient use of resources, departments are entitled to carry forward up to 20% of the adjusted year-end capital expenditures vote authorities to the following fiscal year ($14.3M in 2014-15). This flexibility was used, similar to the re-profiling of funds, to ensure that capital funds are not lapsed, but are available the following fiscal year.

	Budget $	Actuals $	Budget $	Actuals $	Budget $	Actuals $	Budget $	Actuals $
	2011-2012	2011-2012	2012-2013	2012-2013	2013-2014	2013-2014	2014-2015	2014-2015
STB								
Salary	$12,190	$11,677	$8,368	$8,157	$9,102	$8,553	$8,925	$8,949
O&M	$2,099	$2,070	$1,962	$1,588	$2,320	$2,232	$1,905	$2,086
Capital	$508	$525	$867	$1,235	$2,055	$1,830	$748	$735
G&Cs	$380	$380	$329	$329	$373	$373	$298	$298
VNR Salary	$286	$286	$147	$147	$255	$251	$222	$222
VNR O&M	$178	$168	$204	$178	$414	$390	$366	$368
Total	**$15,642**	**$15,106**	**$11,876**	**$11,634**	**$14,519**	**$13,629**	**$12,464**	**$12,646**
Variance	$536	(3.4%)	$242	(2%)	$890	(6.1%)	-$194	(-1.6%)
CSB[34]								
Salary	$8,005	$7,969	$3,880	$4,478	$4,125	$4,219	$5,283	$4,081
O&M	$24,394	$24,486	$3,285	$3,872	$4,224	$4,286	$4,564	$4,265
Capital	$3,169	$2,361	$3,404	$3,764	$2,926	$2,189	$1,508	$1,491
G&Cs	-	-	-	-	-	-	-	-
VNR Salary	-	-	-	-	-	-	-	-
VNR O&M	$500	$490	$2,762	$2,766	$2,708	$2,792	$2,635	$2,494
Total	**$36,068**	**$35,307**	**$13,331**	**$14,880**	**$13,983**	**$13,486**	**$13,990**	**$12,332**
Variance	$761	(2.1%)	$1,549	(11.2%)	$496	(3.5%)	$1,658	(8.8%)
Totals	$138,966	$141,984	$134,762	$131,230	$133,617	$129,726	$138,640	$134,053
Variance	-$3,018	(2.1%)	$3,532	(2.6%)	$3,891	(2.9%)	$4,587	(3.3%)

Source: ECCC's financial system.

Performance Measurement

Evaluation Issue: Performance – Efficiency & Economy	Rating
7. Are performance data being collected and reported? If so, is this information being used to inform senior management/ decision-makers?	Opportunity for Improvement

Although the program has a logic model and collects performance data, performance indicators and targets are either not identified for, or aligned to, most intended outcomes. In addition, the program's intended outcomes may not be fully reflected by the current logic model, as they focus more on satisfaction, awareness and use of weather and environmental services, rather than the impacts the use of these services is expected to achieve. Key informants indicate that performance information is being used for decision-making.

[34] As mentioned previously in Section 2.4, the budget and actual expenditure amounts include IT-related resources, which were transferred to SSC upon its creation in 2012.

- The program has a logic model and does collect various performance data (described in further detail below and Section 4.3), although most of the program's intended outcomes do not have specific performance indicators or targets identified. The performance data collected, therefore, are not necessarily aligned to the intended outcomes in the logic model. This limits the program's ability to report on the extent to which it is achieving its intended outcomes.
- In addition, documentary evidence suggests the program's intended outcomes may not be fully reflected by the current logic model, which focusses on satisfaction, awareness and use of weather and environmental services, rather than the aspirational program goals toward which the use of these services is expected to contribute. In particular, corporate descriptions of this sub-program suggest the program's purpose is to provide weather and environmental services "to help Canadians to anticipate dangerous meteorological events in order to protect themselves and their property."[35]

