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 DIRECT TESTIMONY OF TYLER PARENT
NORMANDEAU ASSOCIATES, INC.

1. I am Tyler Parent, a Fisheries Scientist with Normandeau Associates. I have been in the field of fisheries biology for more than 6 years, with 2 years of work in the Penobscot River watershed. I have experience collecting and interpreting a wide range of data relating to fisheries in Maine and several other states in the country. My resume is attached as Addendum A.

2. My role on the Nordic Aquafarms, Inc. project is to provide the project team with information specifically relating to finfish and shellfish in the freshwater and marine habitat in the project area.

3. Between July 2018 and October 2019 I was tasked with preparing the fisheries portion of a variety of permit applications to evaluate potential impacts to the freshwater and marine environment that could be caused by the proposed Nordic Aquafarms facility. Impact assessment was conducted primarily via a desktop analysis of available resources, and included data collected specifically for this project. Nordic Exhibit 8 is the Natural Resources Report of May 8, 2019, in which we provide the methods and results of the wetland and stream determinations, vernal pool surveys, wildlife, fisheries and benthic assessments. The fisheries sections of that report are referenced and reiterated in this testimony.

Fisheries Methods

4. Normandeau Associates conducted field surveys in 2018 to provide supporting data for the permitting process. Normandeau recorded video of the bay floor by towing a camera below a boat to characterize the habitat present along the proposed pipeline route. Also, water quality data were collected to assess the existing ambient conditions at various locations where in-water structures are proposed. During analysis, the specific engineering characteristics, and construction plan of the proposed project were used to help assess the potential impact to each species. Impacts were characterized as temporary if they would

only exist due to construction activities, or permanent if the impact would continue after construction was finished and facility operation continued.

5. Maine Department of Inland Fisheries and Wildlife (MDIFW) and the Maine Department of Marine Resources (MDMR) were both consulted for guidance on species of interest as well as suggestions regarding potential impact mitigation strategies. MDIFW did not request impact assessment for any freshwater species that might be found in the freshwater reservoir, which is adjacent to, but not on the project site. Maine DMR recommended impact assessment for five species of finfish which use the marine habitat. Those species were American eel (*Anguilla rostrata*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), winter flounder (*Pseudopleuronectes americanus*), and rainbow smelt (*Osmerus mordax*). (MDMR) recommended impact assessment for four species of shellfish. Those species are American lobster (*Homarus americanus*), Atlantic sea scallop (*Placopecten magellanicus*), blue mussel (*Mytilus edulis*), and softshell clam (*Mya arenaria*).

6. In addition to these agency-suggested species of interest, I took some time to review literature regarding three federally listed species of finfish which are thought to inhabit the project area for at least a part of their life history. These species include Atlantic salmon (*Salmo salar*), Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), and shortnose sturgeon (*Acipenser brevirostrum*).

<u>Freshwater</u>

7. The reservoir, "Belfast Reservoir Number One" is a ponded section between two dams on the Little River. This habitat does provide adequate habitat for some freshwater species, however there were no specific reservoir species recommended for impact assessment by the state. In order to minimize potential impact to this water body, erosion and sedimentation control measures will be implemented during Project construction and permanent vegetative buffers will be maintained between the reservoir and the site. Vegetative buffers will include a 250-foot shoreland zone, measured from the mean high water mark that will be retained by the City of Belfast on the project side of the reservoir with the exception of the areas where the water district office building is currently located.

8. Surface water withdrawal from Belfast Reservoir Number One, through existing intake infrastructure located at the dam, is proposed to help meet project freshwater needs. The withdrawal will comply with Chapter 587: In stream flows and lake and pond water levels. If any work should be required for this project within waters considered to be inland fisheries habitat, an in-water work window of July 15th to October 1st will be observed, as requested by MDIFW. At this time, no changes to the existing intake pipe are proposed, so no freshwater work is expected.

9. Other than the intertidal area, the marine portion of the proposed path of the intake and discharge pipes contains habitat that is quite homogenous. Upon review of the video recorded by Normandeau Associates in August 2018, the most predominant habitat within the subtidal area is fine grain sandy, silty, muddy substrate mixed in with relatively small cobble, and almost no vegetation. In the closest section to shore, in the subtidal area, there are some small patches of vegetation that could be used as viable habitat for a variety of finfish or shellfish species. Vegetation consisted of common intertidal and shallow subtidal species. Two Fucaceae species: Bladderwrack (*Fucus vesiculosus*) and *Ascophyllum nodosum*, were observed, as well one rhodophyte species identified to be Irish moss (*Chondrus crispus*). Also present are smaller amounts of some larger diameter substrates including cobble, boulders, and shells. These small patches of vegetation did not represent a substantial portion of the proposed construction area. Fishes, crabs, sea stars, and shellfish were not very prevalent in the video, but it is likely some of the mobile organisms detected the towed camera and boat, moving from the visual field. This indicates that the majority of the seafloor life is likely to temporarily relocate on its own and presumably re-colonize the area post-construction. Mobile organisms will likely recolonize the area soon after construction. Sessile organisms will begin recolonization after the first spawning season post-construction.

10. For the project area, MDMR asked that American eel impact analysis be focused on the "elver" lifestage as this is the stage during which eels attempt to migrate up into freshwater. After being spawned in the Sargasso Sea, leptocephalus larvae drift at sea for up to a year and are transported north by the Gulf Stream. Leptocephali larvae metamorphose into early unpigmented juveniles called glass eels as they approach the North American coast and are 60-65 mm in length. They migrate upstream primarily at night into freshwater were they feed, become pigmented (elvers), and slowly grow until sexually mature, which can take up to 20 years. Glass eels and elvers use a wide range of temperatures, burrow into sand, mud, snags, plant masses and other substrate types during the day and in between upstream movements, and have been reported in salinities from 0 to 25 ppt. Although there is not currently upstream passage infrastructure in place at the dams on the Little River in Belfast, young eels could still be present as they are known to be able to climb nearly vertical wetted structures to get upstream. Due to the depth and placement of the intake, it is unlikely that the proposed project would have a significant impact on elvers because they will already be developed swimmers and able to avoid the intake structure.

11. Alewife and blueback herring are very similar anadromous, euryhaline, coastal, pelagic fish that are difficult to distinguish from one another and occur in similar habitat. Since it is difficult to visually distinguish between the two species, they are often considered together under the name "river herring". Spawning occurs in these species in late April to mid-May in Maine. This means that in the spring, adults could be moving through the project area on their way to the mouth of the Penobscot River. There is no current use of the Little River as freshwater spawning habitat by river herring. After spawning, adults return to sea while young-of-year remain in freshwater for several months before gradually descending to the ocean. Juveniles tend to immigrate in waves as early as June and as late as October. As the egg and larval stages only occur in freshwater, those juveniles which could exist in the project area on their way to the ocean will already be developed enough to be unaffected

by the operation of the intake. Additionally, the in-water work window will ensure that migrating individuals will not be impacted during construction.

