STATE OF MAINE
BOARD OF ENVIRONMENTAL PROTECTION

IN THE MATTER OF

NORDIC AQUAFARMS, INC		
Belfast and Northport	)	APPLICATION FOR AIR EMISSION, SITE
Waldo County, Maine	)	LOCATION OF DEVELOPMENT,
	)	NATURAL RESOURCES PROTECTION
A-1146-71-A-N	)	ACT, and MAINE POLLUTANT
L-28319-26-A-N	)	DISCHARGE ELIMINATION
L-28319-TG-B-N	)	SYSTEM/WASTE DISCHARGE LICENSES
L-28319-4E-C-N	)	
L-28319-L6-D-N	)	
L-28319-TW-E-N	)	
W-009200-6F-A-N	)	

PRE-FILED REBUTTAL TESTIMONY OF THOMAS B. NEILSON
RANSOM CONSULTING, INC.

1. I am providing this written testimony as a response to the pre-filed testimony of Mr. Lawrence Reichard and of Mr. Frederick Johnson of GEI Consultants, Inc. (GEI) on behalf of the Northport Village Corporation and Upstream Watch. The purpose of this response is to address instances where the above referenced testimony differs substantially from the application submission, and provide, to the best of my ability, a factually accurate response or clarification. To this end, I will focus my response on those areas where I have expertise, which includes questions of water supply and use, and concerns relating to potential environmental contaminants.

2. Mr. Reichard testifies that:

    a. It is not possible to truly know the volume of freshwater that will be used by Nordic Aquafarms, Inc. ("Nordic") in their proposed aquaculture facility and Nordic has not accounted for water to refill tanks after cleaning in its total water budget (pages 4 and 5);
    b. Nordic misled the public regarding its proposed water usage and now seeks to increase the agreed upon amount of water it will purchase from the Belfast Water District (BWD) (page 4); and
    c. Climate change will result in entirely unpredictable changes to the hydrologic system at the site (page 5).

3. Mr. Johnson testifies in the GEI report that:

    a. Aquifer testing performed on behalf of Nordic "demonstrates that the [proposed] pumping will cause salt water [sic] intrusion" (Executive Summary, Page 11); and
    b. Nordic's application(s) do not "address the consequences of the anticipated saltwater intrusion" (Executive Summary, Page 11);

c. The integrity of the Lower Dam and Lower Reservoir is imperiled and threatens the proposed groundwater flow regime;
d. Increased nutrient load from unspecified discharge may degrade water quality in the Lower Reservoir (Section 3.4);
e. Sediment impounded by the Upper and Lower dams may contain environmental contaminants such as metals and PCBs that could be exposed (Section 3.4);
f. Per- and polyfluoroalkyl substances (PFAS) may be present in the groundwater and surface water originating at the nearby Belfast Municipal Airport (Section 3.4); and
g. PFAS may also be present in sediment impounded by the reservoirs (Section 3.4).

4. This testimony rebuts Mr. Reichard's statements as follows:

a. The maximum volume of freshwater Nordic will use is flexible and can be adjusted to mitigate environmental impacts. The volume of water allowed by the permit, should it be granted, is the maximum. Violation of the permit requirements will be subject to enforcement action;
b. The agreement between Nordic and the BWD was reached prior to any water supply investigation activities beginning at the site, and still exists in its original form. Nordic has never requested modification to volumes listed in the agreement. The proposed surface and groundwater withdrawals in Nordic's applications to the Maine Department of Environmental Protection ("Department") are based on extensive data collection, analysis, and modeling and are representative of site specific conditions. Any earlier statements were not part of any permit application and were best estimates at the time based on preliminary data; and
c. While climate change may influence the availability of fresh water in the future, information is available to estimate the potential effects. Predictions generally indicate increased rainfall in Maine, and the risk of prolonged drought or other hydrologic changes is substantially mitigated by the robust Water Resources Monitoring Plan included in Nordic's permit application.

5. This testimony rebuts Mr. Johnson's testimony as follows:

a. Data collected at the site during drilling and aquifer tests indicate that a certain degree of saltwater intrusion has already occurred under pre-development conditions;
b. Data indicate that changes to groundwater quality due to Nordic's proposed operations may very well be limited in extent and by seasonally variable conditions;
c. Nordic has submitted a proposed Water Resources Monitoring Plan specifically designed to measure and assess water quality changes, should such changes occur, in the aquifer underlying the site and surrounding area;
d. Nordic's and GEI's reported MEMA assessment of the Lower Dam indicate that the Lower Dam is and can continue to be serviceable. The WRMP includes monitoring of the Lower Reservoir to provide responsiveness to changes with impacts to resources and the project;
e. No discharges to the Reservoir will be occurring from the Nordic project, and stormwater generated on site will be treated as required by all applicable regulations

and as documented in Nordic's permit applications and the pre-filed direct testimony of Andrew Johnson and Maureen McGlone;

f. No evidence has been presented indicating a risk of PCBs or metals in sediment impounded behind the dams; and

g. Per communication with Belfast City officials, no firefighting chemicals containing PFAS have been used at the airport or by the Fire Department in general. Nordic Exhibit 24. The statements regarding PFAS in groundwater, surface water, and sediment are pure conjecture.

Uncertainty Regarding Water Usage

6. The permit application materials submitted by Nordic Aquafarms clearly lay out the maximum proposed water usage of the facility. They include up to 455 gallons per minute (gpm) from site groundwater wells, up to 500 gpm from the BWD, and 70 gpm plus inflows from the Little River. These proposed usage rates, should they be permitted by the relevant regulating bodies, represent the total water usage of the facility and Nordic is not proposing higher withdrawals. One of the primary purposes of the permitting process as it pertains to water usage is to establish what quantities of water can be sustainably used for the proposed activity and to set a permitted amount that takes this into consideration. Water usage cannot exceed that permitted amount, regardless of any real or perceived need of the permit holder unless the permit is amended. Furthermore, conditions of the permit, if issued, would require detailed regular reporting of water usage to the Department, and failure to comply with permit requirements would be met with Department enforcement action.

7. Mr. Reichard implies that Nordic has not accounted for refilling of their tanks after cleaning in their proposed water usage. This is factually incorrect. As stated in Item 4 above, the proposed water usage rates, if permitted, will be strictly adhered to by Nordic and violations of the permit will be subject to enforcement action. There is no exception from the permitted water usage for the facility for refilling tanks after cleaning.

Changes to Water Usage Over Time

8. On page 4, paragraph 3 of Mr. Reichard's Testimony, he states:

> *"When Nordic Aquafarms Publicly announced this project, and for months thereafter, Belfast was repeatedly assured that its aquifer and watershed could easily handle the load that Nordic proposed. But that has been proven untrue by Nordic's own test wells, and now Nordic seeks to draw more water from Belfast's municipal water system."*

This statement misrepresents the nature of the due diligence process undertaken by Nordic to assess available water resources at the proposed site. The agreement between Nordic and the Belfast Water District (BWD) to purchase water was reached prior to the initiation of any on-site investigation of freshwater supply, and that agreement still stands in its original form. Furthermore, "Nordic's own test wells" provide the basis for the proposed groundwater usage rates at the site, which are driven by data collected during four pumping tests, and detailed modeling of the aquifer. Similarly, the proposed surface water withdrawal from the

Lower Reservoir adjacent to the site is data driven. The scientific backing for the proposed water use is detailed in the Hydrogeologic Investigation Report (referred to as the HGI) submitted with Nordic's permit application materials. The proposed water usage rates were determined through extensive on-site testing and modeling as discussed in my and Dr. Mobile's pre-filed direct testimony and Nordic Exhibits 3, 4 and 5; they were not pre-determined as implied by Mr. Reichard.

Impacts of Climate Change

9. On page 5, paragraphs 4 through 8, Mr. Reichard discusses uncertainty associated with climate change and provides a quote from Dr. Mark Gold of UCLA with some general information regarding groundwater response to different climate change scenarios. Mr. Reichard is correct to highlight climate change as a consideration; however, I strongly disagree with his conclusion that there is nothing of value to be learned from model predictions, and that "…the only predictable thing about the climate crisis is its unpredictability." Model based climate predictions provide the best understanding of what we can expect to transpire over coming decades and centuries, and they are typically born from rigorous scientific work.

10. Nordic Exhibit 25 is a summary of climate research and predictions prepared by the Union of Concerned Scientists (UCS) and is based on *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*, which is a report of the Northeast Climate Impacts Assessment. UCS addressed two general emissions scenarios in this document, a "higher" emissions scenario, that represents the high end of expected changes (i.e. unchecked emissions increases), and a "lower" emissions scenario, that represents lowered emissions over time. Predictions indicate that precipitation is generally expected to increase in Maine, primarily in winter and increasingly as rain.

11. A trend of increasing precipitation is already evident in precipitation data for Belfast published by the National Oceanic and Atmospheric Administration (Station ID USC00170480) and discussed in the Section 3.1 of the HGI. NOAA precipitation data indicate that mean annual precipitation (MAP) in Belfast has been increasing. MAP for the entire period of record (86 years) is 46.73 inches, while MAP is 48.41 inches over the last thirty years, 49.39 inches over the past twenty years, and 51.79 inches over the past ten years.

12. The UCS also address drought and streamflow. They find that under the higher emissions scenario, there is expected to be an increase in the recurrence of short-term (i.e., 1-3 months) drought during the summers by the end of the century. However, under the lower emissions scenario, "…little change in either drought or stream flow is expected…."

13. Taken together, the findings of the UCS indicate that by the end of the century more precipitation is likely to occur in Maine on an annual basis, though the timing of that precipitation may vary from current conditions. Precipitation in Maine has three primary paths it can take: it runs off as surface water, infiltrates into the ground and recharges aquifers, or is taken up by plants and put back into the atmosphere. Nordic's proposed freshwater sources include both groundwater and surface water. This means that, even in the face of climate change, Nordic's water systems are likely to be relatively resilient.

14. An additional level of protection in Nordic's proposed water usage against changes in hydrology due to natural phenomena such as climate change or drought is the Water Resources Monitoring Plan (WRMP), which accompanied Nordic's permit application materials. As discussed in my pre-filed direct testimony and Nordic Exhibits 4 and 5, the WRMP sets data-driven performance standards that must be met as a condition of Nordic's proposed water usage. It lays out how these standards will be measured as well as data tracking and reporting. Should the performance standards not be met, the WRMP identifies remedial steps that Nordic can take to correct the issue including modifications to operations as necessary until other measures can be implemented.