- A great deal of performance data is being collected by the program. For example:
  - As part of the Canadian Environmental Sustainability Indicators (CESI), a Weather Warning Index was created to track the performance of ECCC's severe weather warning system in providing warnings far enough in advance of the event for Canadians to act.
  - The program also collects data related to its various tools for dissemination of weather-related information, including the number of visits to ECCC's weather office website, the number of phone calls to MSC's 1-900 weather consultation service, and the number of media calls.
  - Performance information is also collected through POR studies and reported against the Departmental PMF focusing on one specific indicator: the percentage of the population who report that they are "somewhat" or "very likely" to access weather information during a typical day. To date, MSC was able to commission two POR studies during the period covered by the evaluation, targeting the general public and media to capture overall satisfaction with weather and environmental services, as well as specific products (e.g., Weatheroffice website, Weatheradio Canada).
  - The program records feedback from general public and client calls to the National Inquiry Response Team (NIRT), and prepares reports when a corrective or preventive action is needed.
  - In 2013-14, MSC published the Performance in Brief, a publication on the accuracy of temperature forecasts; snowfall and rainfall warnings.
  - Some internal interviewees noted that the collection of certain types of performance data and review processes are also driven in part by ISO certification requirements. The program's QMS therefore has numerous metrics related to business performance (i.e., key performance indicators and detailed metrics for each of the business processes, such as prediction).

- Internal interviewees cited various challenges to data collection. For instance, issues with quality assurance of data produced by the weather monitoring network are flagged automatically but analysis and correction of these data is a manual, time

[35] Environment Canada. Environment Canada Program Alignment Architecture Program Descriptions for 2014-15.

consuming process. A few interviewees feel that feedback on services is hampered somewhat by federal policy restrictions, which limit the ability to commission POR studies, although the program has used online tools (e.g., web-based pop-up surveys) and calls to the NIRT to generate data. The accuracy of forecasts and warnings also suffers as a result of the absence of clear standards on how to interpret and code certain data (e.g., if a tornado warning is issued for Ottawa, but it occurred in Gatineau, is that a hit or a miss; if a temperature forecast is accurate for the Vancouver airport, but not for downtown, how is this to be assessed).

- Internal interviewees noted a number of ways in which performance data is used by senior management to determine, for example, to support program funding requests, to inform management of the effectiveness of the monitoring network and prediction models (e.g., with respect to the reliability of radar network, reports indicate when a station is down or when data is inaccurate, which then triggers required maintenance, accuracy and timeliness of forecasts, watches and warnings), and to report quarterly data on the timeliness and accuracy of various predictions.

4.3 Performance – Effectiveness

Evaluation Issue: Performance - Effectiveness	Rating
8. To what extent have intended outcomes been achieved as a result of the Weather Observations, Forecasts and Warnings Program?	Acceptable

Overall, the evidence indicates that the program is on track to achieve most of its outcomes. Key external factors influencing the achievement of outcomes relate to evolving client expectations (e.g., social media), government-wide restructuring (e.g., SSC), and federal government policy related to communication.

(i) Immediate outcome 1: Acceptable
Users are satisfied with the accuracy, timeliness, geographic precision, reliability and access of EC's public weather and environmental services

Weather information is being used and users are generally satisfied with the accuracy, timeliness, geographic precision, reliability and access of ECCC's public weather and environmental services. Dissemination of information through social media is progressing.

- The reasons for external users' access to ECCC services and information include emergency preparedness and response and search and rescue operations, commercial decision-making (opening and closing roads) and shipping route decision-making, resource planning (snow removal equipment), and hydrological/environmental research. Almost all users interviewed access ECCC weather information at least daily, and often more frequently (i.e., to update every news cycle), and users with specific responsibilities related to emergency management essentially had a continuous link to ECCC services during an emergency or a weather event. Although some external users interviewed access national data (e.g., federal emergency management), users tended to focus on their

own region and those neighbouring regions from which their weather events originate.
- External users most often indicated that they use online forecasts, watches and warnings and/or ECCC Alert Me.

- Most provincial/territorial and industry/media stakeholders supplement what they saw as ECCC's more accurate data with corroborating data from other sources (which were noted to also use ECCC observational data), such as independent stand-alone weather information systems used for highway monitoring in the north, as the National Oceanic and Atmospheric Administration (NOAA), the Weather Channel, and the Weather Network. These users believe more data drives a more accurate forecast. They indicated that they anticipate the accuracy and modelling coming from ECCC to continue to improve as technology improves, leading to even greater reliance on the program.

- ECCC's weather office website has seen large increases in the number of visits each year since 2001, with more than half a million annual visits to the site each year since 2009.