12. Winter flounder come inshore during late winter and early spring to spawn and adults move offshore following spawning. Winter flounder eggs are both demersal and adhesive. They are laid in masses and stay on the seafloor during incubation. The incubation period is temperature-dependent and typically lasts 2 to 3 weeks. When larvae emerge, they are planktonic, drifting in open water, but remaining close to the coves or inshore waters which they use as nursery habitat. They quickly become demersal as the metamorphosis from an upright swimming fish to a flat fish begins. Juveniles settle in shallow water and estuaries in very high densities. Some reports suggest that recently settled groups of young-of-year winter flounder can exceed densities of 1 individual per square meter. It is thought that most juvenile individuals overwinter in estuaries but some are documented to do so offshore. In the Gulf of Maine adults spawn from February through May, later than in more southern portions of the range. Additionally, spawning can occur in water shallower than 5m in the Gulf of Maine. Spawning substrate and depth can be quite variable, but sandy substrate seems to be slightly preferred. Eggs are generally deposited in 90 m of water or less, often being as shallow as just a couple meters. Additionally, it is thought that spawning adults tend to choose to release eggs in areas with minimal flow to prevent recently hatched larvae from drifting far from suitable nursery habitat. The project area, with its mainly soft bottom, would likely be suitable habitat for the Winter flounder spawning and nursery habitat. As this species spawns during the proposed in-water work window, the project is likely to disturb or displace some spawning individuals. However, the project footprint is not very large when compared to the whole of Belfast Bay, so individuals should still spawn in adjacent equivalent habitat during construction. After the facility begins operation larvae of this species could be impacted by the intake.

13. Rainbow smelt are schooling, pelagic fish that occupy inshore coastal waters. They serve as an important prey item for a variety of piscivorous species. In spring, typically March-May in New England, they undertake significant migrations leaving coastal waters and traveling to freshwater streams to spawn above the head of tide. Spawning rainbow smelt that come inshore during spawning season do have the potential to have their migration to upriver spawning areas affected by the project. If individuals come inshore in March, they may come into contact with construction activities. Although spawning occurs in freshwater, after hatching, larvae drift quickly to estuarine waters, making it possible for larvae to occur in the project area. This will likely not be an issue during construction because eggs will not drift into the project area until after the end of the in-water work window. However, once the facility begins operating, larvae may be impacted by the intake. As the seawater intake volume of the proposed project will be quite small when compared to other intake systems, this impact could be minimal.

14. The Atlantic salmon is an anadromous species which is native to the Gulf of Maine. The Gulf of Maine Distinct Population Segment (DPS) was first listed as Endangered in December of 2000, and subsequently re-affirmed as endangered in 2009. The Gulf of Maine, and more specifically the Penobscot River provides habitat to one of the only remaining viable runs of wild Atlantic salmon. Despite management efforts, stocks have continued to decline since the species was federally listed. Individuals of this species hatch in cool, clean upstream areas of rivers such as the Penobscot. After hatching in late

spring, larvae (called alevins) remain upstream where they were spawned. As they absorb the yolk sac and continue development, they remain in the substrate as alevins for three to six weeks. Once the yolk is nearly absorbed, they emerge from the substrate as fry to look for food. The fry stage is short, as they progress to the parr stage rapidly. Fry develop vertical bars down the sides of their bodies, and they remain in the river for 1 to 3 years while they develop. Once developed, in late spring and early summer, parr undergo a process called "smoltification" in which their physiology changes, resulting in a change in appearance as well as the ability to tolerate saltwater. At this time they start a downriver migration to the ocean. After reaching the ocean, they move up to the waters off the coast of Canada and Greenland where for 1 to 3 years they change from a 6 inch, 2 ounce smolt, into a mature adult weighing 8 to 15 pounds. When an individual has matured and is ready to spawn, it migrates back to its natal river to travel upstream to spawning grounds. In late fall, typically October or November, females deposit eggs into gravel nests called redds. Eggs are fertilized in nests called redds and incubate for 175 to 195 days before hatching. Juveniles are documented to use Belfast Bay, as a western corridor of Penobscot Bay to get from their natal waters within the Penobscot River to the ocean. This would only be true of the smolt portion of the juvenile life stage as the other stages remain exclusively in freshwater. Although smolts are known to venture past the project area during emigration, they are almost entirely surface oriented, which would prevent them from ever being in the vicinity of the intake and discharge of the proposed project, as these structures will be fixed to the seafloor. Adults use the entirety of Penobscot Bay, including the project area of Belfast Bay when they travel back to the Penobscot River on their way to spawning habitat. However, adults are not resident in the Belfast Bay. Although adults are not as surface oriented as smolts, a healthy salmon on its way to spawning ground will have more than enough burst speed to make it virtually impossible to be affected by an intake with a through-screen velocity of less than 0.5 ft/sec. Atlantic Salmon will only use the project area as a potential path on a migratory route. They will not use the project area for spawning, nursery, forage, or shelter, so impacts to this species are expected to be insignificant to nonexistent.

15. Listed as endangered in 1967, the shortnose sturgeon is a relatively small sturgeon which has metapopulations within the river systems in the Gulf of Maine. Its range extends from the St. Johns River in New Brunswick to the Altamaha River in Georgia. This species is diadromous, moving in and out of rivers for spawning as well as for shelter and foraging. Like many other species of sturgeon, the shortnose sturgeon splits its time between freshwater and saltwater. Rivers are used as spawning grounds in the spring, while deeper holes in the river are used as thermal refuge during warmer months. Saltwater in estuaries and in coastal water is used as foraging ground as well as a route to move between river systems. This species does not reside much in full saltwater, rather it uses coastal water only as a pathway to other river systems. Other than these journeys to get to a different river, this species rarely uses open ocean habitat, favoring estuarine areas and freshwater. Typically, adult shortnose sturgeon will migrate up their natal river in the fall, overwinter there, and spawn in the spring. Spawning occurs exclusively in freshwater because eggs and larvae have no tolerance to saltwater. Spawning habitat within a river consists of rocky substrate and moderate water velocities across the bottom. In Gulf of Maine rivers, other than the Merrimack, eggs and larvae remain hidden in the rocky substrate as they develop. Although the data are somewhat lacking, it is thought that young of year do not migrate downstream in their first year, instead choosing to winter in

freshwater. Some yearlings begin to move downstream in their natal rivers after developing some salt tolerance during their first winter in freshwater. Two and three year old juveniles remain in their natal river's estuary, moving upriver seasonally to overwinter at or near their spawning site. During all life stages, this species tends to use the most established river channel for travel up and downstream, usually being found in the deepest sections. Shortnose sturgeon are morphologically suited to life in benthic habitat. They are known as a cruising benthic predator, using their vision, barbels, and electroreceptors to locate prey which they then grasp with their ventral protuberant mouths. Within the Gulf of Maine metapopulation, the rivers of focus are the Penobscot, the Kennebec, the Androscoggin, the Saco, and the Merrimack. Although shortnose sturgeon have been observed in each of these river systems, studies suggest that there are not breeding populations in each of the systems. Rather, individuals move between estuaries and river systems to forage, overwinter, and sometimes to reproduce. In the Gulf of Maine, the Penobscot River and estuary does not support a spawning population of shortnose sturgeon and there is currently only evidence of non-spawning adults. The Penobscot River and estuary has, in recent years, been deemed to not have a spawning population because there is currently little evidence of the presence of any individuals of the younger life stages. Regardless of whether spawning occurs in the Penobscot, it is clear that it serves as valuable habitat to this endangered species. Due to the lack of younger life stages in the area, only adult shortnose sturgeon could be affected by the proposed project in Belfast Bay. However, as the proposed aquafarm is designed to have a through screen velocity of less than 0.5 ft/sec, adult sturgeon will have no issues with impingement and they should be able to use habitat around the intake and discharge after construction without impact.