Saltwater Intrusion Near Belfast Bay

15. It is important to understand that data collected during the hydrogeologic investigation performed on Nordic's behalf suggest limited *existing* saltwater intrusion at certain locations on the subject property. Specifically, groundwater chemistry data collected from test well GWW-103 suggest a pre-development seawater signature exists within this borehole, as stated within Section 6.4 of the Hydrogeologic Investigation Report (HGI) filed as a component of Nordic's permit applications:

    "*Chemical and physical measurements document a notable difference in groundwater collected from GWW-103 and GWW-101/PW-1. Laboratory analytical results for GWW-103 samples indicate a seawater chemical signature, with four major cations found in seawater (sodium, magnesium, calcium and potassium), all appearing at elevated concentrations in groundwater samples from GWW-103 compared to the more inland GWW-101/PW-1. Though conductivity readings do not currently indicate brackish or saltwater (seawater has a conductivity of approximately 55 mS/cm* [millisiemens per centimeter]*), an increase in conductivity with depth in GWW-103 indicates some limited degree of mixing between the freshwater/seawater systems under natural conditions at the completed depth of the monitoring well at 340 feet bgs* [below ground surface]."

    Tables 7 and 8 from the HGI, included here as Nordic Exhibit 26, provide the data from which the above conclusions were drawn and clearly demonstrate a pre-development seawater signature in GWW-103.

16. Monitoring of specific conductivity as an analogous measure of salinity within test wells GWW-101/PW-1 and GWW-103 during aquifer testing showed inconsistent responses, both temporally/seasonally and between well locations. Specific conductance monitoring is discussed in Section 6.2.2 of the HGI, which states:

    "Transducer conductivity readings ranged from 0.12 to 0.208 mS/cm in GWW-101 and 0.252 to 0.74 mS/cm in GWW-103. The largest change in conductivity over time occurred in test well GWW-103 during the August 2018 aquifer test, where conductivity increased from approximately 0.3 to 0.7 mS/cm over the course of the test.

During the April 2018[1] *and August 2018 tests, conductivity trends under pumping conditions at GWW-103 were generally increasing with time. After pumping ended in the August 2018 test conductivity decreased relatively rapidly during recovery. During the November 2018 and January 2019 tests, conductivity remain* [sic] *relatively stable from the pre-test period through the test and into the post-test period. Small fluctuations in conductivity in GWW-103, which appear to coincide with tidal fluctuations in groundwater elevation, are evident during portions of the record as well. Conductivity in GWW-101 generally increased slightly at the start of pumping and then decreased slightly over time during pumping, followed by an abrupt (though small in magnitude) increase in conductivity that coincided with pumps being turned off. Conductivity records from the CTD transducers are shown on the plots for GWW-101 and GWW-103 in Appendix E."*

The relevant plots from Appendix E of the HGI referenced above are included herein as Nordic Exhibit 27. The implication of the data collected during these tests is that the magnitude of the conductivity response to pumping in GWW-103 varied by season, and possibly, by the conditions of the aquifer upgradient of GWW-103. For example, in August, when regional aquifer levels are typically lower, the conductivity response in GWW-103 is greater than in November, when fall precipitation typically has begun to recharge aquifers in the region. These findings mean that Nordic's operations may well result in changed responses in these areas; however, such changes may be localized (e.g. limited to those fractures with direct connections between Belfast Bay and a pumping well) and may be temporary over a given annual range of wet and dry seasons. One of the primary functions of the proposed WRMP submitted with Nordic's permit application is to monitor and assess changes such as these and to respond and/or engage with the Department as necessary to address any such changes.

17. Mr. Johnson's comment regarding anticipated consequences due to saltwater intrusion is not accurate. As referenced above, significant effort was dedicated to assessing ambient groundwater chemistry and specific conductivity changes during aquifer testing. More importantly, because of the inherent uncertainty associated with estimating condition changes within the complex fractured bedrock aquifer, a significant monitoring program has been developed and submitted as a required component of Nordic's permit applications (the WRMP). This monitoring program appropriately lays out plans for further understanding pre-development conditions, monitoring for changes, and establishing warning levels and actions to take in cases where the potential for adverse effects is identified. This includes continued characterization of the pre-development saline signature in the aquifer, ongoing monitoring of conductivity as a proxy for salinity in observation wells adjacent to the proposed production wells, pre-development and ongoing water quality monitoring from nearby domestic water supply wells, and a commitment to quickly respond to changes in water quality in domestic wells due to site operations through changes in Nordic operations, water treatment, well or pumping system changes, or extending Belfast Water District Service.

[1] During the April 2018 test the CTD transducer became entangled partway through the test, limiting data recording for the latter portion of the test.

18. While Mr. Johnson's attention to saltwater intrusion potential is reasonable given the coastal location, he does not appropriately credit the efforts made by Nordic to assess existing conditions and provide post-development monitoring. These efforts are reasonable and appropriately protective of groundwater quality as it pertains to private groundwater supplies in the vicinity of the proposed development.

Viability of the Lower Dam and Lower Reservoir

19. Mr. Johnson asserts that the current state of the Lower Dam is such that it threatens the long-term viability of the Lower Reservoir, and, therefore, the surface and groundwater regimes at the property. However, his report states that during inspection performed by Mr. Nicholas Ciomei of MEMA in 2011, "[O]verall, the [lower] dam was considered to be well maintained." Wright-Pierce further assessed the Lower Dam in 2018 and confirmed that the current overall condition of the Lower Dam is considered to be fair and that the Corps classified the Lower Dam as Low Hazard. Nordic Exhibit 28 at § 3.1.1. Wright-Pierce provides recommendations for further assessment, repair, and improvements to the Lower Dam but, their findings do not call into question the long-term viability of the dam provided appropriate repairs and maintenance are performed. Based on the assessment conducted by Wright-Pierce, the Lower Dam can continue to be safely repaired and maintained to support water withdrawal from the Lower Reservoir at the rates sought in the permit applications.

20. The WRMP includes proposed monitoring of the Lower Reservoir, including reservoir stage (elevation). By monitoring reservoir elevation and through restrictions on reservoir drawdown imposed by Department rules Chapter 587 water levels in the Lower Reservoir can be appropriately tracked and drawdown limited. This will allow for response to changes in the reservoir to be conducted as necessary, while simultaneously limiting the potential need for such response. Additional monitoring (e.g. water quality) can be added to the WRMP as deemed appropriate by the Department or voluntarily by Nordic.

Environmental Contaminants in Groundwater, Surface Water, and Sediment

21. In Section 3.4 of their report prepared for the Northport Village Corporation and Upstream Watch, GEI states:

    "What is the nutrient load in the discharge water from the Nordic Operation? Increased nutrient load may lead to detriment of the water quality in the reservoir adjacent to the operation."

    It is unclear what discharge GEI is referring to in this statement. There are no proposed discharges of stormwater to the Lower Reservoir. The majority of stormwater generated on site will be treated and discharged either to the Little River downstream of the Lower Dam or to Stream 9, which discharges directly to Belfast Bay. Approximately 46,000 square feet of the site proposed to be developed as landscaped surface (i.e. pervious) will not be included in the stormwater system. Precipitation delivered to this area will either infiltrate or run off through the existing network of drainage gullies and intermittent streams that deliver water to the Little River, Lower Reservoir, and/or Belfast Bay as it does in the pre-development conditions. This untreated area represents approximately 2% of the total developed area.

Surface water and stormwater generated upgradient of the proposed development will be collected at the upgradient property boundary and routed around the site and back to existing flowage networks downgradient of the site. While some of this flow is to the Lower Reservoir, this water is not project generated and is representative of conditions upgradient of Nordic's proposed development, and the water quality will be a product of activities outside of Nordic's control. In other words, this will not result in a net change in water quality due to Nordic's proposed development.

Discharge of operational water will only be through the wastewater discharge system that will be governed by the MEPDES permit and is not to the Lower Reservoir.

22. GEI goes on in Section 3.4 to list three additional items of concern, based solely on conjecture. These three items are:

    a. Possible contaminants such as metals or PCBs in sediment impounded by the Upper and/or Lower Dams;
    b. Potential PFAS in surface or ground water at or adjacent to the site; and,
    c. Potential PFAS in sediment impounded by the Upper and/or Lower Dams.

23. GEI's suggestions of the presence of these potential environmental contaminants are brought up with no supporting evidence. GEI implies that the nearby Belfast Municipal Airport may be a source for PFAS. There are documented cases of PFAS containing firefighting foams in use at some large airports, and it seems GEI is implying this may also be the case in Belfast. It is important to note that the State of Maine does not currently have any regulatory standards regarding safe or acceptable concentrations of PFAS in the environment. Based on communication with Mr. Thomas Kittredge, Economic Development Director for the City of Belfast, and his communications with the City of Belfast Fire Chief, the only products purchased and used by the Belfast Fire Department, including for use at the airport, have been non-PFAS containing Class/Type A foams. This correspondence is Nordic Exhibit 24.

24. Ransom reviewed relevant Department environmental databases, including spills, hazardous waste generators, and known environmental sites for possible sources of PCBs, metals, or other environmental contaminants that are commonly associated with sediment within the Little River watershed. Within the watershed, none of the databases reviewed included spills, properties, or facilities with known issues that are considered likely sources of these contaminants that could impact groundwater, surface water, or sediment in the vicinity of the proposed development. Furthermore, given the longstanding rural character of the Little River Watershed and limited past or present industrial activity within it, the risk of significant sources of sediment associated contaminants within the watershed is considered to be relatively low.

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Dated January 15, 2020

By ______________________________
Thomas B. Neilson, Geologist
Ransom Consulting, Inc.

STATE OF MAINE
County of Cumberland, ss.

January 15, 2020

Personally appeared the above-named Thomas B. Neilson and made oath as to the truth of the foregoing pre-filed testimony.

Before me, **Makaila E. Statham**
Notary Public, State of Maine
My Commission Expires October 10, 2026

____
Notary Public / Attorney at law

From: Elizabeth M. Ransom <elizabeth.ransom@ransomenv.com>
Sent: Friday, December 20, 2019 4:56 PM
To: Thomas Neilson <thomas.neilson@ransomenv.com>
Subject: Fwd: PFAS

Sent from my iPhone

Begin forwarded message:

From: Thomas Kittredge <economicdevelopment@cityofbelfast.org>
Date: September 30, 2019 at 7:24:44 PM EDT
Subject: PFAS

Elizabeth . . . I went to the Belfast Fire Department this afternoon to discuss the PFAS issue with the Fire Chief, who has worked for the department since 1974.

My understanding is that Class/Type A foam does not contain any PFAS, while Class/Type B foam does.

The Fire Chief does not recall any time that the Belfast Fire Department has purchased or used any Class/Type B foam. They have only ever used Class/Type A foam - attached is a pdf of the images of the containers of Class/Type A foam that they currently have stored at the Fire Department. The ingredient list on the container does not appear to list any PFAS. Generally (and perhaps also obviously) the Fire Department limits their use of any foam in firefighting, using it only truly necessary, so they almost always use only water in firefighting.