- Most external stakeholders were happy with the accessibility of ECCC weather services. The most oft-mentioned positive assessment of ECCC accessibility focussed on personal access to meteorologists, which is thought to be an excellent and responsive personal resource for some specialized client groups, such as emergency response organizations and the media. Some challenges related to accessibility focussed on specific data: historical and other weather data was described as being difficult to access or poorly organized for news organizations' usage (i.e., merging data from different weather stations) and snowfall measurement was seen to be slow and inaccurate because ECCC measures melt.
- Almost all external users and all international stakeholders interviewed indicated they are satisfied or very satisfied with the accuracy, timeliness, geographic precision, and reliability of weather services.

- Studies conducted in 2012 reveal high levels of satisfaction with all weather services:
  - 93% of Canadians who are familiar with ECCC's weather services report that they are "mostly" (68%) or "completely satisfied" (25%) with these services, and more than three-in-four report that these services completely (23%) or mostly (55%) meet their needs. [36]
  - With respect to weather warnings, approximately 60% of respondents indicated that they were provided with all the information they needed, and almost eight in ten (78 per cent) believe warnings give them sufficient notice always (23 per cent) or most of the time (55 per cent).
  - Approximately 93% of Weatheradio Canada users are mostly or completely satisfied with this service. Similarly, most Canadians (90%) who have used Weatheroffice are satisfied with the service.

[36] Harris Decima. National Weather and Environmental Services Survey 2012.

- An online survey of MSC media clients found that 94 per cent of media website users and 87 per cent toll-free national weather line users are overwhelmingly satisfied.[37]

- Half of internal interviewees and external users who identified issues related to weather services pointed to challenges with the dissemination of information, including the organization's lack of a social media presence, including mobile device applications, which is felt to be a barrier to meeting the needs of users. Specifically, almost a quarter of Canadians (24%) are interested in receiving weather information via Facebook, while one-in-ten are interested in receiving information from Twitter (7%) or YouTube (11%). These results are higher among younger respondents.[38]

- A few internal interviewees noted that work was currently being undertaken on an ECCC social media presence as part of the 2015 Service Strategy, as an absence from social media creates a risk that MSC's messages will be seen as less relevant and less authoritative compared to other national weather providers. Central policies pertaining to communications (e.g., the need to have a common government-wide website interface, the approvals process related to mobile apps, as well as the approval process for tweets), however, have hampered efforts to engage users effectively through social media, the web-site and mobile apps. A few others also question the value of an ECCC weather app for mobile devices, as this may duplicate what private sector partners are already providing.
  - It should be noted that on July 14th, 2015 ECCC also announced that weather alerts will now be available on Twitter for 800 communities across Canada, as part of the ECCC Alert Me[39] initiative. The new service means weather warnings will automatically be tweeted out and appear in the Twitter feed of subscribers, with a link back to the local weather page (on the ECCC Weatheroffice website). Tweets will also include a hashtag to report severe weather.

(ii) Immediate outcome 2: Acceptable

Continued access to meteorological data from other countries

Through financial support and active membership in international for a (e.g., WMO and GEO), the program is collaborating with international partners/organizations , to ensure free and open access to meteorological research and data in order to improve the accuracy of weather forecasts and increase program effectiveness.

- Canada has been a member of WMO since 1950 and the ADM, MSC currently serves as president of the organization.
  - Many internal interviewees noted that ECCC's involvement with WMO stakeholders is important to Canada because access to global meteorological data on a real-time basis allows ECCC to predict the weather beyond one or two days. Additionally, participating in WMO activities gives ECCC access to global

[37] Brotton, J. (2013). Media Clients Survey 2012: Final Report of Findings.
[38] Harris Decima. National Weather and Environmental Services Survey 2012.
[39] The "ECCC Alert me" system, a national public alerting system, was developed by ECCC to address a recommendation stemming from the December 2008 Office of the Auditor General report on managing severe weather warnings. Prior to implementing Twitter alerts, ECCC provided email alerts to emergency management organizations and the public.

meteorological research which would otherwise be prohibitively expensive to undertake.
  - The review of G& files revealed that 18% (n=5) of projects sampled involved continued access to meteorological data from other countries, namely Canada's annual contribution to the international organization (i.e., membership fees), as well as multi-lateral projects through the WMO.