16. The Atlantic sturgeon is currently federally listed as threatened in the Gulf of Maine distinct population segment. In the rest of their range which extends down to Florida, they are listed as endangered. The threatened listing for the Gulf of Maine indicates that the Atlantic sturgeon is at significant risk of becoming endangered in the next 20 years. This species grows to a maximum length which is larger than that of the shortnose sturgeon, with adults achieving lengths greater than 4 meters. The life histories of the fish are somewhat similar because the Atlantic sturgeon is also anadromous, spawning in freshwater, while also spending significant time in saltwater. Males spawn every 1-5 years, while females spawn slightly less frequently, every 3-5 years. Individuals enter the Penobscot estuary in the spring (average of May 15th) and leave in the late summer/fall (average of August 31st). Time offshore is one the major differences that separates the Atlantic Sturgeon's behavior from that of the shortnose Sturgeon. While the shortnose sturgeon only seems to venture out of rivers and estuaries to offshore environments to quickly get to a different river system, Atlantic sturgeon leave the estuary and do not come back until they are ready to spawn 1 or more years later. Other than to spawn, adults spend the majority of their lives in marine waters. In a particular year, adults that will spawn, migrate up their natal rivers in the spring (Ranges February through July depending on region). Eggs are adhesive and are deposited onto hard substrate such as cobble in waters 11 to 27 meters in depth and with optimal flow. After eggs hatch, the larvae remain demersal. Once the juveniles have developed a tolerance to saltwater, they move into brackish water within the estuary where they remain resident for months or years. After some time in the estuary, subadults move offshore into coastal waters, returning when they are ready to spawn for the first time. The Atlantic sturgeon is a cruising benthic predator which feeds in the same way as the Shortnose Sturgeon. In the Penboscot River

population, spionoid polychaetes makeup the base of the Atlantic sturgeons diet. Additionally, they feed opportunistically on several other prey species found in the benthic environment. The Penobscot River does support a spawning population of Atlantic sturgeon, but only sub-adults and adults are likely to occur in the project area. Eggs and larvae occur strictly in freshwater, so they cannot occur close to the project area. Adults are known to travel between neighboring river systems sometimes being detected in estuaries that are different than where they were born. Juveniles remain in brackish water, further upstream in the estuary than the project area. This allows them to have some transition time in water that is not full salt yet. Once they develop enough to become a sub-adult, they can venture out into the saltwater portions of Penobscot Bay, which could include Belfast Bay. Even at these younger life stages, Atlantic sturgeon are not known to be resident in the full saltwater portions of their natal river system's estuary. So, sub-adults will most likely just be passing through the project area on their way to the open ocean. Similarly, mature adults may use Belfast Bay as a portion of their migratory corridor to get to get to the Penobscot River on their way to spawning grounds in freshwater. Regardless, both of these life stages should not have issues with habitat quality or connectivity due to their already advanced development. They will be far too large and strong to experience issues with the intake.

17. After the facility begins operation of the intake, the only ongoing potential for loss of finfish due to project operations would be by eggs and larvae at the intake. The intake is engineered to have a through screen velocity of less than 0.5 ft/sec, which will effectively eliminate the chance for adult fish to become stuck to the intake screen. The screen itself is proposed to be a 1-inch slot size wedge wire mesh which may allow some eggs and larvae to enter. It is not expected that mortality would occur due to temperature, rather, eggs and larvae would be lost at the via the intake filtration system. The most likely species to experience this impact would be winter flounder and rainbow smelt as these species are likely to have the egg and/or larval life stages present in the vicinity of the intake. There is some chance that young glass or elver stage eels could be impacted by the intake, but it is unlikely that this would be significant as their swimming ability should be developed enough for them to avoid the screen due to the low intake velocity. The significance of impact of early life stages at the intake cannot be accurately quantified, as no ichthyoplankton data were collected for this project. However, it can be inferred that the overall impact to ichthyoplankton in the bay will be less severe than a similarly designed intake (same through-screen velocity and mesh size) operated for cooling water. This is because the estimated 7.7 million gallons per day (MGD) that the aquaculture facility plans to intake is a much smaller overall volume than many other large-scale seawater intakes in the region which are often in excess of 100 MGD.

18. It is important to note that the actual point of intake will be raised up off the seafloor several feet. This will assist in minimizing intake impacts. Additionally, in response to comments from the Department of Environmental Protection (DEP), Nordic Aquafarms elected to modify the pipeline design to reduce the overall area of permanently impacted benthic habitat. Original designs had the above-ground portion of the intake and discharge pipes resting directly on the seafloor with mattress type anchors holding the pipelines down. After modification in response to agency comment, the pipeline will be suspended above the seafloor with collar type anchors placed periodically to hold the pipes down.

This will significantly reduce the area of benthic habitat which is impacted permanently, as well as provide space for benthic organisms to pass under the pipeline.

19. The American lobster uses a wide variety of substrate. Although no lobsters or burrows were observed during the pipeline habitat survey conducted by Normandeau Associates, the literature suggests that the project area could be suitable for some life stages of this species. As eggs of this species hatch from May to October, it is not expected that the in-water construction will significantly impact lobster in the project area. Individuals present during the November 1st through April 1st in-water construction window are most likely to be fully or nearly fully developed, making them mobile enough to self-relocate to a safe distance from construction activities. After the facility begins operating its seawater intake, it is possible that some loss of the early planktonic larval stages could occur.

20. Mortality of individuals of the four shellfish species in question is not likely to occur strictly from the temporary increase in total suspended solids (TSS) during construction activities. Juvenile and adult lobsters will self-relocate during construction, thereby minimizing the chance for significant impact. Scallops, blue mussels, and softshell clams will be able to modify their behavior to temporarily endure the change in water conditions until their area of residence is no longer part of the active construction zone. If loss of adult shellfish is observed, it is most likely to occur by the individual being physically crushed by a piece of equipment used during in-water construction. As an impact mitigation measure, this project will restrict all in-water work in the marine environment to November 1st to April 1st.