The Fire Chief could not recall any times where the Fire Department conducted any training exercises at the Belfast Municipal Airport. If the Fire Department does any training, they only use water and do not use any foam.

I believe that the Fire Department used foam this summer at the Belfast Municipal Airport when an excavator had caught on fire, but again this would have been the non-PFAS-containing Class/Type A foam being used.

Also attached are some information sheets that the Fire Department made copies/printed out for me that may or may not be helpful.

I hope this is helpful, let me know if you have any further questions or concerns.

Thanks,
Thomas

Total Control Panel Login

To: elizabeth.ransom@ransomenv.com Remove this sender from my allow list
From:
economicdevelopment@cityofbelfast.org

You received this message because the sender is on your allow list.

<buckets at belfast fire department.pdf>

FIRE-TROL® FIREFOAM® 103B

CLASS A FOAM LOT# 5207

MIX RATIOS: 0.1% to 0.7% by volume.

AERIAL APPLICATION: 4 to 7 gallons concentrate to 1000 gallons of water (4 to 7 litres concentrate to 1000 litres water)

GROUND APPLICATION: 1 to 5 gallons concentrate to 1000 gallons water (1 to 5 litres concentrate to 1000 litres water)

NOTE: Add FIREFOAM concentrate AFTER loading water. Avoid excessive stirring or aeration of foam concentrate/water mixture. FIREFOAM can be added with inline eductors or injectors.

DENSITY: 8.52 lbs. per gallon (1.022 kg/litre)

COMPATIBILITY: Product is compatible with fresh, brackish & sea water

STORAGE CONTAINERS: Store in polyethylene or polyethylene lined containers. Shelf life indefinite.

STORAGE: FIRE-TROL FIREFOAM is not affected by freezing and thawing.

ENVIRONMENT: Product is biodegradable and has a minimum impact on the environment. Avoid introduction of concentrate into watercourses.

CLEAN UP: Spills of FIRE-TROL FIREFOAM concentrate should be physically removed using sand or other absorbent material to facilitate removal. Direct application of water may result in excessive foaming. Water can be used for final cleanup after concentrate is removed. Cleanup should be done in accordance with all government regulations.

SHIPPING DATA: 5 Gallon Pails (18.9 litres)
30 Gallon Drums (113.6 litres)
55 Gallon Drums (208 litres)

HAZARDS: Non-Hazardous Composition
Non-Flammable
Non-Corrosive

MIXING: Avoid skin and eye contact when mixing concentrate. Persons handling FIREFOAM concentrate should wear goggles and gloves. Wash thoroughly after handling.

FIRST AID: In case of eye contact, immediately flush eyes with large amounts of water for at least 15 minutes. Call a physician Flush skin with water.

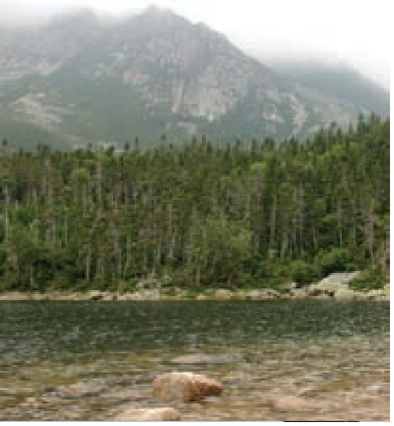
IN CASE OF FIRE: Use water spray, dry chemical, carbon dioxide or foam.

NOTICE OF WARRANTY: Fire-Trol Holdings, LLC warrants that FIRE-TROL products are reasonably fit for the purpose for which they were developed only when used in accordance with recommended use practices under normal conditions. In no case shall Fire-Trol Holdings, LLC be liable for consequential, special or indirect damages resulting from the use or handling of these products. ALL such risks shall be assumed by the buyer.

FIRE-TROL HOLDINGS, LLC MAKES NO WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE NOR ANY OTHER EXPRESSED OR IMPLIED WARRANTY EXCEPT AS STATED ABOVE.

This product has been tested and approved for use under USDA Interim Requiremets for Wildland Fire Foam. This product also meets all technical requirements of NFPA 298 Standard on Foam Chemicals Wildland Fire Control.

FIRE-TROL HOLDINGS, LLC 1227 E. SOUTH ST., ORLAND, CA 95963
PHONE: (530) 865-4932, FAX: (530) 865-5479



Maine

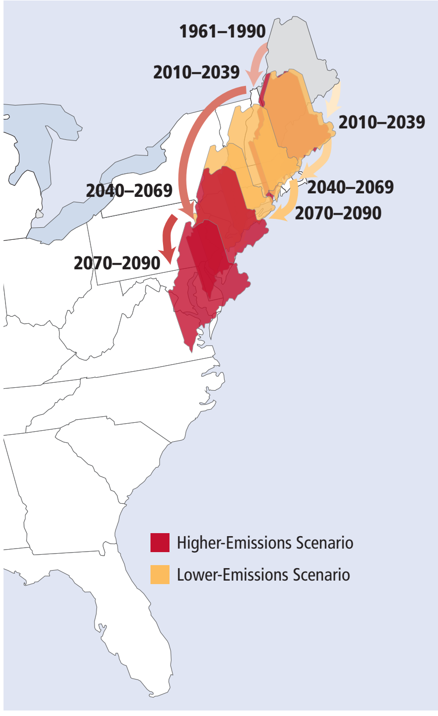
Nordic Exhibit 25

Confronting Climate Change in the U.S. Northeast

From towering Mount Katahdin to the sandy beaches of York, the climate of Maine is changing. Records show that spring is arriving earlier, summers are growing hotter, and winters are becoming warmer and less snowy. These changes are consistent with global warming, an increasingly urgent phenomenon driven by heat-trapping emissions from human activities. New state-of-the-art research shows that if global warming emissions continue to grow unabated, Maine can expect dramatic changes in climate over the course of this century, with substantial impacts on vital aspects of the state's economy and character. If the rate of emissions is lowered, however, projections show that many of the changes will be far less dramatic. Emissions choices we make today—in Maine, the Northeast, and worldwide—will help determine the climate our children and grandchildren inherit, and shape the consequences for their economy, environment, and quality of life.

The research summarized here describes how climate change may affect Maine and other Northeast states under two different emissions scenarios. The higher-emissions scenario assumes continued heavy reliance on fossil fuels, causing heat-trapping emissions to rise rapidly over the course of the century. The lower-emissions scenario assumes a shift away from fossil fuels in favor of clean energy technologies, causing emissions to decline by mid-century.

The research also explores actions that individual households, businesses, and governments in the Northeast can take today to reduce emissions to levels consistent with staying *below* the lower-emissions scenario, and to adapt to the unavoidable changes that past emissions have already set in motion.



Migrating State Climate

Changes in average summer heat index—a measure of how hot it actually feels, given temperature and humidity—could strongly affect Mainers' quality of life in the future. Red arrows track what summers could feel like over the course of the century under the higher-emissions scenario; yellow arrows track what summers in the state could feel like under the lower-emissions scenario.

MAINE'S CHANGING CLIMATE

Temperature. Average temperatures across the Northeast have risen more than 1.5 degrees Fahrenheit (°F) since 1970, with winters warming most rapidly—4°F between 1970 and 2000. If higher emissions prevail, seasonal average temperatures across Maine are projected to rise 10°F to 13°F above historic levels in winter and 7°F to 13°F in summer by late-century, while lower emissions would cause roughly half this warming.

Precipitation and winter snow. The Northeast region is projected to see an increase in winter precipitation on the order of 20 to 30 percent. Slightly greater increases are projected under the higher-emissions scenario, which would also feature less winter precipitation falling as snow and more as rain.

Snow is nearly synonymous with winter in Maine and an integral part of many favorite winter activities and traditions. If higher emissions

Photos: (from top) iStockphoto.com/Andy Thorington; Maine Department of Inland Fisheries and Wildlife; iStockphoto.com/Greg Nicholas; Captains of Industry; iStockphoto.com/Ben Thomas prevail, much of Maine—historically snow-covered for most of the winter—would see its snow season shrink by roughly half by late-century. Under the lower-emissions scenario, however, the state is expected to retain a substantial snow season—between two and four weeks of snow cover per winter month.

Heavy, damaging rainfall events have already increased measurably across the Northeast in recent decades. Intense spring rains struck the region in both 2006 and 2007, for example, causing widespread flooding. The frequency and severity of heavy rainfall events is expected to rise further under either emissions scenario.

Drought and stream flow. In this historically water-rich state, rising summer temperatures coupled with little change in summer rainfall are projected to increase the frequency of short-term (one- to three-month) droughts and decrease summer stream flow, particularly if higher emissions prevail. By late-century, for example, short-term droughts are projected to occur annually under the higher-emissions scenario (compared with once every two to three years, on average, historically), while summertime conditions of low stream flow (detrimental to native fish such as the Atlantic salmon) are projected to last an additional month, increasing stress on both natural and managed ecosystems. By contrast, little change in either drought or stream flow is expected under the lower-emissions scenario.

Sea-level rise. Global warming affects sea levels by causing ocean water to expand as it warms, and by melting land-based ice. Under the higher-emissions scenario, global sea level is projected to rise between 10 inches and two feet by the end of the century (7 to 14 inches under the lower-emissions scenario). These projections do not account for the recent observed melting of the world's major ice sheets—nor the potential for accelerated melting—and may

AP Photo/Robert F. Bukaty

A decline in spruce/fir forests would greatly exacerbate existing stresses on Maine's economically important pulp and paper industry.

therefore be conservative. However, even under these projections, Maine's coast faces substantial increases in the extent and frequency of coastal flooding, erosion, and property damage.

IMPACTS ON FORESTS

Forests cover 90 percent of Maine, providing timber and firewood, plant and wildlife habitat, and terrain for hiking, snowmobiling, snowshoeing, fishing, and birding. In addition, the forestry industry provides the state with more than 19,000 jobs.

As temperatures climb, the character of Maine's forests is expected to change—particularly its spruce/fir forests, which are vital to the state's nearly $1.4 billion pulp and paper industry and treasured for their scenic and recreational value. Spruce and fir species provide 50 percent of all sawlogs (used for lumber) and 20 percent of all pulpwood (used for paper production) harvested in Maine.

Climate conditions suitable for these forests are expected to decline in Maine by late-century under both emissions scenarios, with the steepest losses under the higher-emissions scenario. Losses in spruce/fir forests will eventually affect the animal species dependent on them, such as the Canada lynx, snowshoe hare, and Bicknell's thrush. Under the lower-emissions scenario, patches of the high-elevation spruce/fir habitat required by the Bicknell's thrush could persist in the mountains of Maine, but under the higher-emissions scenario this bird's distinctive song could eventually be muted across the entire region as its suitable habitat gradually disappears.