- Canada is also an active participant in the Group on Earth Observations (GEO). According to documentation, Canada's participation in GEO helps to ensure open and shared access to critical earth observation data, especially from satellites. Canada also engages in extensive bilateral partnerships with US agencies, China, UK, Australia and Germany among others to foster operational improvements and coordinate, collaborate and share scientific and technological advances.
  - Canada is also able to exert influence over international GEO priorities and data access policies, as well as access an immense volume of earth observation data and scientific expertise.

- All internal interviewees indicated that Canada's access to meteorological data from other countries is good or very good. A minority of interviewees specifically referred to the WMO policy for the free and open exchange of data and noted that Canada is an active contributor and huge beneficiary of that global meteorological data set.
  - There was a consensus across internal interviewees who feel that the collaboration with other countries and the WMO on aspects of weather monitoring, forecasting and warnings occurs regularly and is very beneficial for the program. Key informants mentioned several examples of sharing of best practices (e.g., colour coded weather warning system, impact-based forecasting, stakeholder engagement, product design) and technical expertise (e.g., partnership with Germany in the development of the NinJo weather workstation software, coordination and testing of satellite communications system for remote data acquisition).
- International stakeholders noted that the profile of Canada at WMO has facilitated program visibility and increased international alliances, which internal interviewees consider to be an important contributor to program effectiveness. Canada has been able to share and exchange data for global models, advance common goals of the WMO, and participate in forecast support for events such as the 2015 Pan Am Games.

(iii) Immediate outcome 3: Acceptable
Meteorological research addresses issues affecting Canadian interests and priorities

The program is pursuing meteorological research that is aligned to program priorities and user needs, thereby increasing the utility of weather-related products and services.

- The review of G&C files revealed that 93% of projects (n=26) reviewed involved meteorological research addressing issues affecting Canadian interests, with the remaining two assessed contributions being in support of membership to international organizations. Examples include improving hydrological information and

data assimilation, improving radar data observation and assimilation, and tools related to snow avalanche hazards and risk assessment.

- MSC is also implementing the Environmental Prediction Science Signature Project, which has expanded the traditional use of Numerical Weather Prediction models and includes more sophisticated approaches to capture information related to hydrology, the land-surface, urban environments, lakes, oceans, waves and ice.
  - The complex representation of the links between these components dramatically widens the number of useful predicted environmental variables, therefore increasing the utility of operational products in a variety of applications related to environmental emergency response, marine forecasts, management of agriculture and forestry, management of water levels, the preservation of ecosystems, as well as maintaining availability and quality of water.

- The majority of interviewees indicated that meteorological research is aligned with ECCC internal user needs and are driven by program priorities. A few interviewees also feel the program is a model for priority setting and knowledge transfer through various committee structures (see Section 4.2.2). A minority of interviewees, however, feel there is no effective analysis of user needs, priority setting and planning when it comes to STB delivered research.
  - It should be noted that MSC was fully involved in the development of ECCC's *Science Strategy (2014-19)* which included a focus on science related to developing new monitoring and modeling systems and tools, as well as improving existing systems, in order to support early warnings about changing weather. Specifically, this research is intended to support the development and operation of monitoring and modelling systems and tools in order to improve prediction and forecasting of weather, climate and other environmental systems, and to provide high quality, science-based tools and services to Canadians, policy-makers and targeted economic sectors.

(iv) Intermediate outcome 1: Unable to assess

Understanding Environment Canada's weather and environmental products

Methodological and other limitations mean that there is insufficient information to assess the extent to which target audiences understand weather and environmental products. Some qualitative evidence suggests there may be less understanding related to more highly specialized weather products and services.

Although evidence presented as part of the discussion related to immediate outcome 1 clearly demonstrates that users access and use weather and environmental services, limitations of the current evaluation methodology and resources has meant that direct evidence of users' understanding of ECCC's weather and environmental services was not available for the current evaluation.

- A few external users noted specific ECCC weather information or services that were not well-used or understood by their organization, including jetstream data (not seen to have an impact), and one user noted there were some graphs and forecasts that might be used if they were given instructions or more information about what data are available.

- A few internal interviewees noted that the general public does not always have the knowledge to understand the information. There is an ongoing issue of identifying what should be communicated, as there is much more data available than is released.