21. After construction is complete, all shellfish should be able to resume routine use of the project area. During facility operation the only ongoing potential for loss of shellfish due to project operations would be the loss of eggs and larvae at the intake. The intake's less than 0.5 ft/sec engineered intake velocity will minimize the chance for adult shellfish to become stuck to the intake screen. The screen itself is proposed to be a 1-inch slot size wedge wire mesh, which will be too large to reduce the intake of larval and egg life stages. It is not expected that mortality would occur due to temperature, rather, eggs and larvae would be lost via the intake filtration system. As mentioned for finfish the significance of this impact cannot be accurately quantified, as no ichthyoplankton data were collected for this project. It can be inferred that the overall impact to larval and egg life stages of shellfish in the bay will be less severe than that of a similarly designed intake (same through-screen velocity and mesh size) operated for cooling water. No commercial shellfisheries are expected to be negatively affected by the project because the proposed project area is located within an area which MDMR has classified as a prohibited shellfish growing area. Additionally, the substrate is not conducive to the establishment of a shellfishery.

22. Three in-water activities may result in elevated underwater sound pressure during construction; 1) drilling, 2) hydraulic rock breaker (hoe ram) and 3) blasting. Man-made underwater noise has the potential to cause behavioral disturbances, hearing impairment or threshold shifts, physical injury, or morality to marine organisms. When a fish with a swim bladder is exposed to a sound wave, gas in their swim bladder expands and contracts more than the surrounding tissue during the periods of under pressure and overpressure, respectively. This can cause the swim bladder to oscillate resulting in tissue damage and possibly rupture. Hearing loss in a fish is likely to result in reduced fitness from decreased

ability to detect and avoid predators, locate prey, communicate with peers, or sense physical environment. The types of effect on and response from fishes to a sound source will, logically, depend on distance. Very close to the source, effects may range from mortality to behavioral changes. Somewhat further from the source mortality is no longer an issue, and effects range from physiological to behavioral. The potential for effects declines as distance increases between the individual and the source. The actual nature of effects depends on a number of other factors, such as fish hearing sensitivity, source level, sound propagation and resultant sound level at the fish, whether the fish stays in the vicinity of the source, and motivation level of the fish. Generally speaking, species are thought to have different tolerances to noise and may exhibit different responses to the same noise source. To minimize impact on any marine life which may occupy the project area during the in-water construction window, a “soft start” technique will be utilized to encourage temporary relocation.

23. Specific to the Nordic Aquafarms aquaculture project, several activities associated with construction of the new structure have potential to disturb sediments and increase turbidity. These actions include:

- Construction of intake and discharge pipes
- Burying the intake and discharge pipes
- Clearing the path for the subtidal pipes

24. It is important to note that substrate within the project area is predominately silt, sand, and mud, with some rubble and cobble materials mixed in. As a result, impacts from sedimentation and increased turbidity may be temporarily higher in soft bottom areas compared to hard substrate. Although it is anticipated that there will be a significant increase in turbidity in the immediate area of construction, these effects should be short in duration, and minimized by time of year restrictions and through the use of turbidity curtains. Consequently, temporary adverse effects to fish are expected to be minimal.

25. The facility plans to discharge up to 7.7 million gallons per day (MGD) into Belfast Bay. As their water will be coming from 3 sources (Water drawn from reservoir, Purchased from City, Seawater Intake), seawater volume withdrawn will be less than the total discharge volume. Initially, the facility would discharge far less than 7.7 MGD as the first phases of the project will require much less water to initiate operation. Only once the facility construction is 100% complete would the 7.7 MGD of discharge occur.

26. Discharge water quality will be maintained in 2 ways after it is filtered on the way into the facility and becomes “wastewater” by being used for aquaculture:

1. Water will constantly be filtered during use inside the facility using their Recirculating Aquaculture System (RAS),

    - Mechanical, biological and gas balancing in order to maintain a high level of water quality suitable for culturing Atlantic salmon,

2. Water will be treated again at the effluent/ wastewater treatment plant

    - Mechanical, biological and chemical treatment of final discharge.

27. Waste Water Treatment Plant Sequence of Treatment:

    1. Aerobic Moving bed bio-reactor (MBBR)

    2. Chemical precipitation of total P

    3. Micro-Filtration (0.4 µm pore size) in Membrane Bio-Reactors (MBR)

    4. Sludge Dewatering, decanter centrifuges, supernatant returned to biological treatment

    5. Final liquid effluent UV-C sterilization prior to discharge

28. Nordic Exhibit 20 shows these projected effluent concentrations and assumed ambient concentrations at the discharge location. Effluent concentrations are subject to further dilution in the mixing zone resulting in lower concentrations in the receiving waters. Based on projected effluent concentrations predicted by near field and far field dilution modeling as described in the Prefiled Direct Testimony of Nathan Dill, and comparing these numbers to the results of water quality sampling by Normandeau Associates at the proposed discharge location during high and low tide, the discharge of the proposed facility is not expected to significantly impact the water quality of the receiving water. As such, the discharge is not expected to have a significant impact on finfish, shellfish, or benthic organisms in the vicinity.

29. Key Findings

1) Impacts to fisheries during construction are overall not expected to be significant because of the in-water work window proposed and other mitigation measures.
    - November 1st through April 1st is the industry standard in-water work window used to minimize impact to the marine environment during construction. This time period is correlated with low levels of biological activity in the marine environment, reducing the likelihood that any of our species of interest will be present during construction. The main exception to this is winter flounder. This species is known to spawn during the recommended in-water work window which will create the potential for some loss of spawning adults, eggs, and larvae.
    - Adverse impacts from underwater noise will be minimized by using a “soft start”
    - Increases in total suspended solids will be minimized by the use of floating turbidity curtains
2) Ongoing impact to fisheries are possible under the current intake design, but the impact could be minimal as the seawater intake volume of this proposed project will be quite small when compared to other intake systems.
    - Winter flounder, rainbow smelt, American lobster, Atlantic sea scallop, blue mussel, and softshell clam may have eggs and/or larvae in the vicinity of the intake at some point each year leading to potential losses via the intake filtration system. The magnitude of

these impacts cannot be quantified without ichthyoplankton sampling, however they are expected to be significantly smaller than those of a similarly designed seawater intake of a larger volume.

3) Based on the testimony from Nathan Dill regarding effluent concentrations and dilution modelling, the project discharge is not expected to have an adverse impact on finfish or shellfish
   - The exhaustive filtration regimen will reduce potential pollutants.
   - The discharge design will maximize dilution.

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Dated December 10, 2019

By. [signature]
Tyler Parent, Fisheries Scientist
Normandeau Associates, Inc.

STATE OF New Hampshire
County of Rockingham, ss.

December 10, 2019

Personally appeared the above-named Tyler Parent and made oath as to the truth of the foregoing pre-filed testimony.

Before me,

Amber MacDonald
Notary Public / Attorney at law

AMBER D. MACDONALD
Notary Public-New Hampshire
My Commission Expires
March 21, 2023

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

TYLER H. PARENT
Fisheries Scientist

Mr. Parent has worked on projects in a wide range of water bodies throughout New England, as well as several drainages throughout North Carolina, South Carolina, and Virginia. He has been with Normandeau Associates since 2015 and is experienced in the collection of biological data using methods such as gill netting, beach seining, trawling, boat/backpack electrofishing, visual survey, impingement, entrainment, fish passage monitoring with Salmonsoft software, radio telemetry, and more. Mr. Parent aids in Normandeau's scientific reporting and permit applications and is experienced in the identification of Eastern fish species, collection of water quality data, and holds a current commercial boating license and SCUBA certification.