Warm winters interfere with traditional timber harvesting practices in the region, which rely on frozen soil conditions to minimize damage caused by heavy equipment. With projected winter warming, the trend toward an earlier or intermittent "mud season" is expected to continue.

Long-lived trees may persist for some time even as the climate becomes unsuitable for them; however, they may also become more vulnerable to competition from better-suited species and other stresses such as pests and disease. Maine's hemlock trees (which shade streams, providing cool conditions required by native brook trout and other fish) face both shrinking suitable habitat and the northward march of the hemlock woolly adelgid, an invasive insect that has already destroyed hemlock stands from Georgia to Connecticut. With warmer winters projected under the higher-emissions scenario, the adelgid is poised to infest hemlocks as far north as the Canadian border by late-century, but would be prevented from spreading into northern Maine this century under the lower-emissions scenario.

IMPACTS ON WINTER RECREATION

The Pine Tree State has a long-established reputation as a winter getaway. But Maine winters have already changed and, over the course of the century, may look and feel profoundly different.

Snowmobiling. Maine is part of a six-state network of snowmobile trails totaling 40,500 miles and contributing $3 billion a year to the regional economy. Snowmobiling, like cross-country skiing and snowshoeing, relies almost entirely on natural snowfall because of the impracticality of snowmaking on such a vast system of trails. This fact, combined with projected losses in natural snow cover, means that Maine's snowmobiling season could be cut substantially by mid-century. Under the higher-emissions scenario the average season length across Maine is projected to shrink to roughly 30 days by late-century—a nearly 70 percent decline below recent levels—and to roughly 50 days under the lower-emissions scenario (a 40 percent decline).

Skiing. Maine's 17 ski areas contribute $300 million a year to the state's economy, providing recreation for Mainers and visitors. Milder winters are expected to shorten the average ski season, increase snowmaking requirements, and drive up operating costs in an industry that has already contracted in recent years. Under the higher-emissions scenario, western Maine is projected to be the only area in the entire Northeast able to support viable ski operations by late-century. However, in order to stay open, resorts in this area would require substantial increases in snowmaking capacity and, therefore, operating costs.

Lake ice. Ice fishing and pond hockey are winter favorites in Maine. However, global warming will render lake ice cover increasingly thin and shorten its duration; ice cover duration on Sebago Lake has already declined by two weeks over the past several decades. Combined with fewer opportunities for sledding, snowshoeing, and other favorite outdoor activities, winter recreation as it is now known in Maine is at great risk.

MARINE IMPACTS

A regional icon, Maine's coastal fishing villages contribute $393 million to the state economy each year. Commercial fish and shellfish, including cod and lobster, have water-temperature thresholds that define the conditions required for their survival, growth, and reproduction. By increasing the region's water temperatures, global warming is expected to bring more changes to a sector that has already been transformed over the past several decades.

Lobster. In 2005 Mainers landed 70 million pounds of lobster—more than half of the annual U.S. catch. As the Gulf of Maine warms this century, deeper waters and coastal areas of Downeast Maine may become increasingly suitable for lobster habitation. However, these waters may also become more hospitable to diseases such as lobster-shell disease, which is now observed

AP Photo/Robert F. Bukaty

From skiing and snowboarding to snowmobiling, ice fishing, and sledding, many residents of Maine embrace winter recreation. But the state's winters are warming. Over the course of this century more winter precipitation is projected to fall as rain, and snow and lake ice are expected to melt more quickly, reducing opportunities for popular winter activities.

only at low levels in Maine waters but has damaged the fishery farther south.

Cod. Maine's cod landings, valued at $3 million in 2005, continue to derive mostly from the Gulf of Maine and neighboring Georges Bank. The Gulf of Maine is projected to continue to support adult cod under either scenario but, as temperatures rise, these waters are expected to become too warm to support the growth and survival of young cod later this century—a critical factor in the long-term viability of this fishery. This change would likely occur more rapidly under the higher-emissions scenario.

IMPACTS ON COASTAL COMMUNITIES

From Kittery to Quoddy Head, climate change threatens the extensive Maine coast and its communities. Rising sea levels caused by global warming are projected to increase the frequency and severity of storm surges and coastal flooding. Favorite beaches and popular tourist destinations, such as Old Orchard Beach, could experience increased beach erosion and flood-related property damage this century. The state's coastal wetlands (which provide critical nursery habitat for commercial fish and important stopover sites for migratory and other birds) would be at great risk of permanent inundation as sea levels rise.

Maine is currently the only state in the nation that has implemented shoreline regulations that take potential sea-level rise into account. Further strengthening and adequate funding of these regulations can help protect the state's coast as the climate changes.

IMPACTS ON AGRICULTURE

Maine's farms are not only an idyllic symbol of its heritage, but also a mainstay of the state economy, generating $1.2 billion every year. Global warming will present both opportunities and challenges to Maine's growers and producers in the coming decades; for example, increases in the frequency of short-term drought (see p.2) could necessitate increased irrigation (e.g., of the blueberry barrens) and operational costs, while a longer growing season could benefit farmers seeking to invest in warmer-weather crops that are currently hard to grow in Maine.

Crops. Maine's fruit and vegetable crops generate approximately $160 million annually. The state produces more wild blueberries than any other place in the world and ranks sixth in the nation for potato production. Increasing summer temperatures and heat stress could depress the yields of economically important crops, including certain apple varieties and potatoes, by late-century under the higher-emissions scenario. Northward expansion of agricultural pests and weeds could further impede crop production during the course of the century and pressure farmers to increase their herbicide and pesticide use. Under the lower-emissions scenario most of these impacts are expected to be relatively minor.

Ting Li Wang/The New York Times/Redux

Maine's landings of American lobster, the state's highest-value commercial catch, were valued at more than $300 million in 2005. The industry also supported more than 7,000 commercial harvesters in Maine in 2006. As waters warm and lobster ranges shift, lobstermen will need to adapt to the changes and manage the remaining stocks in a sustainable manner.

IMPACTS ON HUMAN HEALTH

Air quality. Air quality is a serious concern in Maine, where 1 in 10 people suffer from asthma. While the state has reduced ozone concentrations in recent years, global warming is expected to worsen air quality in the region, putting more stress on people with asthma and other respiratory diseases. In the absence of more stringent controls on ozone-forming pollutants, the number of poor air-quality days in cities like Augusta could roughly quadruple under the higher-emissions scenario by late this century. Under the lower-emissions scenario such days could increase by half.

Higher temperatures and increasing levels of plant-stimulating carbon dioxide (CO_2) in the air are also expected to accelerate seasonal pollen production in plants over the next several decades under the higher-emissions scenario. This could extend the allergy season, increase asthma risks, and exacerbate symptoms for asthma sufferers.

Vector-borne disease. Mosquitoes and ticks carry West Nile virus (WNV) and Lyme disease-causing bacteria, respectively, and spread them to animals or people. Factors affecting the spread of such vector-borne diseases are complex; however, projections for the Northeast of warmer winters, hotter summers, and more frequent summer dry periods punctuated by heavy rainstorms can set the stage for more frequent WNV outbreaks.

WHAT WE CAN DO

We have an opportunity to help protect our children and grandchildren from the most severe consequences of global warming by reducing emissions today. At the same time, effective adaptation strategies are needed to help reduce the vulnerability of Maine's residents, ecosystems, and economies to those changes that are now unavoidable.

Here in Maine, and across the world, there is growing momentum to meet the climate challenge. Of course our actions alone will not be sufficient to avoid dangerous climate change. But with its reputation as a state of sensible and resourceful people and a history of national leadership in environmental policy, Maine (along with the rest of the Northeast) is well positioned to drive national and international action.

Concerted, sustained efforts to reduce emissions in the region—on the order of 80 percent below 2000 levels by mid-century, and just over 3 percent per year on average over the next several decades—can help pull global emissions below the lower-emissions scenario described here.

State and municipal governments have a rich array of strategies and policies at their disposal to meet the climate challenge in partnership with other states, businesses, civic institutions, and the public. These strategies and policies would reduce emissions in the following sectors:

New England Futures/Maine DOT

The *Downeaster* is a 116-mile Amtrak train route from Boston to Portland, Maine. In fiscal year 2006, it was Amtrak's fastest-growing service, with overall ridership up 23 percent from the previous year.

Electric power. As a participant in the Regional Greenhouse Gas Initiative, Maine can reap substantial energy cost savings, promote economic development, and reduce emissions by auctioning 100 percent of the emissions credits created under the initiative and investing the proceeds in energy efficiency and renewable energy development. Governor Baldacci's Task Force on Wind Power Development can help Maine capitalize on its wind resources (largest among New England states) by ensuring that the state has an efficient and balanced process for evaluating projects and setting targets for substantially increasing new wind generation over the coming decades.

Buildings. Maine's relatively old stock of residential, commercial, and industrial buildings offers substantial opportunities to reduce emissions associated with water and space heating. The state already requires all state building projects to achieve the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) certification; local governments could follow suit and also amend zoning laws to encourage and/or require private projects to attain LEED certification and/or designation as a U.S. Environmental Protection Agency (EPA) Energy Star Building. Significant emissions reductions and energy cost savings could be achieved by eliminating Maine's distinction as the only New England state without a residential building energy code.

Transportation. Cars and trucks account for nearly 40 percent of Maine's total heat-trapping emissions. The state has adopted California's tailpipe emissions standards, which require reductions of approximately 30 percent below 2002 levels by 2016, beginning with the 2009 model year (implementation is contingent upon a ruling expected from the EPA). Vehicle emissions can be further reduced through increased investment in public transportation, incentives to purchase low-emissions vehicles, and incentives and regulations that promote "smart growth" strategies such as concentrating development near existing infrastructure and downtowns. In addition, Maine can adopt standards to reduce the carbon content of fuels.

Industries and large institutions can reduce emissions while lowering energy costs and enhancing their energy security by installing combined-heat-and-power (CHP) and on-site renewable energy systems. For example, Eastern Maine Medical Center in Bangor commissioned a CHP system in 2006 that will save the facility $1 million per year.

Forestry and agriculture policies in Maine can be refined to promote management practices and systems that cost-effectively reduce emissions. Opportunities for capturing carbon or avoiding CO_2 emissions from forests include protection, reduced-impact timber harvesting, reforestation, and bioenergy production—provided the latter is done in a sustainable manner.

CONCLUSION

Global warming represents an enormous challenge, but the solutions are within reach if we act swiftly. The emissions choices we make today in Maine, the Northeast, and globally will shape the climate our children and grandchildren inherit. The time to act is now.