(v) Final outcome 1: Acceptable
Use of Environment Canada's weather and environmental services [to make sound decisions which contribute to mitigating negative environmental, economic, social and health impacts]

The evaluation found evidence that ECCC's weather and environmental services are being used to support decision-making related to public safety/emergency and economic planning in order to mitigate social and economic harm due to weather conditions. It is too early to conclude on the contribution these services have had on mitigating negative social and economic effects.

- Although ECCC lacks information to confirm how weather and environmental services are used, internal interviewees overwhelmingly feel that weather information is used by the public, industry and other stakeholders (e.g., organizers of outdoor sporting events) to support decisions related to avoiding or mitigating the harmful health or property effects of weather and climate conditions.

- These views were confirmed by most external users, who indicated that program data was used to support operational decision-making related to such things as weather event mitigation and emergency planning, staff and resource planning, and commercial freight routing. Several external users also indicated that ECCC weather information contributed to cost savings for their organizations.
- The case studies highlight a few specific examples of weather and environmental services being used to support decision-making:
  - In B.C.-Yukon, the vast mountainous areas and complex coastline create difficult and quick-changing weather conditions that lead to risks for people and the environment. Forecasts, alerts and other weather information are key data in helping individuals and decision-makers to prevent harm caused by weather conditions, by taking actions related to opening and closing roads and shipping routes, resource planning, providing avalanche warnings, etc.
  - Another example concerns PSPC's contribution to avalanche management. Avalanche Canada[40] uses PSPC information (and other information) to assess risks of avalanches, as they are a major threat in B.C. and Yukon.[41] Based on information from the PSPC, the centre's forecasters can predict how the snow and avalanche conditions are going to change and whether the snowpack is strengthening or weakening. According to an Avalanche Canada representative,

[40] According to its website, Avalanche Canada is a non-government, not-for-profit organization dedicated to public avalanche safety. It issues daily avalanche forecasts throughout the winter for mountainous regions of western Canada. It also coordinates and delivers avalanche awareness and education.http://old.avalanche.ca/cac/library/avalanche-accidents.
[41] According to Avalanche Canada's information database, there have been 33 fatalities in BC and Yukon due to avalanches between 2011 and 2014, including skiers and snowmobile enthusiasts. Avalanches can also cause significant damage to residential, industrial and transportation infrastructure, involving financial losses averaging $350,000 per year. http://old.avalanche.ca/cac/library/avalanche-accidents.

ECCC information is reliable and "invaluable" in the development of their avalanche forecasts, which are used to prevent users from venturing within range of high-risk areas.

- PSPC also provides assistance to first responders to emergencies. In March 2015, the PSPC provided guidance to first responders dealing with a shipping container that was burning and emitting chlorine and other toxic gases. The PSPC provided site-specific weather forecasts to assist the emergency responders to better anticipate what was going to happen weather-wise and allow them to decide what course of action would be most appropriate. The local governments shut down roads and the health authorities issued communiqués based on that information.

External Factors

- Key external factors noted as influencing the achievement of outcomes included evolving client expectations (e.g., social media), government-wide restructuring (e.g., SSC), Canada's international reputation as a meteorological expert, and federal government policy related to communication.

5.0 Conclusions

Relevance:

Overall, the activities undertaken as part of the Weather Observations, Forecasts and Warnings program continue to be relevant, as there is an ongoing need for the provision of weather and environmental services, given that severe weather events have significant human and economic consequences. The program is clearly aligned to government priorities related to the economy, public safety and the environment. The program is also consistent with federal roles and responsibilities related to the *Department of the Environment Act*, the *Canadian Weather Modification Act*, the *Emergency Management Act*, as well as supporting Canada's international commitments under the *Convention of the World Meteorological Organization*.

Efficiency and Economy:

The design of the program was found to be appropriate, as the program continues its renewal agenda aimed at improving weather services, including the re-organization of MSC's structure, the Signature Projects, implementing MSC's 2015 Service Strategy, the 2013-16 MSC People Plan, and new investments for overall capital infrastructure renewal and modernization. Evidence suggests that the governance structure is clear, appropriate and effective. Recent restructuring has led to some issues related to IT resources, though mitigation strategies are now in place to address them. Performance information is being collected and reported, and is being used for decision-making. Although the program has a logic model and collects performance data, performance indicators and targets are either not identified for, or aligned to, most intended outcomes.