EDUCATION

Current M.S. Student. Integrative and Organismal Biology, University of New Hampshire

B.S. Wildlife and Fisheries Biology, University of Vermont

PROFESSIONAL EXPERIENCE

2015-Present	Normandeau Associates
2014	Vermont Fish and Wildlife Department
2013-2014	Rubenstein Ecosystem

REPRESENTATIVE PROJECT EXPERIENCE

Juvenile River Herring Radio-Telemetry Downstream Passage Study, Brookfield Renewable Energy, Penobscot River, ME (2019). Normandeau Associates, Inc. conducted a radio telemetry study to collect data on downstream passage of juvenile river herring at one Brookfield Renewable operated hydroelectric dam on the Penobscot River; West Enfield Hydroelectric Project (FERC Project No. 2600). The purpose of this study was to serve as a proof of concept for the viability of tagging downstream migrating juvenile river herring to assess passage survival past hydroelectric stations. Previous studies conducted by other organizations yielded very poor results due to extremely high mortality of tagged fish. This study focused on identifying tagging and transport procedures which would maximize the number of tagged individuals which survived tagging and continued their downstream migration. Data were collected using both manual tracking and an array of stationary radio telemetry receivers. This study yielded a high portion of fish which survived the tagging process without issue and attempted to pass the study dam, thereby proving the concept for use in the future. Fisheries Scientist.

River Herring Radio-Telemetry Upstream Passage Study, Brookfield Renewable Energy, Penobscot River, ME (2019). Normandeau Associates, Inc. conducted a radio telemetry study to collect data on upstream passage of adult river herring at one Brookfield Renewable operated hydroelectric dam on the Penobscot River; Milford Hydroelectric Project (FERC Project No. 2534). The purpose of this study was to serve as a proof of concept for the viability of tagging upstream migrating river herring to assess passage infrastructure efficiency. Previous studies conducted by other organizations had very poor success due to the tagged fish not attempting upstream migration after tagging. This study focused on identifying tagging and transport procedures which would maximize the number of tagged individuals which attempted to pass the dam after being handled. Data were collected using both manual tracking and an array of stationary radio telemetry receivers to assess passage efficiency. This study yielded a high portion of fish which attempted to pass the study dam after tagging, thereby proving the concept for use in the future. Fisheries Scientist.

Juvenile River Herring and American eel Radio-Telemetry Upstream Passage Study, Brookfield Renewable Energy, Androscoggin River, ME (2019). Normandeau Associates, Inc. conducted a radio telemetry study to collect data on downstream passage of juvenile river herring at one Brookfield Renewable operated hydroelectric dam on the Androscoggin River; the Pejepscot Project (FERC No. 4784). American eels were tagged surgically, while juvenile river herring received external tags. Fish were then released above projects at prescribed locations. Through manual tracking as well as an array of stationary receivers, the downstream path and survival was determined for each individual tagged fish. Fisheries Scientist.

FERC Relicensing Biological Studies, Enel Green Power, Merrimack River, MA (2019). Normandeau Associates, Inc. is currently conducting a host of biological assessments as part of the ongoing FERC relicensing process for the Enel Green Power operated Lowell Hydroelectric Project (FERC Project No. 2790). Studies include radio-telemetry studies on river herring and American eels, instream flow, habitat characterization, and fish assemblage. Fisheries Scientist.

Fish Ladder and Fish Lift Passage Counts Using Salmonsoft, Enel Green Power, Merrimack River, MA (2017-2019). Normandeau Associates, Inc. conducted electronic counts of fish passed upstream at two Enel Green Power operated hydroelectric projects; Lawrence Hydroelectric Project (FERC Project No. 2800), and Boott Hydroelectric Project (FERC Project No. 2790). Three in-air video recording systems were deployed during the spring migration season. These systems utilized the purpose-built fish counting software Salmonsoft to minimize output file size and streamline the counting process. The output of this data collected total counts up and down by species as well as time stamps for each detection to provide temporal information associated with passage. Fisheries Scientist.

Atlantic Salmon Smolt, American Shad, and River Herring Radio-Telemetry Downstream Passage Studies, Brookfield Renewable Energy, Penobscot River, ME (2018). Normandeau Associates, Inc. conducted radio telemetry studies to collect data on downstream passage at four Brookfield Renewable operated hydroelectric dams on the Penobscot River; West Enfield Hydroelectric Project (FERC Project No. 2600), Milford Hydroelectric Project (FERC Project No. 2534), Stillwater Hydroelectric Project (FERC Project No. 2712), and Orono Hydroelectric Project (FERC Project No. 2710). Atlantic salmon smolts were tagged surgically, while American shad and River herring received gastric tags. Fish were then released above projects at prescribed locations. Through manual tracking as well as an array of stationary receivers, the downstream path and survival was determined for each individual tagged fish. Fisheries Scientist.

Fort Pickett MTC Roanoke Logperch Fish Survey, VA (2017). Normandeau Associates, Inc. conducted fish surveys as well as habitat assessments in the Nottoway River drainage on Fort Pickett property. Backpack electrofishing surveys were conducted at nine Nottoway River mainstem locations and at five road crossings of tributaries for resident fishes, including the target species, the endangered Roanoke logperch (*Percina rex*). All fish captured were identified to species and enumerated to gain insight into species composition. Additional observational surveys occurred at 18 tributary road crossings for potential hindrances to the upstream passage of fishes. Fisheries Scientist.

Duke Energy/HDR 316(b) Impingement and Entrainment, NC/SC (2016-2018). Normandeau Associates, Inc. conducted 316(b) Impingement, Entrainment, and Collection Efficiency studies at 8 different Duke Energy power plants throughout North and South Carolina; Allen Steam Station, Marshall Steam Station, Belews Creek Steam Station, Roxboro Steam Station, Sutton Combined Cycle Plant, McGuire Nuclear Station, Oconee Nuclear Station, and Robinson Nuclear Station; Project Lead/ Staff Supervisor for 316(b) studies at all 8 plants. Assisted in the manufacturing and deployment of 8 custom-built entrainment systems. Managed/conducted field operations for data collection, and coordinated proper communication with the client as well as the co-consultant (HDR) to ensure smooth sampling for the field crews. Maintained the mechanical portions of the various entrainment systems. Assisted in the creation of standard operating procedures for field data collection. Fisheries Scientist.

TransCanada Hydro Northeast FERC Relicensing, Connecticut River, NH/VT (2015-2016). Normandeau Associates, Inc. conducted studies for the FERC relicensing process of three TransCanada operated hydroelectric dams on the Connecticut River; Wilder Hydroelectric Project (FERC Project No. 1892-026), Bellows Falls Hydroelectric Project (FERC Project No. 1855-045), and Vernon Hydroelectric Project (FERC Project No. 1904-

073); Project Lead for resident fish passage study which monitored the fish ladders at three dams. Mobilized and monitored Salmonsoft motion detection camera systems for motion detection driven video capture to keep track of all fish activity in the ladders; Field crew leader for upstream American eel passage study which included nighttime systematic visual surveys by boat, and trapping using baited pots directly below dams to find potential congregations of eels attempting to migrate upstream; Boat operator for Tessellated darter visual survey; Also assisted in data collection for general electrofishing study, sea lamprey spawning assessment, and various telemetry studies. Field Technician.