DOE/NREL/Judy Forsythe

A Citizen's Guide to Reducing Emissions

1. **Become carbon-conscious.** The problem of global warming stems from a previous lack of awareness of our "carbon footprint" and its effect on climate. Individuals and families can start by using one of several publicly available carbon-footprint calculators that will help you understand which choices make the biggest difference.
2. **Drive change.** For most people, choosing a vehicle (and how much they should drive it) is the single biggest opportunity to slash personal carbon emissions. Each gallon of gas used is responsible for 25 pounds of heat-trapping emissions.
3. **Look for the Energy Star label.** When it comes time to replace household appliances, look for the Energy Star label on new models (refrigerators, freezers, furnaces, air conditioners, and water heaters use the most energy).
4. **Choose clean power.** Consumers in Maine can purchase electricity from local utilities generated from renewable resources that produce no carbon emissions. If your local utility does not offer a "green" option, consider purchasing renewable energy certificates.
5. **Unplug an underutilized freezer or refrigerator.** One of the quickest ways to reduce your global warming impact is to unplug a rarely used refrigerator or freezer. This can lower the typical family's CO_2 emissions nearly 10 percent.
6. **Get a home energy audit.** Take advantage of the free home energy audits offered by many utilities. Even simple measures (such as installing a programmable thermostat) can each reduce a typical family's CO_2 emissions about 5 percent.
7. **Lightbulbs matter.** If every U.S. household replaced one incandescent lightbulb with an energy-saving compact fluorescent lightbulb (CFL), we could reduce global warming pollution by more than 90 billion pounds over the life of the bulbs.
8. **Buy good wood.** When buying wood products, check for labels that indicate the source of the timber. Forests managed in a sustainable way are more likely to store carbon effectively—thus helping to slow global warming.
9. **Spread the word and help others.** A growing movement across the country seeks to reduce individual, family, business, and community emissions while inspiring and assisting others to do the same.
10. **Let policy makers know you are concerned about global warming.** Elected officials and candidates for public office at every level need to hear from citizens. Urge them to support policies and funding choices that will accelerate the shift to a low-emissions future.

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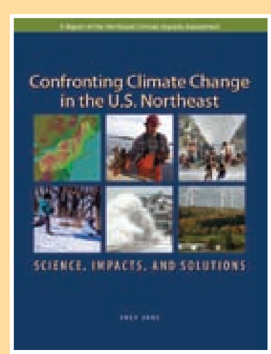
This summary was prepared by the Union of Concerned Scientists based on *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*, a report of the Northeast Climate Impacts Assessment (NECIA, 2007). NECIA is a collaborative effort between the Union of Concerned Scientists and a team of independent scientific experts to assess how global warming may further affect the climate of the U.S. Northeast and to explore options for meeting the climate challenge.

For more information on our changing Northeast climate and what you can do, or to download a copy of the full report and additional state summaries, visit *www.climatechoices.org*.



NORDIC EXHIBIT 26

TABLE 7. GROUNDWATER LABORATORY ANALYTICAL RESULTS
Belfast Water District, Cassida, and Matthews Brothers Properties
285 Northport Avenue
Belfast, Maine

Sample Location	GWW-101	GWW-101	GWW-103	GWW-103	PW-1	PSD-101	PSD-102	DRX-102	Recommended Limits*
Date Collected	2/27/2018	4/5/2018	3/6/2018	4/5/2018	8/30/2018	11/21/2018	11/21/2018	11/21/2018	
Conditions of Collection	collected following well completion	collected at end of 72-hr pump test	collected following well completion	collected at end of 72-hr pump test	collected at end of 72-hr pump test	collected at end of 72-hr pump test	collected at end of 72-hr pump test	collected at end of 72-hr pump test	
Observations	clear	clear	clear	clear	clear, sulfur odor, iron precipitate buildup in discharge tank	clear	clear	clear	
Volatile Organic Compounds (VOCs)	Concentrations in micrograms per liter (ug/L)								
Toluene	nd(0.75)	nd(0.75)	nd(0.75)	nd(0.75)	nd(0.75)	1.9	nd(0.75)	nd(0.75)	ne
Other VOCs**	nd	nd	nd	nd	nd	nd	nd	nd	ne
Semivolatile Organic Compounds (SVOCs)	Concentrations in micrograms per liter (ug/L)								
2-Methylnaphthalene	nd(0.10)	0.13	nd(0.10)	nd(0.10)	nd(0.10)	nd(0.10)	nd(0.10)	nd(0.10)	ne
Other SVOCs**	nd	nd	nd	nd	nd	nd	nd	nd	ne
Elements (Total/Dissolved)	Concentrations in milligrams per liter (mg/L)								
Aluminum	0.188 / nd(0.100)	nd(0.100)	0.468 / nd(0.100)	nd(0.100)	nd(0.100)	nm	nm	nm	0.01-1.00
Antimony	nd(0.00400)	nd(0.00400)	nd(0.00400)	nd(0.00400)	nd(0.00400)	nm	nm	nm	ne
Arsenic	0.006 / 0.005	0.007 / 0.008	nd(0.005)	0.005 / nd(0.005)	0.006 / 0.005	nm / nd(0.005)	nm / 0.008	nm / 0.011	0.05-0.40
Barium	nd(0.010)	nd(0.010)	0.016 / 0.015	0.023 / 0.026	nd(0.010)	nm / nd(0.010)	nm / 0.010	nm / nd(0.010)	5
Beryllium	nd(0.00050)	nd(0.00050)	nd(0.00050)	nd(0.00050)	nd(0.00050)	nm	nm	nm	0.01-1.10
Boron	nd(0.030)	nd(0.030)	0.117 / 0.116	0.087 / 0.081	nd(0.030)	nm	nm	nm	5
Cadmium	nd(0.00020)	nd(0.00020)	nd(0.00020)	nd(0.00020)	nd(0.00020)	nm / nd(0.005)	nm / nd(0.005)	nm / nd(0.005)	0.0003-0.0700
Calcium	8.35 / 8.97	10.8 / 10.1	35.4 / 36.4	21.0 / 20.5	11.6 / 11.8	nm	nm	nm	4-160+
Chromium	nd(0.010)	nd(0.010)	nd(0.010)	nd(0.010)	nd(0.010)	nm / nd(0.010)	nm / nd(0.010)	nm / nd(0.010)	0.03-0.10
Cobalt	nd(0.020)	nd(0.020)	nd(0.020)	nd(0.020)	nd(0.020)	nm	nm	nm	0.010-0.05
Copper	nd(0.010)	nd(0.010)	nd(0.010)	nd(0.010)	nd(0.010)	nm / nd(0.010)	nm / nd(0.010)	nm / nd(0.010)	0.006-0.070
Iron	**2.49 / 2.05**	**3.20 / 3.00**	**2.08** / 0.784	**1.51 / 1.45**	**3.20 / 3.31**	nm	nm	nm	0.1-1.1
Lead	nd(0.010)	nd(0.010)	nd(0.010)	nd(0.010)	nd(0.010)	nm / nd(0.010)	nm / nd(0.010)	nm / nd(0.010)	0.01-4.0
Magnesium	3.93 / 3.99	4.72 / 4.20	14.1 / 13.9	10.2 / 9.36	5.10 / 5.04	nm	nm	nm	15-28+
Manganese	0.030 / 0.028	0.035 / 0.033	0.046 / 0.041	0.029 / 0.030	0.034 / 0.036	nm	nm	nm	0.05-1.00
Mercury	nd(0.00020)	nd(0.00020)	nd(0.00020)	nd(0.00020)	nd(0.00020)	nm / nd(0.00020)	nm / nd(0.00020)	nm / nd(0.00020)	0.0001-0.0020
Molybdenum	nd(0.050)	nd(0.050)	nd(0.050)	nd(0.050)	nd(0.050)	nm	nm	nm	8+
Nickel	nd(0.025)	nd(0.025)	nd(0.025)	nd(0.025)	nd(0.025)	nm	nm	nm	0.01-0.40
Phosphorus (Total / Soluble)	0.071 / 0.035	0.122 / 0.125	0.101 / 0.018	0.048 / 0.049	0.116 / 0.106	nm	nm	nm	3+
Potassium	nd(2.50)	nd(2.50)	9.26 / 8.78	6.58 / 6.25	nd(2.5) / 2.51	nm	nm	nm	5-10+
Selenium	nd(0.010)	nd(0.010)	nd(0.010)	nd(0.010)	nd(0.010)	nm / nd(0.010)	nm / nd(0.010)	nm / nd(0.010)	0.005-0.020
Silicon	10.3 / 10.5	11.4 / 10.7	8.26 / 7.97	9.04 / 8.65	na / 10.8	nm	nm	nm	ne
Silver	nd(0.007)	nd(0.007)	nd(0.007)	nd(0.007)	nd(0.007)	nm / nd(0.007)	nm / nd(0.007)	nm / nd(0.007)	ne
Sodium	14.7 / 15.2	12.6 / 12.1	254 / 253	135 / 134	13.8 / 14.9	nm	nm	nm	600-1500+
Strontium	0.041 / 0.041	0.048 / 0.051	0.440 / 0.422	0.195 / 0.218	0.053 / 0.057	nm	nm	nm	ne
Sulfur (Total)	38.7	4.51	46.2	23.2	4.79	nm	nm	nm	ne
Thallium	nd(0.00050)	nd(0.00050)	nd(0.00050)	nd(0.00050)	nd(0.00050)	nm	nm	nm	ne
Titanium	nd(0.010)	nd(0.010)	0.016 / nd(0.010)	nd(0.010)	nd(0.010)	nm	nm	nm	ne
Vanadium	nd(0.010)	nd(0.010)	nd(0.010)	nd(0.010)	nd(0.010)	nm	nm	nm	0.1
Zinc	nd(0.050)	nd(0.050)	nd(0.050)	0.059 / 0.055	nd(0.050)	nm	nm	nm	0.005-0.269
Additional Parameters	Concentrations in milligrams per liter (mg/L) unless otherwise noted								
Hardness	37.0	46.5	146	94.5	49.9	nm	nm	nm	20-400
Alkalinity (mg CaCO3/L)	57.9	54.9	143	116	71.3	nm	nm	nm	higher the better
Total Suspended Solids	nm	nd(5)	nm	nd(5)	nd(5)	nm	nm	nm	lower the better
Turbidity (NTU)	nm	nm	nm	nm	0.87	nm	nm	nm	lower the better
Dissolved Carbon Dioxide	nm	nm	nm	nm	17.7	nm	nm	nm	ne
Total Carbon Dioxide	nm	nm	nm	nm	980	nm	nm	nm	ne
True Color (A.P.C.U.)	nm	nm	nm	nm	7	nm	nm	nm	ne
Apparent Color (A.P.C.U.)	nm	nm	nm	nm	13	nm	nm	nm	ne
UV Absorbance @ 254nm (Abs/cm)	nm	0.023	nm	0.011	0.034	nm	nm	nm	lower the better

Notes:
1. nm = not measured; nd = not detected above laboratory detection limit, as noted in parenthesis; ne = not established
2. **Bold** = above recommended limit for salmonid aquaculture
3. * Recommended limits for salmonid culture based on tables provided by Nordic Aquafarms, Inc. in a February 5, 2018 email.
4. **For individual VOC and SVOC detection limits, refer to the laboratory results in Appendix G.
5. A groundwater sample from GWW101 on 4/4/2018, 48-hr into the pump test, was analyzed for pesticides; no pesticides were detected.
6. Concentrations of carbon dioxide may have been impacted by the discharge pipe assembly causing results to be biased high.