The evaluation concludes that the program is being efficiently delivered, given that Canada's weather and environmental services compare favourably to international benchmarks in terms of cost, the low variance between budget and actual expenditures, the high level of automation of the program's observing network, and the program's continued collaboration with international partners. Challenges to the delivery of the program related to reporting burden, as well as delays in procurement.

Effectiveness:
Evidence indicates that progress is being made toward the achievement of all the program's intended immediate outcomes. Users are satisfied with ECCC's weather and environmental services; ECCC has continued access to meteorological data from other countries and international organizations; and meteorological research addresses issues affecting Canadian interests and priorities. The evaluation was unable to directly measure the level of users' understanding of ECCC's weather and environmental services, although there is clear evidence that weather and environmental services are used with some frequency, which would be indicative of users understanding ECCC's weather and environmental products. With respect to the final outcome, ECCC's weather and environmental services are being used to support decision-making related to public safety/emergency and economic planning, although is too early to conclude on the contribution these services have had on mitigating social and economic harm.

6.0 Recommendations and Management Response

The following recommendation is based on the findings and conclusions of the evaluation. The recommendation is directed to the ADM of the MSC, as the senior departmental official responsible for the management of the Weather Observations, Forecasts and Warnings Program.

Recommendation #1: Develop and implement a performance measurement strategy for the Weather Observations, Forecasts and Warnings Program, including an updated logic model, the identification of performance indicators and targets for each intended outcome, and a performance reporting strategy.

Although the program has a logic model and collects performance data, performance indicators and targets are either not identified for, or aligned to, most intended outcomes.

Furthermore, despite that the logic model is appropriately aligned to departmental strategic outcomes, a stronger performance statement might be made if the program was to update the logic model's long-term outcomes to focus more on program objectives as stated in the departmental PAA: namely to enable Canadians to anticipate dangerous meteorological events in order to protect themselves and their property. As the program proceeds with its renewal agenda and moves towards an impact-based approach, there will be a need to ensure a focus on the actual impacts of weather and environmental services beyond their use.

Management Response

Statement of Agreement/Disagreement with the Recommendation
The ADM MSC agrees with the recommendation.
Management Action
The Weather and Environmental Services program has been a measurement-centric program since the 1980's when forecast verification began. The first ISO certification in 2007, built on that tradition of performance measurement and continuous improvement. Consequently the Weather and Environmental Services program collects and reports on

numerous performance indicators at various levels, including key performance indicators that report on the efficiency of processes, to broader indicators that assess progress toward wide-ranging outcomes through the DPR, FSDS and CESI, to name a few. Further, the establishment of detailed work processes, quality objectives and key performance indicators allows us to measure productivity, ensure quality services and influence management decisions. As part of the QMS process, certified to the ISO 9001:2008 standard, regular annual reviews of processes and key performance metrics is required and therefore the culture of reviewing performance is ingrained in the organization.

It is important to note the program has a mandate to produce information to equip Canadians to make decisions about their safety. It is beyond the scope of the program to ensure the safety of Canadians, however, the program works with emergency management organizations and Public Safety to tailor products to increase understanding of risks and address client needs.

Via a step-wise approach, we will first review the logic model to determine whether outcome statements should be adjusted to better reflect the impacts of the program. Subsequently the corresponding performance measurement strategy, including indicators and performance reporting approach will be reviewed and updated accordingly. The analysis will take into consideration the constraints of conducting public opinion research and measuring longer term outcomes and establishing attribution.

Timeline	Deliverable(s)	Responsible Party
October 2016	Review and update of program logic model (as required)	DG Leads
May 2017	Update Performance Measurement Strategy accordingly	DG Leads

Annex 1
Summary of Findings[42]

Evaluation Question	Acceptable	Opportunity for Improvement	Attention Required	Not Applicable
Relevance:				
1. Continued need for the program	●			
2. Aligned to federal government priorities	●			
3. Program consistent with federal roles and responsibilities	●			
Performance:				
4. Program design appropriate for achieving expected program results	●			
5. Governance structure is clear, appropriate and effective for achieving expected results	●			
6. Program undertaking activities and delivering products at the lowest possible cost and achieving its intended outcomes in the most economical manner	●			
7. Performance data is being collected and reported, and is being used to inform senior management/decision-makers?		●		
8. Achievement of intended outcomes	●			

[42] The rating symbols and their significance are outlined in Table 3 on Page 11.

Annex 2
Program Logic Model