***Vermont Fish and Wildlife Department, Fisheries Division, VT (2014).** Conducted field work for a host of long term monitoring projects for the state of Vermont. Projects included trout population monitoring using backpack and generator electrofishing, bass pond population monitoring using boat electrofishing, fish ladder monitoring using Salmonsoft motion detection software, water quality monitoring, creel surveys, database upkeep, and field gear maintenance. Field Technician.

***Rubenstein Ecosystem Science Laboratory, Lake Champlain, VT (2013-2014).** Conducted each step of a population genetics project pertaining to the fragmenting effect of causeways in Lake Champlain, and how they may create genetically distinct populations of lake whitefish (*Coregonus clupeaformis*). Sampled lake whitefish using gillnets in many sections of the lake in order to collect muscle tissue for microsatellite DNA analysis. Extracted DNA from tissue samples and conducted polymerase chain reaction (PCR) to analyze differences in microsatellite loci. Gave a presentation of findings at the 2014 Northeast Fish and Wildlife Conference in Portland, Maine. Paid Intern/Field and Lab Technician working under Dr. J. Ellen Marsden.

***Project experience prior to being employed by Normandeau Associates.**

SPECIAL TRAINING

2017-Open Water SCUBA Certification

2019-First Aid, CPR, and AED Certification

2015-New Hampshire Commercial Boating License

Memo

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Date:	September 27, 2018
To:	Nordic Aquafarms
From:	Nathan Dill, P.E.
Subject:	Near-field Dilution of Proposed Discharge

This memorandum provides a summary of estimated initial dilution of wastewater discharge from the proposed Nordic Aquafarms Recirculating Aquaculture System into Belfast Bay, Maine. This memorandum focuses on dilution of the effluent that would occur within the near-field region. That is, the region near the discharge port where mixing is dominated by forces of the discharge itself, and thus can be influenced by the outfall design.

Understanding the near-field dilution of a wastewater discharge is typically important when there is a need to assess impacts of toxic pollutants on aquatic organisms near the outfall. However, in this case, the proposed discharge for Nordic Aquafarms does not contain any toxic components, and there is no need to define a mixing zone. As such, the information in this memorandum is provided primarily to elucidate near-field mixing processes and aid in outfall design.

To aid in understanding near-field mixing process and outfall design, dilution has been evaluated for a variety of possible conditions, including a single-port or multi-port diffuser, and for a range of conditions representative of seasonal and tidal variations in ambient conditions. Dilution values and associated information provided in this memorandum are representative of the dilution that would occur within the plume after 15 minutes of travel time along the plume centerline from the point of discharge.

DILUTION MODELING WITH CORMIX

The Cornell Mixing Zone Expert system (CORMIX)[1] is a series of software subsystems for the analysis, prediction, and design of aqueous toxic or conventional discharges into diverse water bodies. CORMIX utilizes a rule-based, expert systems approach to determine the relative importance of various physical processes, and then applies the appropriate numerical modules to simulate mixing, dilution, and plume trajectory in both near-field and far-field regions. The result is a qualitative and quantitative description of the discharge as it evolves from a near-field jet dominated by effluent characteristics and port geometry to a far-field plume transported and

[1]Doneker, R.L. and G.H. Jirka. CORMIX1: An Expert System for Mixing Zone Analysis of Conventional and Toxic Single Port Aquatic Discharges. 1990, USEPA: Athens, GA.

dispersed by ambient conditions. The expert system methodology reduces the potential for user input error, resulting in a reliable system for jet/plume analysis. CORMIX is supported by the U.S. Environmental Protection Agency (USEPA) and is widely applied and accepted by the environmental community. CORMIX version 11.0 was used for the analysis documented in this report.

EFFLUENT AND DISCHARGE

CORMIX requires specification of various parameters that describe the physical characteristics of the effluent, as well as the geometry of the outfall and discharge port. The following effluent and discharge port characteristics have been assumed based on information provided by Nordic Aquafarms:

- Flow rate of 0.337 m^3/s (7.7 mgd)
- Effluent Density 1014.8 kg/m^3 (representative of a 2:1 mixture of seawater:freshwater at approximately 13 degrees C)
- Discharge port diameter 0.762 m (2.5 feet), or 0.381 m (1.25 feet)
- Discharge port oriented 20 degrees above horizontal, perpendicular to ambient flow direction 1.5 meter (5 feet) above bottom
- Alternative multi-port diffuser with three 0.3 meter (1 foot) diameter ports, spaced 15 m (50 feet) apart, oriented perpendicular to ambient flow. Discharge ports oriented 20 degrees above horizontal and perpendicular to ambient flow direction.
- Outfall located at depth of 8 meters, 500 meters from the shoreline; or depth of 15 meters, 1000 meters from the shoreline.

AMBIENT CONDITIONS

Ambient conditions have been characterized using information from available literature.[2,3,4] It is noteworthy that none of the available data used to approximate ambient tidal current velocity conditions were collected specifically in the area of the proposed discharge in Belfast Bay. Although an attempt has been made to use information that is relevant to the Belfast Bay region in northwestern Penobscot Bay, the available tidal current velocity data were collected in locations that generally farther offshore and in deeper water than the proposed discharge locations.

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[2] Burgund, H.R. 1995. The Currents of Penobscot Bay, Maine, Observations and a Numerical Model. Senior thesis presented to the faculty of the Department of Geology and Geophysics, Yale University.
[3] Normandeau, 1978. An Oil Pollution Prevention Abatement & Management Study for Penobscot Bay, Maine. Volume II, Chapters 6-7. Prepared for the State of Maine Department of Environmental Protection Division of Oil Conveyance Services under Contract No. 907313.
[4] Fandel, C. L., T.C. Lippmann, J.D. Irish, L.I.Brothers. 2016. Observations of Pockmark Flow Structure in Belfast, Bat, Maine. Part 1: Current-induced Mixing. Geo-Mar Lett.

The following assumptions have been made to describe the depth averaged tidal current range and seasonal stratification at the proposed discharge location within Belfast Bay:

- Tidal currents of 0.05 m/s for slack tide, 0.2 m/s for flood and ebb tide.
- Ambient density stratification for winter, spring, summer, and fall seasons as illustrated in Figure 1 and Figure 2 for the deep and shallow discharge location, respectively.