TABLE 8. FIELD ANALYSES OF GROUNDWATER QUALITY
Belfast Water District, Cassida, and Matthews Brothers Properties
285 Northport Avenue
Belfast, Maine

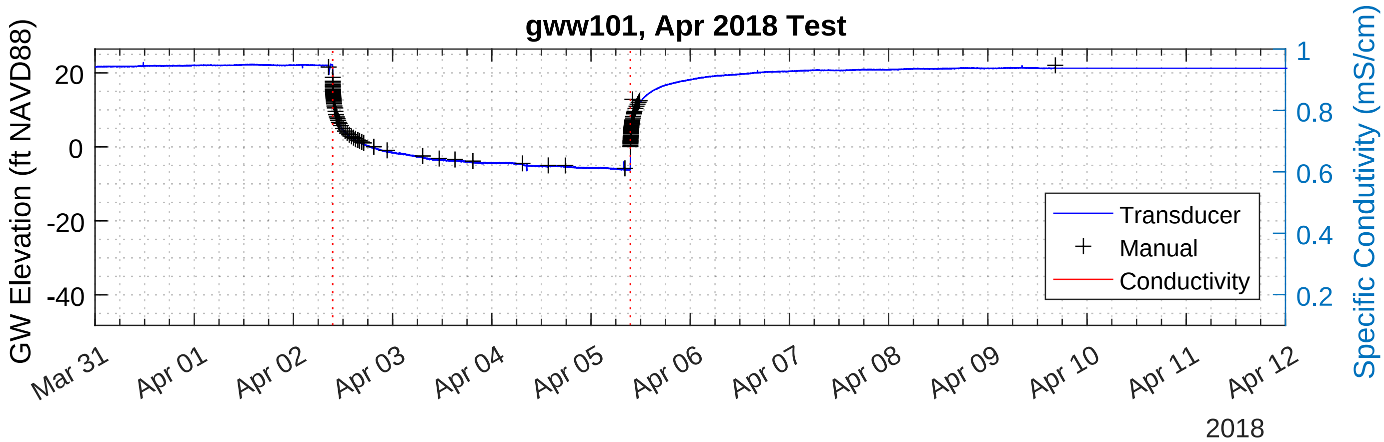
Sample Location	NTB-101	NTB-102
Date Collected	2/21/2018	2/27/2018
Observations	clear pumped water, end of drilling	clear pumped water, end of drilling
Temperature (degrees C)	9.6	8.2
pH	8.3	7.21
ORP (mV)	nm	-56
TDS (ppt)	0.112	0.10
Conductivity (mS/cm)	nm	0.20

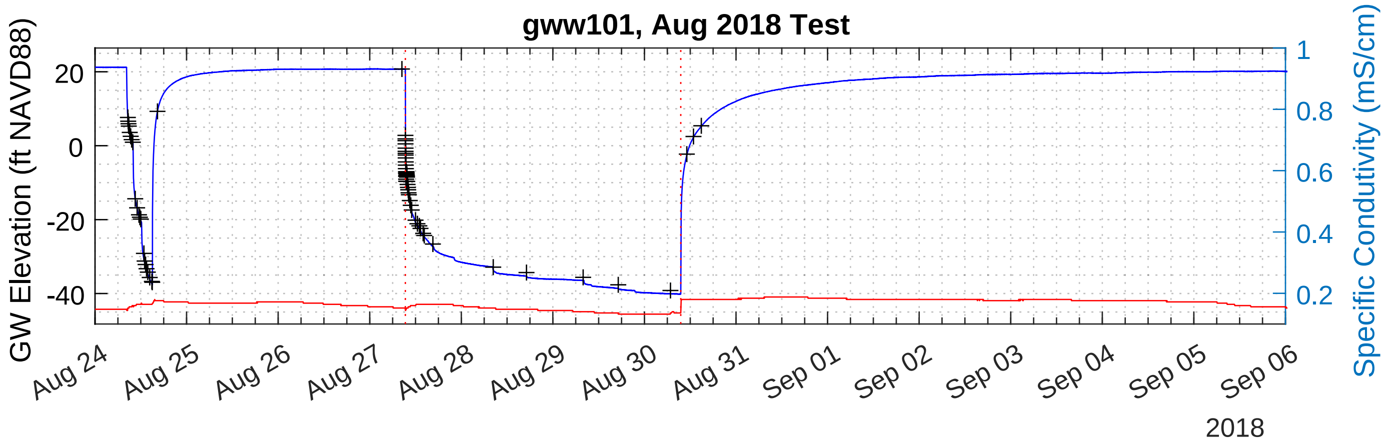
Sample Location	GWW-101	GWW-101	GWW-101	GWW-101	GWW-101
Date Collected	2/26/2018	2/27/2018	2/27/2018	4/4/2018	4/5/2018
Observations	murky wash water during drilling at 140'	clear wash water during drilling at ~300'	clear wash water, end of drilling at 320', collected samples	47 hours into pump test	71 hours into pump test, collected samples
Temperature (degrees C)	10.1	8.8	8.2	8.0	7.3
pH	7.33	7.68	7.54	6.58	7.33
ORP (mV)	-39	-72	-76	-44	-29
TDS (ppt)	nm	0.09	0.09	0.07	0.07
Conductivity (mS/cm)	0.17	0.18	0.19	0.14	0.14

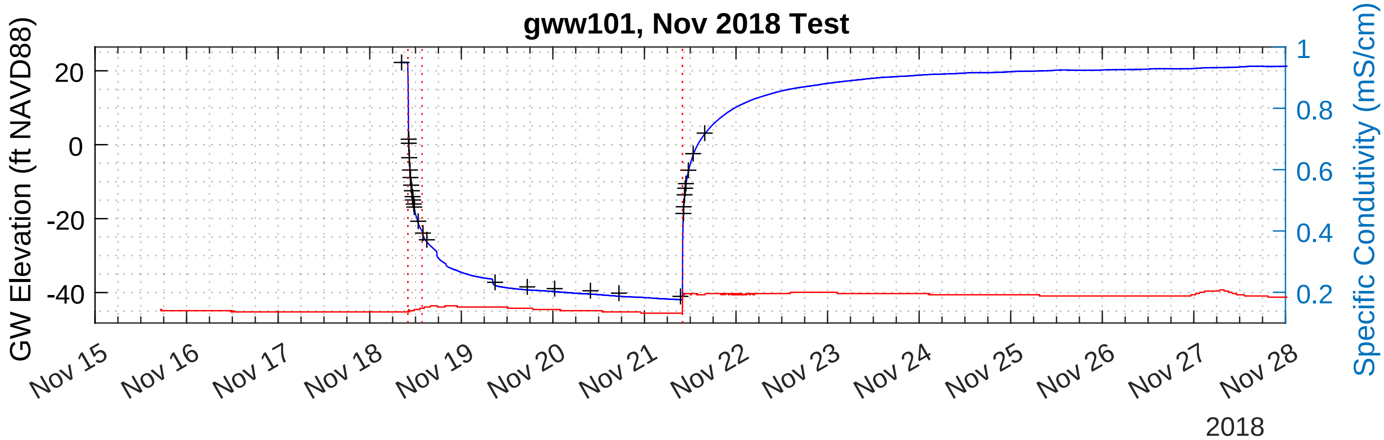
Sample Location	GWW-103	GWW-103	GWW-103	GWW-103	GWW-103	GWW-103	GWW-103
Date Collected	3/5/2018	3/5/2018	3/6/2018	3/6/2018	4/3/2018	4/4/2018	4/5/2018
Observations	murky wash water during drilling at ~200'	murky wash water during drilling at ~265'	fairly clear wash water during drilling at 300'	clear wash water, end of drilling at 340', collected samples	31 hours into pump test	47.5 hours into pump test	71.5 hours into pump test, collected samples
Temperature (degrees C)	10.4	10.8	10.4	9.9	9.4	8.9	6.7
pH	nm	7.09	7.83	7.86	7.60	7.13	7.18
ORP (mV)	nm	-31	-94	-101	-79	-72	-30
TDS (ppt)	0.20	0.35	0.65	0.69	0.38	0.35	0.37
Conductivity (mS/cm)	0.40	0.70	1.29	1.38	0.74	0.69	0.74

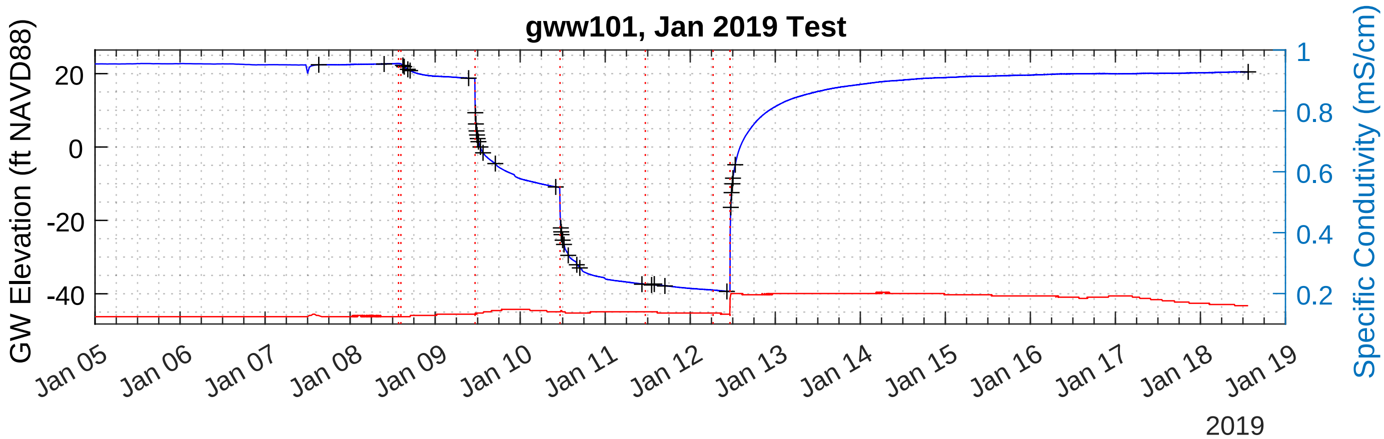
Sample Location	PW-1	PSD-101	PSD-102	DRX-101	DRX-102
Date Collected	8/30/2018	11/21/2018	11/21/2018	11/21/2018	11/21/2018
Observations	71 hours into pump test, collected samples	clear; end of 72-hr pump test	clear; end of 72-hr pump test	clear; end of 72-hr pump test	clear; end of 72-hr pump test
Temperature (degrees C)	8.6	9.9	8.1	7.0	7.8
pH	6.72	6.65	6.13	6.93	6.94
ORP (mV)	-38	14	79	-48	-31
TDS (ppt)	nm	nm	nm	nm	nm
Conductivity (mS/cm)	0.19	0.16	0.19	0.19	0.19
Dissolved Oxygen (mg/L)	0.55	nm	nm	nm	nm

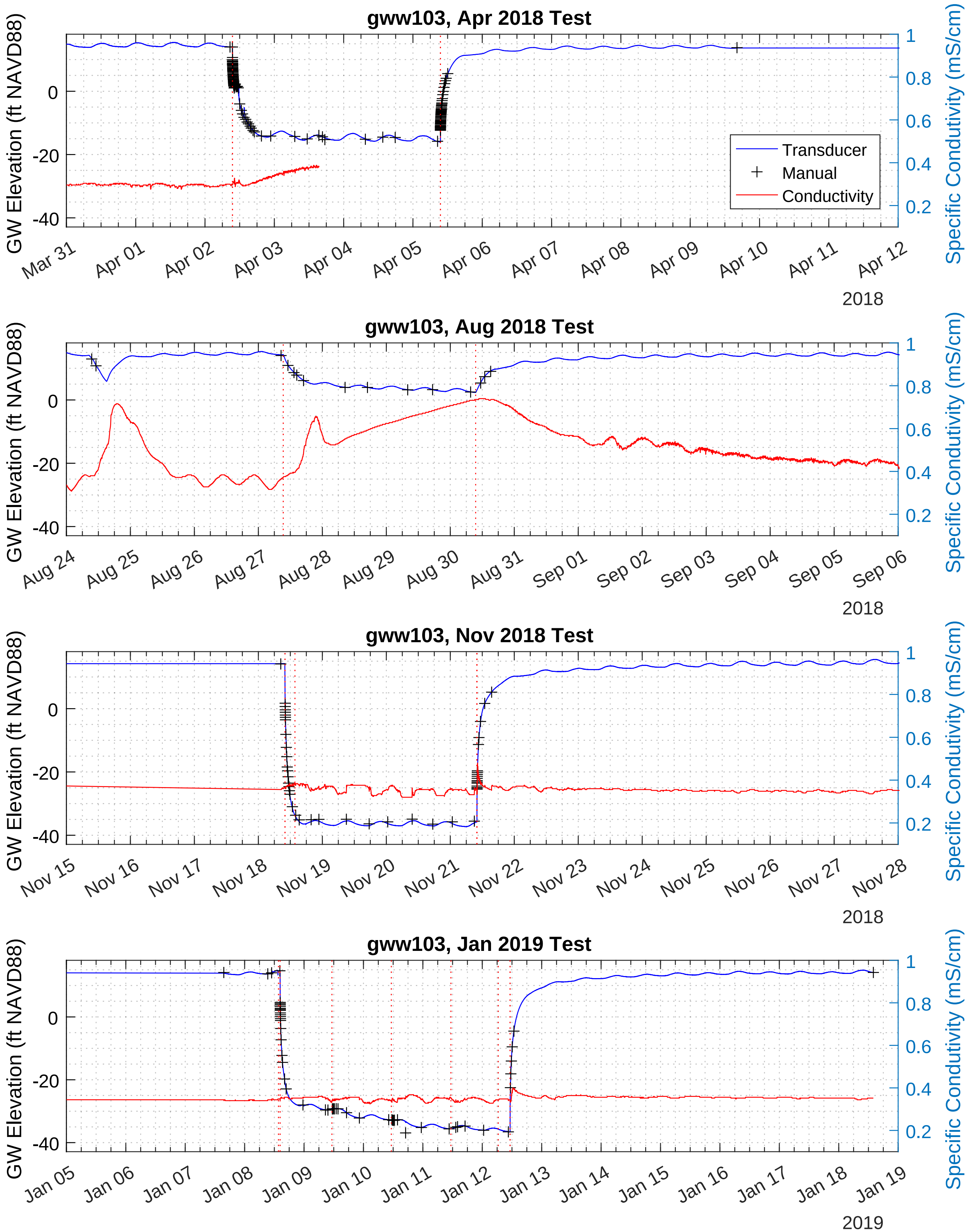
Notes:
1. nm = not measured


gww101, Apr 2018 Test
GW Elevation (ft NAVD88)
20
0
-20
-40
Specific Condutivity (mS/cm)
1
0.8
0.6
0.4
0.2
Transducer
Manual
Conductivity
Mar 31
Apr 01
Apr 02
Apr 03
Apr 04
Apr 05
Apr 06
Apr 07
Apr 08
Apr 09
Apr 10
Apr 11
Apr 12
2018


gww101, Aug 2018 Test
GW Elevation (ft NAVD88)
20
0
-20
-40
Specific Condutivity (mS/cm)
1
0.8
0.6
0.4
0.2
Aug 24
Aug 25
Aug 26
Aug 27
Aug 28
Aug 29
Aug 30
Aug 31
Sep 01
Sep 02
Sep 03
Sep 04
Sep 05
Sep 06
2018


gww101, Nov 2018 Test
GW Elevation (ft NAVD88)
20
0
-20
-40
Specific Condutivity (mS/cm)
1
0.8
0.6
0.4
0.2
Nov 15
Nov 16
Nov 17
Nov 18
Nov 19
Nov 20
Nov 21
Nov 22
Nov 23
Nov 24
Nov 25
Nov 26
Nov 27
Nov 28
2018


gww101, Jan 2019 Test
GW Elevation (ft NAVD88)
20
0
-20
-40
Specific Condutivity (mS/cm)
1
0.8
0.6
0.4
0.2
Jan 05
Jan 06
Jan 07
Jan 08
Jan 09
Jan 10
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
Jan 16
Jan 17
Jan 18
Jan 19
2019


gww103, Apr 2018 Test
GW Elevation (ft NAVD88)
Specific Condutivity (mS/cm)
Transducer
Manual
Conductivity
Mar 31
Apr 01
Apr 02
Apr 03
Apr 04
Apr 05
Apr 06
Apr 07
Apr 08
Apr 09
Apr 10
Apr 11
Apr 12
2018
gww103, Aug 2018 Test
GW Elevation (ft NAVD88)
Specific Condutivity (mS/cm)
Aug 24
Aug 25
Aug 26
Aug 27
Aug 28
Aug 29
Aug 30
Aug 31
Sep 01
Sep 02
Sep 03
Sep 04
Sep 05
Sep 06
2018
gww103, Nov 2018 Test
GW Elevation (ft NAVD88)
Specific Condutivity (mS/cm)
Nov 15
Nov 16
Nov 17
Nov 18
Nov 19
Nov 20
Nov 21
Nov 22
Nov 23
Nov 24
Nov 25
Nov 26
Nov 27
Nov 28
2018
gww103, Jan 2019 Test
GW Elevation (ft NAVD88)
Specific Condutivity (mS/cm)
Jan 05
Jan 06
Jan 07
Jan 08
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Jan 10
Jan 11
Jan 12
Jan 13
Jan 14
Jan 15
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Jan 17
Jan 18
Jan 19
2019

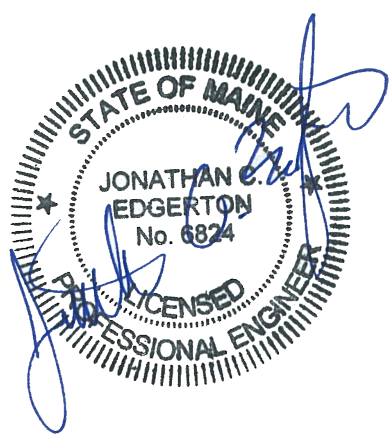
UPPER AND LOWER LITTLE RIVER DAMS

DAM ASSESSMENT REPORT

prepared for

RANSOM CONSULTING, INC.

APRIL 2018



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SECTION 3
LOWER LITTLE RIVER DAM

3.1 Visual Inspection

Lower Little River Dam was inspected on March 15, 2018 and April 10, 2018. At the time of the April inspection, the temperature was near 35^{o} F with partly sunny with a light wind. Photographs to document the current conditions of the dam were taken during the inspections and are included in Appendix F. The level of the impoundment at the time of both inspections was estimated to be approximately 1-3" inches above the top of spillway/weir crest. Underwater areas were not inspected.

3.1.1 General Findings

In general, the Lower Little River Dam was found to be in FAIR condition with deteriorated concrete. See below for a discussion regarding the factors of safety against sliding and overturning.

The Corps of Engineers gave this dam a classification of "low hazard" due to limited potential for loss of life downstream should the dam fail.

3.1.2 Dam

- Abutments

Both abutments appear to be stable and in fair condition.

- Upstream Face - Spillway

The upstream concrete face is believed to be vertical and is cast in place concrete. There may be a portion of stone masonry wall below. We were unable to observe the face of the wall as it was underwater.

- Downstream Face - Sprillway

The downstream concrete face is ogee shaped. No unusually movement was observed. Although some water was passing over the concrete, the spillway face appeared to be in generally sound condition.

Below the concrete ogee is a stone masonry wall of about 10 to 11 feet in height. We were limited in our ability to see this portion of the wall due to flows over the spillway as well as tail water below the dam.

- Crest

The condition of the concrete slab crest appears to be in good condition.

- Instrumentation

No instruments were observed at the dam.

- Access Roads and Gates

There is no road to or over the dam. The dam is unsecured and can be accessed from the right embankment (west) from Elm Street across private property or from the left embankment (east) from the Water District Offices.

- Drains

No drains were observed during the inspection.

3.1.3 Appurtenant Structures

- Dikes

Not Applicable

- Flow Chamber/vault

On the easterly side, there is a concrete and stone masonry chamber that historically accepted flows for use as potable water (distribution to the District's customers), and drove generating equipment for the pumping system. The concrete on all visible faces of this chamber exhibits cracking and spalling. Some seepage is evident on the downstream face of the structure, which is comprised of mortared stone masonry (see photos).