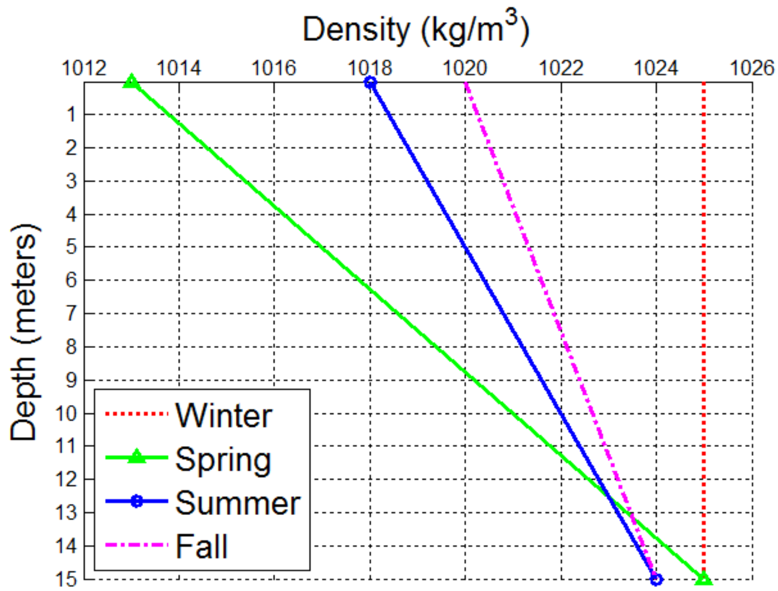

Figure 1. Assumed seasonal density profiles at deep discharge location

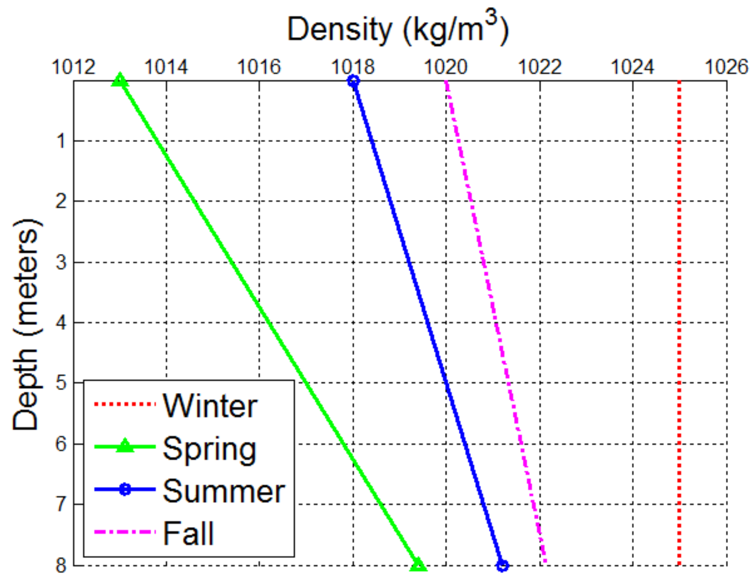

Figure 2. Assumed seasonal density profiles at shallow discharge location

RESULTS AND DISCUSSION

The range of ambient conditions and discharge locations results in a total of 32 unique CORMIX simulations for consideration with a single port discharge, or 16 unique simulations for the multi-port diffuser. The results describing the predicted CORMIX flow class and near-field dilution for the single port discharges are listed in Table 1. Results for the multiport diffuser are listed in Table 2. Important plume characteristics given in Table 1 and Table 2 include the distance from the discharge port at 15 minutes travel time[5], dilution at 15 minutes travel time, and the associated percent of initial concentration excess.

The dilution is the proportion of ambient water to effluent entrained in the plume. For example, if 1 liter of effluent is mixed with enough ambient water to make 10 liters of mixed water, the resulting dilution is 10. The percent initial concentration excess is related to the dilution by the following equation; it allows for easy estimation of the concentration of a specific wastewater constituents when the effluent concentration and background concentrations are known. For example, if the excess concentration (i.e. effluent concentration minus background concentration) is 100 mg/l, a 10% initial concentration excess would mean the concentration at the end of the near-field region is predicted to be 10 mg/l (above background).

$$C = Cs + \frac{1}{S}(Cd - Cs)$$

[5] This distance is calculated along the portion of the plume centerline downstream from the discharge port. where upstream intrusion is predicted the length of the plume may approach twice this distance. Upstream intrusion is generally predicted when the ambient current speed is low relative to the influence of buoyancy. This tends to occur during simulations representative of slack tide conditions.

Where *C* is the concentration corresponding to dilution, *S*. *Cs* is the background concentration, and *Cd* is the effluent concentration[6].

CORMIX input files, session reports and prediction files are available upon request.

Shallow Discharge Location

At the shallow discharge location CORMIX predicts the possibility of 3 different flow classifications for the range discharge and ambient configurations (classes H2, H4-90, and S3 for single port discharge, and MU6, MS1, MS4, and MU1V for the multi-port diffuser). It is likely that the discharge jet-plume will evolve through these different flow classes within the tidal cycle and throughout the seasons.

Shallow Single Port

For the single port discharge the H2 class occurs when the current speed is relatively high and discharge port is large, while the H4-90 class occurs for the smaller port size and at slack tides. In general, the "H" classes describe a jet/plume that is dominated by buoyancy in a relatively uniform ambient layer. This results in a plume that rises quickly after the discharge port and forms a layer at the water surface. For the H4-90 class, the plume may become attached to the bottom at times because the depth becomes relatively small when compared to the length of the initial jet, and the discharge is nearly horizontal. The S3 class, which describes a plume that becomes trapped below the surface within the ambient stratification, is only predicted during slack tides in the spring season when the stratification is strong, and currents are weak.

Shallow Multi-Port

The MU6 flow class is predicted for the multi-port diffuser at the shallow discharge location during the winter season for both slow and fast current speed. MU6 is also predicted during spring, summer, and fall when the current speed is low. MU6 describes a plume that becomes vertically mixed throughout the water column within the near field region as turbulence from the discharge jet dominates the relative unimportance of the stratification. In contrast, "MS" classes are predicted with stratification dominates resulting in buoyant plume that quickly rises after the point of discharge and becomes trapped below the surface within the ambient stratification. This occurs for both current speeds during the spring, and when currents are faster in the summer and fall. The MS4 class, which occurs in spring during slow currents, differs from the MS1 class in that significant upstream intrusion of the plume may occur. During the summer and fall when the current is faster, upstream intrusion of the trapped plume is prevented by the speed of the current.

Deep Discharge Location

Deep Single Port

At the deep discharge location CORMIX predicts the possibility of 6 flow classes (H1, H2, H4-90, S1, S3, S4, and S5). In general, the "H" classes describe a jet/plume that is dominated by

[6] Fischer, H.B., E.J. List, R.C.Y. Koh, J.Imberger, N.H.Brooks,. 1979. Mixing in Inland and Coastal Waters. Academic Press Inc., New York, NY. 483 p.

buoyancy in a relatively uniform ambient layer. This results in a plume that rises quickly after the discharge port and forms a layer at the water surface. At the deep discharge location these conditions primarily occur during the winter season when there is no stratification, and in the fall when stratification is weak and the smaller discharge port is used. In general, “S” classes describe a near-bottom discharge of buoyant plume that becomes trapped in the ambient stratification. The behavior can be qualitatively described by considering that a less dense effluent discharged into the ambient water will entrain ambient water lowering the density of the plume while it rises in the water column until it forms a stable layer where the density of the ambient water above the layer is less than the density of the plume. More detail of the behavior is elucidated by considering whether the plume is more jet like or plume like, and whether the ambient current dominates the jet/plume. In the S1 or S3 class the plume has a more jet like behavior, while S4 or S5 indicate a more plume like behavior. The more jet like conditions occur with the smaller port diameter, which tends to increase the dilution. The S1 or S4 classes occur when currents are stronger during flood or ebb tides indicating that the plume will be strongly deflected increasing dilution. The S3 or S5 classes occur during slack tide when some buoyant upstream intrusion of the plume is expected, tending to reduce dilution somewhat.

Deep Multi-Port

In general buoyancy is more important at the deep discharge location and plume behavior will be more stable because of the greater depth. When current speeds are fast during flooding or ebbing tides the deep multi-port diffuser is plume is classified the same as it is for the shallow discharge location. That is, a fully vertically mixed near-field plume during winter, and a trapped buoyant plume in the spring, summer, and fall seasons that is strongly deflected by the ambient current. When current speeds are low significant upstream intrusion is predicted. During slack tides in winter the plume is predicted to rise to the surface and intrude upstream (MU1V), while during slack tides in the other seasons the upstream intruding plume is expected to become trapped within the ambient stratification.

Table 1. CORMIX Results for Single Port Discharge at 15 minutes Travel Time

Location	Current (m/s)	Season	Port Diameter (m)	CORMIX Flow Class	Distance From Port* (m)	Dilution	% Initial Conc. Excess
Shallow	0.2	Winter	0.761	H2	182.2	51.5	2.0
Shallow	0.2	Winter	0.381	H4-90	183.9	51.1	2.0
Shallow	0.2	Spring	0.761	H2	182.0	73.5	1.4
Shallow	0.2	Spring	0.381	H4-90	185.9	83.0	1.2
Shallow	0.2	Summer	0.761	H2	182.6	60.7	1.7
Shallow	0.2	Summer	0.381	H4-90	187.9	72.8	1.4
Shallow	0.2	Fall	0.761	H2	182.6	60.2	1.7
Shallow	0.2	Fall	0.381	H4-90	184.8	56.9	1.8
Shallow	0.05	Winter	0.761	H4-90	46.3	7.7	13.0
Shallow	0.05	Winter	0.381	H4-90	83.9	48.7	2.1
Shallow	0.05	Spring	0.761	S3	47.5	7.3	13.9
Shallow	0.05	Spring	0.381	S3	48.7	14.8	6.8
Shallow	0.05	Summer	0.761	H4-90	66.3	24.1	4.2
Shallow	0.05	Summer	0.381	H4-90	82.6	32.8	3.0
Shallow	0.05	Fall	0.761	H4-90	46.5	7.2	13.9
Shallow	0.05	Fall	0.381	H4-90	83.6	38.7	2.6
Deep	0.2	Winter	0.761	H1	186.1	96.9	1.0
Deep	0.2	Winter	0.381	H2	187.0	116.4	0.9
Deep	0.2	Spring	0.761	S4	182.3	47.4	2.1
Deep	0.2	Spring	0.381	S1	184.8	79.6	1.3
Deep	0.2	Summer	0.761	S4	183.3	58.8	1.7
Deep	0.2	Summer	0.381	S1	186.1	97.3	1.0
Deep	0.2	Fall	0.761	S4	184.2	68.4	1.5
Deep	0.2	Fall	0.381	H2	187.4	106.8	0.9
Deep	0.05	Winter	0.761	H4-90	48.8	16.4	6.1
Deep	0.05	Winter	0.381	H4-90	91.3	104.9	1.0
Deep	0.05	Spring	0.761	S5	47.5	9.3	10.8
Deep	0.05	Spring	0.381	S3	49.1	16.4	6.1
Deep	0.05	Summer	0.761	S5	48.6	13.0	7.8
Deep	0.05	Summer	0.381	S3	50.9	20.6	4.9
Deep	0.05	Fall	0.761	S5	48.6	12.6	8.0
Deep	0.05	Fall	0.381	S3	52.2	24.0	4.2

*straight line distance to plume centerline at 15 minutes travel time from port. In some cases, the plume may be significantly wider than this distance and may include upstream intrusion.

Table 2. Summary of CORMIX Results for Diffuser at 15 minutes Travel Time

Location	Current (m/s)	Season	CORMIX Flow Class	Distance From Port* (m)	Dilution	% Initial Conc. Excess
Shallow	0.2	Winter	MU6	180.2	212.2	0.5
Shallow	0.2	Spring	MS1	190.5	50.3	2.0
Shallow	0.2	Summer	MS1	194.7	66.8	1.5
Shallow	0.2	Fall	MS1	197.6	80.9	1.2
Shallow	0.05	Winter	MU6	47.5	43.9	2.3
Shallow	0.05	Spring	MS4	53.5	13.5	7.5
Shallow	0.05	Summer	MU6	47.5	43.6	2.3
Shallow	0.05	Fall	MU6	47.5	43.7	2.3
Deep	0.2	Winter	MU6	180.6	350.1	0.3
Deep	0.2	Spring	MS1	192.2	56.9	1.8
Deep	0.2	Summer	MS1	195.5	72.1	1.4
Deep	0.2	Fall	MS1	197.8	84.3	1.2
Deep	0.05	Winter	MU1V	69.2	61.5	1.6
Deep	0.05	Spring	MS4	55.1	17.5	5.7
Deep	0.05	Summer	MS4	55.8	19.3	5.2
Deep	0.05	Fall	MS4	58.1	24.0	4.2

RECOMMENDATIONS

- In general, the results indicate that a reduced port size will lead to higher outlet velocity and increased initial dilution. It is recommended that the smaller port size be considered in design of the outfall, for either the single port or multi-port diffuser.

- The multi-port diffuser yields similar initial dilution as the single port with smaller outlet diameter. However, the behavior of the multi-port diffuser is more consistent at the different depths in terms of CORMIX flow classifications. This suggests the plume behavior from a multi-port diffuser may be less sensitive to the outfall location.

- The results presented here assume the discharge is occurring at full capacity. Discharge at a reduced rate at facility start up may require design modifications to achieve similar initial dilution at reduced discharge rates. The use of duckbill type check valves on the outfall ports may be considered to help maintain outlet velocities under a range of discharge flow rates. Furthermore, the use of a multi-port diffuser may facilitate a scaling up of the discharge flow rate as ports may be initially closed and then opened in sequence as the discharge capacity is increased.

- Site specific ambient conditions data should be collected during facility operations to evaluate whether observations are significantly different than model assumptions and predictions.

- The application of the CORMIX model in tidal environments is limited by an assumption of steady-state conditions. This precludes the ability of CORMIX to estimate long term dilution when it is possible for reversing tidal currents to recirculate the plume past the discharge location. Evaluation of the 2-dimensional far-field behavior of the plume and the potential for recirculation of discharged water and build up of effluent in the receiving water body is discussed in an additional memo that accompanies the Maine Pollutant Discharge Elimination System (MEPDES) Permit Application.