- Slide Gate

On the easterly side of the dam, there is one steel slide gate that drains to the concrete flow chamber feeding the old water pumping system. The gate is controlled by a manually operated rack and pinion drive stem. We were unable to confirm the operability of this gate.

3.1.4 Downstream Area

The left channel immediately downstream of the dam is comprised of Water District structures and then primarily of small boulders and and cobbles.

The right channel was reportedly stabilized in 1988 – 1989 with a precast concrete segmental retaining wall. According to Corps documents “tidal fluctuations, currents from water flowing over the dam’s spillway, ice flows, and weathering of the bedrock had caused erosion of about 60 feet of the streambank adjacent to the dam’s southern abutment. If allowed to continue, erosion would have caused a breach in the dam. To prevent continuing erosion, the Corps constructed a precast concrete modular wall, 80 feet long and 10-20 feet high. The modules are backfilled with earth materials and supported on a concrete footing bearing on bedrock. Construction was completed in December 1989 at a cost of $122,000. The project was built under Section 14 of the Corps’ Continuing Authorities Program.”

In the course of our observations, it was noted that the bottom edge of the concrete panels appears to extend out beyond each underlying unit, suggestive of settlement (see photos). We have approached the Corps to ascertain whether documentation is available that would establish whether this was intentional or whether the wall system has, in fact, been subject to settlement.

3.1.5 Impoundment Area

No unusual conditions were observed upstream of the dam, with the exception of the concrete retaining wall just above the dam on the left (easterly) bank. This wall appears to be deteriorated and unstable.

3.2 DAM BREACH ANALYSIS

3.2.1 General Discussion

Breach is the sudden failure of a dam and release of the water from behind it. Breach can result through a variety of mechanisms, including: an increase in the hydraulic forces on a dam during high flows, mechanical failure caused by events such as an earthquake or sabotage, or as a result of long-term, steady erosion of the foundation or an abutment. For concrete dams, such as these, failure typically relates to mechanical failure brought on by extreme high flows or due to deterioration of concrete, or both. When the water level at a dam increases enough during a flood, abutment failure leading to dam breach is also possible. At the same time, hydraulic force on the dam increases as the water level increases. The amount of this force is directly proportional to the depth of the water at the dam.

Dams are generally designed to be strong enough to withstand the forces of predictable flooding but are not normally designed to withstand the largest flood that could possibly occur in a watershed, primarily due to economic considerations. The design flood to be used for analysis is typically selected based on the hazard rating of the dam. The most significant flood that could be expected, based on the meteorological and hydrological characteristics of a watershed, is called the Probable Maximum Flood, or PMF. The PMF is a hypothetical event. The flood a dam is designed to withstand is normally expressed as a percentage of the PMF. This flood is called the Test Flood or the Design Basis Flood (DBF).

3.2.2 Corps Breach Analysis

The Army Corps of Engineers recommended in their 1979 assessment effort that the Upper and Lower Little River Dams be evaluated using a Test Flood of 50% of PMF. In their analysis of the watershed and flood hydrology, the Corps of Engineers evaluated the depth of water in the Little River at the location of each dam and in the river channel below each dam under 50% of PMF conditions.

In the river channel downstream from the Upper Dam at the Herrick Road Bridge, the routed flow (total discharge over the dam) would result in a water depth of 12 feet (below the lowest chord of the bridge). Downstream of the Lower Dam, the routed flow would result in a water depth in the river channel of 10 feet, well below the Route 1 bridge. The depth of water at both dams under these conditions would be above the abutments which could result in abutment erosion, but damage to downstream structures is not expected to occur under the Test Flood conditions.

It was determined that in the event of a breach at the Upper Dam, the resulting "flood wave" would continue on to the Lower Dam reservoir and overtop the Lower Dam. The breach wave could possibly damage or destroy the Lower Dam and damage the adjacent Water District facilities, and could result in loss of life should anyone be in the immediate area.

3.2.3 Lower Dam Breach

The Corps of Engineers analyzed a breach failure of the Lower Dam under a Full Dam condition. Under the Full Dam condition, the elevation of the water surface would be 30.3 feet, or 5.3 feet deep over the spillway. The Corps' failure analysis (based on an instantaneous, catastrophic failure of the Lower Dam) predicted a discharge of 14,780 cubic feet per second. The resulting breach wave would raise the water level in the downstream channel adjacent to the bridge to 19 feet above the channel bottom. Water would not overtop the U.S. Route 1 bridge, but would possibly damage it. Damage to a building just downstream from the Route 1 bridge downstream of the Lower Dam may also occur.

If breach failure of the Lower Dam is considered under a 50% PMF condition, the elevation of the water surface would be 36.7 feet, or 11.7 feet deep over the spillway portion of the dam (6.4 feet over the abutment portions). An instantaneous, catastrophic failure of the Lower Dam in this case predicts a discharge of 33,300 cubic feet per second. The resulting breach wave would raise the water level in the downstream channel adjacent to the bridge to 23.6 feet above the channel bottom. Water would not overtop the U.S. Route 1 bridge, but would likely damage it. Damage to a building just downstream from the Route 1 bridge downstream of the Lower Dam may occur.

The Corps did not consider the impact on the Lower Dam of a simultaneous Upper Dam breach while a 50% PMF precipitation event is occurring in the Little River watershed. Under this condition, inflow to the Lower Reservoir would include the routed outflow (including breach flow) from the Upper Reservoir and inflow from the watershed area between the Upper and Lower Dams. Under this condition, the total peak flow reaching the lower dam is estimated to be 29,920 cfs. The elevation of the water surface at the Lower Dam would be 39.7 feet, or 14.7 feet over the spillway (9.4 feet over the abutment portions). A subsequent instantaneous, catastrophic failure of the Lower Dam is predicted to result in a discharge of 38,790 cubic feet per second. This breach wave would raise the water level in the downstream channel adjacent to the bridge to 25.1 feet above the channel bottom. Water would overtop the U.S. Route 1 bridge to a water depth of 8.6 feet over the roadway, likely damaging or destroying it. Damage to a building just downstream from the Route 1 bridge downstream of the Lower Dam is also likely.

3.3 STABILITY ANALYSIS

3.3.1 General

In general, dam stability is affected by the size of the dam and the type of material used to construct it (the weight and strength of the dam itself), the condition and integrity of the foundation and base on which the dam sits, and the depth of water behind or above the dam during a flood. Stability against overturning and sliding must both be considered.

Stability safety factors represent the ability of a dam to withstand abnormal conditions. Water level behind a dam affects its stability (assuming the strength of the dam doesn't change). The "normal condition" occurs when the dam is full to the height of the spillway. If the safety factor is less than one, the dam will fail under normal conditions. If the safety factor is equal to one, the dam will be stable until the water level rises above the level of the spillway during a flood. If it is greater than one, the dam will remain stable as the water rises until the force of the water on it is equal to the safety factor times the normal force.

If the condition of a dam changes, its stability may be impacted. For example, if the concrete deteriorates or if the foundation is eroded, the dam will weaken and its stability will be reduced. Overtopping of a dam could possibly result in severe side-slope erosion of the embankment and a corresponding reduction in stability.

3.3.2 Stability of the Lower Dam

A stability analysis of the Lower Dam was performed as a part of this assessment effort, based on the assumption that the structure is a concrete gravity dam founded on a stone masonry base. It is important to note that in areas where assumptions have been necessary, due to lack of definitive information regarding the construction of the dam, such assumptions are conservative. We have been unable to access design drawings for the dam that would allow us to refine the analysis.

With the water level at a depth of 5.5 feet above the spillway crest and assuming the there is no uplift pressure developed beneath the dam, then the factor of safety against sliding is approximately 0.9 to 1.0. The factor of safety against overturning was not computed as the safety factor against sliding would be the governing criterion in this instance.

This analysis suggests that the dam is of marginal stability under high flood conditions. We strongly suspect that the calculated factor of safety is conservatively low based on our need to work off assumptions and that if we were able to gain a better understanding of the underlying foundation conditions and the bathymetry immediately upstream of the dam we would be able to provide a more accurate prediction of this safety factor.

As noted, to accurately determine the dam stability, additional information would need to be obtained. Specifically, the condition of the contact between the dam itself and the bedrock under the dam, the nature and limits of the underlying masonry must be defined. Draining the reservoir and physical examination or corings into the dam would be necessary to determine these conditions.

Because the dam has been in place since 1946, has withstood floods in the past, and currently shows no sign of obvious distress, it is plainly stable under normal conditions. It is important to note that, should the toe, foundation, or abutments of the dam be compromised through erosion, tree roots, freeze-thaw action, or some other mechanism, the current stability could be diminished.

The impact of abutment failure due to embankment erosion is not included in the stability analysis. This situation could occur if the water level were to rise to the elevation predicted for the Test Flood. Note that it is not possible to evaluate the extent of abutment slope erosion without excavation or boring along the slopes adjacent to the abutments.

3.4 Assessment Summary

In general, the overall condition of Lower Little River Dam is FAIR. Areas of the dam that we were able to observe were in generally good to fair condition. There are several areas where repairs or improvements should be made, as noted.

3.5 Commentary from Maine Emergency Management Agency

As is customary in our assessment of dams in the State, we contacted Tony Fletcher, the State's Dam Safety Officer. He indicated that, in his opinion, "the lower dam is probably a low hazard, but this assessment needs to be confirmed by breach analysis, which, currently we do not have the staff to do."

3.6 Recommendations

The following recommendations generally describe tasks that should be considered to address current deficiencies at the dam and allow for its safe operation into the future. Prior to undertaking recommended maintenance, repairs, or remedial measures, the applicability of environmental permits needs to be determined for activities that may occur within or adjacent to resource areas under the jurisdiction of the local municipal government, the Maine DEP, the Corps of Engineers or other regulatory agencies.

Our assessment identified several areas that should be considered for repairs or improvements:

1. Conduct a more detailed review of the stability of the left (westerly) bank downstream retaining wall. Based on our observations, it appears that some of the precast units may have been displaced over time. As noted above, we have contacted the Corps of Engineers to determine whether As-Built drawings are available for the wall in question.
2. Install a low-level drain which would facilitate dewatering for the purposes of inspection, maintenance or repairs. This should likely be included in the rehabilitation of the flow chamber/vault area located at the right (easterly) end of the dam, as discussed below.
3. Conduct repairs to concrete and stone masonry at the flow chamber/vault between the dam and Water District Building. This effort should be coordinated with the installation of a gated low level drain.
4. Conduct repairs/replacement to retaining wall just upstream of the Vault/Flow Chamber on the right (easterly) bank.
5. Consider whether further efforts to refine assumptions relative to the stability analysis (sliding – depends on foundation conditions) are warranted.

Further discussion is included in Section 4 of this report.